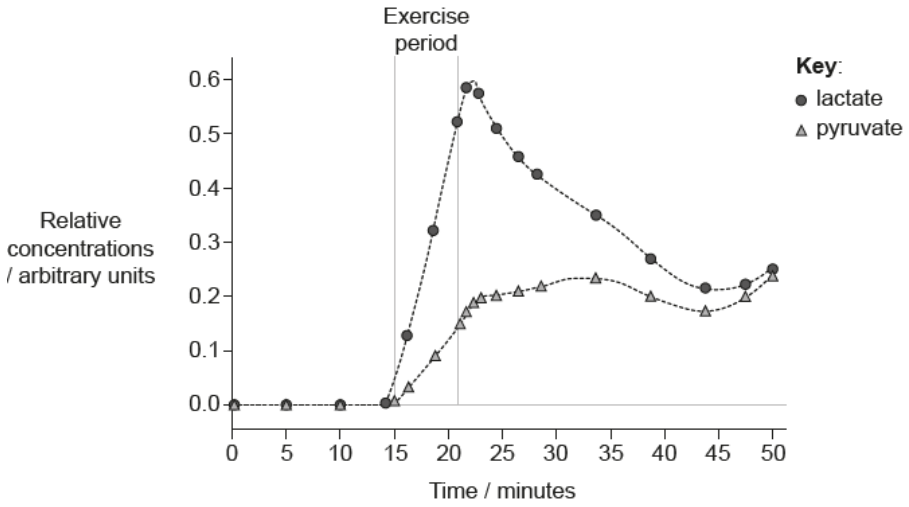
Metabolism Test A *[50 marks]*

1. The graph shows the changes in lactate and pyruvate measured in an athlete's blood during and following a mild exercise period as compared to the period before the exercise. *[1 mark]*



[Source: W. E. Huckabee (1958) *The Journal of Clinical Investigation*, 37 (2), page 257.]

What do these curves suggest?

A. Before the exercise, there was no pyruvate produced because there was no cell respiration.

B. During the exercise, there was not enough oxygen available for cell respiration, so the process was partly anaerobic.

C. During the exercise, the level of lactate increased due to aerobic respiration.

D. After the exercise, the level of lactate decreased because there was enough pyruvate to be used for anaerobic cell respiration.

Markscheme

B

2. What is the relative wavelength in the visible spectrum of red light and blue light and are these colours absorbed or reflected by chlorophyll? *[1 mark]*

	Red light		Blue light	
A.	longest wavelength	absorbed	shortest wavelength	absorbed
B.	shortest wavelength	reflected	longest wavelength	reflected
C.	longest wavelength	absorbed	shortest wavelength	reflected
D.	shortest wavelength	absorbed	longest wavelength	absorbed

Markscheme

A

3. Which technological advance enabled Calvin to perform his lollipop experiment on the light-independent reactions of photosynthesis in 1949? *[1 mark]*

A. Methods for tracing radioactive carbon incorporated in molecules produced by the alga *Chlorella*

B. Development of electron microscopes enabling the molecules produced by the alga *Scenedesmus* to be viewed

C. Methods for changing the wavelength of light shining on the alga *Scenedesmus* contained in the lollipop

D. Development of X-ray diffraction techniques enabling the molecules produced by the alga *Chlorella* to be identified

Markscheme

A

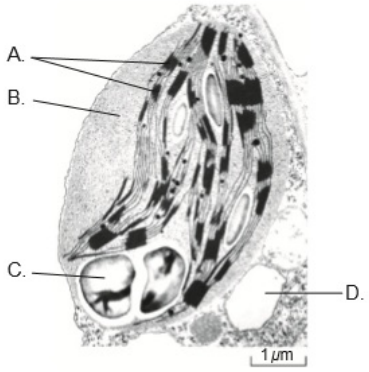
4. Which process requires oxygen in aerobic cell respiration? *[1 mark]*

A. Oxidation of triose phosphate
B. Reduction of hydrogen carriers
C. Maintaining an oxygen concentration gradient in mitochondria
D. Accepting electrons at the end of the electron transport chain

Markscheme

D

5. The electron micrograph shows part of a plant cell. Where do the light-independent reactions of photosynthesis take place? *[1 mark]*



[Source: adapted from http://themicroscopicplant.weebly.com]

Markscheme

B

6. What is a feature of shorter wavelength visible radiation? *[1 mark]*

A. It includes violet light.
B. It has less energy per photon than longer wavelengths.
C. It is absorbed by greenhouse gases.
D. It is reflected by chlorophyll.

