

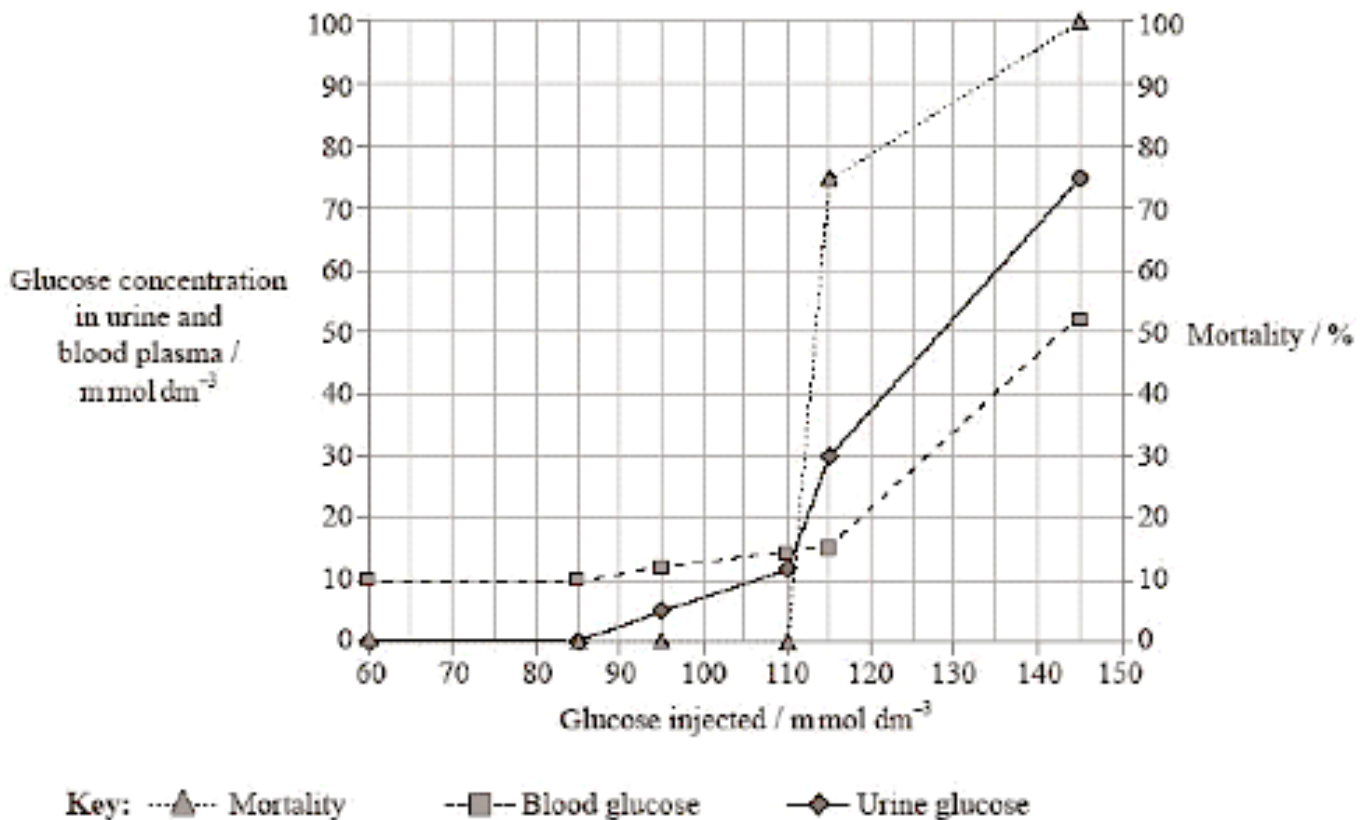
TOPIC 6 – EQUILIBRIUM

Glucose Concentration (7 marks)

Intravenous nutrition is used in patients who cannot feed by mouth. Introducing nutrients directly into veins bypasses the rate at which the digestive system absorbs them. Scientists studied the effect of injecting six different glucose concentrations into rats. They measured the glucose concentration in the urine per day and the glucose concentration in blood plasma per day. These values were compared to control rats that received the same six glucose concentrations through the mouth. The percentage of rats that died during the experiment (mortality) was measured. The results for all control rats orally fed with six different glucose concentrations were the same and are shown in the table below.

