

Maturitätsprüfungen 2023 – Biologie Schwerpunktfach schriftlich

Englisch

Class: 4Be (JuC)

Exam duration: 4 hours

Auxiliary materials: writing tools, ruler, bilingual dictionary

Total marks: 120

General work instructions:

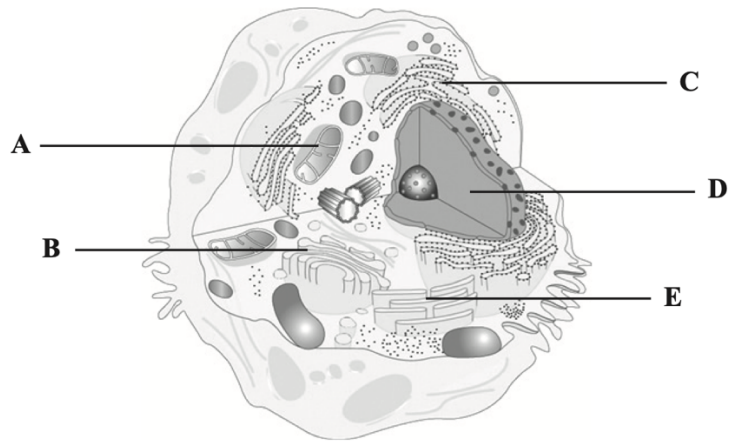
- ✓ Read each task carefully and completely before you answer!
 - ✓ Use technical terms you know.
 - ✓ Answer all questions directly on the questions sheets.
 - ✓ Only legible answers will be corrected. Do not forget to write your name on all sheets.
 - ✓ For multiple-choice tasks, the following applies: For the full score, all correct answers must be marked. Incorrectly marked answers will be deducted. However there is a minimum of 0 points per question.
 - ✓ To achieve the maximum grade not all answers need to be correct.
-

Name: _____

Basic knowledge - cell biology and metabolism (30 marks)

1. Give the names to the cell structures A to E in the table below.

2.5



Structure	Name
A	
B	
C	
D	
E	

2. The following table compares some of the features of prokaryotic cells and eukaryotic **animal** cells. Complete the table by placing a cross (X) for the correct answers only.

1.0

	Prokaryotic cells	Eukaryotic animal cells
Nuclear envelope (membrane) present		
Cell wall present		
May contain plasmids in the cytoplasm		
Endoplasmic reticulum present		

3. In an experiment investigating the role of organelles in cellular protein transport, cells were given radiolabelled amino acids for a set period of time. The percentage of radioactivity found in four different organelles was measured at different time intervals.

The following table shows the results.

Time after addition of radioactively labelled amino acids / min	Percentage of radioactivity present			
	RER	Golgi-Apparatus	Secretory vesicles	Mitochondria
4	65	25	1	3
6	55	40	2	1
20	11	75	10	3
140	11	10	75	2

- a) Construct a graph to accurately illustrate these results.

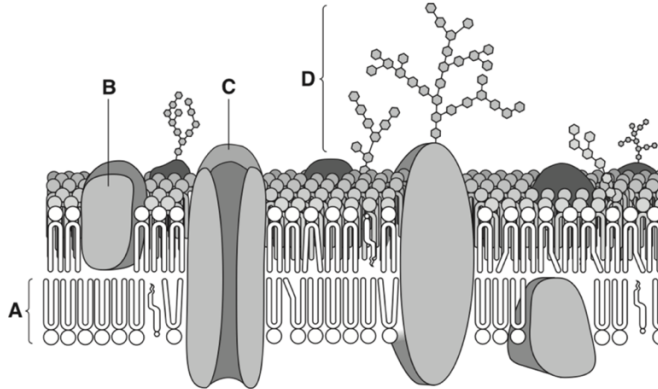
3.0

b) Explain how the data and graph can provide evidence for the sequence of events in the process of protein transport in these cells. 2.0

c) Suggest **one** reason for the presence of radioactivity in the mitochondria. 0.5

4. a) Give the figure below a **title**.

0.5



2.0

b) Name the structures A-D in the table below.

A	
B	
C	
D	

c) Label the outer and inner sides of the diagram with the correct technical terms. 0.5

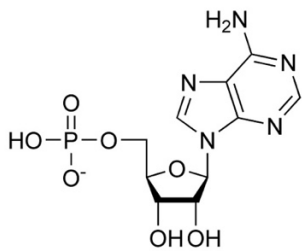
d) Justify your answer to part c).

0.5

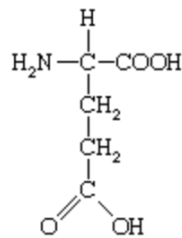
5. Complete the following table.

2.0

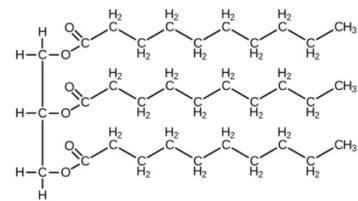
Chemical compound	Example from living cells	Subunits of the chemical compound	Identify the molecular structure from a-d below the table
Polysaccharide			d)
Protein	Enzyme		
Lipid	Phospholipid		
Nucleic acid		Nucleotide	



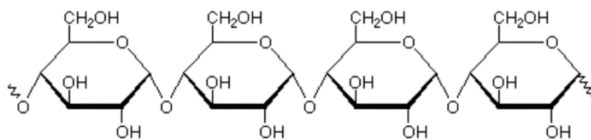
a)



b)



c)



d)

6. The table below refers to three transport mechanisms. If the statement is **correct** place a cross (X) in the appropriate box. 2.0

Statement	Osmosis	Facilitated diffusion	Active transport
Water transport takes place			
Requires ATP			
Molecules move down their concentration gradient			
Carrier proteins are needed			

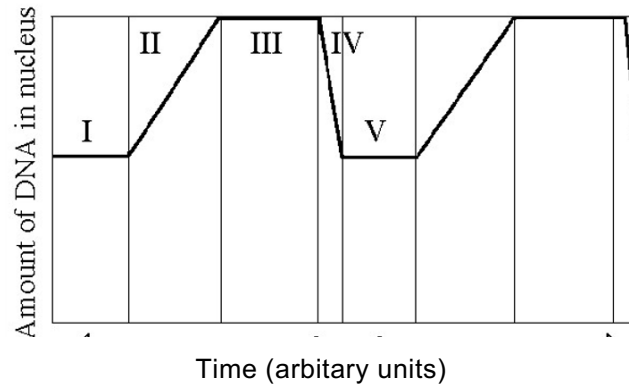
7. Celery stalks that are immersed in fresh water for several hours become stiff and hard. Celery stalks in a saline (salt) solution become floppy and soft. 1.0

Tick **the one correct** answer only.