Markscheme

A

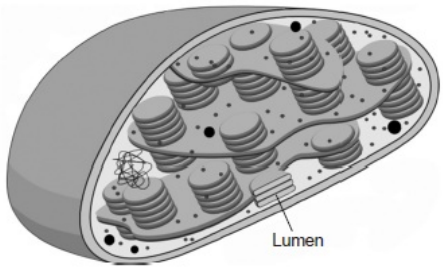
7. Which molecule would first contain ^{14}C if the alga *Chlorella* was grown in the presence of light and radioactive CO_2? *[1 mark]*

A. Glycerate 3-phosphate
B. Glucose
C. Rubisco
D. Ribulose bisphosphate (RuBP)

Markscheme

A

The image shows a chloroplast.



[Source: adapted from http://evolutionaryroutes.files.wordpress.com]

8. During photosynthesis, what happens in the chloroplast at the location labelled lumen? *[1 mark]*

A. Protons accumulate.

B. Pyruvate undergoes decarboxylation.

C. NADH is oxidized.

D. Oxygen is produced.

Markscheme

A

9. What products of the light-dependent reactions are used in the light-independent reactions? *[1 mark]*

A. ATP and NADPH

B. NADPH and ribulose bisphosphate (RuBP)

C. CO_2 and ATP

D. ATP and O_2

Markscheme

A

10. What process occurs during the light-independent reactions of photosynthesis? *[1 mark]*
A. Oxygen is released into the atmosphere.
B. Protons are pumped from the thylakoid space to the stroma.
C. RuBP is carboxylated then regenerated in the Calvin cycle.
D. Triose phosphate is converted to glycerate 3-phosphate.

Markscheme

C

11. How can the rate of photosynthesis be measured? *[1 mark]*

I. By the amount of oxygen produced

II. By the increase in biomass

III. By the amount of carbon dioxide produced

A. I only
B. I and II only
C. I and III only
D. I, II and III

Markscheme

B

12. What happens during glycolysis for one molecule of glucose? *[1 mark]*

A. Two pyruvates are formed.
B. There is a net gain of two NADPH + H^+.
C. There is a net loss of two ATP.
D. Two acetyl CoA are formed.

Markscheme

A

13. What is light energy used for in photolysis? *[1 mark]*

A. Formation of hydrogen and oxygen
B. Formation of carbon dioxide only
C. Formation of ATP and glucose
D. Formation of oxygen only

Markscheme

A

14. What happens during oxidative decarboxylation of pyruvate? *[1 mark]*

A. Reduction of NAD^+ and oxidation of CO_2
B. Oxidation of NADH and production of CO_2
C. Reduction of NAD^+ and production of CO_2
D. Oxidation of NADH and reduction of CO_2

Markscheme

C

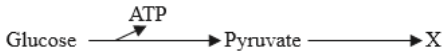
15. In a chloroplast where are the enzymes of the Calvin cycle located? *[1 mark]*

A. Thylakoid membranes
B. Stroma
C. Grana
D. Outer membrane of chloroplast

Markscheme

B

16. The diagram shows anaerobic respiration in yeast cells. *[1 mark]*



What would be produced at X?

A. ATP
B. Lactate
C. Ethanol and CO_2
D. CO_2 and H_2O

Markscheme

C

17. What is the total number of ATP molecules used and produced during glycolysis? *[1 mark]*

	ATP used during glycolysis	ATP produced during glycolysis
A.	2	2
B.	0	2
C.	2	4
D.	4	4

Markscheme

C

18. What occurs during oxidative phosphorylation? *[1 mark]*

A. ATP production using electrons from NADP
B. Coupling of ATP synthesis to electron transport
C. Chemiosmosis in the matrix of the mitochondrion
D. Release of energy as ATP reacts with oxygen

