



Baden-Württemberg

MINISTERIUM FÜR KULTUS, JUGEND UND SPORT

Hinweise für die Abiturientinnen und Abiturienten

Abiturprüfung an den allgemein bildenden Gymnasien

Nachtermin 2019

Prüfungsfach: Biologie (bilingual) in englischer Sprache

Bearbeitungszeit: 270 Minuten einschließlich Auswahlzeit

Hilfsmittel: Taschenrechner

Codesonne

Nachschlagewerke zur deutschen Rechtschreibung und Zeichensetzung

einsprachiges Wörterbuch (Englisch)

zweisprachiges Wörterbuch Englisch-Deutsch / Deutsch-Englisch

Hinweise: Sie erhalten **vier** Aufgaben.

Wählen Sie davon **drei** Aufgaben aus und bearbeiten Sie diese.

Verwenden Sie für jede Aufgabe für Reinschrift (weiß) und Entwurf (grün) jeweils einen neuen Bogen Papier.

Vermerken Sie auf jedem Bogen, welche Aufgabe Sie hier bearbeitet haben.

Sie sind verpflichtet die Vollständigkeit der vorgelegten Aufgaben vor Bearbeitungsbeginn (auf Anzahl der Blätter, Anlagen usw.) zu überprüfen.

Lösungen auf den Aufgabenblättern werden nicht gewertet.

Lösungen in deutscher Sprache werden nicht gewertet.



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Blatt 1 - 10

Task I:

In early 2016 about 40,000 tons of salmon perished in the fish farms of the Los Lagos region in Chile. Many whales and seals died in the ocean.

This mass extinction was triggered by an extreme reproduction of unicellular algae belonging to the group of dinoflagellates. Such short-lived algae proliferation occurs every once in a while all over the world. Of the thousands of algae species, a few are toxic. These algae contain toxic compounds such as the neurotoxins saxitoxin or ciguatoxin. Saxitoxin blocks voltage-gated Na^+ channels while ciguatoxin causes their permanent activation.

These dinoflagellates only become dangerous to humans if they eat mussels that have previously filtered such algae from the water, digested them, and stored the toxins in their bodies. That is why beachgoers in regions affected are warned not to eat mussels and other shellfish (*Meeresfrüchte*) (Figure 1). Usually, the mussels themselves are not harmed by the toxins.



Figure 1: warning

- 1.1 Draw a graph depicting the course of an action potential (size: ca. $\frac{1}{2}$ page) and describe and explain the molecular processes leading to the changes in the membrane potential. 4 VP
- 1.2 Describe and explain the effects of saxitoxin and ciguatoxin on the conduction of impulses and describe the cause of the observed mass extinction. 3 VP
- 1.3 Give two possible explanations for the mussels' resistance to the toxins of dinoflagellates. 2 VP