From this information we can deduce that the cells of the celery stalks are:

- A) hypotonic to both fresh water and the saline solution.
- B) hypertonic to both fresh water and the saline solution.
- C) hypertonic to fresh water but hypotonic to the saline solution.
- D) hypotonic to fresh water but hypertonic to the saline solution.
- E) isotonic with fresh water but hypotonic to the saline solution.

8. The following graph shows the amount of DNA measured in arbitrary units of time during the different stages of the cell cycle.



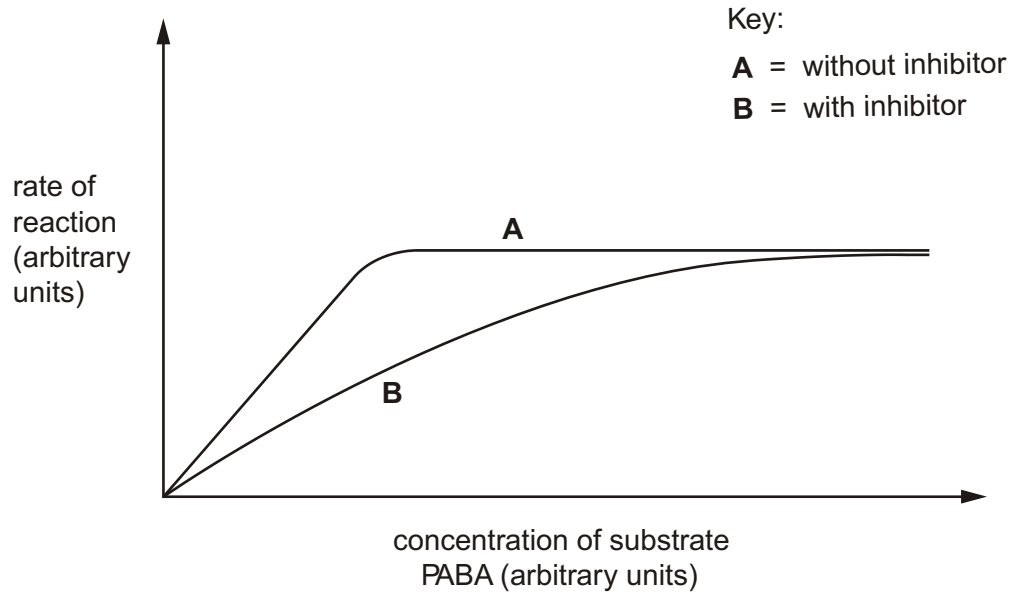
Fill in the table below as follows.

4.0

Give each stage a name and briefly explain what happens in the cell during stages I-IV.

Stage	Name the stage	Describe the main cellular activity in this stage
I		
II		
III		
IV		

9. The following graph shows the general effect of increasing the substrate concentration (PABA) on the reaction rate when the amount of the enzyme is kept constant.
- Curve A shows the general reaction rate without the presence of the competitive inhibitor sulfonamide.
 - Curve B shows the general reaction rate in the presence of the competitive inhibitor sulfonamide.



Describe and give reasons for the effect of increasing the substrate concentration on the rate of reaction.

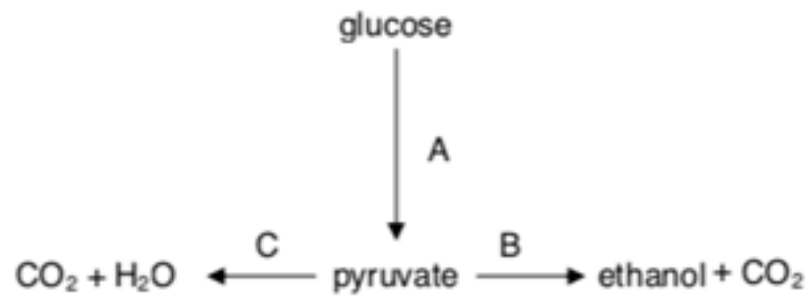
a) without inhibitor

2.0

b) with inhibitor

2.0

10. The figure below shows the relationship between different metabolic processes in yeast cells in the presence of glucose. 1.5



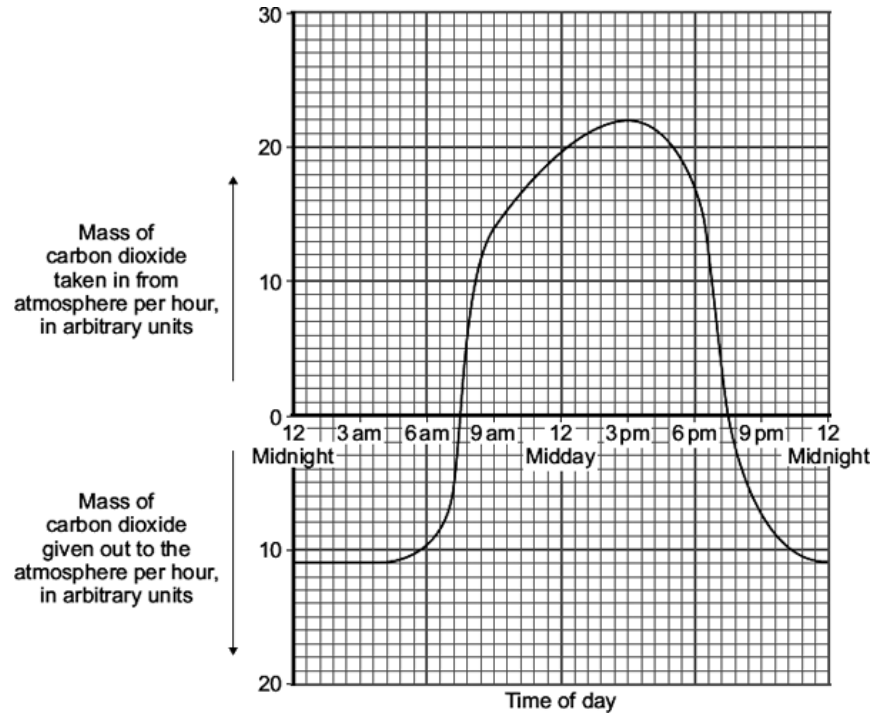
Identify the three metabolic processes A-C in the figure.

