

Name: _____

Class: _____

Maturitätsprüfungen 2021 – Fach Biologie schriftlich ENGLISH

Klassen: 4B, 4Be, 4BW (MtM JuC, MoN, SoP)

Testing duration: 4 hours

Auxiliary materials: writing tools, calculators, set square, bilingual dictionary

General work instructions:

- ✓ Read every task carefully and thoroughly before you answer.
- ✓ Use the technical terms you know.
- ✓ Answer all questions directly on the question sheet. Extra, spare pages are to be found at the end.
- ✓ Only legible answers will be corrected.
- ✓ For multiple-choice tasks, all correct answers must be indicated to achieve full marks. Incorrectly indicated answers give deductions. However, there is a minimum of 0 points per question.
- ✓ To achieve the maximum grade not all answers need to be correct.

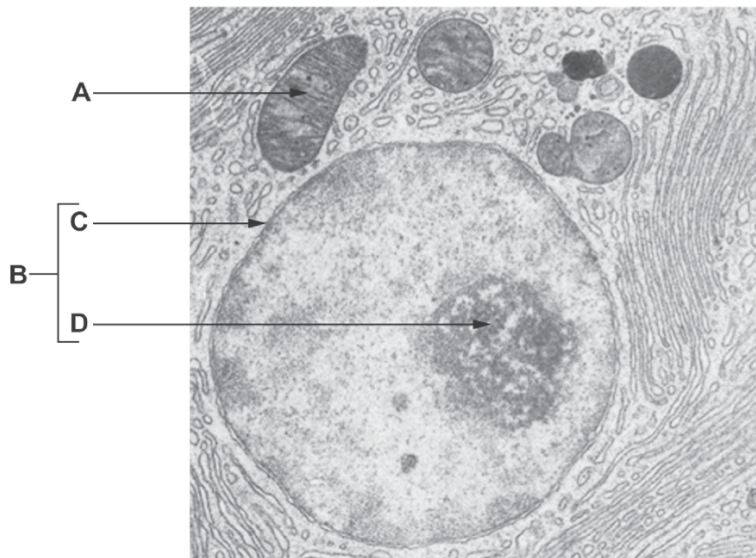
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Basic knowledge: Cell biology, Cell constituents, Metabolism (30.5 points)

Task 1 (2.5P)

1. a) Complete the table with the help of the EM illustration below. (1.5 P)
 b) Explain the functions of A and D. (1P)



Letter	Structures	Functions
A		
B		
C		
D		

Task 2 (4P)

Mark the one correct answer.

a) Which of the following organelles would only be found within a cell that was both eukaryotic and autotrophic?

- mitochondria
- ribosomes
- rough endoplasmic reticulum
- chloroplasts
- vesicles

b) Which of the following is NOT offered as evidence in support of the theory of endosymbiosis?

- Mitochondria and chloroplasts are similar in size and structure to some species of bacteria
- Mitochondria and chloroplasts have their own DNA coding separate from the eukaryotic nucleus.
- Mitochondria and chloroplasts have their own DNA what allows them to split independently.
- The ribosomes of chloroplasts and mitochondria are similar to those of eubacteria

c) Check the following two statements individually, as well as the "because" connection, for accuracy, and answer the MCQ.

1 Prokaryotes cannot perform cell respiration

Because

2 Prokaryotes do not possess mitochondria.

- 1 wrong, 2 wrong
- 1 wrong, 2 right
- 1 right, 2 wrong
- 1 correct, 2 correct, link incorrect
- 1 correct, 2 correct, link correct

d) Which of the following processes is not found in bacteria?

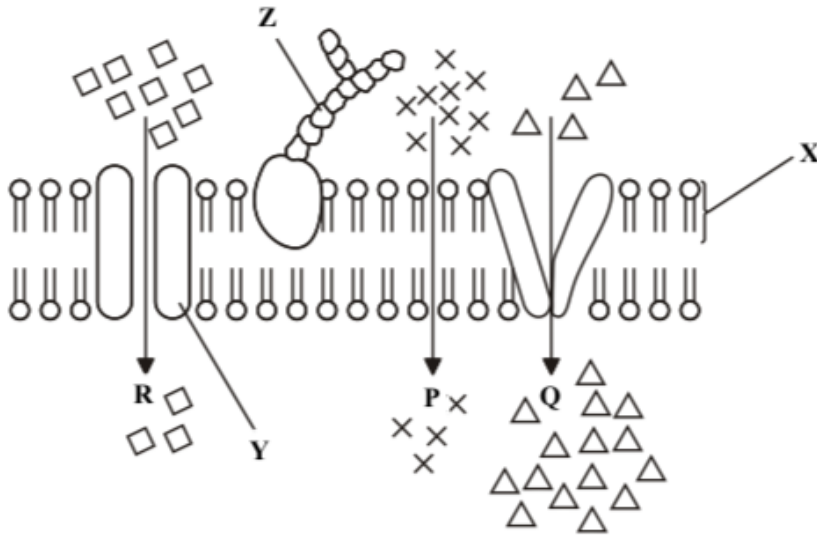
- DNA synthesis
- RNA splicing
- DNA repair
- Transcription of DNA
- Translation of the mRNA

Task 3 (3P)

The figure below shows a model of a cell membrane and various molecules that are transported into the cell.

a) Name the structures X, Y and Z (1.5P)

b) Name the transport processes P, Q and R. (1.5P)

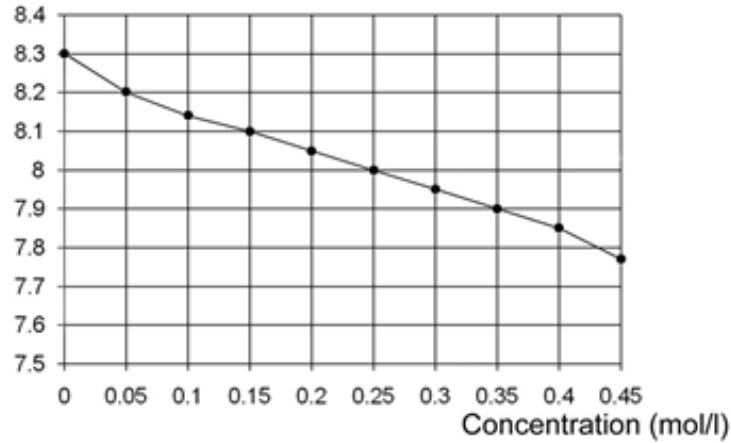


Task 4 (5P)

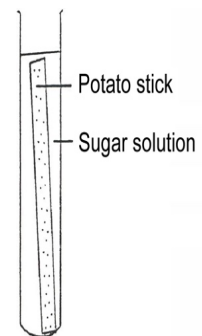
A concentration series of sugar solutions was prepared, (see figure below). On the left of the x-axis is water, to the right the sugar concentration increases linearly. Elongated pieces of potato tuber tissue, exactly 8 cm long were placed into each sugar solution of known concentration. After 60 minutes the potato sticks were removed from solution, felt and the length was measured accurately.

