

Supplemental Material B

CK in biology inventory (CK-IBI)

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Knowledge of Ecology

EC1

The leaves of plants which live in arid regions display characteristic features.

Check **THREE** common features of these plants' leaves!

low leaf mass to surface ratio _____ ☐

dark green color _____ ☐

sunken stomata _____ ☐

waxy cuticle _____ ☐

long, pointed leaf tips _____ ☐

vertical arrangement of leaves _____ ☐

EC2

Biotic interactions play important roles in the ecology of species.

Fill the blank spaces of the table with the types of interaction between the species!

		Effect on 2nd Species	
		negative	positive
Effect on 1st Species	negative		
	positive		

EC3

In ecology, research is conducted from three perspectives. These perspectives are captured by the notions of (1) autecology, (2) population ecology, and (3) synecology.

Consider the following scenarios and decide which research perspective (1, 2, or 3) is used!

Scenario	Research Perspective
An ecologist examines the temperatures sunflowers tolerate, how sunflowers react to different amounts of water, and whether sunflowers have defense mechanisms against fungal pathogens such as <i>Botrytis</i> .	<input type="text"/>
An ecologist counts the individuals in a pack of wolves, examines its spatial distribution, and observes how the animals defend their territory. He/she also determines the age distribution and both birth and death rates in the pack over a decade.	<input type="text"/>
An ecologist explores the diversity of life forms in a tree top. He/she examines how the plants and animals that live there interact with the tree and each other. He/she also observes what the plants and animals feed on and what happens to dead plants and animals.	<input type="text"/>
An ecologist counts and records ages of wild potatoes. He/she examines their spatial distribution and observes whether (and if so how) the potatoes prevail over other plants or they are suppressed. The ecologist also examines the development of the potatoes over a decade.	<input type="text"/>

EC4

Complete the following sentence by checking the CORRECT answer!

When climbing a mountain, you detect a change in the composition of biotic communities; this change is analogous to the change ...

in biomes with an increase in latitude. _____ ☐

in biocenoses with an increase in depth of the sea. _____ ☐

within a community during the course of the year. _____ ☐

within an ecosystem developing over the course of time. _____ ☐

in European biocenoses from east to west. _____ ☐

EC5

Complete the following sentence by checking the CORRECT answer!

The 'competitive exclusion principle' states that ...

two species cannot co-exist in the same habitat. ☐

the competition between two species always results in the extinction or migration of one of them. ☐

the competition within a population fosters survival of the best-adapted individuals. ☐

two species that occupy exactly the same ecological niche cannot co-exist in a biotic community. ☐

two species discontinue their reproduction until one of them leaves the habitat. ☐

EC6

The interactions between predators and prey have major effects on both the population size and dynamics of the involved species. Lotka and Volterra presented two fundamental equations that model these biotic interactions by describing:

a) the change in number of predators over time: $dx/dt = (Z_x * x * y) - (A_x * x)$

b) the change in number of prey over time: $dy/dt = (Z_y * y) - (A_y * y * x)$,

where:

x is the number of predators,

y is the number of prey,

Z_x is the rate of population increase of the predators,

Z_y is the rate of population increase of the prey,

A_x is the mortality rate of the predators, and

A_y is the mortality rate of the prey.

State which of the following factors is both accounted for in the equations and crucial for a realistic description of the predator-prey dynamics!

occurrence of non-overlapping generations _____ ☐

interdependency of predator/prey numbers _____ ☐

occurrence of overlapping generations _____ ☐

the environmental carrying capacity for the prey population _____ ☐

EC7 & EC8 (Items deleted in evaluation 2)

Knowledge of Evolution**EV1**

Adaptive evolution, i.e. changes in populations of organisms that enhance their adaptation to environmental conditions, requires two preconditions.

Check **BOTH** preconditions!