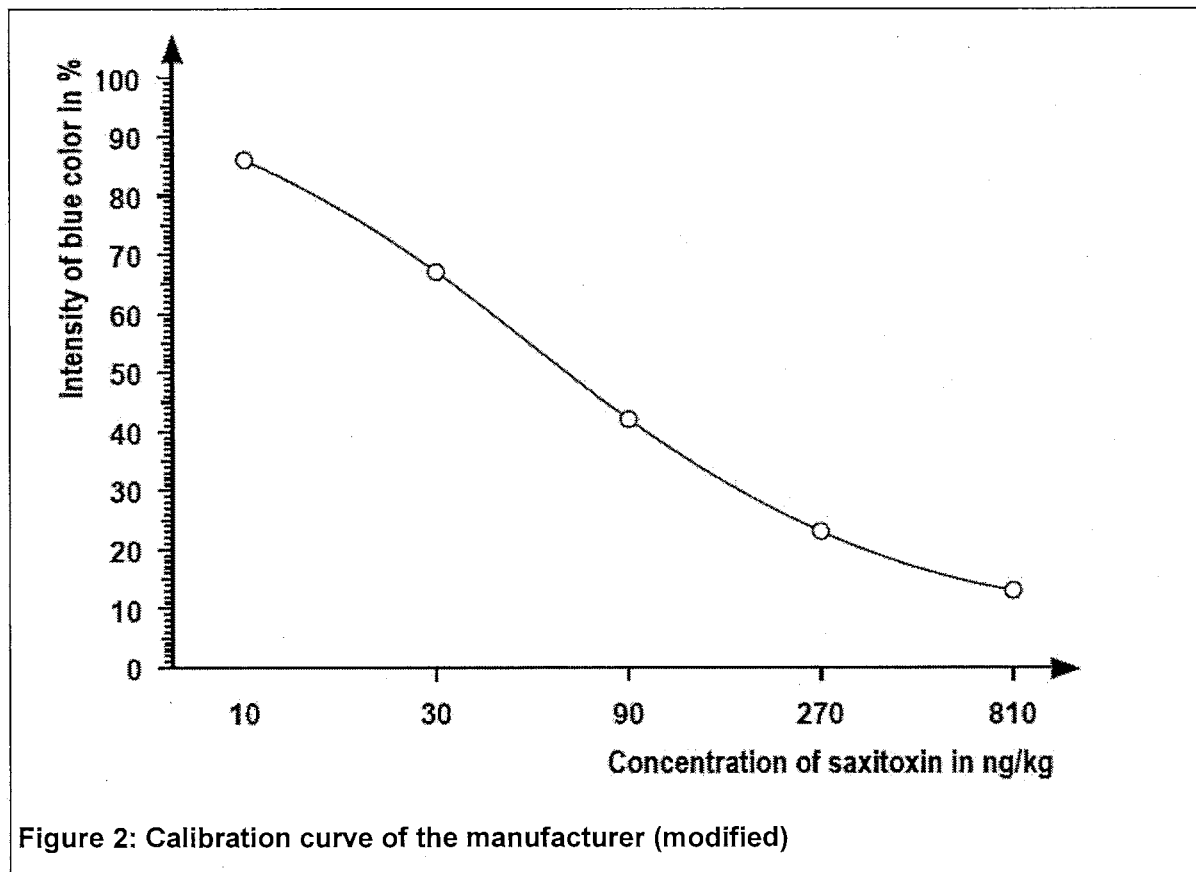
The chemical weapons of the dinoflagellates are actually aimed at tiny copepods (*Ruderfußkrebse*) that feed on these unicellular algae. As scientists at the University of Gothenburg have recently found out, dinoflagellates increase their toxin production depending on the number of copepods in their environment. The production of saxitoxin already increases when the dinoflagellates are exposed to water which copepods have previously swum and eaten other dinoflagellates in.

- 2.1 Describe and explain how the described increase of saxitoxin production could be initiated in the dinoflagellates. 3 VP
- 2.2 Describe and explain what the connection could be between the dinoflagellates' toxin production and their periodically occurring massive increase in numbers (algal bloom, *Algenblüte*). 2 VP

Task I:

To detect toxins in mussels, food safety inspectors (*Lebensmittelkontrolle*) use a "saxitoxin test", which is a quantitative immunological test.

The test kit contains wells which are coated with antibodies against saxitoxin. Two solutions are added into the wells at the same time. One solution is a sample taken from the mussels to be tested, and the other is a standardized solution of enzyme-linked saxitoxin molecules (enzyme-conjugate solution). After a short incubation period the unbound components of both added solutions are washed out. Subsequently a defined amount of colorless substrate is added which is catalyzed by the enzyme conjugate into a blue end product. After a defined period of time the enzymatic reaction is stopped by adding sulfuric acid (*Schwefelsäure*) and the intensity of the color is measured. Figure 2 shows a diagram which the manufacturer of the test kit provides for the quantitative analysis of the test.



- 3.1 Describe the course (*Verlauf*) of the calibration curve (*Eichkurve*) (Figure 2). Describe and explain the processes in the well of the test described above and explain what causes the different intensities of blue coloring of different saxitoxin concentrations.
- 3.2 Give reasons for the necessity of washing and the addition of sulfuric acid after a defined period of time.

4 VP

2 VP

20 VP

Task II:

Cystic fibrosis (*Mukoviszidose*) is one of the most common congenital metabolic diseases. In Germany around 8,000 children, teens and young adults are affected by this disease for which there is currently no cure. Its cause on a molecular level is a mutation of the CFTR gene. This gene codes for a channel protein that transports chloride ions through the cell membranes of mucosa cells (*Schleimhautzellen*).

