Bildungs-, Kultur- und Sportdirektion
Kanton Basel-Landschaft

GYMNASIUM OBERWIL

Maturprüfung 2016
Biologie SPF (immersiv)

Klasse	4b
Anzahl Seiten (ohne Deckblatt):	18
Inhalt:	A Cell contents, metabolism [19] B Evolution and systematics [22] C Blood circulatory system and immune system [26] D Inheritance and blood types [21] E Molecular genetics [15.5] F Neurobiology [25.5] G Ecology and hydrology of plants [27]
Anweisungen/ Erläuterungen:	Write / draw your solutions onto the printed test sheets only if explicitly requested. All other answers should be written onto the supplied blank sheets. **Start a new page for each part of the exam (A-G).** Please write your name and class on each of these sheets. Examination time: 13:30 to 17:30
Hilfsmittel:	Pens Pencils (for drawings only)
Bewertung:	The number of marks that can be obtained are indicated in square brackets in the subheadings. The grade is based on the total of marks obtained in all parts (A-G). The grade 6 does not require the maximum number of marks.

Bevor Sie mit dem Lösen der Aufgaben beginnen, kontrollieren Sie bitte, ob die Prüfung gemäss obiger Aufstellung vollständig ist. Sollten Sie der Meinung sein, dass etwas fehlt, melden Sie dies bitte **umgehend** der Aufsicht.

A Cell contents, metabolism [19]

A1 Multiple choice [10]

Clearly mark the entirely correct answers. In each question (1, 2, 3, ...) only one answer is correct; you get one mark for each correctly answered question.

1 Hydrolysis is a very important biochemical reaction, which is carried out enzymatically in cells. Which statement is correct for hydrolytic reactions?

a During hydrolysis, two monomers (e.g., two amino acids) are linked by incorporating a water molecule, resulting in a dimer.

b In a hydrolytic cleavage [Spaltung] of a polymer (e.g., a polysaccharide or a protein) water is always released.

c Hydrolysis is defined as the dissociation of a water molecule when a dimer (e.g., a disaccharide or a dipeptide) is cleaved.

d Hydrolytic processes are chemical reactions in which molecules are cleaved by the addition of water.

2 Which of the following carbohydrates is not a disaccharide:

a sucrose
b ribose
c lactose
d maltose

3 Glucose is a widely used building block within the large group of carbohydrates. Which polysaccharide does **not** consist entirely of glucose?

a glycogen
b starch
c chitin
d cellulose

4 Fats are lipids that occur mainly in animals. Fats have different functions within the human body. Which function does fat / fatty tissue **not** have?

a Some organs are embedded in fatty tissue to protect them from jolts [Stössen].

b Fats are used for thermal insulation and are therefore mostly deposited in the subcutaneous tissue.

c Fats are used as a reserve fuel for the energy needs of the body.

d In fatty tissue, substances are produced which influence the blood sugar level of the body.

5 Vegetable oils and animal fats are essentially made up of the same building blocks. Yet they differ chemically, which has an impact on their physical and chemical properties. Which of the following statements is correct?

a Vegetable oils are usually liquid at room temperature because their fatty acids have shorter hydrocarbon chains.

b Vegetable oils are usually liquid at room temperature, because their unsaturated fatty acids occupy more space due to their double bonds and cannot be packed as closely together as saturated fatty acids.

c Animal fats can be converted easily in vegetable oils (= fatty oils).

d Animal fats are usually solid at room temperature because its intra-molecular forces are stronger than in vegetable oils.

6 On many food nutrition panels there is some information on fatty acids. Fatty acids are (among others) a component of fats. There are many different fatty acids. Which statement is correct?

a Saturated fatty acids are considered to be healthier than unsaturated ones

b A fat molecule is composed of one fatty acid and one glycerol molecule.

c Essential fatty acids have one or more double bonds in the hydrocarbon chain.

d All essential fatty acids must be taken up with the food.

7 The spatial structure of proteins is a key to their function. Heating up proteins can cause them to denature because

a the excessive heat movements cause some of the hydrogen bonds between the amino acids to break, thereby altering the spatial structure of proteins.

b the excessive heat movements cause individual atoms to break loose from the amino acids, thereby altering the spatial structure of the proteins.

c the excessive heat movements cause the sulphur bridges within the protein molecules to loosen, thereby destroying their spatial structure.

d the amino acid chains of the different protein molecules fuse with each other, thereby causing the proteins to solidify (e.g., when boiling an egg)

8 Some bacteria species are able to live and reproduce in hot springs. They can be metabolically active there because

a they can keep their internal temperature low.

b the high temperature allows their metabolism to function without the biocatalytic help of enzymes.

c they use molecules other than proteins as enzymes, and these molecules are more heat-resistant because they are not proteins.

d their enzymes have a high temperature optimum.

e their enzymes can absorb much heat and do therefore not denature at these temperatures.

9 Nucleic acids are chainlike macromolecules and have different functions within a cell. Nucleic acids are, for example,

a carriers of genetic information and responsible for converting RNA into DNA.

b carrier of genetic information and responsible for the direct control of most metabolic reactions.

c carrier of genetic information and important components of ribosomes.

d involved in the synthesis of amino acids. In addition, amino acids are transferred from nucleic acid molecules to the ribosomes.

10 Which statement is **not correct**?

a All natural amino acids are soluble in water, as the amino acid residue can always interact with water.

b Amino acids are always dissolved in the water as ions.

c Amino acids are the building blocks of proteins, which are formed by chain-like concatenation [Verknüpfung] of amino acids.

d Peptide bonds are formed by connecting the amino group of one amino acid with the carboxyl group of another amino acid.

