Country Code: _____	Student Code: _____

The 21st INTERNATIONAL BIOLOGY OLYMPIAD

11th – 18th July, 2010

Changwon, KOREA

PRACTICAL TEST 2

PHYSIOLOGY AND ANATOMY

Total Points: 49

Duration: 90 minutes

Dear Participants,

- In this test, you have been given the following 2 tasks:

  Task I: The response of the rat cerebral cortex to skin stimulation (25 points)

  Task II: Anatomy of spider (24 points)

- Write down your results and answers in the **Answer Sheet. Answers written in the Question Paper will not be evaluated.**

- Please make sure that you have received all the materials listed for each task. If any of the listed items is missing, please raise your hand.

- If you have any problem with your computer, raise your hand.

- Stop answering and put down your pencil **immediately** after the end bell rings. The supervisor will collect the Question Paper and the Answer Sheet.

Note: All animals used in the pictures and the described experiments were treated according to guidelines approved by the institutional animal care and use committee and conformed to the NIH guidelines on care and use of animals in research.

PHYSIOLOGY AND ANATOMY

This practical test is composed of 2 tasks.

TASK I. (25 points) The response of the rat cerebral cortex to skin stimulation

Welcome to the Electro-Physiology Laboratory!

Today you are going to examine one of the principles of how the brain works. This test is composed of 4 parts: one background section on how electrophysiological experiments are conducted and three experimental sections. You are required to answer a total of 15 questions by analyzing data presented on screen.

The home-page photo of the notebook computer shows the tools and equipment used in an electrophysiology laboratory.

Press 

above the photo

The primary somatosensory (S1) cortex receives tactile information from a specific body surface region. These specialized receptive areas in the human brain is shown in **Figure 1.** A similar body representation within the rat S1 (**Fig. 2**) will be created from these experiments.

Press  **or** 

1. Background information

1.1 Skull immobilization with brain exposure

The stereotaxic device is used to immobilize the skull (**Fig. 3**). The incisor bar is adjusted to make the skull surface horizontal (**Fig. 4**). Following a scalp incision, a hole is drilled in the skull over the location of S1, and a recording electrode (*a red, moving needle*) is inserted into the brain (**Fig. 5**). A micro-driver is used to move the electrode downward (25 μm/step) from the surface into the brain (**Fig. 6**).

Press  **or** 

1.2 S1 neuronal response following skin stimulation

The rat skin can be stimulated either mechanically with a cotton probe or electrically with an electrode. Following the electrical stimulation of forepaw digit (**Fig. 7;** *a white, moving arrow*), S1 neuronal activity is recorded using an electrode (**Fig. 7;** *a red, moving needle*). Using an oscilloscope (**Fig. 8**), S1 neuronal activity can be visualized (**Fig. 9**).

Press  **or** 

1.3 Response histogram

When an S1 neuron is responsive to the stimulation of a body part, the body part is within the receptive field (RF) of the neuron; a neuron does not show any response to the stimulation of body parts outside of its specified RF.

Using the amplifier (**Fig. 10**) and the analyzer (**Fig. 11**), activities of many S1 neurons surrounding the electrode can be recorded (**Fig. 12;** *left panel*). Subsequently, single neuronal activities can be isolated (**Fig. 12;** *spikes on the right panel*). To quantify the S1 neuronal responses, the stimulation of the body part is repeated within a certain period of time, and the

action potentials are accumulated to produce a histogram (**Fig. 13**). In the histogram, the X-axis stands for time (ms) before (-), the exact moment of (0), and after (+) stimulation. The Y-axis represents the mean firing rate (Hz) within the recorded neuron.

Press  **or** 

2. S1 neuronal response to forepaw digit stimulation

2.1. Forepaw digit region in S1

For the location of recording electrode, x-y coordinates are drawn over the skull (**Fig. 14**). The point where three bones meet (the bregma) is the origin (0, 0) of the coordinate system. Previous investigations reported that the point (0.3, 4.3) (**Fig. 15**) is one of the responding spots for stimulation of the **2nd** forepaw digit (**Fig. 16**).

Press  **or** 

2.2. Mechanical stimulation

To find the general boundaries of the S1 region responding to stimulation of a specific skin area, it is better to perform mechanical stimulation prior to electrical stimulation. A recording electrode is positioned above the coordinate (0.3, 4.3) and is lowered stepwise at **25 µm/step** (**Fig. 17;** *a red, moving needle*). The responses to mechanical stimulation of the **2nd** forepaw digit are given in Table 2.2

Table 2.2

Fig.	Depth (number of steps)	Area of skin stimulation	S1 response to skin stimulation	S1 Response to joint movement
18	0-30	Broad	Weak	no
19	31-48	Tip	Strong	no
20	49-60	Broad	Weak	strong

Press  **or** 

2.3 Electrical stimulation

A stimulating electrode is inserted into the **2nd** forepaw digit, whereas the recording electrode is inserted into the S1. The measured distance from the stimulating electrode to the recording one is ***12 cm***. The response of the S1 neuron to weak and strong stimuli is shown in Table 2.3. and Figures 21 and 22. (*Note the pop-up histogram at the bottom in both actions.*).