- 1 Draw a labeled sketch of a section of the plasma membrane based on the fluid mosaic model (size: ca. ½ page). Indicate the intra- and extracellular space.

3 VP

The G551D mutation is one of many possible mutations of the CFTR gene. The sections shown in figure 1 are a part of the CFTR gene.

Normal gene:	3'... TCA CCT CCA GTT GCT CGT TCT TAA ...5'
Mutated gene:	3' TCA CCT CTA GTT GCT CGT TCT TAA ...5'

Figure 1: Sections of the CFTR gene

- 2 Using the codon wheel (see appendix) determine the amino acid sequence for the two gene sections. Give a possible explanation for the channel protein's loss of function as a result of the G551D mutation.

3 VP

The CFTR ion channels are also present in the cell membrane of bronchial mucosa cells and are involved in the ion and water transport of these cells. In healthy people the respiratory tract (bronchi) is covered with a mucus layer of low viscosity.

Figure 2 shows the function of the CFTR ion channel in bronchial mucosa cells of a healthy person. In people suffering from cystic fibrosis the mucus in the respiratory tract is of high viscosity and can only be moved with difficulty, causing the small branches of the bronchi to become obstructed. As a consequence patients often suffer from respiratory distress (*Atemnot*) and insufficient oxygen supply.

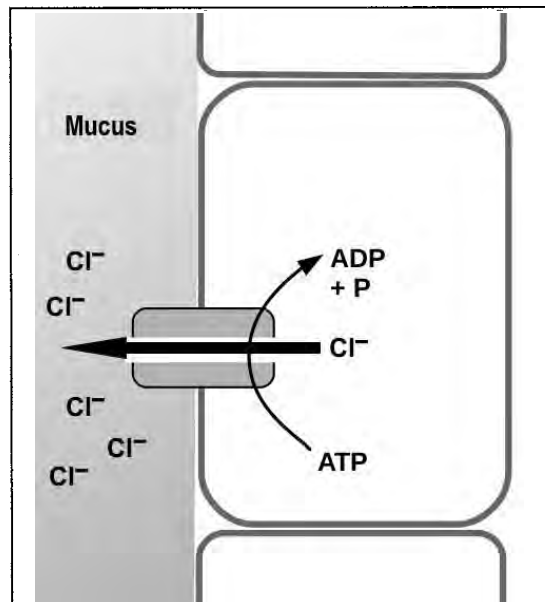


Figure 2: Ion transport out of bronchial mucosa cells in a healthy person

- 3 Using the information in figure 2 describe and explain the occurrence of highly viscous mucus in cystic fibrosis patients.

2 VP

Task II:

The highly viscous mucus of cystic fibrosis patients makes an ideal breeding ground for pathogenic bacteria. In many cases this results in pneumonia which is treated with antibiotics. Penicillins (β -lactam antibiotics) play a key role here. Growing bacterial cells burst when penicillins are taken.

Many bacteria have a cell wall made of murein. Murein consists of many polysaccharide chains cross-linked by oligopeptide bridges (Figure 3). As bacterial cells grow, the cell wall needs to grow as well. It does so by first breaking down the peptide bonds of the oligopeptide bridges. With the help of the enzyme transpeptidase new polysaccharide chains are then built and linked with each other again through a diaminopimelic acid-alanine bond (Dap-Ala). The enzyme transpeptidase can bind the amino acids Ala and Dap as well as the Dap-Ala complex.

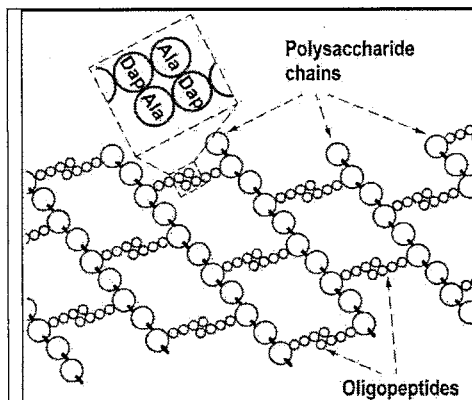


Figure 3: Structure of murein (simplified)