A2 Macromolecules [9]

1 Compile a legend for figure A1. [3]

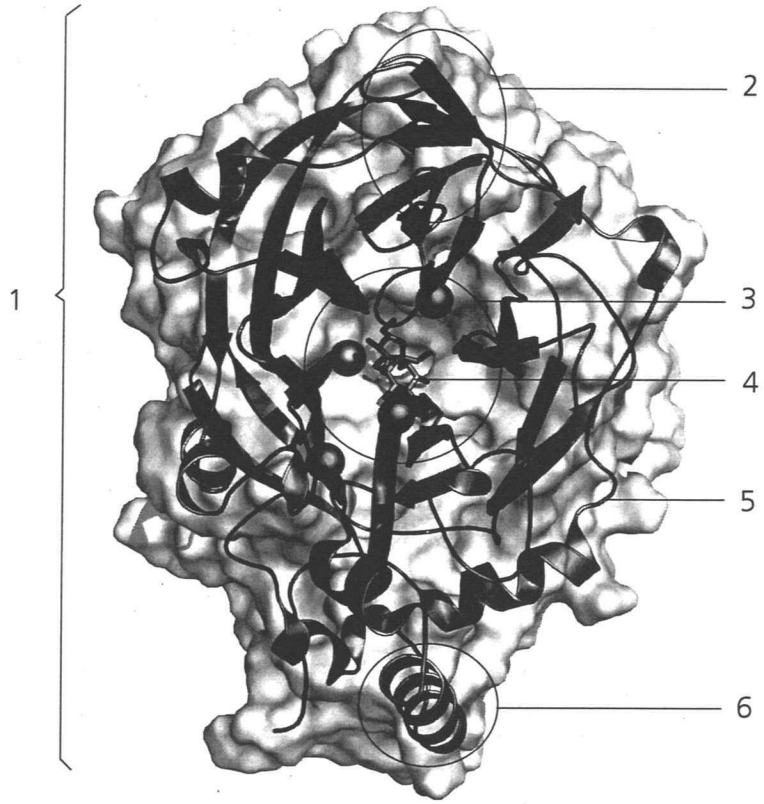

Fig. A1 – Three-dimensional representation of a macromolecule

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2 Bees can **fight intruders** attacking their hive using various methods. In one method, many bees swarm around the intruder and begin to **tremble** strongly, i.e. they contract and relax their muscles at a high frequency. What could be the purpose of this behaviour and what could be its consequences for the intruder? Explain these observations using your knowledge of biochemistry. [2]

3 In industrial applications, fats are hydrolysed mostly using water vapour at high temperature, whereas this biochemical reaction takes place in organisms at a much lower temperature. Show graphically how the **rate** of biochemical fat hydrolysis **depends on temperature** in a homoiothermic animal (e.g. a mammal) and explain the **shape of the curve**. [4]

B Evolution and systematics [22]

B1 Lice [7]

1 Two blood-sucking parasites of humans are the head louse, *Pediculus humanus,* living in the head hair, and pubic louse, *Phthirus pubis*, living in the pubic hair [Schamhaare]. Researchers at the University of Florida studied lice of human, gorilla and chimpanzee, to determine how closely related the lice are to each other and when the different parasite species have arisen.

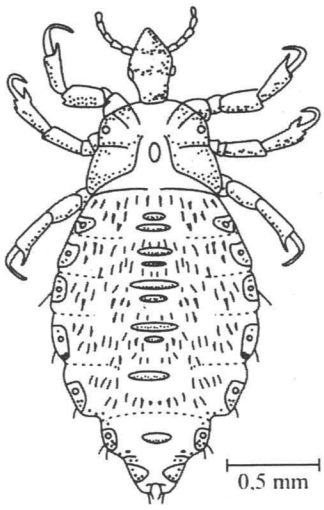

Fig. B1 – Head louse Pediculus humanus

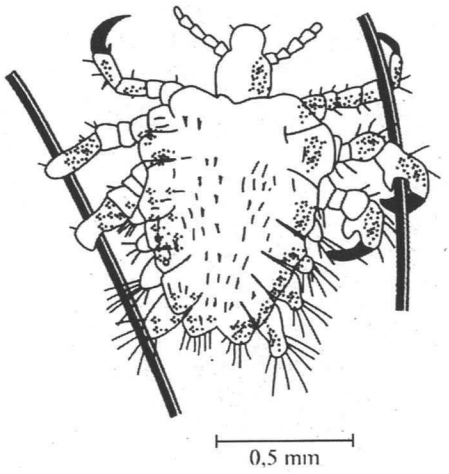

Fig. B2: Pubic louse, Phthirus pubis

a Assign the lice to a systematic group. Name a characteristic of the lice that justifies this assignment. [1]

b Identify two adaptations of the lice to their parasitic lifestyle. [1]

2 By comparing the DNA sequences of the two genera *Pediculus* and *Phthirus*, it could be shown that these genera separated approximately 13 million years ago. The two species *Pediculus schaeffi* and *Pediculus humanus*, which parasitize chimpanzees and humans respectively, are presumed to have separate lineages for 6 million years and thus for about the same time as their hosts. Furthermore, researchers were able to show that the two species *Phthirus pubis* and *Phthirus gorillae*, specialised to humans and gorillas respectively, have separated about 3.3 million years ago.

a Draw a phylogenetic tree of the four mentioned parasites with the appropriate time scale (size approx. ½ page). [2]

b Describe and explain how an early species of *Phthirus* could have split into the two species *P. gorillae* and *P. pubis* and name the kind of speciation you have described. Take into account that the ancestors of modern humans and the ancestors of modern gorillas used the same nests to sleep in. [3]

B2 Closely related species [7]

To study the relationships between closely related species, the DNA hybridisation technique is used. In this technique, corresponding single strands of DNA of the species to be examined are combined to hybrid DNA. DNA double strands can be split into single strands by heating ("melting"): Pure DNA and hybrid DNA have different "melting temperatures". It is assumed that in the case considered, a "melting temperature difference" of 1 Kelvin corresponds to a development period of about 4 million years.

1 Explain why the "melting temperature" of hybrid DNA is lower than that of DNA from one species. [3]

2 Explain the relationship between a change in "melting temperature" and the duration of the development period. [2]

	Gorilla	Humans	Chimpanzee
Gorilla	0	2.3	2.3
Humans	2.3	0	1.6
Chimpanzee	2.3	1.6	0

Table B2 – Difference of "melting temperatures" (in Kelvin) of pure and hybridised DNA of gorilla, human and chimpanzee.