Variation in heritable traits	<input type="checkbox"/>
Variation in inheritable traits	<input type="checkbox"/>
Variation in the reproductive success of organisms with the same characteristics	<input type="checkbox"/>
Variation in the reproductive success of organisms with different characteristics	<input type="checkbox"/>

EV2

Darwin called the origin of species the "mystery of mysteries." Today, huge numbers of examples allow us to observe how new species arise, or at least help us to unambiguously reconstruct the process.

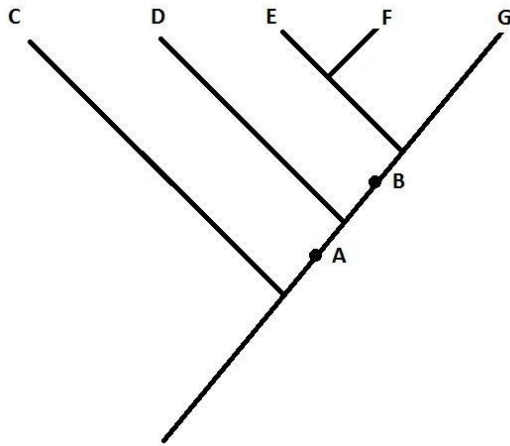
Check **WHICH** of the following processes fosters speciation (two answers are correct)!

- geographical separation of populations_____ ☐
- settlement of an island by a few individuals of a species_____ ☐
- migration between populations _____ ☐
- sexual reproduction and recombination _____ ☐

EV3

Metazoa are the taxon of multi-cellular animals.

Allocate the following terms to the taxonomy of metazoa by putting the letters A to F into the respective boxes!



	Letter
Deuterostomes	
Porifera	
Bilateria	
Eumetazoa	
Lophotrochozoa	
Cnidaria	
Ecdysozoa	

EV4

Check whether the following pairings are homologous or analogous!

Pairings	homologous	analogous
paw of a mole and extremity of a mole cricket	<input type="checkbox"/>	<input type="checkbox"/>
fore extremities of a bat and a Eurasian blackbird	<input type="checkbox"/>	<input type="checkbox"/>
a dog's paw and a human hand	<input type="checkbox"/>	<input type="checkbox"/>
a human eye and an octopus eye	<input type="checkbox"/>	<input type="checkbox"/>
pectoral fins of a whale and forelegs of a horse	<input type="checkbox"/>	<input type="checkbox"/>
breasts as a means of milk production in humans and mice	<input type="checkbox"/>	<input type="checkbox"/>

EV5

Selection is an important evolutionary factor. We distinguish various types of selection, including:

- (1)** disruptive selection
- (2)** stabilizing selection
- (3)** directional selection

By placing the numbers 1 to 3 in the boxes to the right, indicate which of these three types of selection is believed to be responsible for the development of:

	Number
giraffes' long necks	
differently sized beaks in Darwin's finches	
proportionally equal wingspans of spectacled parrot lets	
large antlers of deer	

EV6

To which class of vertebrates do these species belong? Put your answer in the boxes next to the species!

	Your Answer
Panamanian golden frog	
saltwater crocodile	
Baird's tapir	
hawksbill turtle	
spectacled parrot let	
bottlenose dolphin	

EV7

In the course of evolution, angiosperms have changed considerably. This is discernible in numerous characteristics.

Check THREE of the following characteristics that are believed to be PRIMITIVE CHARACTERS of angiosperms.

indefinite number of floral organs borne on the floral axis in a helical arrangement	<input type="checkbox"/>
defined number of floral organs in a verticillate arrangement	<input type="checkbox"/>
pollen with sulcate apertures	<input type="checkbox"/>
pollen with three or more apertures	<input type="checkbox"/>
unfused floral organs	<input type="checkbox"/>
fused floral organs	<input type="checkbox"/>

EV8

Bird identification guides used to state that the Eastern crowned leaf-warbler (*Dendroica coronata*) and Audobon's warbler (*Dendroica auduboni*) were independent species. More recently, however, these taxa are considered to be eastern and western sub-species of a single species (*Dendroica coronata* and *Dendroica coronata auduboni*, respectively).