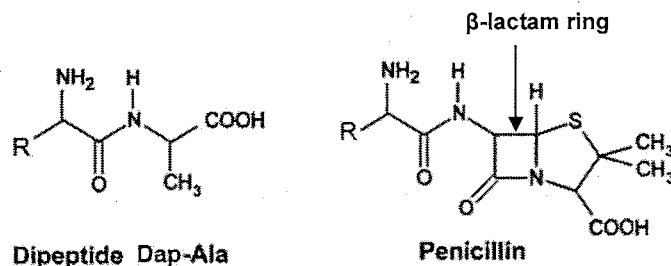


Figure 4: Structure of the dipeptide Dap-Ala and general structure of penicillin

- 4.1 Using the information in figure 3 and 4 explain how penicillin leads to the death of bacterial cells.

4 VP

Many bacteria have become resistant to β -lactam antibiotics since penicillin was first used. This is because bacteria synthesize β -lactamases, enzymes able to destroy the β -lactam ring (Figure 4) in penicillin, thereby rendering the antibiotic agent useless. However, if penicillin and clavulanic acid (Figure 5) are administered in combination to break such resistant bacteria, penicillin's efficacy can be restored. Clavulanic acid by itself is not bactericidal.

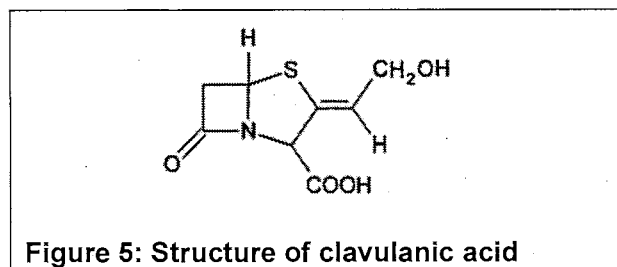


Figure 5: Structure of clavulanic acid

- 4.2 Using figure 4 and 5 describe and explain the effect of combined administration (*Verabreichung*) of penicillin and clavulanic acid.

2 VP

Task II:

- 4.3 Describe an experiment which can show the difference in efficacy between penicillin and the described combination of penicillin and clavulanic acid.

3 VP

The emergence of multi-resistant bacteria is one of the biggest problems of modern medicine. Today there are already pathogenic bacteria which are resistant to many antibiotics.

- 5 From an evolutionary point of view explain why the frequent use of antibiotics has led to the emergence of multi-resistant bacterial strains in a relatively short period of time.

3 VP

20 VP

Task III:

Heart attacks (*Herzinfarkt*) are one of the most common causes of death in Germany. If there is a blood clot (thrombus) in a vessel which supplies the heart with blood (coronary vessel), this thrombus can block the blood flow. This can impede the oxygen supply to cardiac muscle cells. The resulting heart attack leads to permanent damage of the heart muscle after only a short period of time. If a heart attack is suspected, an immediate diagnosis followed by treatment is essential for survival. After the thrombus has been dissolved, hirudin is given intravenously as prophylaxis. The short polypeptide prevents the formation of a new thrombus.

- 1 Describe and explain why cardiac muscle cells die without oxygen supply.
Explain why hirudin cannot be given orally and which additional advantage the intravenous administration offers.

3 VP

Thrombi form during the process of blood clotting and help to close injured blood vessels. Blood clotting is a cascade-like metabolic process. The end product of this process is the enzyme thrombin. It splits soluble fibrinogen in the blood plasma into fibrin and fibrinopeptides (Figure 1). The fibrin molecules then polymerize spontaneously and form long, insoluble fibrin threads. These threads form a mesh and become a thrombus by trapping blood cells. This thrombus then closes blood vessels or wounds.