Urine glucose concentration / mmol dm^{-3}	Blood plasma glucose concentration / mmol dm^{-3}	Mortality / %
0	10	0

The results for the injected rats are shown in the line graph below.



a. State the mortality for rats when injected with 110 mmol dm^{-3} glucose. (1 mark)

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b. Estimate the difference in blood glucose concentration between rats injected with 145 mmol dm^{-3} glucose and the blood glucose concentration of control rats orally fed 145 mmol dm^{-3} glucose. (1 mark)

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c. Using the data, explain the conclusions that can be drawn about the ability of the rats to regulate blood plasma glucose levels successfully. (3 marks)

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d. Suggest reasons for the differences between rats that were injected and the rats that were orally fed high levels of glucose concentrations. (2 marks)

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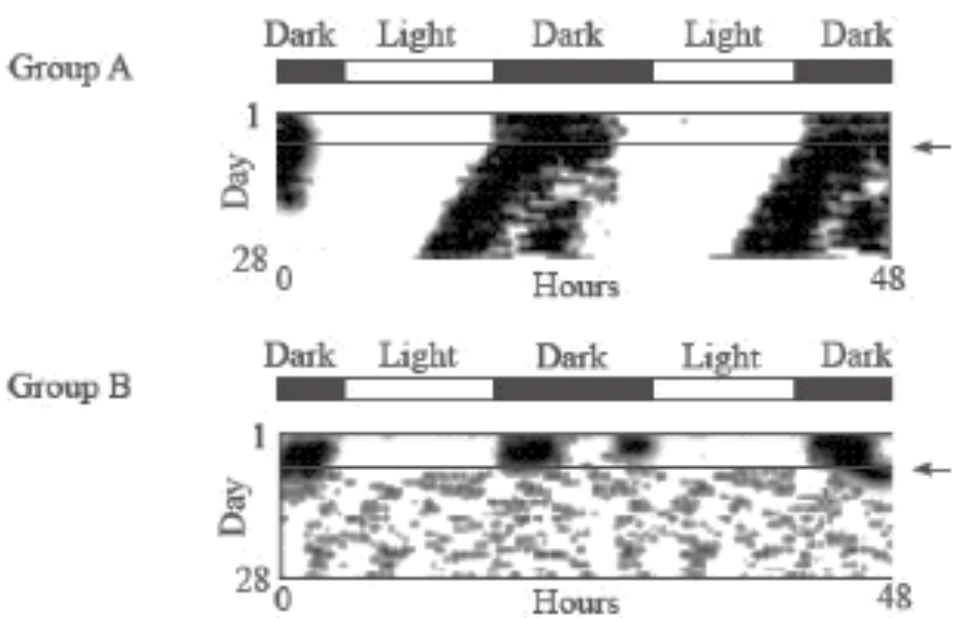
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Circadian Rhythms (7 marks)

Circadian rhythms are daily cycles in physiology and behaviours. Cryptochromes are proteins that are thought to be involved in circadian rhythm in mammals. Two groups of mice were identified. Group A could produce cryptochrome, Group B could not. The behaviour of the mice was assessed by monitoring wheel running activity over a 28-day period. For the first seven days the animals were given alternating 12-hour periods of light and dark. Between days 8 and 28 they were kept in continuous darkness. The rotation of the running wheel is plotted as a dark area within the boxes, the time of day is plotted on the x-axis. The band on top indicates the dark and light periods in the first seven days.



a. State the light conditions when mice were most active during the first 7 days. (1 mark)

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b. Suggest **one** reason for mice showing this behaviour. (1 mark)