A: _____

B: _____

C: _____

11. The graph below shows the uptake of carbon dioxide and the release of carbon dioxide by a bean plant on a hot summer's day.



- a) Describe and justify the reasons for the shape of the curve above.

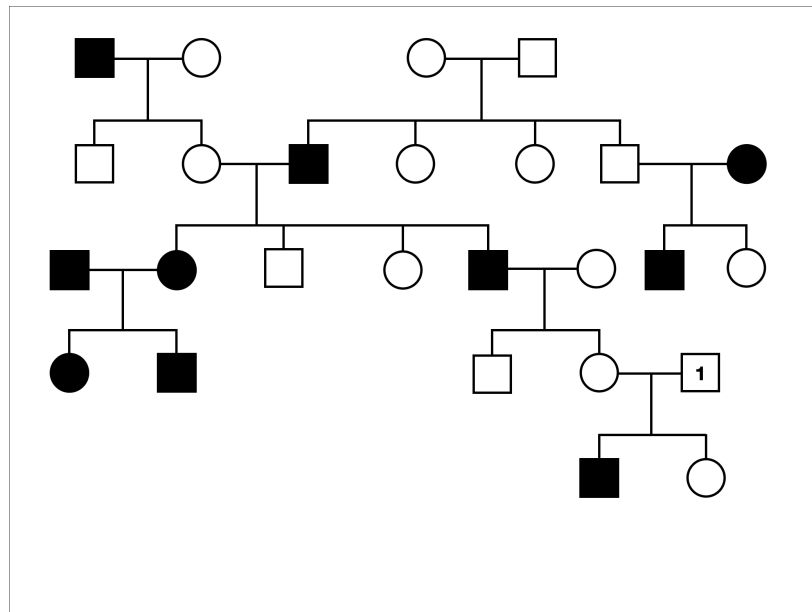
2.0

- b) Explain the significance of the intersection point of the curve with the x-axis (where $y=0$) using the technical term.

1.0

Classical and molecular genetics (22 marks)

12. a) A degenerative disease is common in the family tree (pedigree) as illustrated below. 1.0
If you know that person 1 is not a carrier, what is the inheritance pattern of the disease?



- b) Justify your answer to part a) by marking the status of the appropriate individuals in the family tree and explaining your decision. 1.0

- c) Give an example of a disease with this mode of inheritance. 1.0

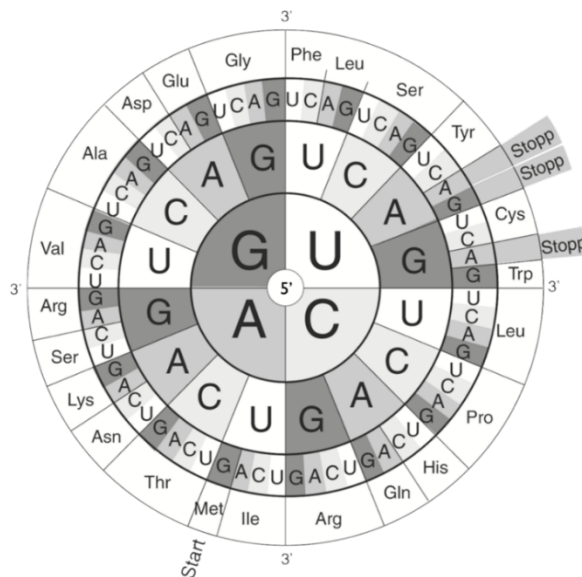
- 13.** A pea plant with long stems and green seeds is crossed with a pea plant with yellow seeds and short stems. The F1 has yellow seeds and long stems.
- a) Determine the traits/genes with their alleles and the dominance ratios. 1.0
- b) i) Give the genotype for the F1 generation. 1.5
ii) Illustrate the outcome of the F2 generation using a Punnett square.
iii) State the phenotypic ratio of the F2.
- c) What is this type of inheritance called? 0.5
- d) Where does a Mendelian rule apply in the above task? Name a Mendelian rule and explain this rule with the given example. 1.0

14. You have been injected with the mRNA strand shown below, during an mRNA vaccination.

a) Build a protein according to the instructions of this mRNA strand. Use the genetic sun-code provided. 1.0

mRNA:

5' GACAUGAUACCAUUAUGGAAGUACGCUUUAACUUAUUAAUUAUAC 3'



Alanin	Ala
Arginin	Arg
Asparagin	Asn
Asparaginsäure	Asp
Cystein	Cys
Glutamin	Gln
Glutaminsäure	Glu
Glycin	Gly
Histidin	His
Isoleucin	Ile
Leucin	Leu
Lysin	Lys
Methionin	Met
Phenylalanin	Phe
Prolin	Pro
Serin	Ser
Threonin	Thr
Tryptophan	Trp
Tyrosin	Tyr
Valin	Val

b) What is the process in part a) called? 0.5

c) Where in the cell does this take place and what else is needed for the process to occur? 1.0

d) Construct the template DNA strand used to produce the mRNA strand given above. 1.0

1.0

e) Which processes do eukaryotes use to transform DNA into mature mRNA?

f) During the Covid pandemic, fears were often expressed that mRNA vaccination would alter human DNA. 0.5

Which enzyme is needed to convert mRNA into DNA?

g) Do humans naturally possess this enzyme? Where does it occur naturally? 0.5

h) In the laboratory, faulty, mutated mRNA was also detected during the production of the vaccine, which had a G instead of the U at position 15. 1.5

What would this mean for the protein? Would this vaccination have been successful? Justify your answer.

i) Referring to part h) what is this type of mutation called? 0.5

15. a) Name **three** structural differences between DNA and RNA.