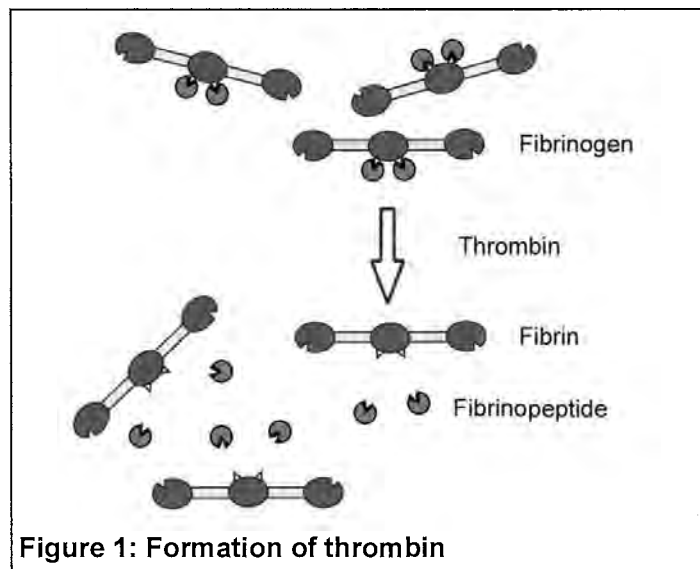


Figure 1: Formation of thrombin

- 2.1 With the help of a sketch and using the symbols shown in figure 1 explain the forming of long, insoluble fibrin threads.
- 2.2 Describe and explain two possible ways to explain how hirudin prevents blood clotting.

2 VP

2 VP

Hirudin is produced in the salivary glands of leeches (*Blutegel*) (Figure 2). It prevents the host's blood from clotting while the leech is sucking. To meet the medical demand for hirudin, these days it is produced in large quantities with the help of genetically modified bacteria.

- 3 Describe the essential steps necessary to produce and select genetically modified bacteria which are capable of producing hirudin.

4 VP

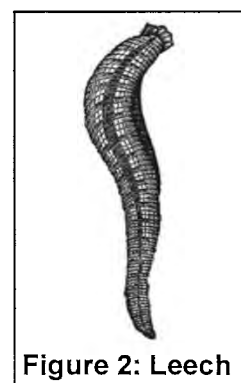


Figure 2: Leech

Task III:

Leeches locate their hosts with the help of sensory hair cells in their skin which are stimulated by water movement caused by these hosts. Those sensory hair cells are specialized mechanoreceptors which have membrane evaginations (*Membranausstülpung*) – so-called stereovilli – on their surface. Figure 3 shows how the signal transduction works in a sensory hair cell as well as the electrical signals generated at the axon of the downstream (*nachgeschaltet*) nerve cell.