3. Use the values in table B2 to draw a phylogenetic tree for gorilla, human and chimpanzee with the appropriate time scale (size approx. ½ page). [2]

B3 Analogous or homologous [4]

Check for each pair of characteristics below whether it is homologous or analogous. [4] (For each incorrect answer, ½ mark is deducted, missing answers are considered as incorrect)

Characteristics	analogous	homologous
Long neck of giraffes – long neck of ostriches [Strausse]	❑	❑
Tail fin of whales [Wale] – tail fin of trouts [Forellen]	❑	❑
Beak of ducks – beak of swallows [Schwalben]	❑	❑
Beak of ducks – beak of duck-billed platypuses	❑	❑
Wing of swallows – wing of bats [Fledermaus]	❑	❑
Wing of bats – wing of butterflies	❑	❑
Wing of butterflies – wing of mosquitoes	❑	❑
Neural tube of lancelets – spinal cord of elephants	❑	❑
Lensed eyes of squid – lensed eyes of ducks	❑	❑
Tail of elephants – tail of zebras	❑	❑
5 toes of humans – 5 fin bones in whales	❑	❑

B4 Lamarck and Darwin [4]

Cheetahs belong to the family of Felidae (Mammals: Carnivora). With their extremely long legs they can run very fast. The cheetah is the fastest land animal in the world with running speeds well above 100 km/h.

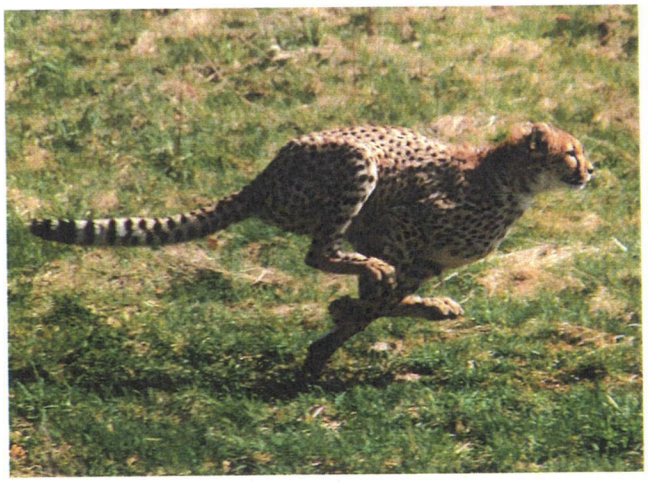

Fig. B4 A cheetah in pursuit of its prey.

Explain how the cheetahs evolved the ability to run so fast according to the theory of Lamarck, as well as according to the theory of Darwin. [4]

C Blood circulatory system and immune system [26]

C1 Heart [13.5]

1. Compile a legend to figure C1a [4]

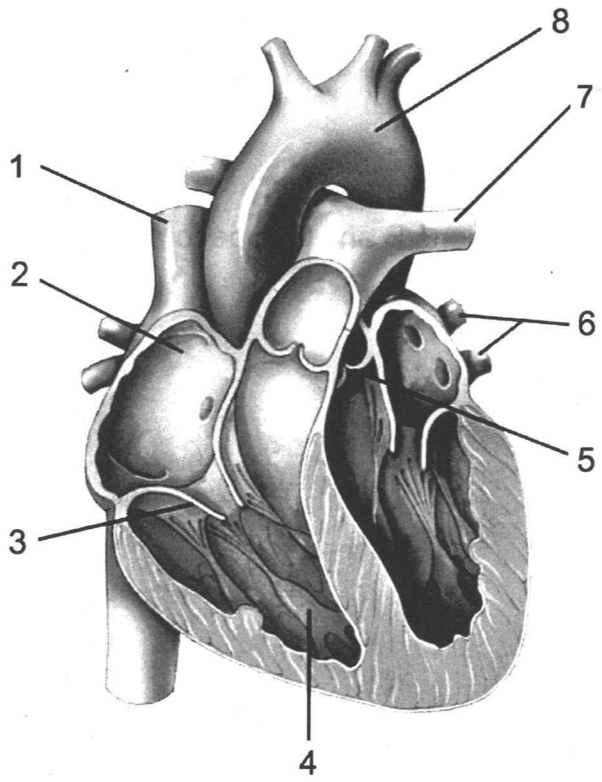

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Fig. C1a – Schematic drawing of a longitudinal section of a heart

2 Suppose a patient suffers from a constriction of a large coronary artery. The examining doctor recommends the insertion of a stent (small metal lattice tube) in order to ensure that the lumen of this vessel remains open. In such a surgery, the stent is inserted via a cardiac catheter, starting in one of the large vessels in the leg.

a In which vessel does the doctor start inserting the cardiac catheter? [1]

b Describe the exact path through which the physician must pass the catheter. Indicate where and why the catheter must be guided with special care to reach its destination. [2.5]

3 Draw the flow of blood in the heart and in the large peripheral vessels by drawing arrows directly into figure C1a. [2]

4 Figure C1b shows the pressure changes inside heart chambers and adjacent vessels in the left side of the heart associated with the pumping function of the heart.

a Which heart chamber or vessel do the 3 different lines represent? [1]

A .....

B .....

C .....

b Describe what happens at X. What causes this to happen? [1]

c Explain in detail what causes the pressure in parts B and C to become negative (compared to the outside pressure) [2]