1.5

b) Draw a piece of mRNA encoding for the amino acid tryptophan (Trp).

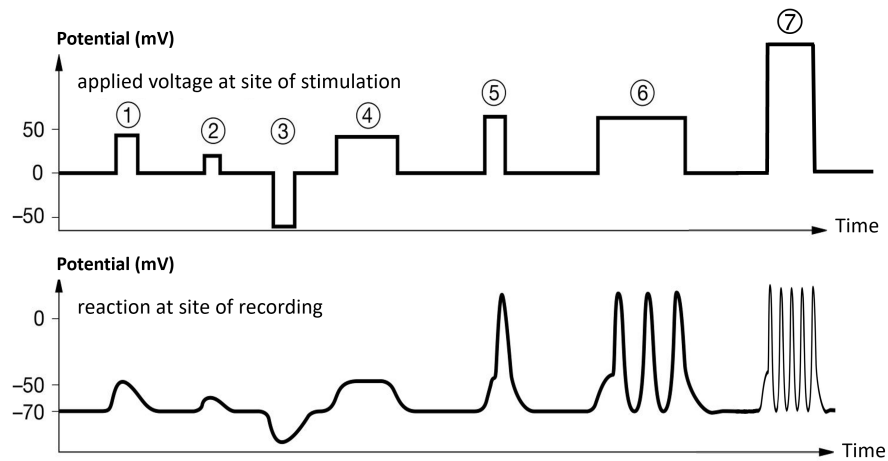
1.0

16. Tick the **right** answers. **Several answers are correct.** Incorrectly ticked answers will be deducted.

- a) Restriction enzyme 1.0
- Restriction enzymes settle on a specific section of a protein and cut it at a specific location.
 - Restriction enzymes settle on a specific section of DNA and cut it at a specific location.
 - Restriction enzymes always cut in such a way that sticky ends are formed.
 - Restriction enzymes can produce smooth cuts and sticky ends.
 - Restriction enzymes cut DNA and RNA indiscriminately at any point.
- b) The replication of DNA in interphase requires the following substances: 1.0
- Helicase
 - RNA Nuclotides
 - Replicase
 - Ligase
 - DNA Polymerase
- c) The following modifications are classified as epigenetic changes of the genetic material: 1.0
- Acetylation of DNA
 - Methylation of histones
 - Methylation of DNA
 - Acetylation of histones
- d) Polymerase chain reaction (PCR) 1.0
- PCR is a reaction to amplify RNA
 - PCR is a reaction to produce enough usable DNA for sequencing
 - PCR works at different temperature levels
 - PCR is a reaction to amplify DNA
 - PCR needs a polymerase that works particularly well at cool temperatures
- e) tRNA 1.0
- The tRNA carries the amino acid on the opposite side to the anticodon
 - The tRNA anticodon is complementary to mRNA
 - The tRNA anticodon always matches an amino acid
 - The tRNA anticodon is 3 bases long
 - The tRNA matches more than one amino acid

Neurobiology (16.5 marks)

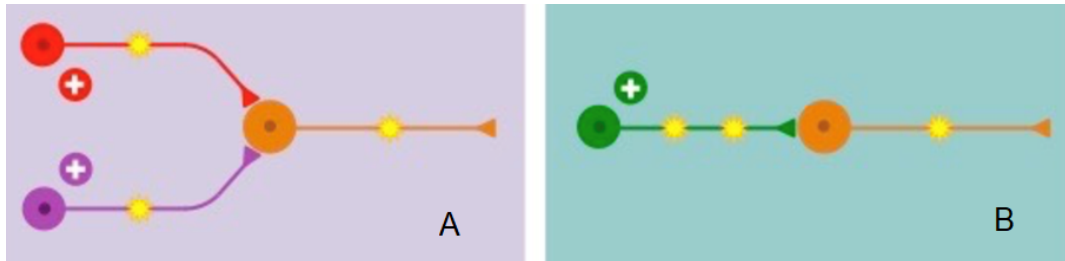
17. Action potentials can be artificially induced by electrical stimulation of an isolated axon. To do this, a microelectrode is inserted into the axon to generate the stimulus. A voltmeter measures the voltage between the microelectrode tip inside the cell and a reference electrode placed in the solution outside the cell. The results of the experiment are summarised in the following graphs a and b below.



The graphs show a) the electrical stimulation b) the voltage on the axon, over time in msec.

- a) Explain the result on the axon of the stimulation at number 1. 1.0
- b) Which stimulation (number) leads to hyperpolarization of the axon? 0.5
- c) Explain in detail the result of stimulation at number 5. Include the processes taking place in the axon within your answer. 2.0
- d) Explain the differences between the stimulations 6 and 7 referring to both graphs. 1.0

18. a) Identify the types of neural summation illustrated in Figures A and B below. 1.0



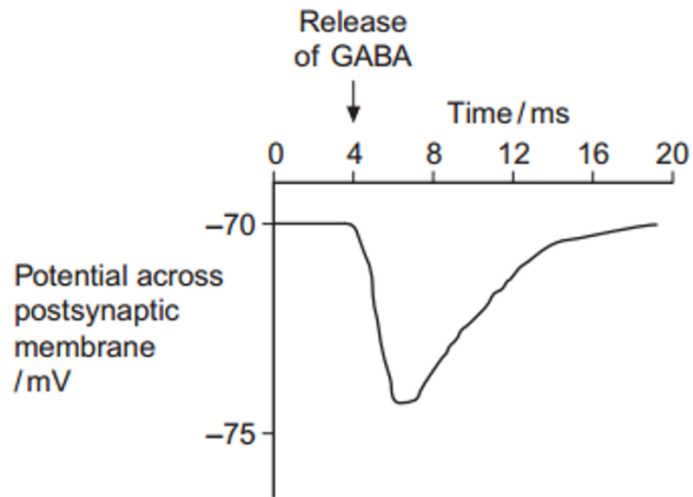
- b) Name the part of the neuron that is important for the summation of the electrical charge. 0.5

19. Nerve gases were used as chemical weapons. Some nerve gases work by inhibiting acetylcholinesterase.

- a) Explain the effect of this nerve agent. 1.0

- b) Name **two** symptoms that may occur in a person exposed to the nerve gas. 1.0

20. The following graph illustrates the effect of the neurotransmitter gamma-aminobutyric acid (GABA) on the postsynaptic membrane of a synapse.