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c. Compare the effect of constant darkness on groups A and B. (3 marks)

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d. Evaluate the hypothesis that cryptochromes are necessary for establishing circadian rhythms. (2 marks)

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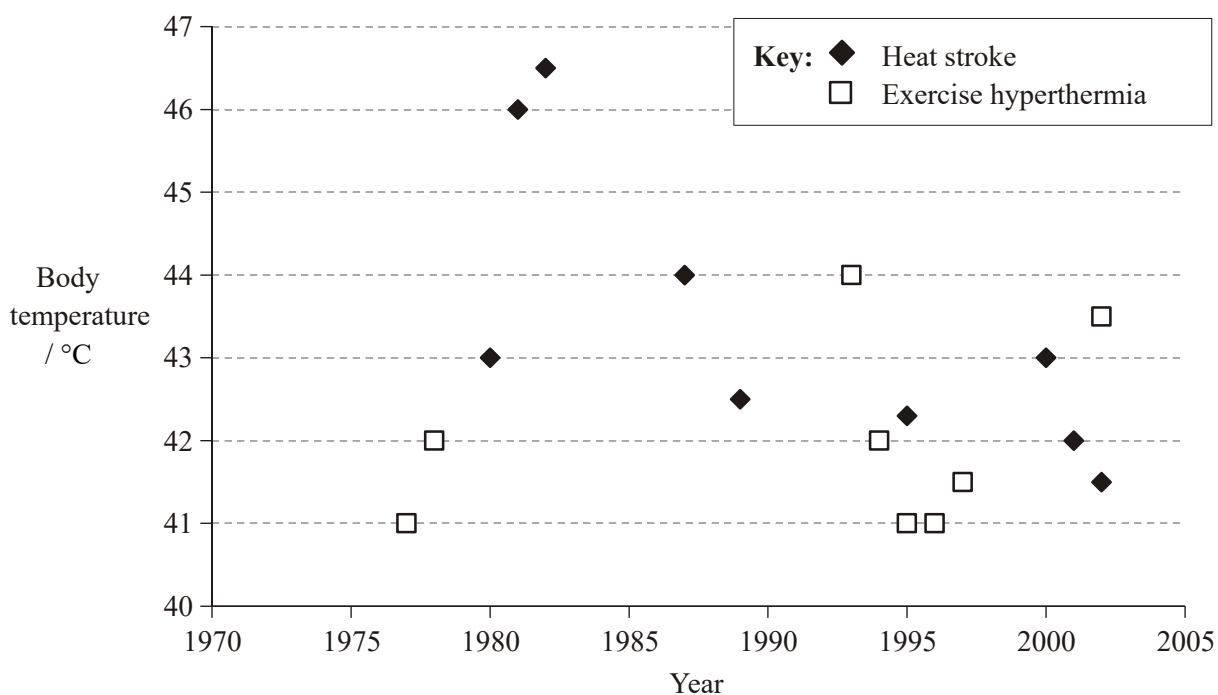
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Hyperthermia (6 marks)

In warm humid weather, marathon runners are at risk of hyperthermia. Sometimes during races, their body temperatures exceed 41°C. At this level of hyperthermia, fatigue and other physiological problems are common. For example, heat stroke occurs when the body becomes dehydrated. This condition reduces blood volume making it difficult for the body to lose heat through vasodilation and sweating.

The graph below shows the relationship between the maximum temperatures recorded in individual patients suffering hyperthermia and heat stroke. All of the patients in this study subsequently recovered without any long-term health effect.



a. Identify the year in which the maximum temperature achieved by a patient was recorded. (1 mark)

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b. Compare temperatures of those with heat stroke against those suffering exercise hyperthermia. (1 mark)

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c. It has been claimed that publication of research on hyperthermia has led to a reduction in the number of cases of hyperthermia in athletes. Evaluate this claim using the data provided in the graph. (2 marks)