Results:

Length of potato stick (cm)



Stick no. 1 2 3 4 5 6 7 8 9 10



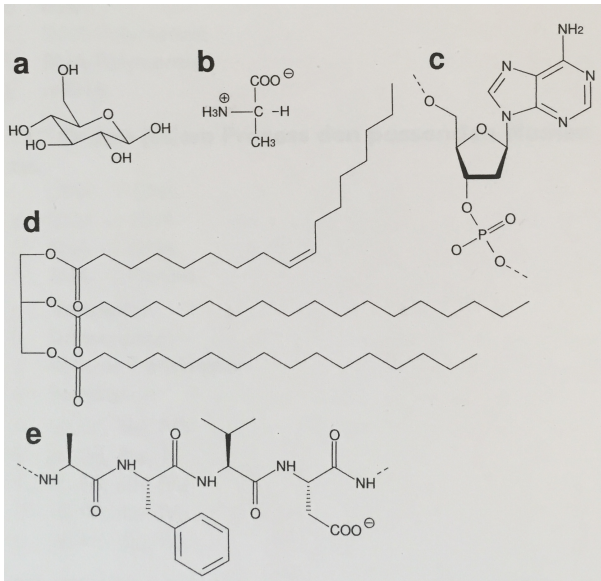
a) Explain the shape of the curve (2P)

b) If a potato cell is placed in the 0.45 m sugar solution for one hour, how would it appear? Make a sketch of this cell and label it. What is the technical name for this process? (2P)

c) What can actually be determined with this experimental set-up? (Describe briefly) (1P)

Task 5 (2.5P)

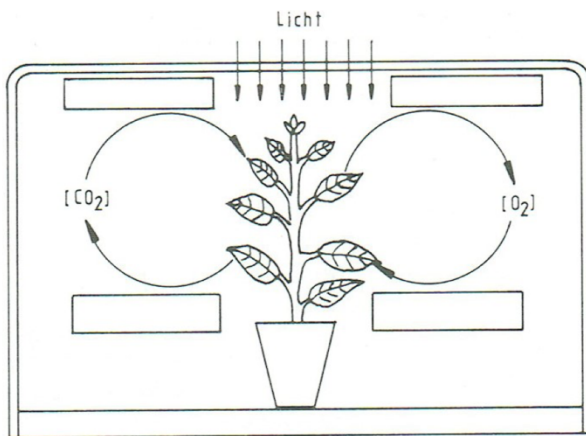
Match the following molecules to their chemical class.



- I. Amino acid
- II. Lipid (fat)
- III. Nucleotide/DNA
- IV. Peptide/Protein
- V. Sugar

Task 6 (5.5P)

a) Complete the illustration below by inserting the matching terms into the empty boxes. (2P)



In an airtight container, in which there is a green plant, the CO₂ concentration drops in the light within a short time to a value which then remains constant. This value is called the CO₂ compensation point (K).

b) Use the illustration to explain why a constant CO₂ concentration occurs. (1P)

c) Explain why this CO₂ value is referred to as a CO₂ compensation point. (1P)

d) Describe using keywords the situation of three plants that are forced to thrive in CO₂ concentrations above K, at K or below K. (1.5P)

Task 7

a) What are chromatin fibers made of? (1P)

b) What functionality is provided by the chromosomal shortening (condensing) during the mitotic phase of the cell cycle? (1P)

c) Name one plant and one animal tissue in which mitosis occurs permanently. (1P)

Task 8 (5P)

The influence of temperature on the alcoholic fermentation of yeast cells was investigated in an extensive series of experiments.

The determination of the rate of fermentation is based on the carbon dioxide production of the yeast cells in a glucose solution. The carbon dioxide is transferred from the reaction vessel to a gas measuring tube filled with water. Here the gas accumulates, so that the amount of gas produced per unit of time can be read off a scale.

To determine the temperature dependence on the rate of fermentation, the same amount of a 10% glucose solution is added to 8 conical flasks. The individual conical flasks are now placed in water baths with different temperatures and kept constant. After temperature equalisation between the water bath and reaction vessel, the same amount of a yeast cell suspension is pipetted into each conical flask and the resulting gas volume is measured.

Results

Trial no.	1	2	3	4	5	6	7	8
Temperature °C	20	25	30	35	40	45	50	55
ml CO ₂	2	5	12	22	28	26	16	0

a) Give the overall balanced equations for alcoholic fermentation and cell respiration. Briefly compare the respective gain in energy. (2P)

b) Display the numerical values given in the table as a graph and explain the curve. (2P)

c) If a 20% glucose solution is used in the same test series, the carbon dioxide production does not increase but shows even lower production levels than in the described experiment. Suggest an explanation for this result. (1P)

- c) State the ratio of blue, yellow, green, and white birds in the F₂ generation. (1P)
- d) What would the phenotype ratio be in the F₂ generation if the two genes were on the same chromosome and no crossing-over took place? (1P)

Task 10 (4P)

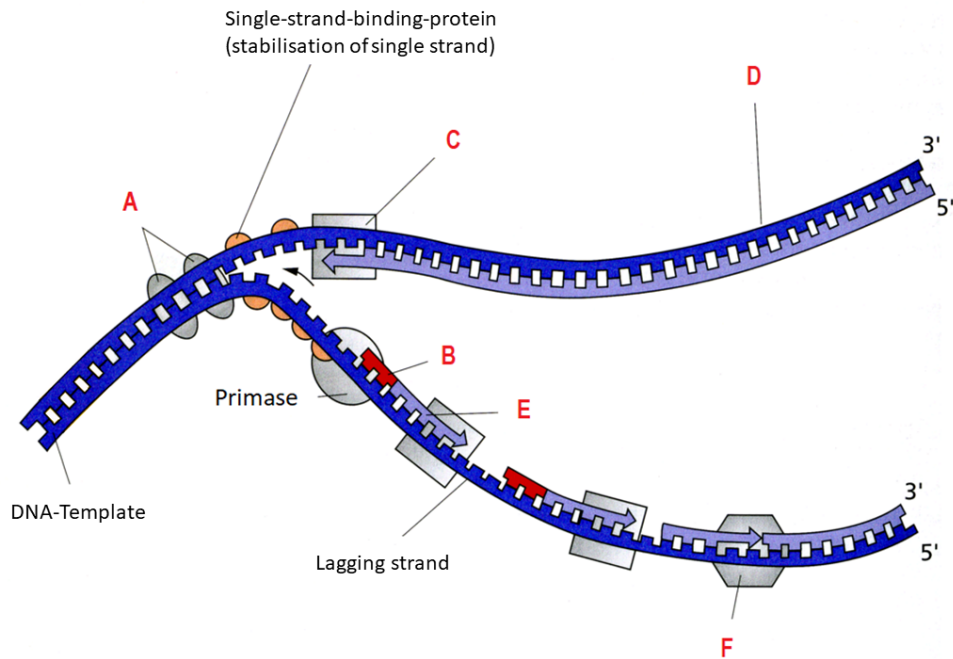


Figure 1

a) In which stage of the cell cycle does the process shown in figure 1 take place? (0.5P)

b) Name the structures A-F on figure 1. (1.5P)