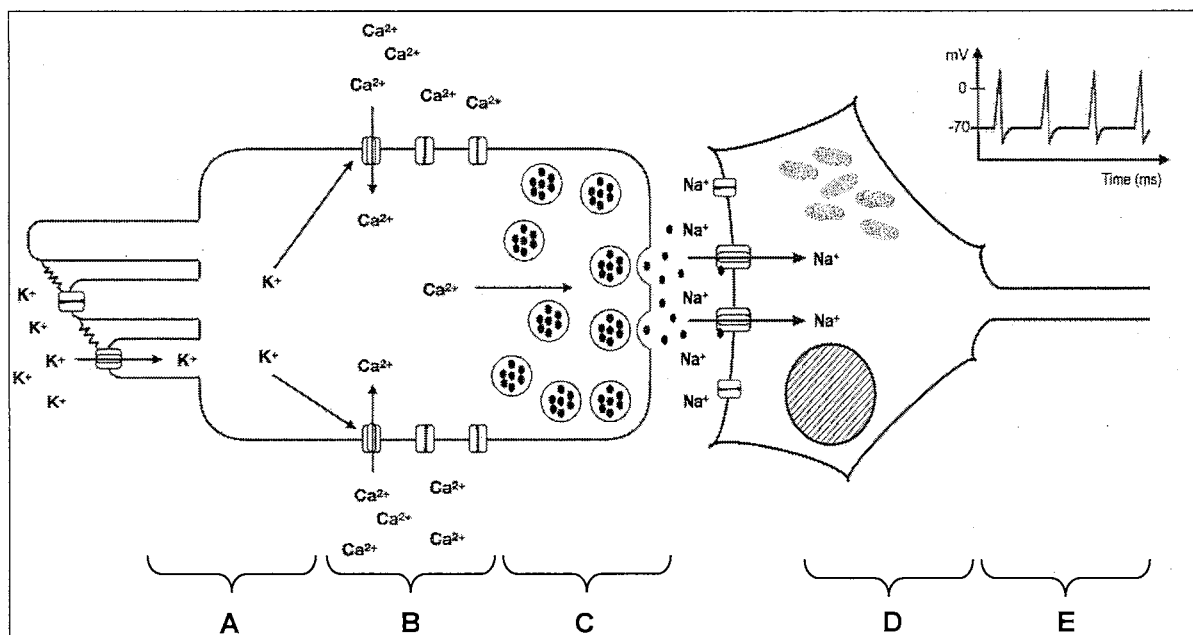


Figure 3a: Sensory hair cell with stereovilli in neutral position (without water movement) and downstream nerve cell

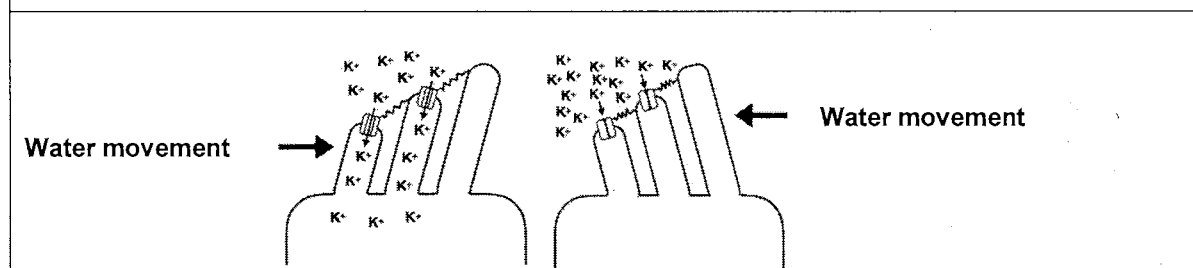


Figure 3b: Effect of water movement on stereovilli in sensory hair cells

Figure 3: Signal transduction in sensory hair cells (schematic)

- 4.1 Describe the processes in a sensory hair cell with its stereovilli in neutral position and explain the effects on the downstream nerve cell (Figure 3a).
- 4.2 Describe and explain the effects of water movement on the sensory hair cell and on the downstream nerve cell as well as its significance for locating the host (Figure 3b).

2 VP

3 VP

Task III:

In the sections A to E (Figure 3a) the intensity of the stimulus (intensity of water movement) is encoded in different ways.

- 5 Name the type of coding that encodes the stimulus intensity for each of the sections A to E. Compare the types of coding for sections C, D and E regarding conduction speed and weakening of the signal. Give reasons.

4 VP

20 VP

Task IV:

Marsupials (*Beuteltiere*) are a group of mammals. One of the differences to higher mammals (placentals) (*Plazentatiere*) is that their offspring are born at a very early stage of development and then continue to develop in the pouches of their mothers. In Australia there is a wide variety of marsupials (e.g. kangaroo and Tasmanian devil). Additionally a few species can be found in South America (e.g. microbiotheria (*Beutelratte*) and didelphis (*Opossum*)). For a long time the question of whether Australian marsupials colonized South America or the other way around was the subject of scientific debate. This issue could be solved by applying molecular biological techniques to analyze phylogenetic relationships.

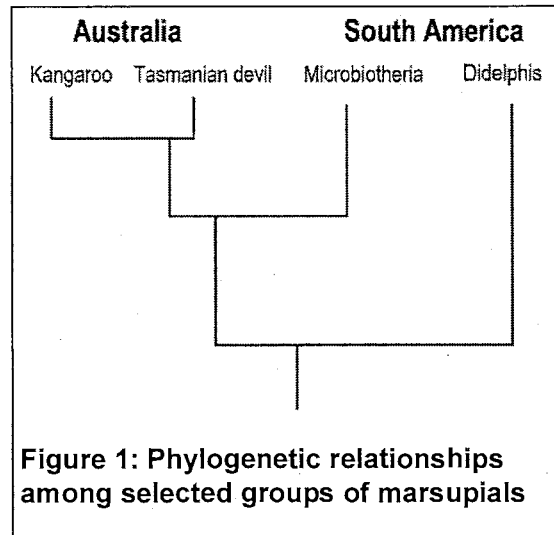


Figure 1: Phylogenetic relationships among selected groups of marsupials

- 1.1 Describe a molecular biological or immunological technique used to determine the phylogenetic relationships. Using figure 1 describe and explain the expected experimental results. 4 VP
- 1.2 With the help of figure 1, describe and explain whether colonization is more likely to have started in Australia or in South America. 3 VP

Australia's best-known marsupials are kangaroos. The different species of kangaroo have developed from a small tree-dwelling and leaf-eating common ancestor whose front and hind legs were equally long (Figure 2). Today a number of species are considered to be extinct.