Table 2.3

Action	Stimulus to **2nd** forepaw digit	Response of S1 neuron
Cursor on 21	Weak (0.1 mA)	No conspicuous spike
Cursor on 22	Strong (2 mA)	One conspicuous spike

Q1. (1 point) Based on the results of mechanical and electrical stimulation, which of the following statements is correct?

A. The strongest response to mechanical stimulation is observed in neurons at 0.5-0.75 mm deep from the surface.

B. Neurons at a depth of 0.775-1.2 mm respond to the smallest skin area.

C. Neurons at a depth of 0.775-1.5 mm respond only to skin touch.

D. The thickness of the S1 cortex is less than 1mm.

E. The firing rate (Hz) of S1 neurons has no correlation with stimulus intensity.

Q2. (1 point) Calculate the minimum (p) and maximum (q) velocities (**unit: m/sec**) of information transmission from the digit to the S1.

Q3. (1 point) During the period of 6-15 ms after stimulation, what is the **net increase** in the mean value ($\overline{\mathbf{X}}$) of firing rate (Hz) evoked by strong (2 mA) stimulation?

2.4. Response to a gamma-aminobutyric acid (GABA) antagonist

GABA is a neurotransmitter in the brain. The response of the S1 neuron to weak and strong stimuli following the topical application of a GABA antagonist (i.e., inhibitor of GABA action) to the S1 cortex is shown in Table 2.4 and Figures 23 and 24. (*Note the pop-up histogram at the bottom in both cases.*).

Table 2.4

Action	Stimulus to **2nd** forepaw	Response of S1 neuron
Cursor on 23	Weak (0.1 mA)	No conspicuous spike
Cursor on 24	Strong (2 mA)	Two conspicuous spikes

Q4. (2 points) Based on the results of before and after the antagonist application, which of the following statements is correct?

A. The **net increase** in the mean firing rate (Hz) of the first peak in histogram **24** is about 2.14 times of that of the peak in histogram **22**.

B. After the antagonist application, the mean firing rates (Hz) always increase regardless of stimulation intensity.

C. The GABA antagonist inhibits excitatory synaptic activity in the S1.

D. Based on histogram **24**, a **net increase** in the mean firing rate (Hz) for the first peak is 4.5 times of the one for the second peak.

E. The second peak in histogram **24** is not associated with S1 processing of the cutaneous input from the digit.

Press  **or** 

3. S1 neuronal response to hindpaw digit stimulation

3.1 Electrical stimulation

Previous investigations reported that the point (-1.0, 2.5) is one of the responding spots for hindpaw digit stimulation (**Fig. 25**).

A recording electrode is lowered stepwise (**25 μm/step**) downward from the brain surface. Responses of neurons at three locations (**a=25 steps, b=41 steps, c=52 steps**) along the vertical track are recorded (**Fig. 26**).

Following strong (2mA) electrical stimulation of the **2nd**, **3rd**, and **4th** hindpaw digits (**Fig. 27**), responses of the three neurons at **a**, **b**, and **c** are recorded (**Fig. 29**).

3.2 Response to local anesthesia

A local anesthetic drug applied to the **3rd** hindpaw digit (**Fig. 28**, *grey color*) causes a sensory loss within 2 minutes, and the effect lasts for 30 minutes. Afterward, recovery of sensation gradually occurs. The drug effect completely disappears by 60 minutes post-application. When strong (2 mA) electrical stimulation is applied to the digit 40 minutes after drug application, the response of the three neurons is changed (**Fig. 30**).

Q5. (1 point) Based on neural response before anesthesia (**Fig. 29**), choose the correct statement.

Case	Neurons	Stronger or longer response	Weaker or shorter response
A	Locations **a**, **b** and **c**	**2nd** digit	**3rd** digit
B	Locations **a**, **b** and **c**	**4th** digit	**3rd** digit
C	Location **b**	**4th** digit	**2nd** digit
D	During **3rd** digit stimulation, neurons at locations **a** and **c** have longer response durations than neuron at location **b**.		
E	Location **a**	**4th** digit	Other digits

Q6. (1 point) Based on neural response before anesthesia (**Fig. 29**), choose the correct statement.