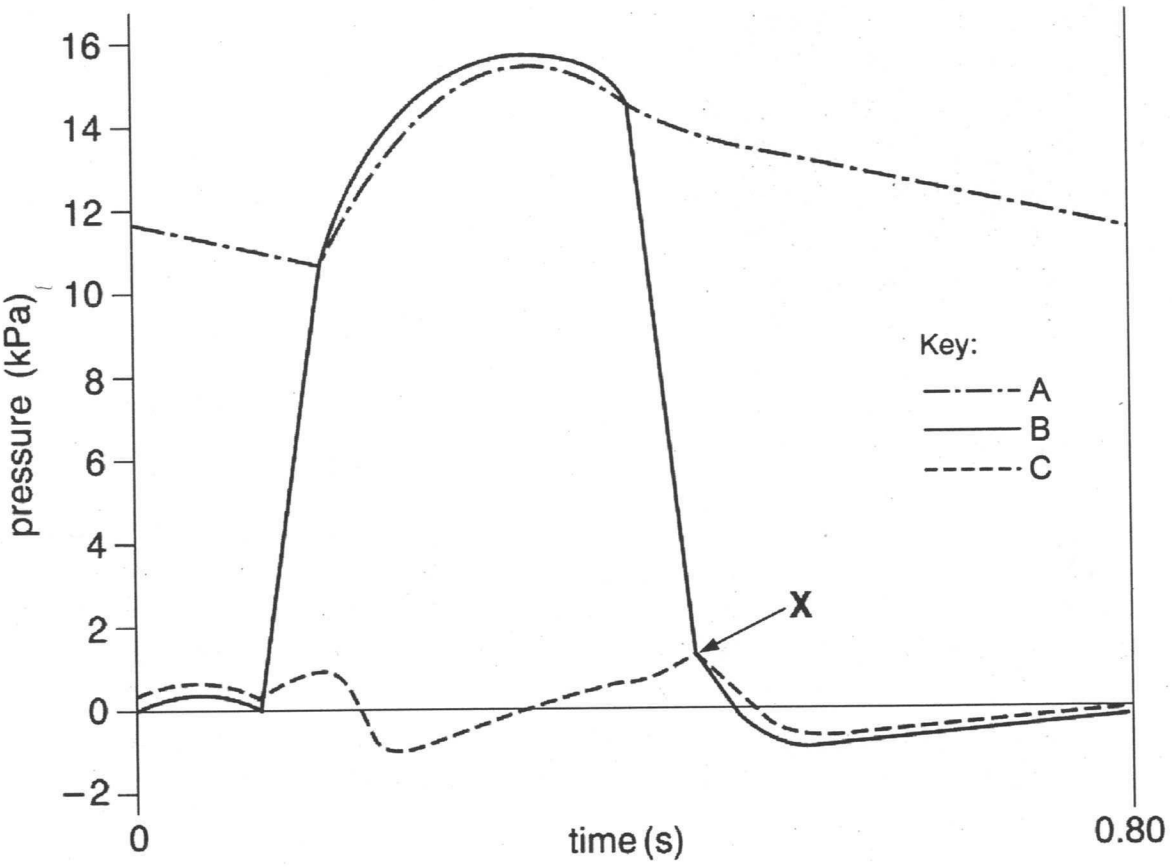

Fig. C1b – Pressures inside heart chambers and adjacent vessels in the left side of the heart during one heartbeat. A pressure of 0 kPa equals the pressure outside of the body.

C2 Blood cells [12.5]

1 Compile a legend for figure C2 [1.5]

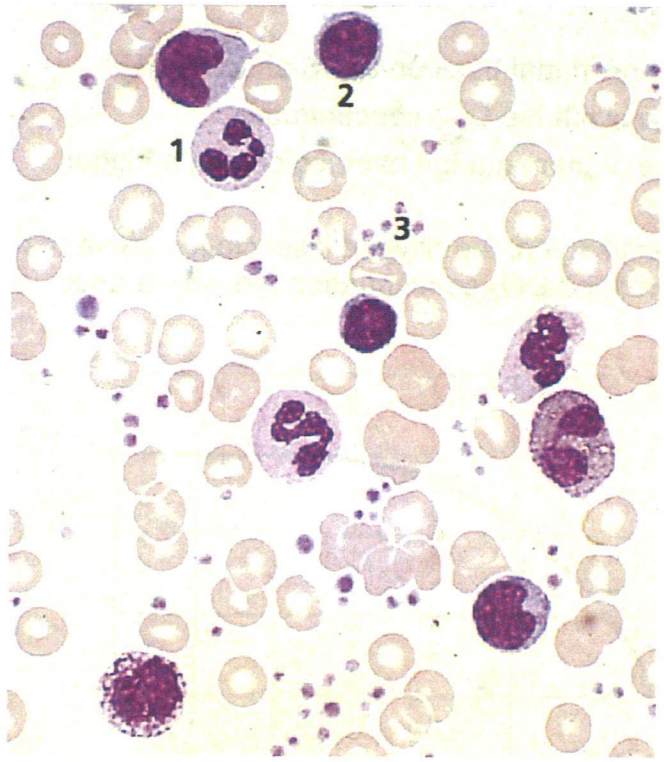

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Fig. C2 – Stained blood smear.

2 What does figure C3 show? Interpret / explain the illustrated graphic using the proper terminology. [4]

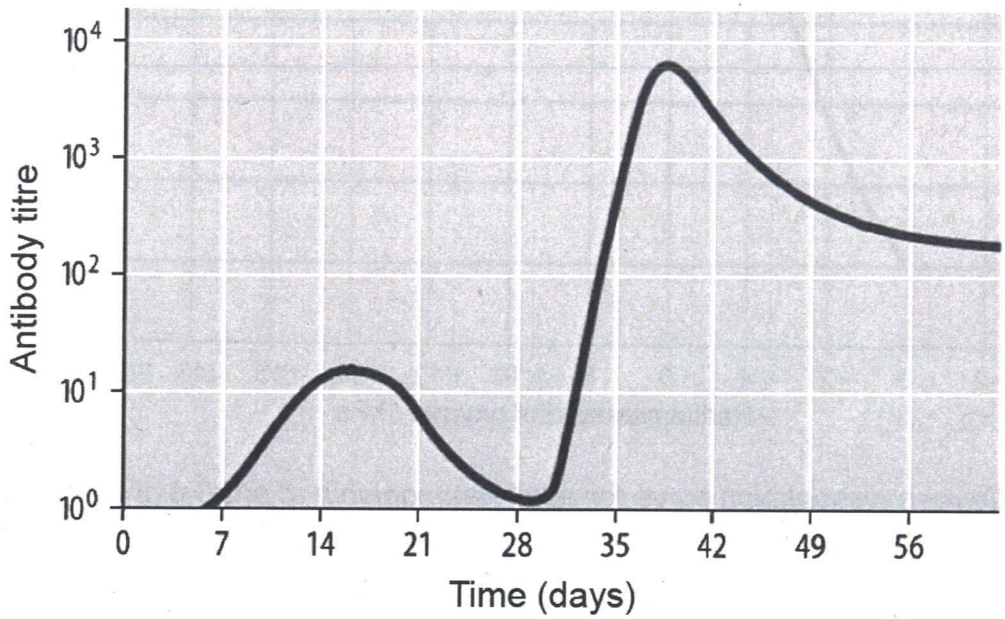

Fig. C3 – Change of antibody concentration during 60 days.