- 2 Explain what is meant by the term species. Describe and explain the evolution of different kangaroo species from the common ancestor mentioned in the text above.

4 VP

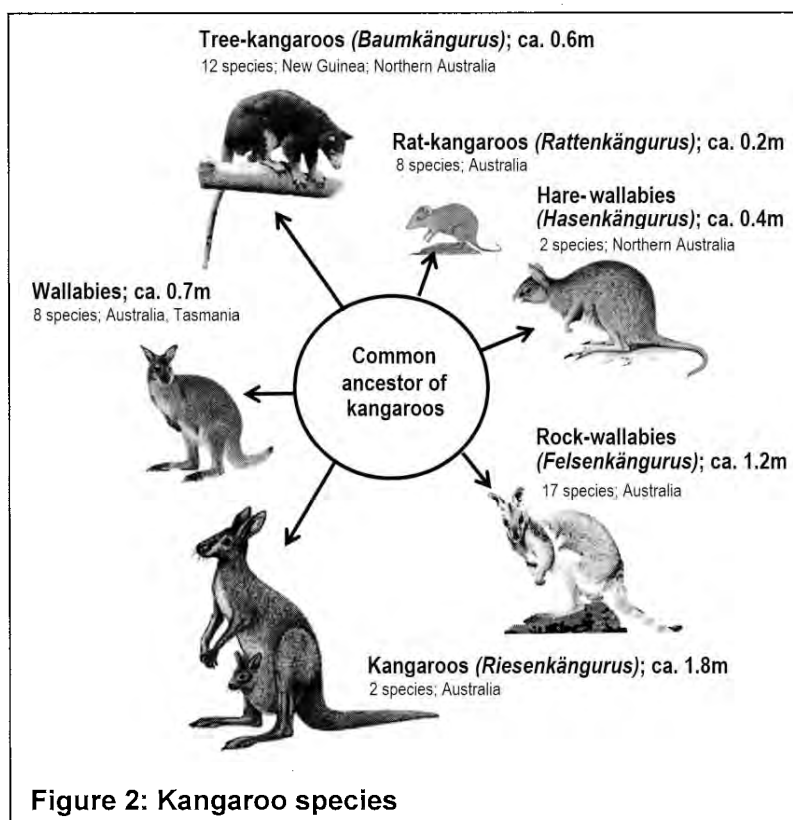


Figure 2: Kangaroo species

Task IV:

The Tasmanian devil (*Tasmanischer Teufel*) (Figure 3) is severely threatened by a form of cancer called Devil Facial Tumor Disease (DFTD) that leads to big facial tumors and death within a few months.

Since the discovery of the disease in 1996 the number of Tasmanian devils has been reduced by more than 80 percent. Recently it has been observed that female Tasmanian devils are now starting to reproduce at age one instead of age two like they used to.



Figure 3: Tasmanian devil

- 3 Give a possible explanation for the early onset of sexual maturity according to the synthetic theory of evolution.

3 VP

The cancer DFTD is passed on from one animal to another, which is unusual. Tumor cells are transferred through bites. Tumor cells are normally eliminated by the immune system like virus-infected body cells or non-self cells.

- 4 Describe the process of the cell-mediated immune response against virus-infected body cells.

3 VP

MHC I proteins are specific proteins in the cell membrane of nucleated body cells. They allow the immune system to differentiate between self and non-self cells. However, because of missing MHC I proteins the DFTD tumor cells transferred by biting are neither recognized as non-self nor malignant. A cell-mediated immune response does not occur.

- 5 Give two possible explanations for the fact that there are no MHC I proteins in the membranes of the tumor cells even though the genes for the MHC I proteins exist.

3 VP

20 VP

codon wheel