Markscheme

B

19. Where is chlorophyll found in a plant cell? *[1 mark]*

A. Thylakoid membranes
B. Stroma
C. Matrix
D. Cristae

Markscheme

A

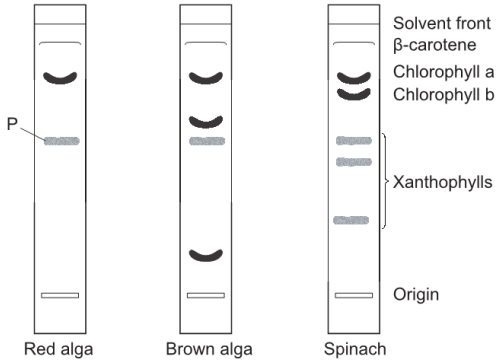
20. What is the advantage of having a small volume inside the thylakoids of the chloroplast? *[1 mark]*

A. High proton concentrations are rapidly developed.
B. High electron concentrations are rapidly developed.
C. Photosynthetic pigments are highly concentrated.
D. Enzymes of the Calvin cycle are highly concentrated.

Markscheme

A

Thin-layer chromatography was carried out on red and brown algae to discover what photosynthetic pigments they contained. The results were compared with the known pigments found in spinach leaves.



21a. Identify pigment labelled P. *[1 mark]*

Markscheme

xanthophyll

21b. State a suitable solvent for extracting photosynthetic pigments from plant tissue. *[1 mark]*

Markscheme

acetone

OR

alcohol

OR

ether

Accept other named organic solvent

If there is more than one answer accept only the first one. (Note: "Water mixed with alcohol" would be correct as would "alcohol, water" but "water, alcohol" would be incorrect)

21c. Explain how the pigments in the chromatogram of spinach are identified. *[3 marks]*

Markscheme

a. they can be identified by their colour/analysis with spectrometer

b. measure the distance travelled by the solvent front

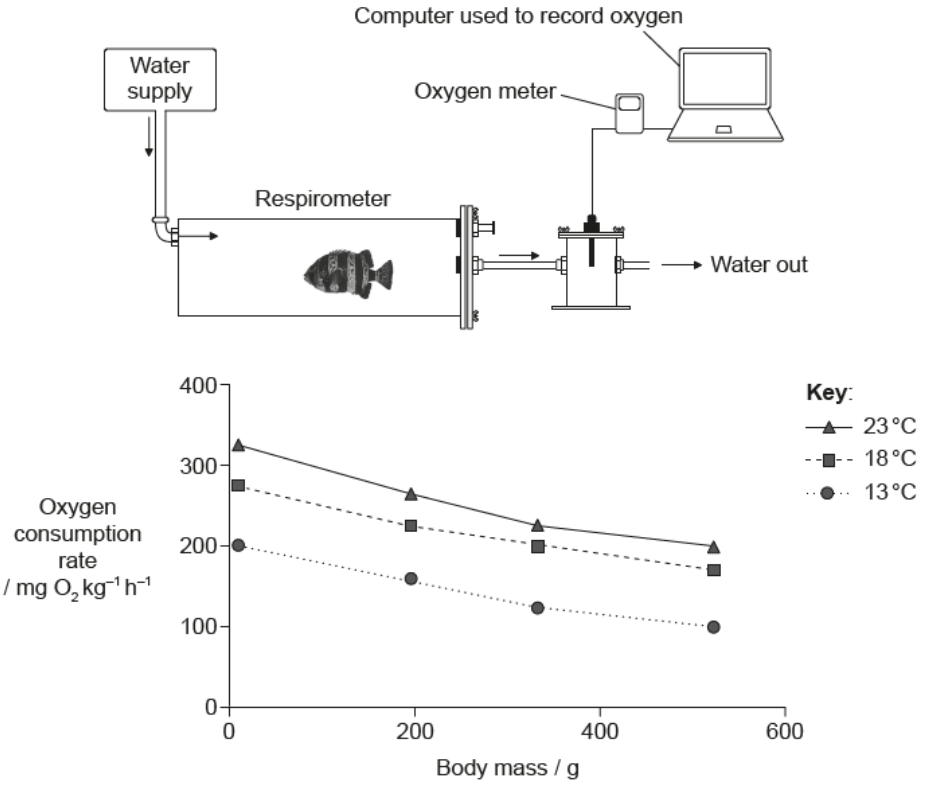
c. measure the distance travelled by the pigment

d. calculate the R_f value

e. they can be identified by comparing R_f values to known values

[Max 3 Marks]

The oxygen consumption rate of the fish *Oplegnathus insignis* was examined in a respirometer at three different water temperatures and at four different body masses.