A. All three neurons respond to **4th** digit stimulation.

B. A single S1 neuron responds to the stimulation of only one digit.

C. Neurons at location **a** respond to the stimulation of more of the hindpaw digits than neurons at location **b**.

D. Neurons at location **c** respond to the stimulation of more of the hindpaw digits than neurons at location **b**.

E. All three neurons receive convergent sensory information from two or more digits.

Q7. (1 point) Based on the responses shown by the neurons in all three locations in **Figs. 29** and **30,** choose the **incorrect** statement.

Case	Location of stimulation	Timing of response	Magnitude of response
A	**2nd** digit	40 min after drug application	Increased
B	**3rd** digit	40 min after drug application	Decreased
C	**4th** digit	40 min after drug application	Increased
D	**2nd** and **4th** digits	Before and after drug application	Greater in **4th** than in **2nd** digit
E	A neuron not responding to a certain stimulus may respond to it under certain conditions		

Q8. (2 points) Based on the response after anesthesia (**Fig. 30**), select an appropriate inference.

A. The drug is absorbed into the blood and is transferred to the S1.

B. The drug has changed the structure of peripheral nerve branches.

C. Neuronal response is not altered after local anesthesia.

D. The drug causes reversible, temporary changes in S1 neuronal synapses.

E. The change in response after anesthesia is due to newly-synthesized proteins within the S1.

Press  **or** 

4. S1 body map

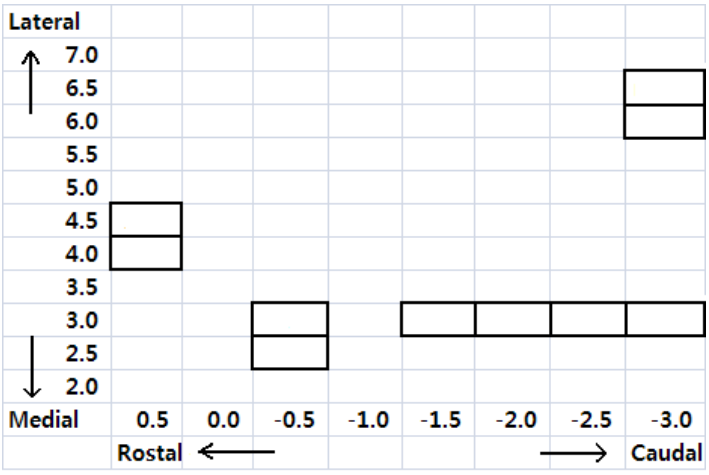
4.1 Normal S1 map

Following repeated stimulation/recording procedures, the normal S1 body map (**Fig. 31**) is obtained (**Note**: the electrode is moved along the x or y axis by the distance of 0.5 mm). If the computer cursor is laid on each symbol (○, ●, ▲, □), the *abbreviation* for appropriate body surface is shown as a note and, at the same time, the equivalent body position will be depicted at the bottom. The following table provides the anatomical term for each abbreviation used in the figure.

	Abbreviations	
forelimb	**fl**	forelimb
	fp	forepaw
	fpd 1-5	forepaw digits 1-5
	fm	forelimb muscle
hindlimb	**hl**	hindlimb
	hp	hindpaw
	hpd 1-5	hindpaw digits 1-5
	hm	hindlimb muscle
trunk	**t**	trunk
vibrissa	**mv**	mystacial vibrissa
	rv	rostral vibrissa

Q9. (5 points = 0.5 × 10) Find the following points (n=10) from **Fig. 31** and fill in the blanks with

abbreviations (*i.e., notes within the boxes of the screen*) for body surfaces.



Q10. (1point) Based on the answers to **Q9**, which of the following statements is correct?

A. The **fpd4** region is medial to the **fpd2** region.

B. The **hpd2** region is medial to the **hpd4** region.

C. The **fl** region is rostral to the **hp** region.

D. The **fl** region is caudal to the **t** region.

E. The **mvB2** region is lateral to the **mvA3** region.

Q11. (1 point) Based on the normal S1 map, what can you conclude about the following areas?

Case	Smaller area	Larger area
A	Forelimb (**fl** + **fp** + **fpd** + **fm**)	Hindlimb (**hl** + **hp** + **hpd** + **hm**)
B	Forelimb (**fl** + **fp** + **fpd** + **fm**)	Trunk (**t**)
C	Hindlimb (**hl** + **hp** + **hpd** + **hm**)	Trunk (**t**)

D	Mystacial vibrissa (**mv**)	Rostral vibrissa (**rv**)
E	Forelimb (**fl + fp + fpd + fm**)	Vibrissa (**mv + rv**)

Q12. (1 point = 0.5 × 2) In the hindlimb region, S1 neurons receiving sensory information overlap with the motor neurons that cause muscle contraction. Find a coordinate (**unit: mm**) which supports this observation.