3 Suppose a patient has a bacterial infection. Which immune cells recognize these pathogens first? [1]

4 Explain the different functions of granulocytes and lymphocytes in 1-2 sentences each [2]

5 Figure C4 shows the oxygen dissociation curve of human adult haemoglobin at $p(CO_2)$ (partial pressure of CO_2) of 3 kPa.

a Why is it advantageous for the organism that this curve is S-shaped? [1]

The oxygen dissociation curve changes with the CO_2 concentration.

b Draw the oxygen dissociation curve of human adult haemoglobin at a higher $p(CO_2)$ directly into figure C4 [1.5]

c Why is it advantageous for the organism that the oxygen dissociation curve of human adult haemoglobin changes with the CO_2 concentration the way is does. [1.5]

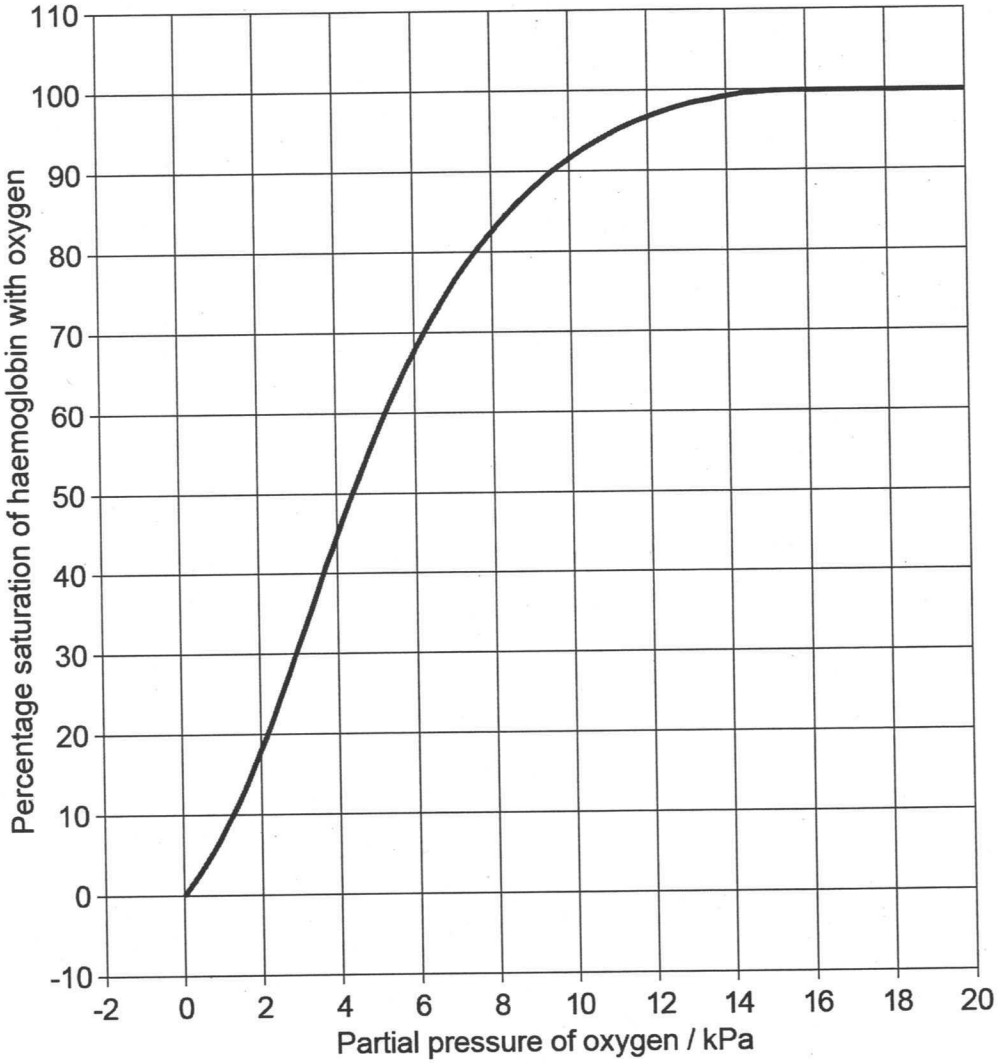

Fig. C4 – Oxygen dissociation curve for adult haemoglobin at $p(CO_2)$ of 3 kPa.

D Inheritance and blood types [21]

1 a Define the term 'allele' in one sentence. [1]

b Describe one specific example of alleles and of the corresponding gene. [2]

2 Around 1900, Karl Landsteiner had established that a mixture of blood from different persons sometimes agglutinates, and sometimes not. On the basis of these observations he conducted an experiment in which he systematically mixed the blood serum and the erythrocytes of himself and of five of his co-workers. The figure shows the results of this experiment.

Determine, as far as possible, the blood types of Landsteiner and his 5 co-workers on the basis of the results shown in figure D1. Explain your assignments. [4]