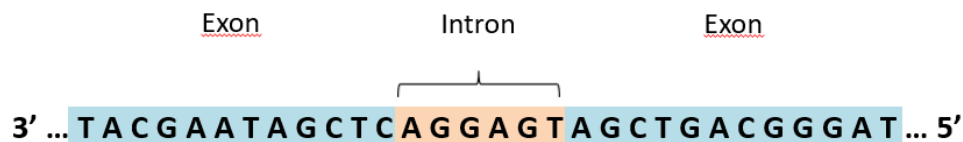
c) What is the role of helicase in the process shown above? Explain your answer. (1P)

- d) There are many more A-T base pairs than G-C base pairs at replication start points. Suggest a hypothesis as to what might be the advantage of this fact. (1P)

Task 11 (5P)

Sun code and genetic table: see Fig. 3 on the page 18.

Below is the template strand of a section of DNA:



- a) Use this section of DNA to determine the codes of the spliced messenger RNA (mRNA). (1P)
- b) Carry out the translation of the spliced mRNA. In the subsequent processing of the peptide, the first amino acid is cleaved off. Indicate the remaining amino acid sequence using a single-letter code (that is e.g., alanine = A,) see Fig. 3. (1P)
- c) Insert a silent mutation into the fourth codon of the DNA template strand. (1P)

d) A mutation can be detected indirectly by multiplying the affected gene using a PCR and then cutting it with a restriction enzyme. In our example, the base sequence in a 267 bp long gene section was modified by a mutation in such a way that a cleavage site (cut) for the restriction enzyme was removed. The result of the analysis is shown in Figure 2. Of two people studied, one is homozygous with respect to the mutated gene and one is heterozygous. Assign persons 1 and 2 to the relevant genotype giving an explanation for your answer. (1P)

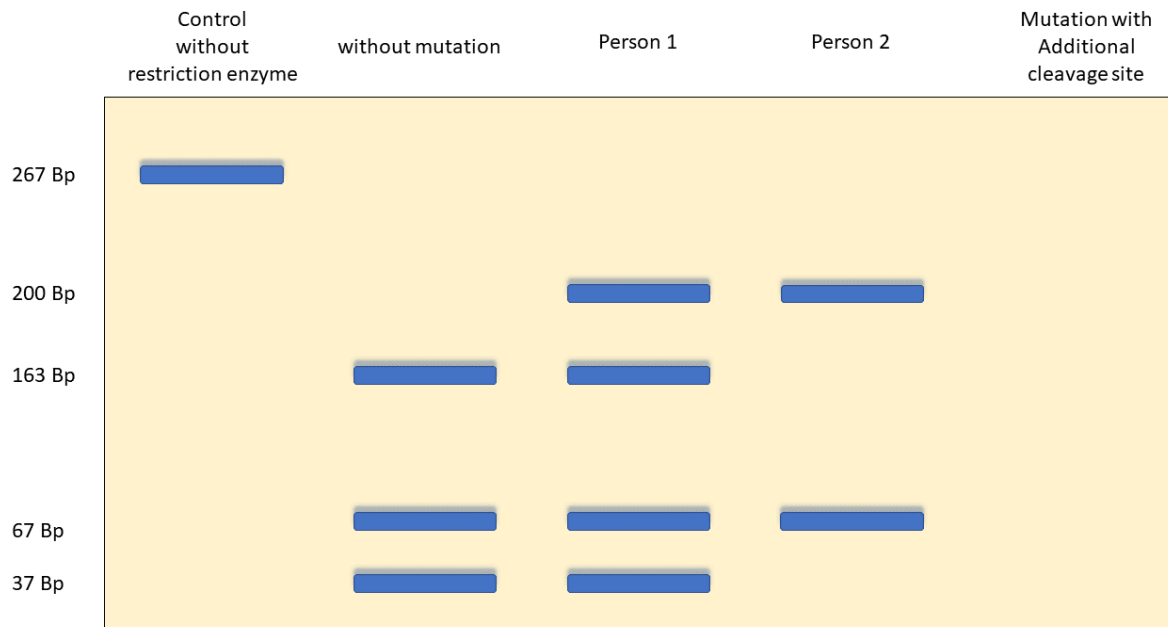
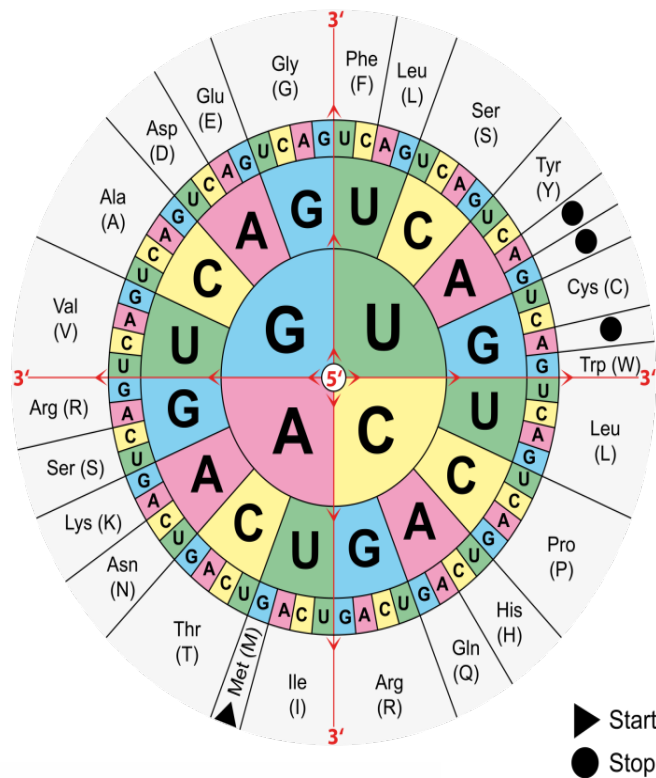


Figure 2: Gel electrophoresis band pattern analysis.