State which of the following observations may have led to the current systematic classification (there is only one correct answer)!

The two sub-species can interbreed and produce fertile offspring.	<input type="checkbox"/>
Both sub-species populate the same habitat.	<input type="checkbox"/>
Both sub-species share numerous genes.	<input type="checkbox"/>
Both sub-species feed in a similar fashion.	<input type="checkbox"/>
Both sub-species have very similar coloration.	<input type="checkbox"/>

Knowledge of Genetics & Microbiology**GM1**

Endosymbiotic theory explains the origin of eukaryotic cells. It states that mitochondria and plastids are derived from independent prokaryotic cells that were taken up by a host cell via phagocytosis.

Check the following statements that support endosymbiotic theory.

The mRNA of the organelles displays the typical 5'-cap sequence and polyadenylation.	<input type="checkbox"/>
The DNA of the organelles is not associated with histones.	<input type="checkbox"/>
The organelles have their own nuclei.	<input type="checkbox"/>
The organelles have their own DNA.	<input type="checkbox"/>

GM2

Transcription factors play an essential role in gene transcription.

Check the TWO statements that correctly describe aspects of their role!

- Transcription factors bind to gene promoters. _____ ☐
- Transcription factors initiate the binding of ribosomes to genes. _ ☐
- Transcription factors activate or repress the expression of genes. _ ☐
- Transcription factors initiate the binding of mRNA to genes. _____ ☐

GM3

Identify the term that relates to sexual reproduction of bacteria!

- transformation _____ ☐
- conjugation _____ ☐
- transduction _____ ☐
- meiosis _____ ☐

GM4

Identity the difference between apoptosis and necrosis (there is only one correct answer)!

- | | |
|---|--------------------------|
| Apoptosis is a program of cellular self-destruction, while necrosis is cell death caused by damaging external influences. | <input type="checkbox"/> |
| <hr/> | |
| Apoptosis only occurs in differentiated cells, while necrosis only occurs during the development of cells. | <input type="checkbox"/> |
| <hr/> | |
| Apoptosis refers to cell death during embryogenesis, and necrosis to the destruction of differentiated cells. | <input type="checkbox"/> |
| <hr/> | |
| Apoptosis is another term for the necrosis that occurs during cell development. | <input type="checkbox"/> |

GM5

Complete the following sentence by checking the correct answer!

The second meiotic cell division resembles mitosis because ...

- the sister chromatids separate during anaphase. _____ ☐
- the DNA replicates before the division. _____ ☐
- the daughter cells are diploid. _____ ☐
- crossover occurs between homologous chromosomes. _____ ☐
- the number of chromosomes is reduced. _____ ☐

GM6

Complete the following sentence by checking the correct answer!

The way an enhancer works is an example of ...

- the promotion of translation through initiation factors. _____ ☐
- a post-transcriptional mechanism of mRNA editing. _____ ☐
- transcriptional control of gene expression. _____ ☐
- post-translational regulation that activates specific proteins. _____ ☐
- a eukaryotic functional equivalent of a promoter in prokaryotes. _____ ☐

GM7

In which phase of the cell cycle does most of the core DNA doubling occur? Check the correct answer!

metaphase _____ ☐

anaphase _____ ☐

telophase _____ ☐

interphase _____ ☐

GM8 (Item deleted in evaluation 2)**Knowledge of Morphology****M1**

The epidermis is the outer surface layer of the body. In human beings it consists of a five-layer keratinized squamous epithelium. State the order in which these five layers occur – from the outside (superficial) to the inside (basal).

Indicate the order of the layers' positions from outside to inside by placing numbers from 1 to 5 in the boxes beside them!

	Number
Stratum lucidum (translucent cell layer)	
Stratum corneum (cornified cell layer)	
Stratum basale (basal cell layer)	
Stratum granulatum (granular cell layer)	
Stratum spinosum (spinous cell layer)	

M2

In a number of plants, secondary diameter growth causes the generation of additional vascular and supporting tissue.