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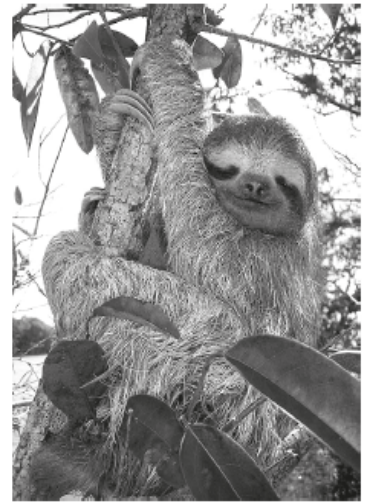
d. Suggest how athletes can avoid hyperthermia. (2 marks)

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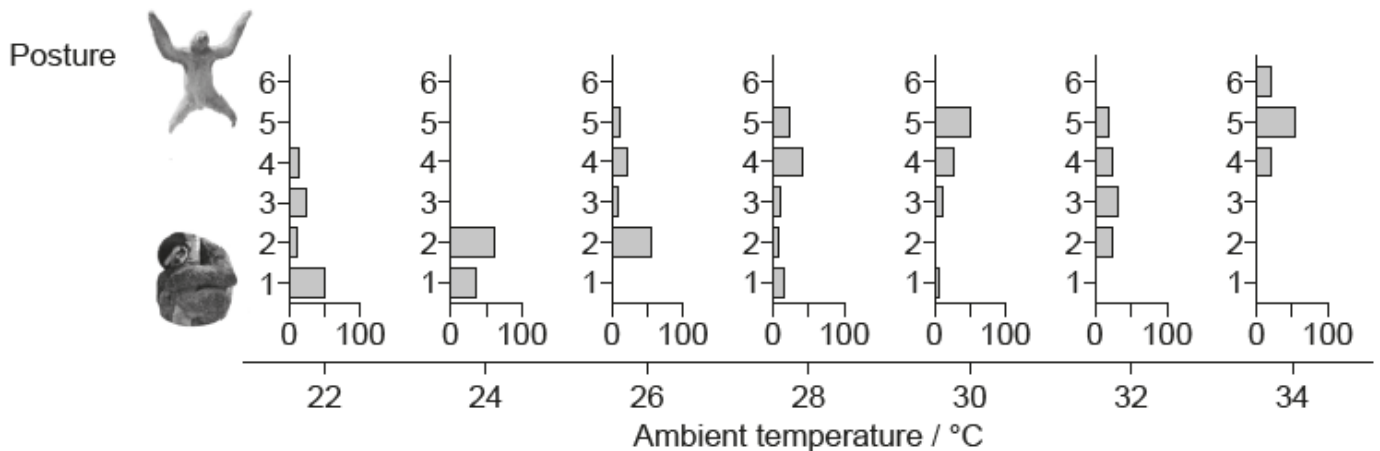
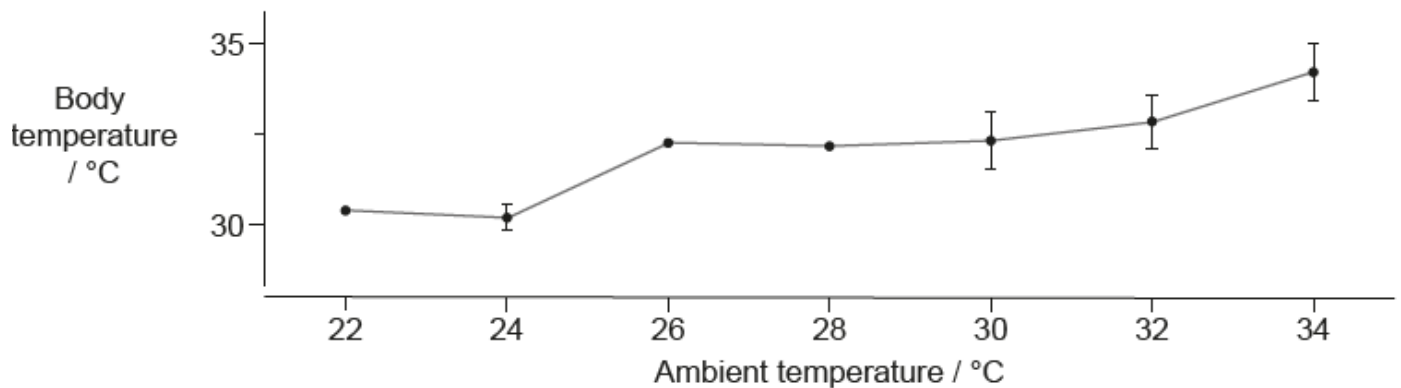
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Thermoregulation (9 marks)