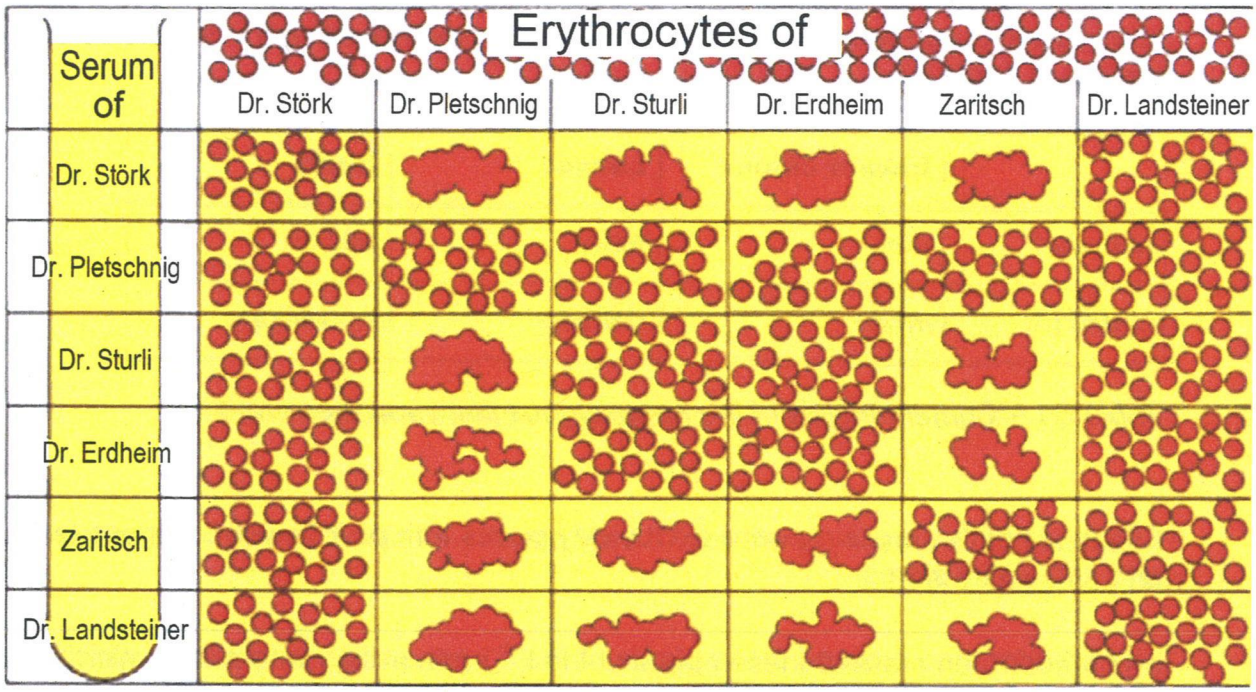

Fig. D1 Schematic representation of the results of the blood type experiment by K. Landsteiner.

3 The pedigree in figure D2 shows the phenotypic blood types in a family.

a Determine the possible phenotypes of the blood types of persons 2 and 4. [1.5]

b Determine the possible genotypes of the blood types of persons 1, 4, 5 and 6. [3]

c Briefly explain how the genotype of person 6 can be determined. If no clear assignment is possible, write down all possibilities. [0.5]

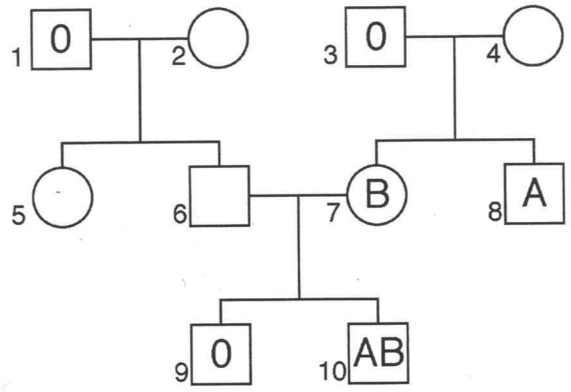

Fig. D2 – Pedigree of a family.

4 A breeder crossed two different homozygous plant varieties with the features described in Table D1.

	Flower colour	**Leaves**	**Stem**
Variety I	pink	hairy	sticky
Variety II	white	hairless	non-sticky

Table D1 – Characteristics of the homozygous plant varieties I und II

The result of this crossing were exclusively plants with pink flowers, hairless leaves and non-sticky stems.

The breeder then crossed these plants of the F1 generation with plants, which had white flowers, hairy leaves and sticky stems. This second cross resulted in the following plants:

Number of individuals	**Characteristics**
242	pink, hairy, non-sticky
249	pink, hairy, sticky
246	white, hairless, non-sticky
239	white, hairless, sticky

a Document the genotypes of the crossings of the two varieties I and II up to the F1 generation using appropriately selected letters; do not forget a legend to the letters in your answer. [3]

b What kind of inheritance is it? [1]

c Explain how the four different phenotypes have arisen at the second crossing. Use (among others) a suitably reduced Punnett square. [5]

E Molecular genetics [15.5]

E1 Hybridisation [4]

In one experiment, growing rice cells were studied in a cell culture. Their DNA was isolated and purified. In addition, some mRNA of these cells was obtained from the cytoplasm. In a hybridisation experiment, the DNA was first denatured to form single strands. Subsequently, this single-stranded DNA was mixed with the sample with the purified mRNA and brought to hybridisation. The result of a single hybridisation is schematically shown in figure E1.

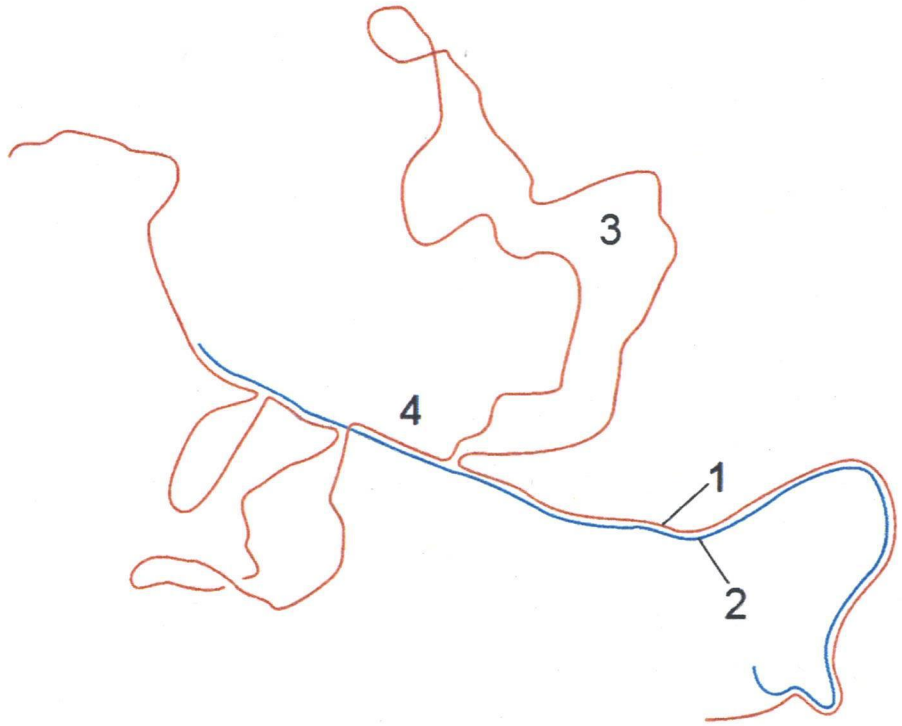

Fig. E1 – Schematic representation of the result of the hybridisation experiment.

1 Explain this result. [2]

2 Compile a legend to figure E1 [2]

1.....

2.....

3.....

4.....