State the name of the meristematic tissue that triggers secondary diameter growth!

M3

The development of corms is a significant event in the evolution of terrestrial plants.

Check which of the following statements explains the origin of corms BEST! They provide selective advantage because:

- | | |
|--|--------------------------|
| They have an optimal surface area to volume ratio | <input type="checkbox"/> |
| They have the simplest possible form of vegetative body. | <input type="checkbox"/> |
| They enable functional specialization of organs. | <input type="checkbox"/> |
| They facilitate sexual reproduction (important for evolution). | <input type="checkbox"/> |

M4

Anthocyanins are an important class of plant pigments.

State the cell organelle in which they are PREFERENTIALLY stored!

M5

Fill in the parts of the ear in the order in which they transmit sound from the outer ear via the middle ear to the inner ear!

Outer ear:	1. auditory canal
	2. <input type="text"/>
Middle ear:	3. <input type="text"/>
	4. <input type="text"/>
	5. <input type="text"/>
Inner ear:	6. <input type="text"/>
	7. vestibule

M6

Ruminants have a stomach with multiple chambers, each of which has different functions.

Check which FOUR elements can be found in the digestive tract of ruminants!

- abomasum_____ ☐
- gizzard _____ ☐
- masodaeum_____ ☐
- rumen _____ ☐
- omasum _____ ☐
- goiter _____ ☐
- hepatic caecum_____ ☐
- pylorus _____ ☐
- reticulum_____ ☐

M7

Check which cell structures can be found in ALL LIVING prokaryotic and eukaryotic cells (there is only one correct answer)!

ribosomes and mitochondria _____ ☐

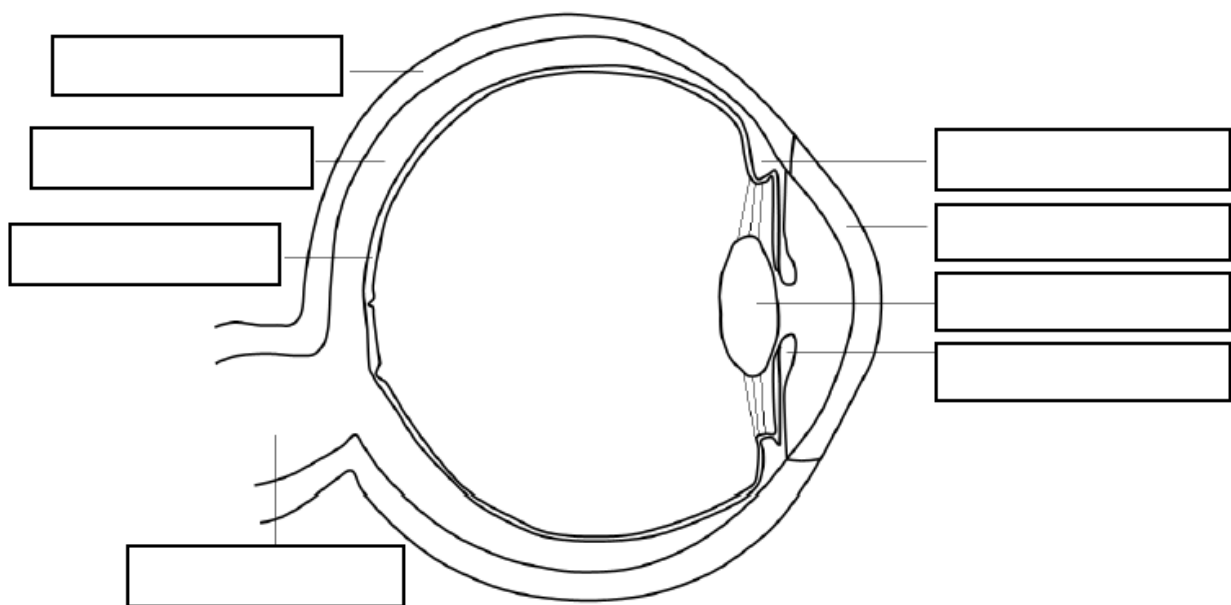
plasma membrane and vacuoles _____ ☐

plasma membrane and nuclear membrane _____ ☐

plasma membrane and ribosomes _____ ☐

M8

Label the indicated structures in the schematic illustration of a longitudinal section through the human eye below!