e) What would the band pattern in Fig. 2 look like if a mutation had created an additional cut (cleavage site) in the gene. Draw an invented but possible result for the homozygous case in the fifth column and specify the length of the resulting fragments to the right. (1P)



		Second letter					
		U	C	A	G		
First letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } Ser UCC } UCA } UCG }	UAU } Tyr UAC } UAA STOP UAG STOP/Pyl	UGU } Cys UGC } UGA STOP/Sec UGG Trp	U C A G	
	C	CUU } Leu CUC } CUA } CUG }	CCU } Pro CCC } CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } Arg CGC } CGA } CGG }	U C A G	
	A	AUU } Ile AUC } AUA } AUG Met	ACU } Thr ACC } ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G	
	G	GUU } Val GUC } GUA } GUG }	GCU } Ala GCC } GCA } GCG }	GAU } Asp GAC } GAA } Lys GAG }	GGU } Gly GGC } GGA } GGG }	U C A G	

Amino Acid	Three Letter Code	One Letter Code
Alanine	Ala	A
Arginine	Arg	R
Aspartic Acid	Asp	D
Asparagine	Asn	N
Cysteine	Cys	C
Glutamic Acid	Glu	E
Glutamine	Gln	Q
Glycine	Gly	G
Histidine	His	H
Isoleucine	Ile	I
Leucine	Leu	L
Lysine	Lys	K
Methionine	Met	M
Phenylalanine	Phe	F
Proline	Pro	P
Serine	Ser	S
Threonine	Thr	T
Tryptophan	Trp	W
Tyrosine	Tyr	Y
Valine	Val	V

Figure 3: Sun code, genetic code table and list of amino acids with one letter code

Task 12 (5P)

Collagen is an important structural protein in tissues. It is responsible for tissue strength and has an α helix structure. Collagen fibers consist of bundles of such α helices. In the polypeptide chains of the collagen fibers, the following amino acid sequence is present in continuous repetition:

5'-- [- Glycine (Gly) - Alanine (Ala) - Prolin (Pro) -] n-- 3'

Brittle bone disease or Osteogenesis imperfecta (O.i.), is a hereditary tissue disease, where the amino acid cysteine in the collagen polypeptide is found instead of glycine. The amino acid cysteine can form disulfide bridges with other cysteine molecules.

- a) Give a possible template DNA strand for the normal DNA sequence for collagen and for the amino acid sequence leading to brittle bone disease. To do this, use the sun code or genetic code table (see Fig. 3). (1P)

- b) Analyse the pedigree illustrated below for brittle bone disease (see Fig. 4). With regard to this illustration describe the type of inheritance shown. Give reasons for your decision. (2P)

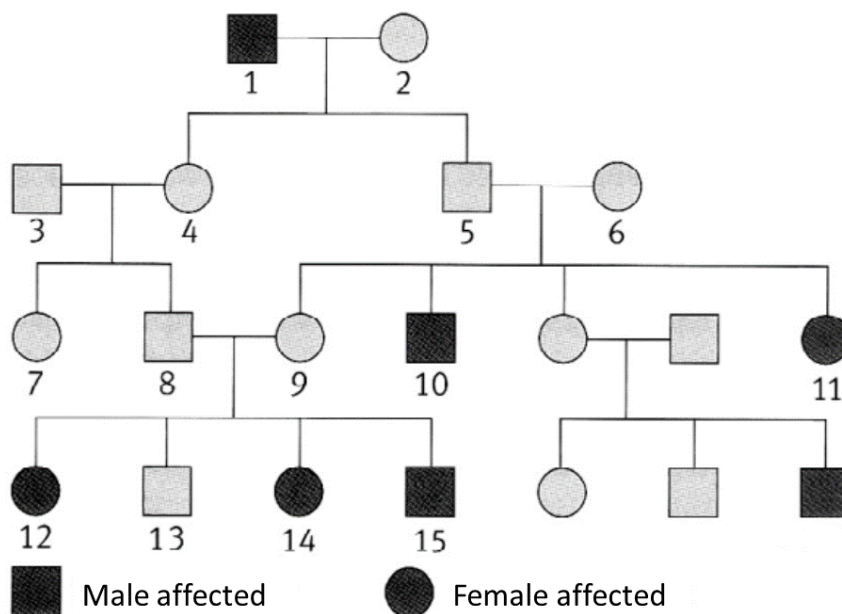


Figure 4: Pedigree of a family with brittle bone disease

c) Enter all possible genotypes of family members 1, 9 and 13. (1P)

d) Describe how the mutated gene may cause changes at the protein building level. (1P)

Task 13 (4P)

Mark a cross in all the correct answers. Several answers can be correct per question. For full marks, all statements must be marked correctly. 0.5P is awarded if 3 out of 4 statements are crossed correctly. If no cross is marked 0 points are awarded.

a) Check correct statements about the operon model in prokaryotes.

- The lactose operon works according to the principle of end product repression.
- In the operon model, there is a repressor sequence on the DNA directly in front of the structural genes to be read.
- Operons can both inhibit and promote the reading of genes.
- The transcription of genes which encode for enzymes involved in degradation can be induced via an operon by the enzyme substrate.

b) Fat cells, skin cells and liver cells differ in many ways because they ...

- ... contain other genes.
- ... have different numbers of chromosomes.
- ... use another tRNA code.
- ... express other genes.

c) Epigenetic markings ...

- ... may change during life.
- ... are partially hereditary.
- ... influence transcription.
- ... are a type of mutation.

d) What is the original function of the CRISPR-Cas system?

- Protect bacteria from viral infections.
- Protect bacteriophages from bacteria.
- Protect leukocytes from viruses.
- Protect bacteria from antibiotics.

Evolution (14P)

Task 14 (3P)

Evolutionary theories:

a) Compare and contrast the evolutionary theories of Darwin and Lamarck illustrating each theory with an example. In a coherent text (minimum $\frac{1}{4}$ page), explain the similarities and differences based on your chosen examples. (2P)

b) Assess Lamarck's theory of evolution from today's perspective. (1P)

Task 15 (2P)