E2 The genetic code [7.5]

1 Comment on the statement: "The genetic code is universal" [2]

2 The complete DNA of a given organism contains 35% thymine. Determine the percentages of the remaining bases. Explain your answer [1.5]

3 The non-transcribed strand of the DNA of a mini gene is known:

3' CCAGATATGCTTAAAGAACCGTTATATGTAGATG 5'

a Determine the sequence of the complementary DNA strand. [0.5]

b Determine the sequence of the mRNA. [0.5]

c Use the code table to translate the mRNA sequence into the amino acid sequence. Explain your approach. [3]

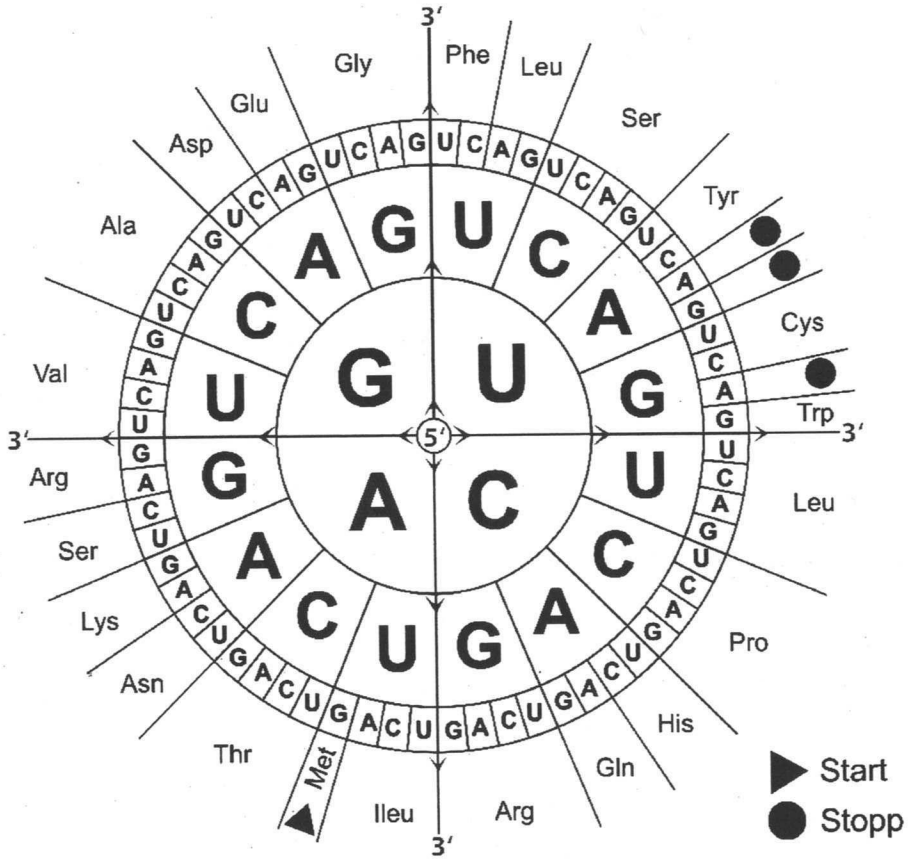

Fig. E2 – Code table

E3 DNA-Sequencing [4]

1. Explain why one primer is needed to perform a Sanger DNA sequence analysis. [2]

2. DNA sequencing often involves a DNA synthesis reaction in which labelled nucleotides are incorporated. These methods also use some form of gel electrophoresis. What is the purpose of gel electrophoresis when employed in DNA sequencing? [2]

F Neurobiology [25.5]

F1 Propagation of a nerve impulse [9.5]

1. Explain where and how an action potential in a nerve cell arises naturally and how it is passed on. In your answer name and describe different phases of an action potential. [4.5]

2. a What is "saltatory conduction"? Explain in 3-4 sentences. [3]
   b What are the two relevant advantages of saltatory conduction? Explain exactly. [2]

F2 Synapse [7]

1 Order the statements listed in Table F1 chronologically. [3]

1	Acetylcholine is recycled from its components and packaged in vesicles. This process requires energy (ATP).
2	The neurotransmitter (acetylcholine) separates from the receptor.
3	Voltage-gated Ca^{2+} channels are opened and Ca^{2+} enters the presynaptic cell.
4	The neurotransmitter (acetylcholine) is released into the synaptic cleft.
5	Receptor-activated Na^{+} channels open and Na^{+} ions flow into the postsynaptic cell.
6	An action potential reaches the synapse.
7	The neurotransmitter (acetylcholine) is broken down into its components and thus inactivated.
8	Due to the Ca^{2+} inflow, presynaptic vesicles merge with the presynaptic membrane.
9	The components of acetylcholine are absorbed by the presynaptic cell.
10	Neurotransmitters bind to receptor-activated Na^{+} channels of the postsynaptic membrane.
11	The postsynaptic membrane is depolarized.

Table F1 – Processes that take place in and around a synapse.

2 Many neurotransmitters are peptides or derivatives of peptides. They are stored in the synaptic vesicles in the presynaptic knob.

Describe where these neurotransmitters are produced and where and how they are packaged into the vesicles. [4]

F3 Neurotoxins [9]

Neurotoxin	Primary effect
Tetrodotoxin	Blocking of sodium channels
Botulinum toxin (Botox)	Inhibition of acetylcholine release
Parathion (E 605)	Irreversible inhibition of acetylcholinesterase
Atropine	Competitive antagonist to acetylcholine in parasympathetic nerves
Neostigmine	Reversible inhibition of acetylcholinesterase

Table F2 Neurotoxins with their primary effects

Curare is a neurotoxin used by the indigenous population of South America as an arrow poison [Pfeilgift] and made from extracts of bark and leaves of different kinds of liana. Curare acts as a competitive antagonist to acetylcholine, but in contrast to acetylcholine, Curare cannot depolarize the membrane.

1 What is a competitive antagonist? Explain exactly using curare as an example. [3]

2 Curare affects neuromuscular synapses of skeletal muscles. Explain why curare can be successfully used as an arrow poison and explain the relationship between the effects of curare and the consequences for the affected organism. [2]

3 Explain which of the substances listed in Table F2 can be administered as a successful antidote to a curare poisoning. [4]

G Ecology and hydrology of plants [27]

G1 Algae in a lake [12]

Large quantities of algae grow in lakes with a high plant nutrient content. Such lakes have a strong water turbidity [Trübung] and are therefore unsuitable as recreational areas. Manipulating fish stocks is one approach to reduce the quantity of algae.