[Source: adapted from E Segovia, *et al.*, (2012), *Latin American Journal of Aquatic Research*, **40** (3), pages 766–773]

22a. Suggest how the oxygen consumption rate is determined using this apparatus. *[2 marks]*

Markscheme

a. the data logger measures the differences in oxygen concentration
OR
the oxygen concentration is measured before and after the water passes through the respirometer

b. over time

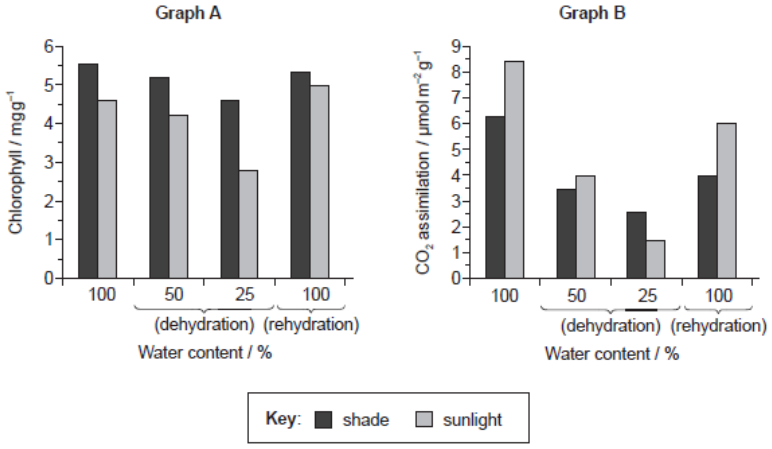
c. the mass of fish needs to be measured

22b. State the relationship between body mass and the oxygen consumption of fish. *[1 mark]*

Markscheme

greater body mass, less consumption of oxygen
OR
indirect/negative relationship

The *Haberlea rhodopensis* plant is capable of tolerating extreme dryness. Chlorophyll levels and CO_2 assimilation were evaluated during dehydration and rehydration using plants grown in shade and sunlight. Graph A shows the changes in chlorophyll content with increasing dehydration and during rehydration. Graph B shows the changes in CO_2 assimilation with increasing dehydration and during rehydration.



[Source: adapted from K Georgieva, *et al.*, (2013), *15th International Conference on Photosynthesis*, pages 536–542]

23a. State the level of chlorophyll at 50 % water content for plants growing in sunlight, giving the units. *[1 mark]*

Markscheme

4.2 mg g^{-1} (units required)

Accept answers in the range of 4.1 mg g^{-1} to 4.3 mg g^{-1}.

23b. Outline the effect of sunlight and shade on CO_2 assimilation during dehydration. *[2 marks]*

Markscheme

a. decreases with dehydration in both shade and sunlight;

b. greater decrease in sunlight than shade;

c. at 100/50 CO_2 assimilation greater in sunlight than shade but at 25 shade greater than sunlight;

23c. Compare the effect of rehydration on chlorophyll levels in plants grown in shade and sunlight. *[2 marks]*

Markscheme

a. both increase (over the 25% water content);

b. (chlorophyll in) shade plants increase to almost the same/slightly less than original levels;

c. plants grown in sunlight have almost the same/slightly more than original levels;

d. the difference between plants grown in the shade and sunlight is less than at any time at dehydration;

23d. Using the data, deduce, with a reason, **two** stages of photosynthesis that may be limited during dehydration in a plant. *[2 marks]*