Homologies and analogies

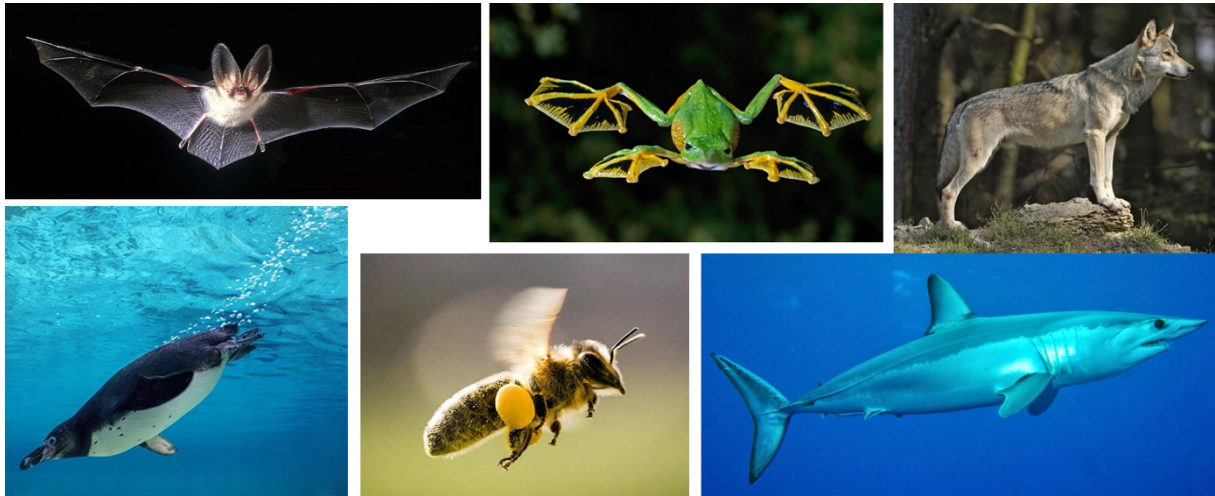


Fig. 1: Homologies and analogies of selected examples

From Figure 1, select two examples of homologies and two examples of analogies. Use your selected examples to explain how either homology or analogy is illustrated. (2P)

Task 16 (3P)

Indicate with a cross the one correct answer for each question.

(a) In the unrelated plant families Cactaceae, Apocynaceae and Euphorbiaceae, there are species with stunted leaves, well-developed spines and cylindrical-round, thickened growth structures. In relation to this information which of following statements is NOT true?
These plants...

- have probably evolved their growth habit convergently due to similar selection pressures.
- invest heavily in defence against herbivores (plant eaters) compared to other plants.
- have special adaptations to habitats with high evaporation rates.
- store some limiting resources in their tissues for certain periods of time.
- have a large surface-to-volume ratio.

b) Which of the following observations support the theory of natural selection?

A As soon as a population becomes too large in relation to the resources of its habitat, there is a struggle for survival among the individuals. Only some of the offspring survive in each generation.

B The survival of an individual depends partly on inherited traits. The individuals whose traits favour survival and reproduction in their environment are very likely to leave more offspring than less favoured individuals.

C Since individuals do not have the same probability of survival and do not have the same reproductive success, the population changes gradually. Advantaged traits will be more prevalent in subsequent generations.

Correct answer is:

- only A
- only B
- only A and C
- only B and C
- All

c) Which of the following organs is not a vestigial structure?

- The remains of the pelvic girdle in humpback whales.
- The gills of tadpole grass frogs.
- The coccyx in chimpanzees.
- The vermiform appendix of the human intestine.
- The remains of shoulder bones in slow worms.

Task 17 (1P)

Which of the family trees shown in Fig. 2 (A-E) best takes into account the degree of kinship of the species based on the table of properties below?

Properties:	African Ostrich	Topaz Hummingbird	Nile crocodile	Komodo dragon
Two temple pits/orbits	X	X	X	X
Nictating membrane (third eyelid)	X	X	X	
First toe pointing backwards	X	X		
Movable quadratum, paired skull bone				X

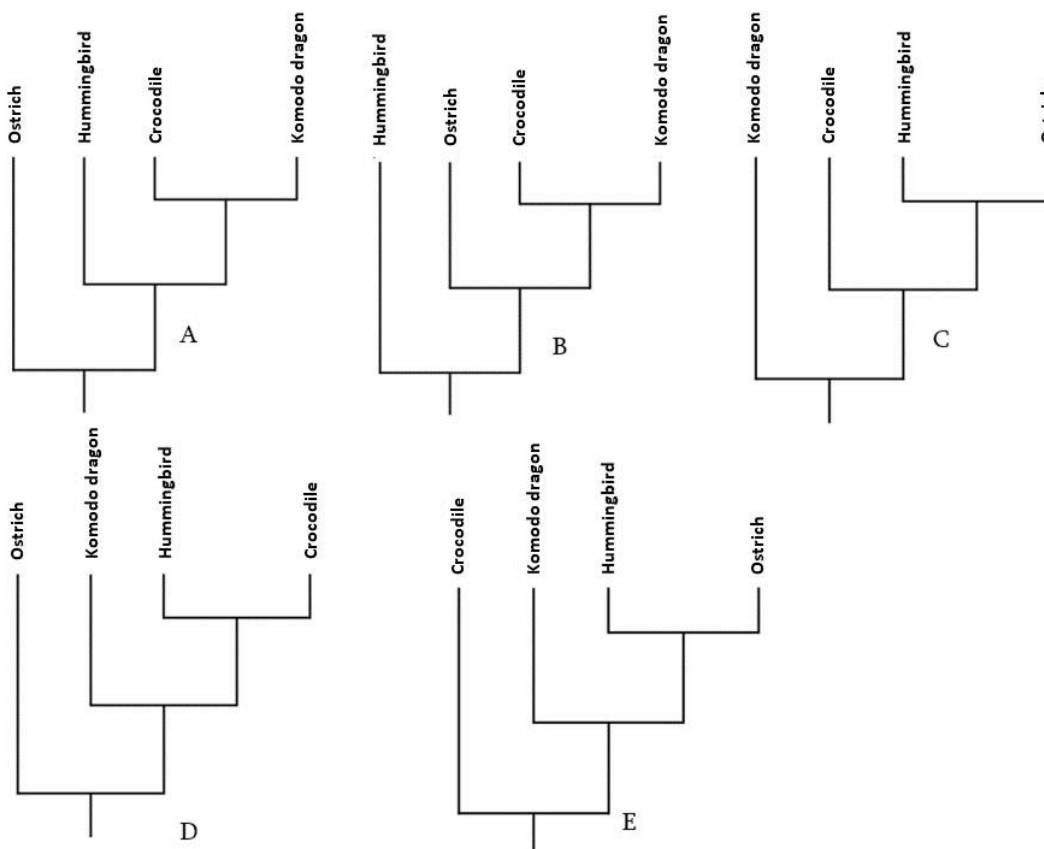


Fig. 2: Vertebrate family trees

Task 18 (2P)

In the formation of species, we can basically distinguish between sympatric and allopatric speciation. Explain the main differences between these two processes of speciation. (2P)

Task 19 (3P)

Name three differences in skeletal structure between a chimpanzee and *Homo sapiens* and explain them in an evolutionary context. (3P)

Mouse Anatomy (5P)