Knowledge of Physiology**P1**

The cardiovascular system of mammals can be functionally separated into two circulatory systems, systemic and pulmonary, both of which include oxygenated and deoxygenated blood vessels.

Choose the oxygenated blood vessel in mammals from the following list!

pulmonary artery (Arteria pulmonalis) _____ ☐

pulmonary vein (Vena pulmonalis) _____ ☐

superior vena cava (Vena cava superior) _____ ☐

portal vein (Vena portae) _____ ☐

P2

The synthesis of ATP is an important part of the light reactions that occur during photosynthesis.

Complete the following sentence by checking the CORRECT answer!

ATP synthesis in chloroplasts is driven by ...

the reduction of NADPH by a ferredoxin-NADPH reductase. _____ ☐

the proton gradients across the thylakoid membrane. _____ ☐

the high proton concentration in the chloroplast stroma. _____ ☐

the export of phosphate residues via the phosphate translocator. _ ☐

P3

Angiosperm sexual reproduction typically involves double fertilization by two male gametes, one of which fuses with the egg cell while the other fuses with the embryo sac nucleus.

State which TWO tissues result from the two fusion processes!

embryo _____ ☐

secondary endosperm _____ ☐

perisperm _____ ☐

seed coat _____ ☐

embryo sac mother cell _____ ☐

P4

In humans and other amniotes the growing the growing embryo and fetus are located in a fluid-filled sac: the amniotic sac.

Check the structure that refers to the amniotic sac!

blastocyst _____ ☐

endoderm bladder _____ ☐

yolk sac _____ ☐

amniotic cavity _____ ☐

P5

The brain and spinal cord (the constituents of the central nervous system) are both composed of gray matter and white matter. They also both contain huge numbers of neurons, but different parts of the neurons.

State the parts of neurons that are typically found in GRAY MATTER and those typically found in WHITE MATTER!

	Your Answer
Gray Matter	
White Matter	

P6

Check which of the following plant cell structures (e.g. in angiosperms) are responsible for storage!

all plastids_____ ☐

chloroplasts_____ ☐

amyloplasts_____ ☐

mitochondria_____ ☐

P7

Amphibians' respiratory systems depend on their age and way of life.

Check the FOUR kinds of respiration that amphibians exhibit!

- respiration with an air sac system _____ ☐
- lung respiration (positive pressure breathing) _____ ☐
- lung respiration (negative pressure breathing) _____ ☐
- cutaneous respiration _____ ☐
- buccal pumping _____ ☐
- breathing through spiracular gills _____ ☐
- breathing through gills _____ ☐
- breathing through papulae _____ ☐

P8

The immune system is traditionally divided into two subsystems, the innate immune system and the adaptive immune system, which have different but overlapping sets of cellular and humoral effectors (defense structures).

Check whether the cellular and humoral effectors mentioned below belong to the innate AND/OR adaptive immune system!

Components	Innate Immune System	Adaptive Immune System
granulocytes	<input type="checkbox"/>	<input type="checkbox"/>
T lymphocytes	<input type="checkbox"/>	<input type="checkbox"/>
B lymphocytes	<input type="checkbox"/>	<input type="checkbox"/>
macrophages	<input type="checkbox"/>	<input type="checkbox"/>
antimicrobial proteins	<input type="checkbox"/>	<input type="checkbox"/>
immunoglobulins	<input type="checkbox"/>	<input type="checkbox"/>