- a) Draw a **synapse** illustrating the activity of GABA in relation to the graph above. Label the main features of this synapse. Illustrate the functional role of GABA on the postsynaptic membrane in your drawing.

2.0

21. a) Circle the **ONE** correct answer!

2.0

A Which part of the brain must be affected if the nerve impulses cannot travel from the right hemisphere to the left?

cerebrum, cerebellum, hypothalamus, corpus callosum, amygdala

B Which one of the following structures control temperature, endocrine activity, metabolism and thirst?

cerebellum, medulla oblongata, hypothalamus, thalamus, cerebrum

C Before stimuli can reach the cerebral cortex, they are sorted and channelled by a centre in the brain called the ...

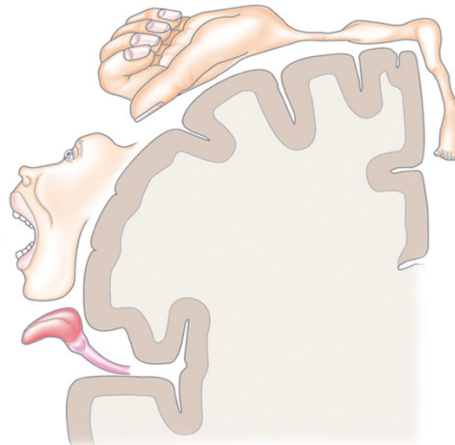
meninges, corpus callosum, cerebellum, hypothalamus, thalamus

D A person recovering from a head injury finds that he has difficulty maintaining balance. Which part of the brain has been injured?

thalamus, cerebellum, hypothalamus, medulla oblongata

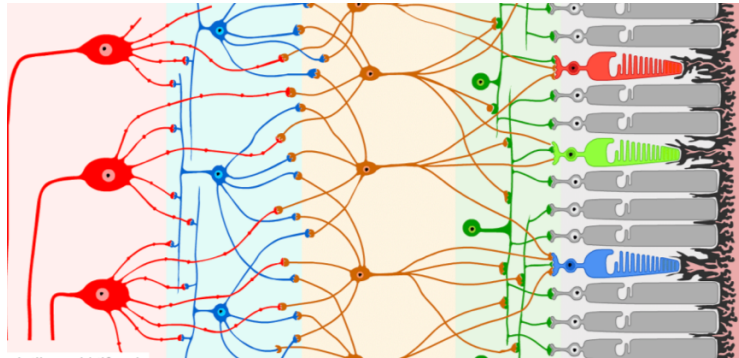
b) What does the motor homunculus (figure) below illustrate?

1.0



22. a) Label **four** relevant structures onto the diagram of the human retina below.

1.0



b) Add an arrow to the diagram that clearly indicates the direction of light passing through the retina.

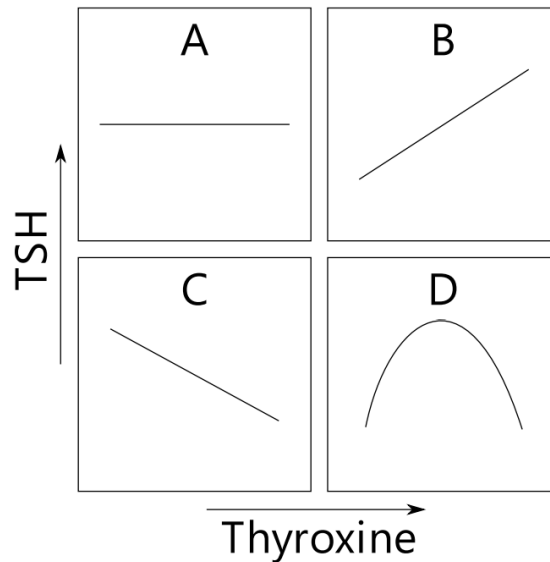
0.5

c) Why do we see a star better in the night sky when we look slightly to the side? Explain your answer in relation to the structures and functions of the retina.

2.0

Hormonal System (8 marks)

23. a) Thyroxines (thyroid hormones) act on the production of the hormone TSH via a negative feedback loop. Which of the following figures best reflects the correlation between thyroxines and TSH? 1.0

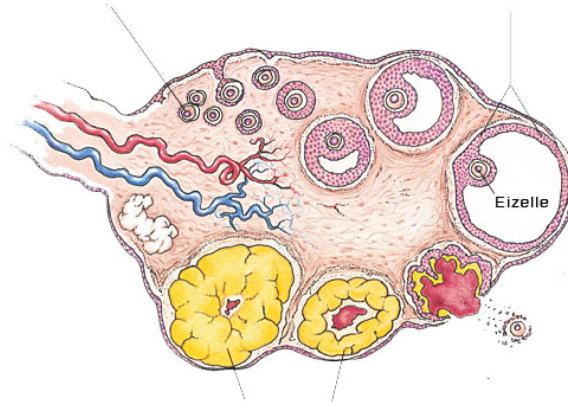


- b) Are the following statements about type I diabetes (untreated) true or false? 1.0

	true	false
The concentration of insulin in the blood is increased.	<input type="checkbox"/>	<input type="checkbox"/>
The blood sugar level is elevated.	<input type="checkbox"/>	<input type="checkbox"/>
The tissues are not properly supplied with glucose.	<input type="checkbox"/>	<input type="checkbox"/>
The blood has an increased osmotic concentration.	<input type="checkbox"/>	<input type="checkbox"/>