Markscheme

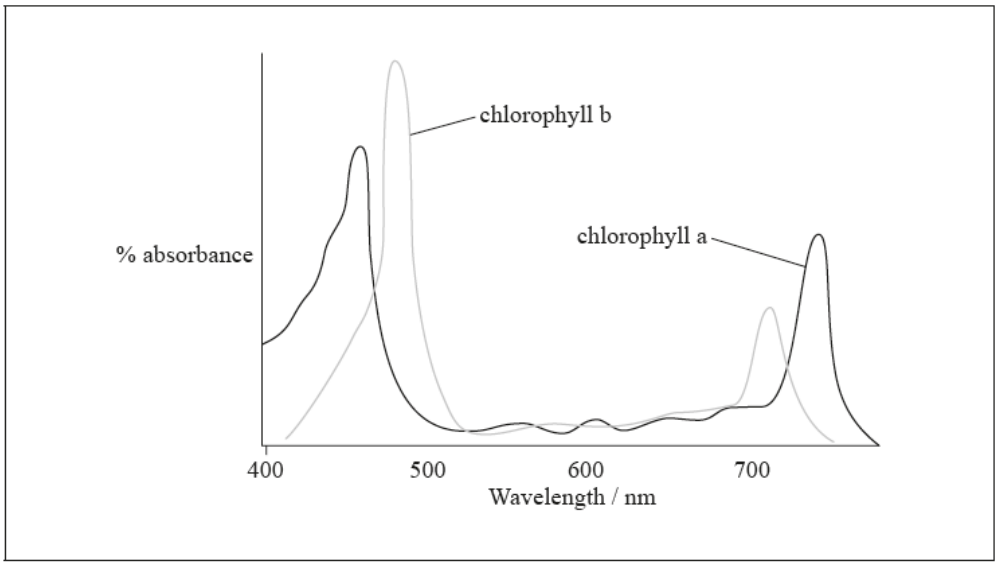
a. decrease in chlorophyll causes lowered rate of light dependent reaction/less absorption of light energy;

b. decrease in CO_2 assimilation causes lowered rate of light independent reaction/ less CO_2 fixation/Calvin cycle;

c. both stages reduced due to wilting/less surface of leaf/closure of stomata;

Candidates must include a reason to receive the mark.

24a. The graph shows the absorption spectrum for two types of chlorophyll. *[3 marks]*



[Source: © International Baccalaureate Organization 2014]

(i) Sketch on the graph, the action spectrum of photosynthesis.

(ii) Explain the relationship between the absorption spectrum for chlorophyll and action spectrum of photosynthesis for green plants.

Markscheme

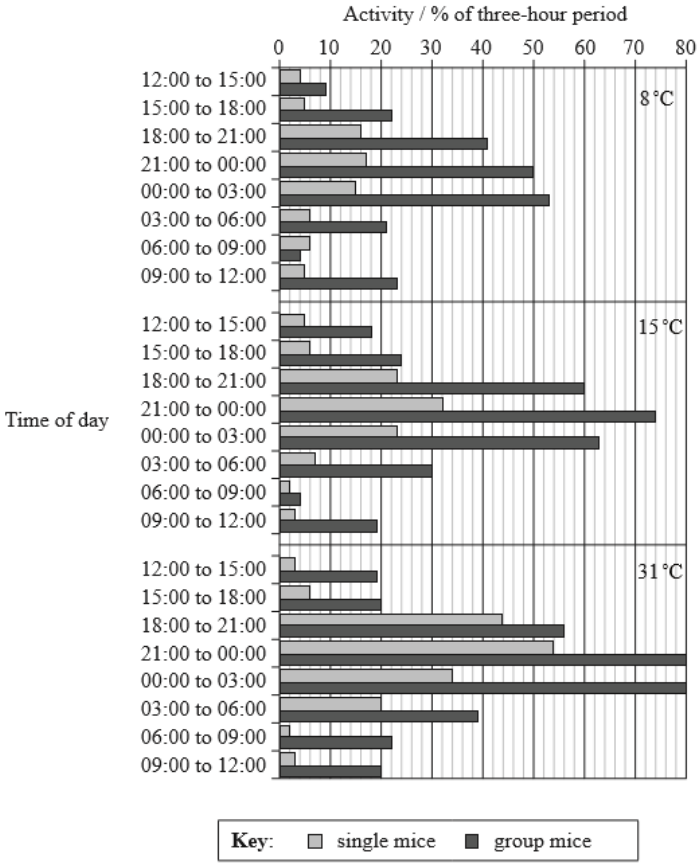
(i) line slightly above absorption spectrum with peaks in red and blue and a trough between but not as low as for absorption spectrum
(ii) energy/light absorbed by pigments/chlorophyll is used for photosynthesis;
peaks in action spectrum correspond to peak absorption by chlorophyll;
differences due to absorption by accessory/other pigments (*eg* carotene);
least absorption in green range/approximately 600nm as most light reflected;

24b. Outline photoactivation of photosystem II in the light-dependent reaction of photosynthesis. *[2 marks]*

Markscheme

light/photon absorbed by pigment molecules (in photosystem II)/chlorophyll;
energy/electrons passed to chlorophyll molecule at the reaction centre;
causes electron to be raised to higher energy level / electron is excited;
this electron passed along chain of carrier molecules in photosystem II;

Investigators carried out experiments to find the relationship between the energy used by mice (the metabolic rate) and their activity. They found that the amount of time mice are active depends on the time of day, whether they are single or in groups and on the temperature of their surroundings. The bar chart below shows the percentage of time mice were active during three-hour periods at three different temperatures.