Task 20 (5P)

a) Label the numbered arrows 1 – 4, in Figure 1 and name the function of each organ using key words. (2P)

b) Label two different glands. (1P)

c) Label three parts of the CNS. (1P)

d) Label three parts of the digestive tract. (1P)

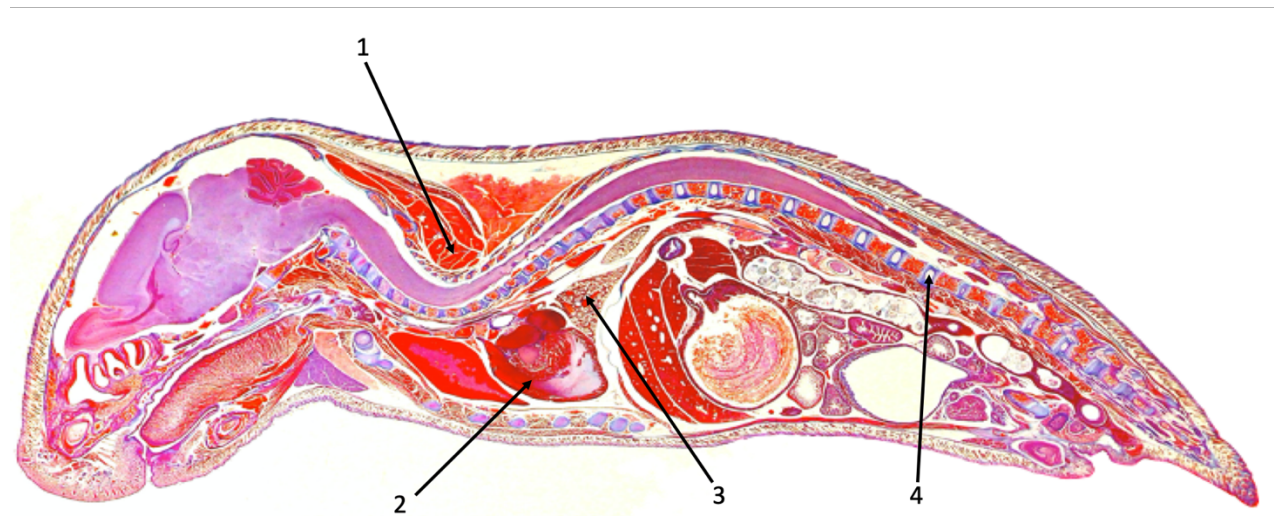


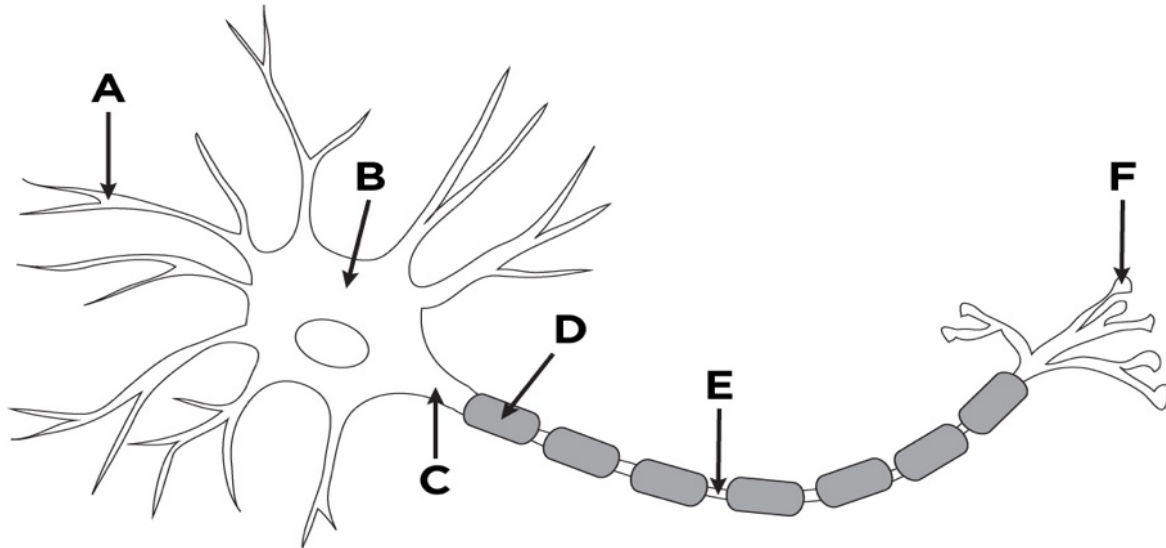
Figure 1: Mouse Sagittal section

Neurobiology (18.5P)

Task 21 (2P)

a) In the table below, indicate the structures A, C, E and F in relation to Fig. 1 (1P)

b) Write in the table the respective functions for the structures. (1P)



Letter	Structure	Function
A		
C		
E		
F		

Task 22 (3P)

Mark with a cross the one correct answer.

a) The conduction of a nerve impulse in a neuron is normally transmitted ...

- From the cell body (soma) to the axon to the dendrite.
- From the dendrite to the cell body to the axon.
- From the axon to the cell body to the dendrite.
- From the cell body to the dendrite to the axon.

b) Where in the membrane of a nerve cell would you expect to find the highest concentration of voltage-gated Na⁺ channels?

- Cell body
- Dendrite
- Axon hillock
- Presynaptic membrane

c) Chemical neurotransmitters are released from the presynaptic membrane by:

- Exocytosis
- Secondary active transport
- Facilitated diffusion
- Ion channels

Task 23 (5P)

Figure 1 shows the changes in membrane potential on an axon during the passage of an action potential.

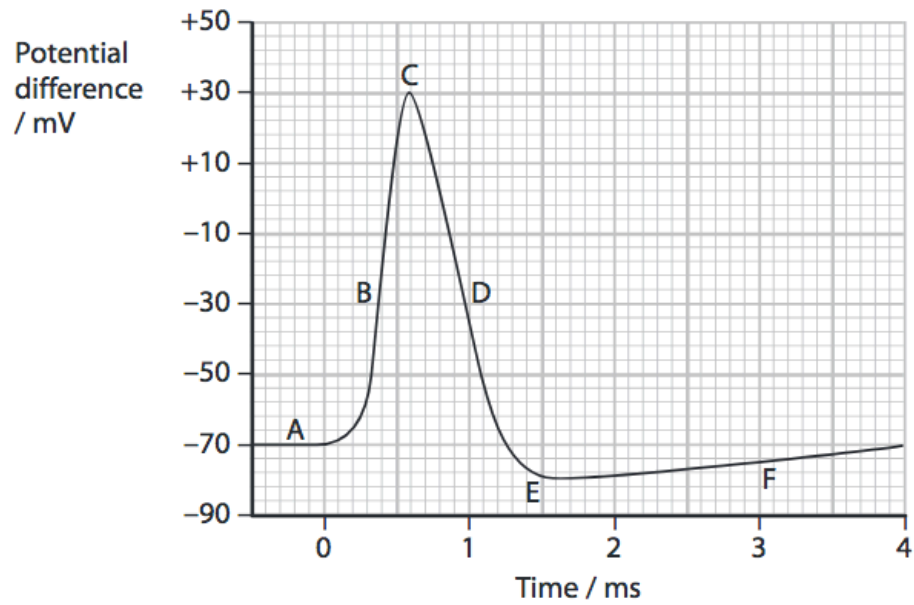


Fig. 1: Sequence of the action potential on an axon

Explain the events occurring on the nerve cell membrane at the locations, identified by the letters A-E. Use the relevant technical terms in your explanation.