In a lake in the Swiss 'Mittelland', large numbers of zander were released annually, which lead to a reduction of young perch from 8000 to 3000 individuals per hectare within six years. Water turbidity also decreased considerably.

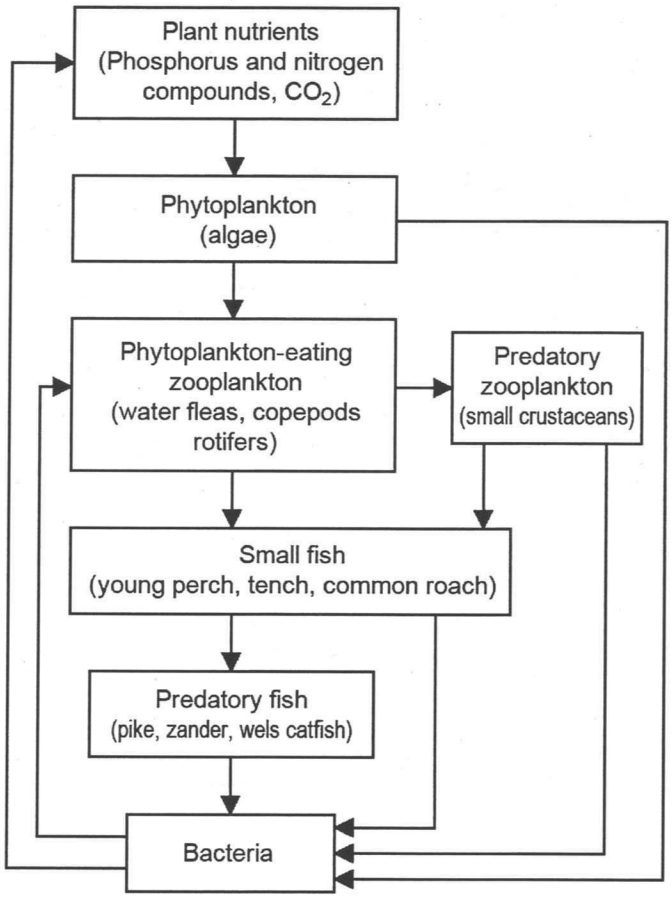

Fig. G1 – Schematic representation of an aquatic nutrient cycle.

1 Show the relationship in the nutrient cycle shown in figure G1 as a pyramid of numbers and assign all organism groups to the different trophic levels of the ecosystem. (For this task ignore the predatory zooplankton). [4]

2 Explain why a regular release of predatory fish can lead to a reduction of water turbidity. [3]

3 Could such an increased predatory fish population also cause an undesirable shift in plankton composition? Explain your answer. [3]

4 Eutrophic lakes are often found in regions with intensive agriculture. Explain this observation. [2]

G2 Water uptake [8]

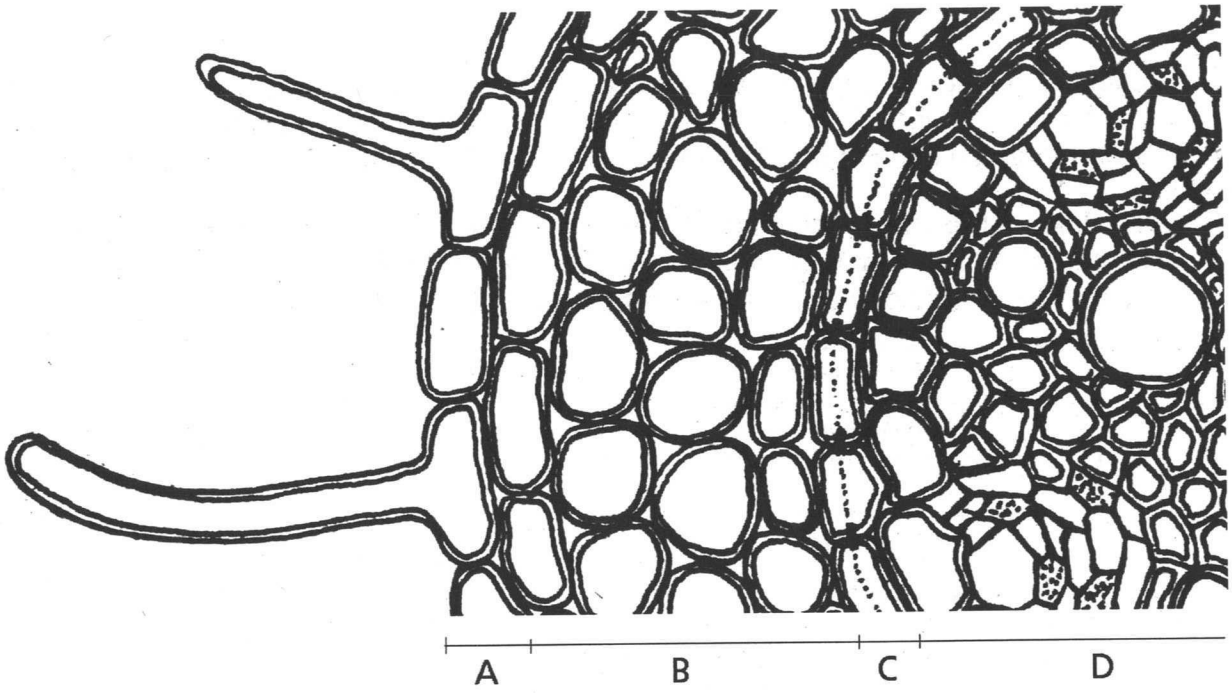

Fig. G2 – Schematic representation of a root cross-section.

1 Compile a legend for parts A–D in figure G2. [2]

2 Describe qualitatively how the water potential changes from A to D. [1]

3 Describe how the water potential of plant cells could be assessed experimentally? [3]

4 Discuss how over-fertilisation affects the water uptake. [2]

G3 Definitions [7]

Define the following terms in 1–2 sentences and briefly explain them using examples.

1 Mutualism [1.5]

2 Ecological community [1.5]

3 Biotic factor [1.5]

4 Biodiversity [2.5]