L. E. Mount and J. V. Willmott (1967) Journal of Physiology, 190, pages 371–380. Published by Wiley-Blackwell. Used with permission.

25a. Calculate how many minutes the group mice are active between 21:00 and 00:00 at 8 °C. *[1 mark]*

Markscheme

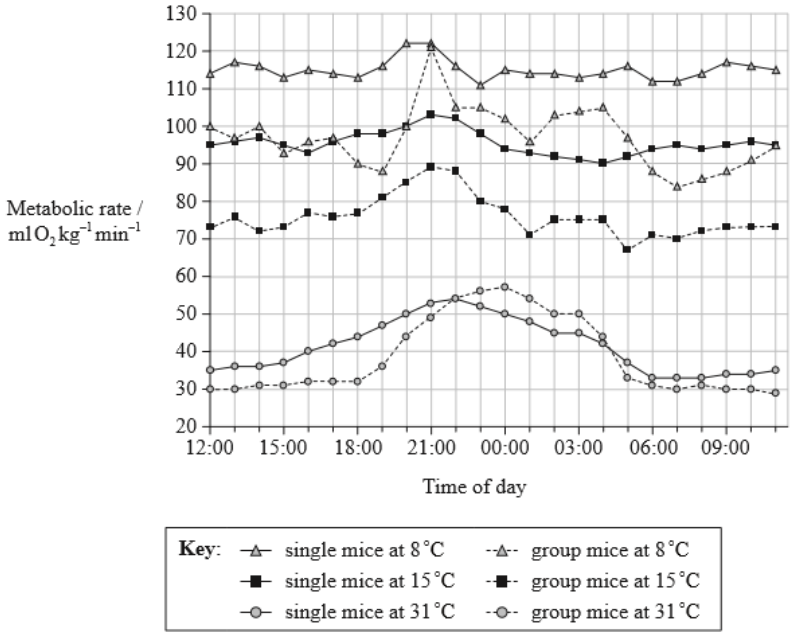
90 (minutes)

25b. Outline the relationship between activity and temperature from 21:00 to 03:00 in all of the mice. *[1 mark]*

Markscheme

as temperature increases activity increases/positive correlation.

The investigators also found that the metabolic rate of the mice changed at different times of the day. Mice were kept at one of the three constant temperatures for 24 hours and their oxygen consumption was measured. The graph below shows the results for single mice and the mean values for group mice.



25c. State the relationship between temperature and metabolic rate. *[1 mark]*

Markscheme

as temperature increases metabolic rate decreases/negative correlation (*accept converse*)

25d. Compare the results for the single mice at 15 °C with those for the group mice at 15 °C. *[2 marks]*

Markscheme

metabolic rate of group mice is always less than single mice; (*accept converse*)
both follow similar pattern of increases/decreases/fluctuations at same time of day;
fluctuations greater in group mice;
both most active/higher metabolic rate during evening/21:00; (*accept any reference to times between 18:00 and 00:00*)

25e. Suggest **one** reason why the results differ for single mice and group mice. *[1 mark]*

Markscheme

single mice need to produce more heat/have greater heat loss because of greater surface exposed to air / group mice huddle together to reduce the surface exposed to air
Allow any other reasonable answer.

25f. Explain why oxygen consumption is used as a measure of metabolic rate. *[2 marks]*

Markscheme

oxygen is required for (aerobic) respiration;
respiration produces ATP/releases energy/heat in the mice;
metabolic rate is a measure of total energy released/consumed in the body / oxygen consumption is proportional to energy released/consumed in body/ proportional to metabolic rate;

25g. Using the data from both graphs, evaluate the hypothesis that increased activity causes an increase in metabolic rate in mice. *[2 marks]*

Markscheme

metabolic activity high when mice more active supports the hypothesis;
activity is normally correlated with energy consumption;
but another factor may be causing both to increase at the same time / correlation does not always establish cause and effect;
grouping/environmental temperature also affect metabolic rate;