Task 24 (5P)

Draw an accurate diagram to illustrate a chemical synapse.
Label the diagram with 6 important structures.

Task 25 (3.5P)

In order to understand the functioning of the neurotoxin tubocurarine, various synaptic processes under the influence of this neurotoxin were investigated. The results are summarised in Figure 2.

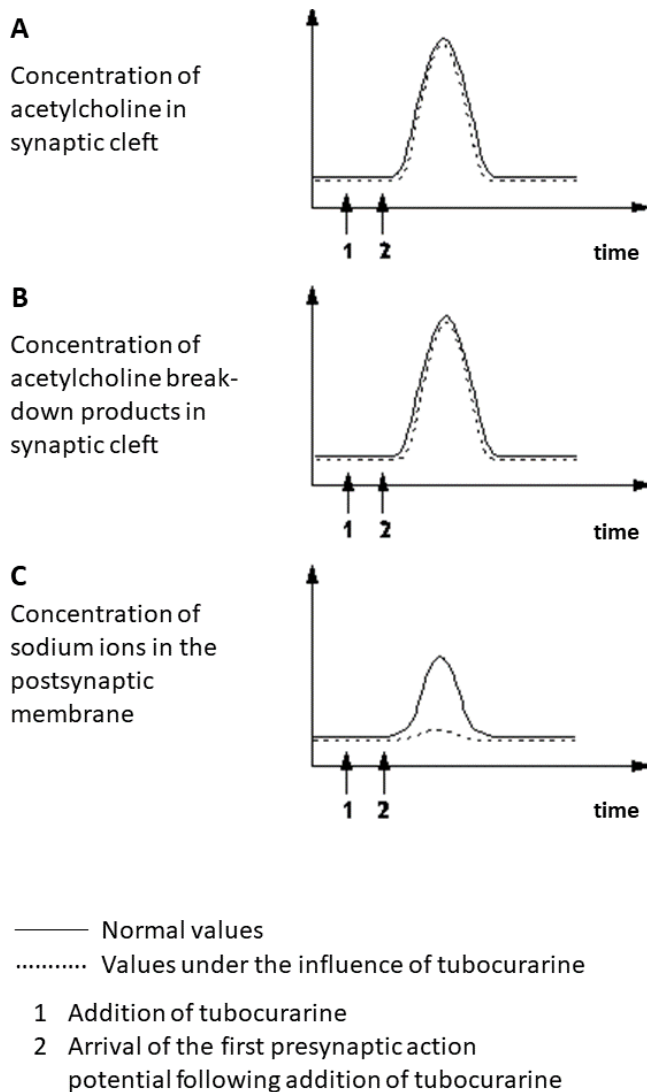


Fig. 2: Effect of tubocurarine on various synaptic processes

a) Which synaptic processes are not influenced by tubocurarine?
Which synaptic processes are influenced by the toxin? Explain how this affect occurs. (1.5P)

b) Why does the toxin cause muscle paralysis? (2P)

Hormones (8P)

Task 26 (2P)

Explain the following:

Where are hormones produced in the body, **how** are they distributed and **where** do they work. (2P)

Task 27 (4P)

Diabetes mellitus is caused by insufficient function of the beta cells in the wall of the pancreas. These cells produce the hormone insulin, which plays a decisive role in regulating carbohydrate metabolism.

The forms of diabetes can be detected with the oral glucose tolerance test (GTT). First, the patient has to drink a tea in which a precisely defined amount of glucose has been dissolved. Then the change in the amount of glucose or insulin in the blood is observed over a few hours.

Figure 1 shows characteristic results of the following groups of people:

1: diabetic type I, 2: diabetic type II and 3: normal person.

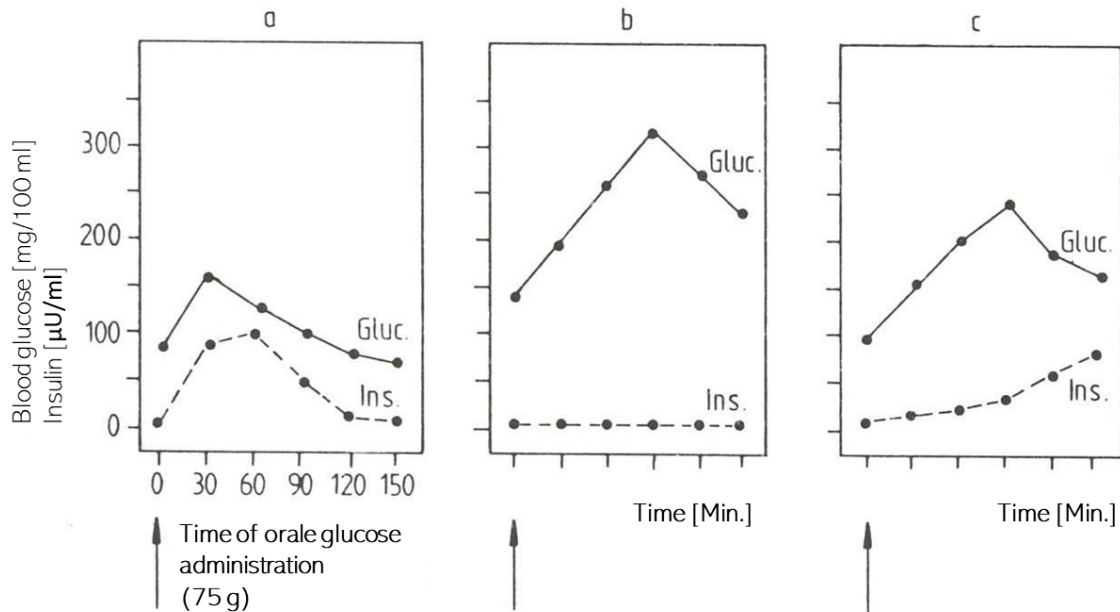


Fig.1: Oral glucose tolerance test of patients a, b and c.

a) Match the three groups of people (1-3) to the appropriate letter in Fig. 1 (a-c). (1P)

b) Discuss the results a - c shown in Fig. 1 and compare the results with each other. (3P)

Task 28 (2P)

Explain the main differences in the mechanism of action between a peptide hormone and a steroid hormone. (2P)

Animal Behaviour

Task 30 (3P)

i) A student made the following statements about some examples of animal behaviour observed at the zoo. Read the statements and **identify** the term/s for each type of animal behaviour the observation illustrates. (0.5 each)

A I moved a log in one enclosure and noticed that the woodlice, which had been resting underneath the log, began to move around quickly once the log was lifted.