Press  **or** 

4.2 Change in S1 body map after digit amputation

By reducing the distance between checkpoints (**Note:** the electrode is moved along the x or y axis by the distance of 0.2 mm), a more precise map for the hindpaw region is obtained (**Fig. 32**). Surgery is performed to remove the **4th** hindpaw digit. At 4 weeks after digit amputation, a new body map is obtained (**Fig. 33**).

Q13. (4 points = 0.5 × 8) Put the cursor on the corresponding spots within **Figs. 32** and **33,** and notice where the post-amputation response is different from the normal response. For the locations where alterations occurred, fill in the appropriate table boxes with the **abbreviations** (i.e., *notes within the boxes of the screen*) for the digit numbers (you will fill in **4** boxes on each table, for a total of **8** boxes).

Normal

lateral

2.8				
2.6				
2.4				

hpd4 amputated

lateral

2.8				
2.6				
2.4				

2.2				
(mm)	−0.6	−0.8	−1.0	−1.2

→ caudal

2.2				
(mm)	−0.6	−0.8	−1.0	−1.2

→ caudal

Q14. (1 point) What changes occurred in the S1 body map after digit amputation?

Case	Activation of neurons by stimulation of	Became responsive to
A	**hpd3**	**hpd2**
B	**hpd3**	**hpd2** or **hpd5**
C	**hpd4**	**hpd2**
D	**hpd4**	**hpd3** or **hpd5**
E	**hpd5**	**hpd2** or **hpd3**

Press  **or** 

4.3 Biochemical and histological changes after digit amputation

(1) Biochemical changes (**Fig. 34**)

Glutamate is a neurotransmitter. To explore the molecular basis of S1-body-map reorganization following amputation, changes in the amount of glutamate- and GABA- receptors in S1 tissue were tracked over an extended period of time. The amount of glutamate-receptors (*green curve*) increased by 250% of control (*dotted line*) at 1 week after the 4th hindpaw digit amputation; whereas, the amount of GABA-receptors (*blue curve*) rose to 180% of control at 4 weeks post-amputation.

(2) Histological changes (**Fig. 35**)

Using transverse sections of S1 tissue, the location of glutamate- or GABA-receptors on the neuronal surface can be visualized using antibodies against those receptors. Immunostaining of the S1 cell surface (asterisks) shows that glutamate-receptors (**a** and **c**, arrows) increase at 1 week post-amputation, whereas GABA-receptors (**b** and **d**, arrows) rise at 4 weeks post-amputation.

Q15. (2 points) Based on **Figs. 33**, **34**, and **35**, choose the **incorrect** statement.

A. An increase in neuronal excitability is observed at 1 week after amputation.

B. An increase in neuronal inhibition is observed 4 weeks after amputation.

C. In the normal state, the S1 body map is maintained by a balance between excitatory sensory input and local inhibition within the cortex.

D. During 1-4 weeks after amputation, the balance between excitatory input and local inhibition is always maintained.

E. Electrophysiological changes at 4 week after amputation are accompanied by biochemical and histological changes in S1 tissue.

Hope you've got interested in Neuroscience.

Press 

Let's dissect a spider and be a Spiderman!

TASK II. (24 points) Anatomy of spider

Caution: Handle carefully, because only **one** spider will be provided for each student.

Please note that the vials are labeled Venom gland, Silk gland, Heart, and Book lung in English.

This task is composed of 2 parts.

Part I. (14 points) Exploration of the spider cephalothorax.

Q16. Both spiders and insects are members of phylum Arthropoda. In general, insects have two kinds of eyes; compound eye and single eyes (ocelli). Examine the spider specimen carefully under the microscope and answer the following questions.

Q16.1. (2 points) Record the types and total number of the spider's eyes.

Q16.2. (2 points) Generally, spider's eyes are arranged around its head in two distinct rows; i.e. the anterior and posterior rows. Within each row, the inner pair of eyes are designated as medial, while the outer pair is described as lateral (Table 1). Each eye is defined using two anatomical terms: anterior vs. posterior and medial vs. lateral. Examine the specimen and **draw** the relative position of eyes in the figure on the Answer Sheet. **Label** the drawn eyes with specific **codes** given in Table 2.