- c) With prolonged stress, the steroid hormone cortisol is increasingly released from the adrenal cortex. Describe in general terms where and how cortisol exerts its effect at the cellular level. 1.0

24. a) Identify the organ shown in the figure below giving the technical term. Which male sexual organ is homologous to this one? 1.0



- b) Label **two structures**, on the organ above which would be present in the first trimester of a pregnant woman (not including the blood vascular system). 1.0

- c) How does this organ in a woman who takes the contraceptive pill (not the mini-pill!) differ to that of a pregnant woman not taking this pill? Give an explanation! 1.0

- d) Thanks to egg donation and in vitro fertilisation, it is now possible in certain countries for women who have had to have the organ shown in Figure a) removed, e.g. as part of cancer treatment, can still have a child. The egg donor and egg recipient must undergo hormone treatment. **Which** naturally occurring **hormone** is suitable (with justification) for: 2.0

A Treatment of the egg donor in order to be able to retrieve as many eggs as possible?

B Treatment of the egg recipient after embryo transfer?

Mouse Anatomy (4.5marks)

25. a) There are three different muscle types in mammals. Using the illustration below identify where each of the three different muscle types occur using one location each. Name the muscle types. 1.5



3.0

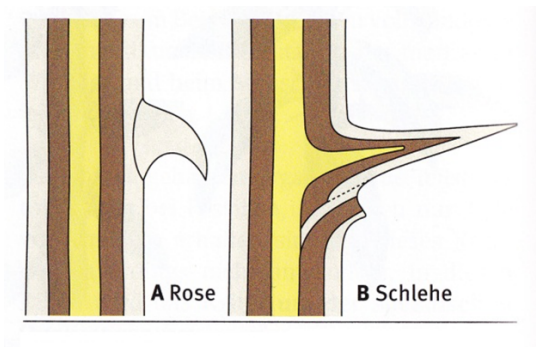
- b) i) Name two organs for **each** of the following organ systems in the table below.
 ii) Use the relevant number to label the organ on the illustration above.
 iii) Give a function for each organ in the table below.

	Cardiovascular system	Digestive system	Nervous system
Organ 1			
Number	1	3	5
Function			
Organ 2			
Number	2	4	6
Function			

Evolution (11marks)

26. a) Are the following statements about **homologous traits** true or false? 1.0

	true	false
The eyes of insects and mammals are homologous.	<input type="checkbox"/>	<input type="checkbox"/>
Homologous organs show an adaptability to a habitat.	<input type="checkbox"/>	<input type="checkbox"/>
A homologous trait of two species was also present in the common ancestor.	<input type="checkbox"/>	<input type="checkbox"/>
Rose spines (A) and sprouting thorns of the blackthorn plant (B) see figure, are homologous organs	<input type="checkbox"/>	<input type="checkbox"/>

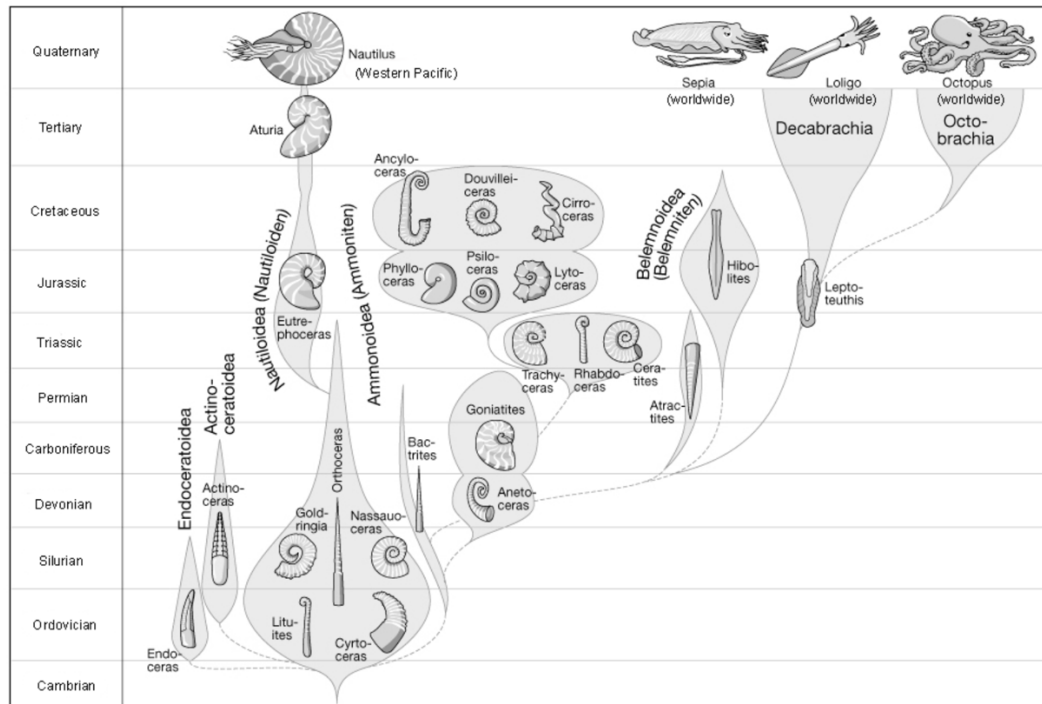


b) A fish population enters a new lake as a result of flooding. Since the soil there is cloudy, especially the brightly colored fish are eaten, darker ones survive. What kind of selection is this? 0.5

c) After a very long time, the two lakes are connected by a shipping channel. The dark fish can now return to the lake of origin, but there is no longer reproduction between the light and dark fish. 0.5

How can this be explained? Give the correct terminology.