B A banana had fallen a short distance away from the chimpanzee pen. A chimpanzee used a stick to reach out and drag the banana towards her.

C A mother duck escaped from her enclosure and all her baby ducklings followed her through a hole in the wire.

D Cockroaches living in the dark in the house for nocturnal animals ran away from the light of my torch.

E Zoo deer are free to roam amongst the visitors. Although deer usually run away from humans, the zoo deer do not.

F Birds beat their wings in front of the sensors of the automatic doors of the zoo café, thereby gaining entry to food inside the café.

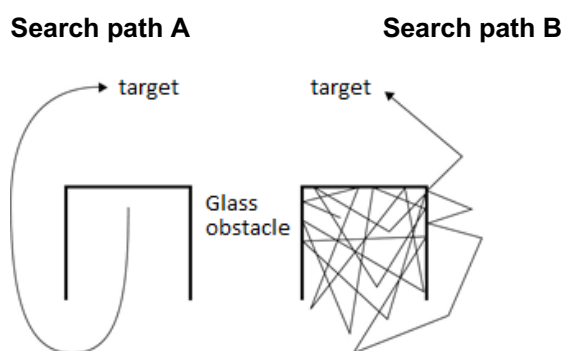
Task 31 (2P)

Which type of learning may explain why different species of distasteful or stinging insects have evolved with similar colours? Explain your answer. (2P)

Task 33 (2P)

A chicken and a chimpanzee are placed separately in a container surrounded by glass walls on three sides and are offered food, indicated by the word "target".

Which search path indicated below, best represents the behaviour of the chicken and which best illustrates that of the chimpanzee? Justify your decision by analyzing the two behaviours. (2P)



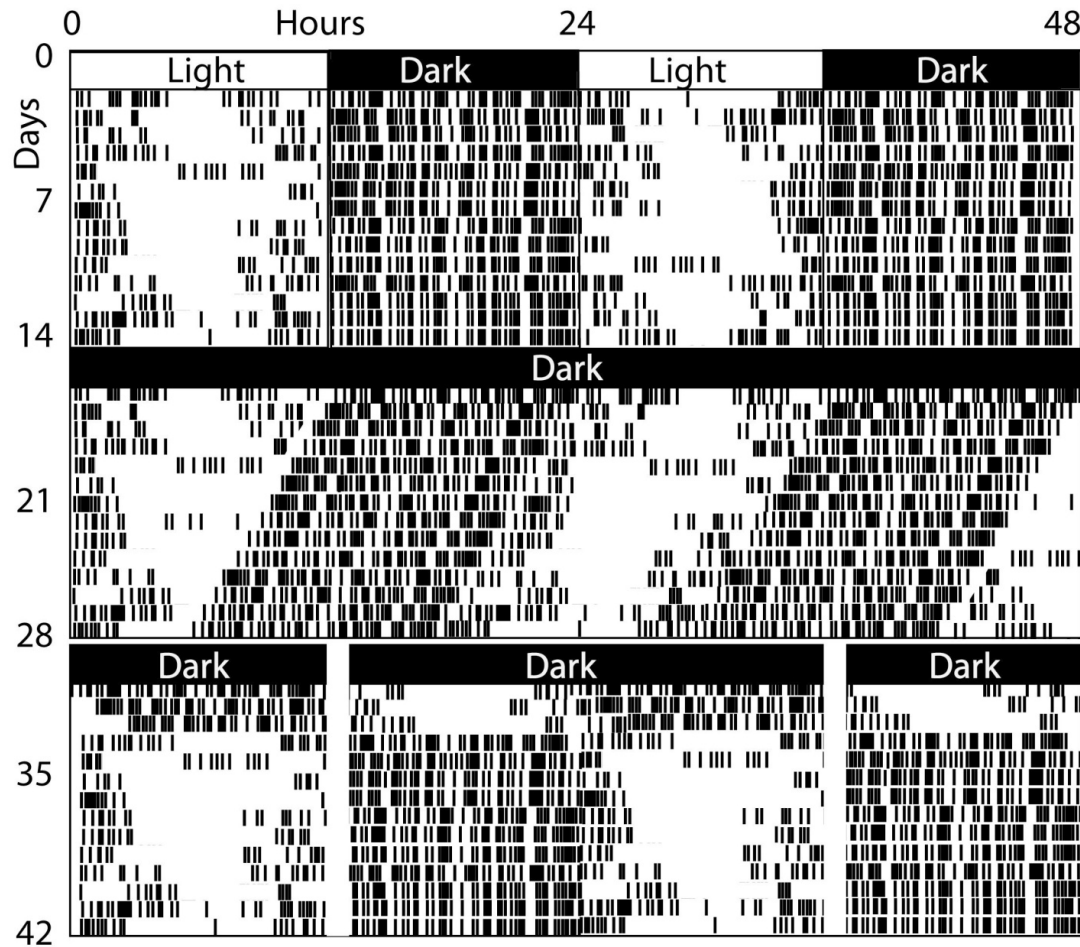
Task 34 (6P)

Mouse Activity Patterns - actogram

The actogram below illustrates the physical activity of a mouse over a six-week period.

During week five and six a 10-minute burst of daylight (the white vertical bars) was administered at noon.

Note. The data in this idealised actogram is a compilation from numerous trials, with numerous mice.



- What term is given to the rhythm shown by the mice during the first two weeks. (0.5P)
- Explain the endogenous and exogenous factors that influence the rhythms in weeks 1 and 2. (2.5P)

c. In relation to the actogram what can be concluded from week 3 and 4? (2P)

d. What can be concluded from weeks 5 and 6? (1P)

Task 35 (3P)

Maternal Behaviour

Research has identified ways in which maternal behaviour affects rat pups` response to stress.

a) How and why might the level of nurturing (grooming and licking) of a rodent mother affect the offspring`s response to stress? Explain your answer. (2P)

b) Explain why stress levels in the mice pups may have adaptive functions. (1P)

Extra paper if needed