Three-toed sloths (*Bradypus variegatus*) are placental mammals that live in trees in Central and South America. They eat leaves and fruit and get almost all their water from succulent plants.



Three-toed sloths change their body posture in response to the temperature of their environment (ambient temperature). Researchers assessed posture on a scale from 1 to 6, with 1 being when the sloth was curled into a tight ball and 6 when it had all limbs spread. The percentage of time the sloths were observed in each position was recorded at ambient temperatures from 22 °C to 34 °C. The researchers also measured the body temperature of the sloths over the same range of ambient temperatures.



a. State the relationship between sloth body temperature and ambient temperature. (1 mark)

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b. Explain how this relationship differs from that in humans. (1 mark)

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c. Describe the trend in body posture as ambient temperature rises from 22 to 34 °C. (1 mark)

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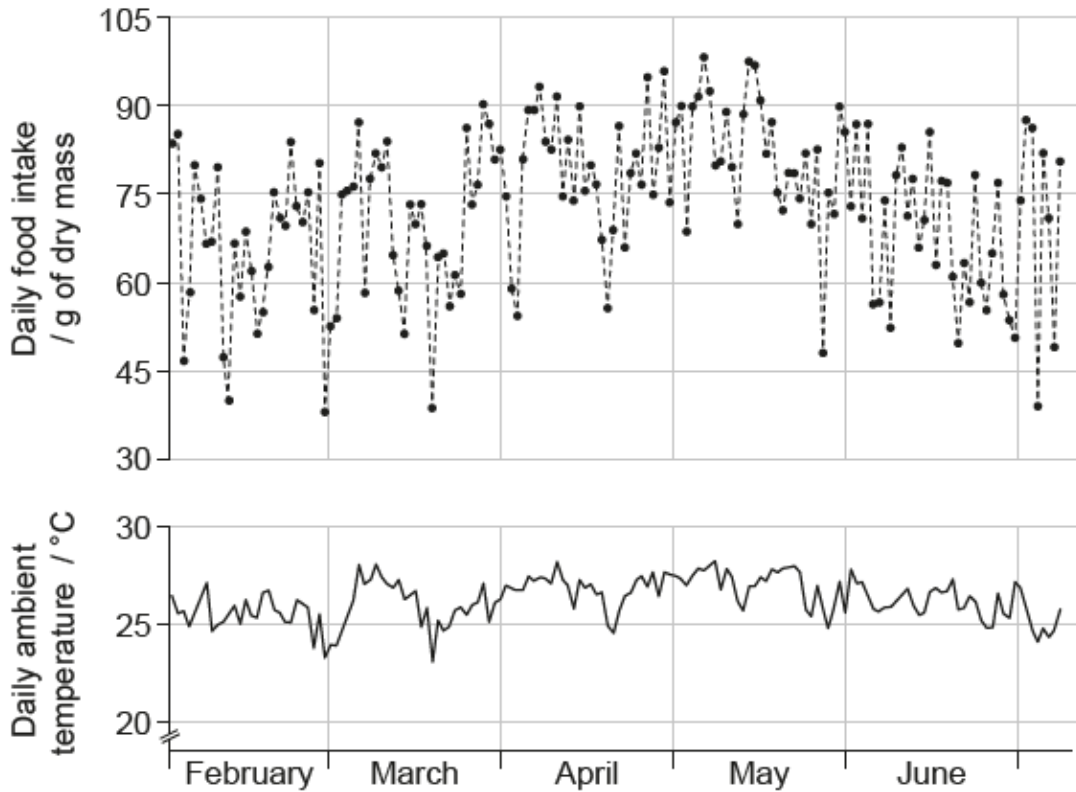
d. Suggest reasons for this trend. (2 marks)