27. The illustration below shows a phylogenetic tree of the cephalopods.



a) Whilst constructing a pond in your garden, ammonite fossils were discovered. 2.0

Use the family tree above to describe how the shape of these creatures changed over the course of evolution. Include the timeframe periods given in the table, as to when these forms existed.

b) Explain how these fossils are used to determine the age of other fossils. 1.0

27. c) Explain the following terms with an example from the phylogenetic tree given in part a):

A Living fossil

B Adaptive Radiation

28. On the small island of Flores in Indonesia in 2003, researchers found the remains, including the skull pictured below, of an extinct human species of exceptionally small stature (about 1m), whose brain was the size of an orange.

The discoverers referred to the species as *Homo floresiensis*. Because of their resemblance to Tolkien's mythical creatures, however, these prehistoric humans were soon known as hobbits.

Since their discovery, scientists have puzzled over where these people came from, why they were so small and why they disappeared again. New excavations unearthed further fossils of *Homo floresiensis*. These have been dated to an age of 700,000 years. Around 50,000 years ago, they died out.



- a) How could researchers be sure that the skull found was an ancestor of humans and not ancestors of chimpanzees or gorillas? Name **four** characteristics. 1.0

- 28.** b) For a long time, *Homo floresiensis* was not accepted by some researchers as a separate early human species. Rather, they assumed that the fossils were the remains of *Homo sapiens*, who may have suffered from certain diseases such as stunted growth, microcephaly (small head) or hypothyroidism due to inbreeding on the island. Use the information above (and your knowledge) to explain why this theory cannot be true. 1.0
- c) Based on your knowledge of human ancestors make a well-founded hypothesis from whom *Homo floresiensis* probably descended. 1.0
- d) Suggest why the small stature on the island of Flores may have given selective advantages. 1.0

Ethology (8marks)

29. A chick at the age of 2-3 days follows any moving object and forms a bond with it. If, after a few days, the chick is given the choice between a member of the same species and the moving object with which the chick has established a relationship, the chick will always choose the moving object.

a) What is this form of learning called? 0.5

b) Why is it not possible for the chick to relearn? 0.5

c) Does this form of learning make evolutionary sense when so much can go wrong? 1.0
Explain your answer.

d) What does this mean for a chick which has been chasing a remote-controlled car in the first days of life? Will this chick's behaviour differ from other members of the same species later in life? Explain your answer. 1.0

30. Identify the **forms of behavioural learning** described from a) to e) below?

- a) Young chimpanzees watch attentively as parents fish for termites with blades of grass. 1.0
- b) In West Africa, individual chimpanzees could be seen hitting nuts with a tool on the banks of a river. Chimpanzees on different sides of the river use different tools. The use of both tools has now spread into the two populations along the two river banks. 1.0
- c) Decades after the Second World War, many people still felt a sense of fear at the sound of a siren announcing bombs during the war. 1.0
- d) If you let a hamster that is shaking a metal door out of the cage, you can observe after a few repetitions that the hamster shakes the metal frame with increasing frequency. 1.0
- e) If you live right next to a bar, over time you will no longer wake up when the last clients are noisily making their way home. 1.0

Class specific questions (20 marks)

Stem cells (6.0 marks)

- 1) Describe two properties that are unique to all stem cells. 1.0

- 2) Complete the table below using the appropriate term. 1.5

Stage of embryonic development	Use one term to describe the potency (extent of cell differentiation possible) for a stem cell removed from the relevant embryonic stage.
Cleavage	
Blastocyst	
Adult bone marrow	

- 3) Briefly explain two advantages induced pluripotent stem cells (iPSC`s) have over non-induced pluripotent stem cells. 1.0

- 4) i) Give two cell types that can be produced from mesenchymal stem cells (MSC). 1.0

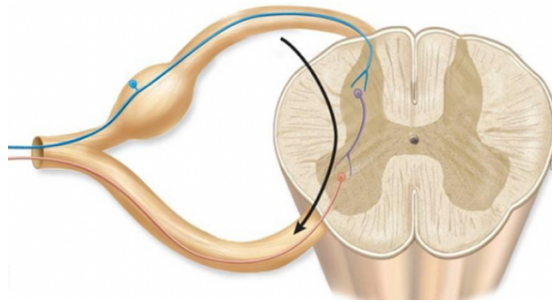
- ii) Name one potential medical application concerning these stem cells (MSC). 0.5

5) i) Which embryonic layer produces blood (hematopoietic) stem cells? 0.5

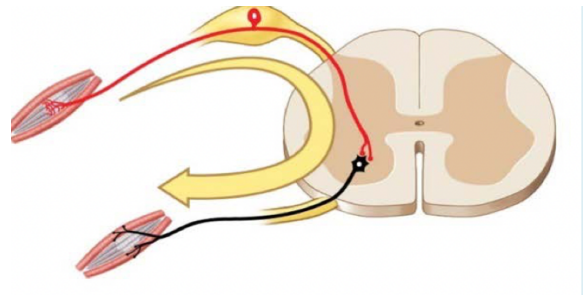
ii) Name one tissue type that becomes differentiated from the ectodermal embryonic layer. 0.5

Animal Behaviour (7.5 marks)

1) A reflex action is the simplest type of animal behaviour. The images a and b below partially illustrate two spinal reflex arcs.



a)



b)

i) Identify, using one word for each, the types of reflexes shown in illustrations a) and b) above. 1.0

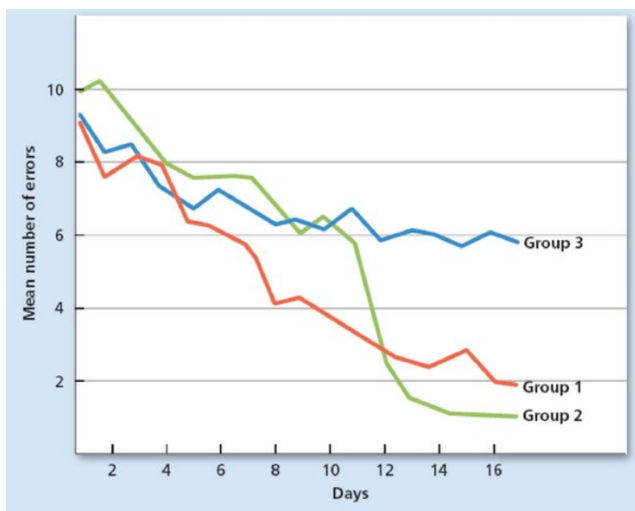
ii) Which type of reflex, a or b above can be altered voluntarily? Explain your answer. 1.0

2) If an egg rolls out of the nest, a mother graylag goose will retrieve it by nudging it with its beak. If researchers remove the egg or substitute a ball during this process, the goose continues to bob her beak and head back and forth towards the nest.

i) What is the name given for this type of behaviour? 0.5

ii) Describe both the i) proximal explanations and the ii) ultimate explanations for this type of behaviour. 2.0

3) In relation to the graph below answer the question which follow.