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The daily food intake of three-toed sloths and daily ambient temperatures were monitored over a 160-day period from February to early July. The graphs show the mean results.



e. The mean daily food intake fluctuated from day to day. State the month that contains the day on which the mean intake of food was highest. (1 mark)

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f. Outline the relationship between ambient daily temperature and food intake in March. (2 marks)

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g. Suggest, with a reason, how the activity of the sloth varies with ambient temperature. (1 mark)

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Answers

1a (1 mark)

zero / none died / 0 / 0%

1b (1 mark)

$52 \text{ mmol dm}^{-3} - 10 \text{ mmol dm}^{-3} = 42 (\pm 1) \text{ mmol dm}^{-3}$ (units required)

1c (3 marks)

- intravenous after 85 mmol dm^{-3} , the glucose starts appearing in urine / glucose is no longer reabsorbed in kidneys / tubules
- up to 110 mmol dm^{-3} , the values in blood serum are close to normal / glucose excreted through urine / no mortality
- above 110 mmol dm^{-3} / 115 mmol dm^{-3} , rats start dying / blood levels still close to normal / excreted through urine
- after 115 mmol dm^{-3} , values of glucose in blood / mortality start increasing drastically

1d (2 marks)

- the excess glucose in orally fed rats is egested / not absorbed
- in orally fed rats it enters body more gradually
- in orally fed rats it goes straight to liver while in injected rates it goes straight to rest of body
- in orally fed rats, insulin regulates blood sugar at all levels (10 mmol dm^{-3})

2a (1 mark)

Dark

2b (1 mark)

because they are nocturnal / avoid predation by being active at night

2c (3 marks)

- group A is able to maintain a rhythm while group B is not
- group B is active more frequently than group A
- group B is active for a shorter period than group A

2d (2 marks)

- (before constant darkness) group B had a rhythm suggesting cytochromes are not necessary
- (after constant darkness) group B were unable to re-establish a rhythm suggesting cytochromes are necessary
- cytochromes involved along with other variables

3a (1 mark)

1982

3b (1 mark)

heat stroke temperatures were generally higher than exercise hyperthermia

3c (2 marks)

- there is no change / a slight increase in the maximum body temperature recorded for exercise hyperthermia
- the data is limited so difficult to draw a conclusion
- accept numerical data (e.g 1993 is highest recorded body temperature)

3d (2 marks)

- reducing exposure to high temperature conditions
- drinking sufficient water / fluids while exercising
- reduce body hair
- minimize clothing
- spray with water
- acclimatisation training

4a (1 mark)

body temperature increases with ambient temperature / positive correlation

Since direct can be either -/+ , no credit for direct correlation alone.

4b (1 mark)

humans maintain/regulate a constant body temperature at different ambient temperatures/maintained by homeostasis

4c (1 mark)

- a. As ambient temperature increases, the sloth spends more time with limbs spread
- b. as ambient temperature increases the sloth spends less time curled in a ball
- c. as ambient temperature rises, the posture changes from 1 to 6

4d (2 marks)

- a. less surface area is exposed when curled up **OR** more surface area is exposed when all limbs spread
- b. curled position prevents heat loss/provides warmth **OR** stretched out position allows more heat loss/body cooled

4e (1 mark)

May

4f (2 marks)

- a. food intake rises as daily temperature increases / positive correlation
- b. the lowest food intake corresponds to the lowest temperature

4g (1 mark)

- a. the sloth will be more active at higher temperatures as it takes in more food for energy
- b. as temperature rises, the sloth uncurls to dissipate/lose heat

Reason required.