Graph illustrating results of the number of errors by rats in the maze over the 16-day period.

Key

Group 1 Rats regularly rewarded with food on exit to maze

Group 2 Rats not rewarded with food until day 11, on exit to maze

Group 3 Rats not rewarded with food at all.

What conclusion can be made about the learning of the maze from these results? 1.0

Multiple choice questions-circle the ONE correct letter ONLY. 0.5 each

- 1) Woodlice become more active in dry areas and less active in humid areas. This is an example of
A) taxis. B) tropism. C) kinesis. D) cognition. E) reflex.
- 2) You turn on a light and observe cockroaches scurrying to dark hiding places. What have you observed?
A) taxis B) learned behavior C) migration D) visual communication E) operant conditioning
- 3) People who have lived next to a church bell tower for some years do not wake up in the night when the bell strikes the hour. This is an example of
A) imprinting B) a sign stimulus. C) operant conditioning. D) a reflex E) habituation
- 4) _____ cycles include seasonal changes in a range of body functions, including body weight and reproductive status.
A) Circadian B) Circannual C) Circatidal D) Ultradian E) Infradian

Biological Clocks (6.5 marks)

Read the following experimental details and answer the questions which follow.

To better understand the physiological mechanism of circadian clocks, Martin Ralph and colleagues used artificial selection to produce two strains of hamsters: one with a short circadian period, of about 20 hours and one with a long circadian period of about 24 hours.

When the suprachiasmatic nuclei (SCN) in some of these adult hamsters were destroyed, the animals became arrhythmic.

After several weeks, the scientists then transplanted SCN tissue from fetal hamsters into the brains of the adult hamsters with destroyed SCNs. Long-period adult hamsters received SCN tissue from short-period fetuses, and short-period adults received tissue from long-period fetuses. The effects of these treatments on the hamsters' circadian rhythms are shown in the table of results below.

Results

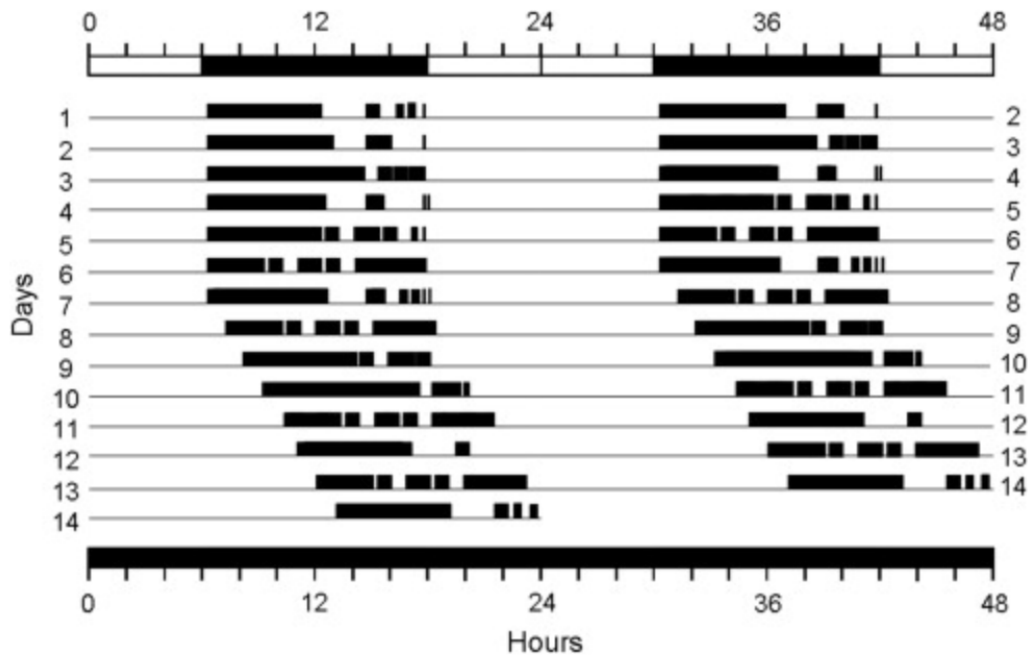
RECIPIENT	TYPE OF RHYTHMICITY SHOWN AFTER VARIOUS TREATMENTS			
	NO TREATMENT	SCN DESTROYED	SCN DESTROYED AND SHORT-PERIOD TRANSPLANT	SCN DESTROYED AND LONG-PERIOD TRANSPLANT
Short-period adult	Short period	Arrhythmic	Not done	Long period
Long-period adult	Long period	Arrhythmic	Short period	Not done

M. R. Ralph et al. 1990. Science 247: 975–978.

1. What do you understand by the term *circadian rhythm*?

0.5

1) Actogram



The actogram above illustrates the physical activity of a mouse over a 14 day period.

Data for two consecutive days (48 h) are plotted in one line. For the first 7 days the mouse was housed under a Light:Dark (L:D) cycle of 12:12 as indicated by the white/black/white bar on top. From day 7 onwards the mouse was kept in constant darkness (DD) as indicated by the black bar at the bottom.

- a. Describe and explain the changes to behaviour seen when the mouse is kept in constant darkness. 2.0

- b. Discuss two adaptive features of this rhythmic behaviour for a mouse living in its natural environment. 1.0

3) Explain why symptoms of *jet lag* are usually more severe when travelling rapidly from the West to the East than travelling East to West. 1.0

End of the test!