Table 1. Terms of anatomical position

Anterior	situated near or toward the head
Posterior	opposite of anterior
Medial	toward the midline of the body
Lateral	away from the midline

Table 2. Codes for spider eyes

Code	Terminology of spider eyes
AME	Anterior Medial Eye
ALE	Anterior Lateral Eye
PME	Posterior Medial Eye
PLE	Posterior Lateral Eye

Q17. Spiders can be divided into two suborders based on the positions of the cheliceral fangs. Using the forceps, examine the movement of the spider fangs under the dissecting microscope. Then, answer the following questions.

Q17.1. (1 point) What is the striking direction of the fangs?

A	from forwards to downwards
B	from downwards to forwards
C	from inside to outside
D	from side to center
E	from center to side

Q17.2. (1 point) The fang forms an articulation (or joint) with the chelicerae. What type of joint is the articulation?

A	Plane joint
B	Pivot joint
C	Hinge joint
D	Saddle joint
E	Ball-and-socket joint

Q18. (1 point) As arthropods, spiders have segmented bodies with jointed limbs. The head is composed of several segments that fuse during development. Being chelicerates, their bodies consist of two segments – the cephalothorax and the abdomen (Figure 1).

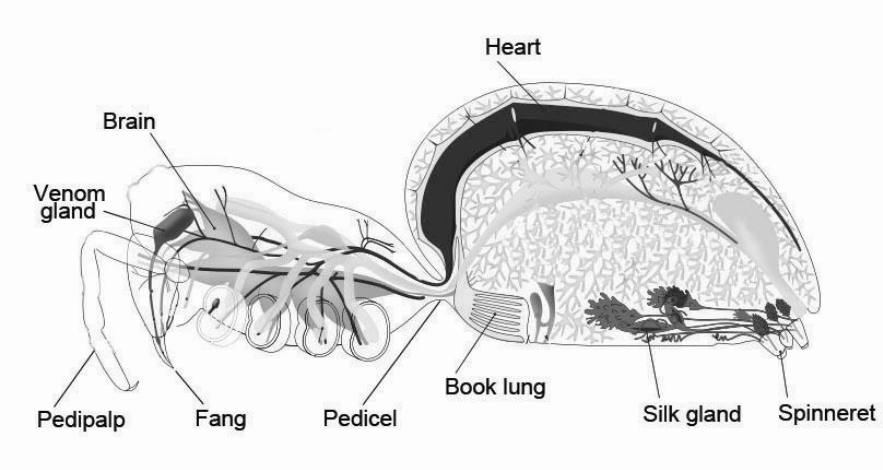


Figure 1. Diagram of spider

Which of the following (1~4) correctly represents the segmental differentiation of the cephalothorax in spiders compared to Trilobite, an ancient chelicerate?

Trilobite	1	2	3	4
Eye	Eye	Eye	Eye	Eye
A			A	A
L	C	P	C	P
L	P	C	P	C
L	L	L	L	L
L	L	L	L	L
L	L	L	L	L
L	L	L	L	L
Body	Body	Body	Body	Body

<Abbreviations>

A: Antenna, C: Chelicera, L: Leg, P: Pedipalp

Caution: From now on, you will dissect the internal organs (venom glands, silk gland, heart, and book lung) of the spider. Using the Ringer's solution provided, you need to keep the dissected organs from drying. You will be scored based on the correctness and the intactness of the preparation. Points will be deducted when there is a failure to remove the correct organ.

Q19. Most spiders possess venom that is injected into prey through the fangs of the chelicerae. Spiders have a pair of venom glands that lie either in the chelicerae or in front of the cephalothorax (see the diagram of spider in Figure 1). The venom gland consists of an outermost muscle layer, an underlying secretion layer and a duct. Locate the venom glands of the spider provided.

Q19.1. (2 points) Dissect out the pair of venom glands from the spider and put it in the vial labeled Venom gland after the following examination. It is not required to separate the venom glands from the chelicerae.

Q19.2 (1 point) Examine the outermost muscle layer of the venom gland under the microscope. What is the direction of the muscular orientation?

A	Longitudinal direction
B	Circular direction
C	Spiral direction
D	Bilateral direction
E	Irregular direction

Q20. (2 points) In most spiders, each leg has several segments and the tip of the last segment has claws. Remove the 1st and 2nd legs from the spider body. Using the microscope, count the number of segments and claws on each leg.

Q21. Many spider species exhibit sexual dimorphism. In sexually mature male spiders, the final segment of the pedipalp develops into a complicated structure that is used to transfer sperm to the female during mating. This apparatus makes the male palp so enlarged that it is often described as resembling a boxing glove.

Q21.1. (1 point) Examine the external morphology of the spider specimen provided and identify the sex of the spider.

Q21.2. (1 point) Pedipalps of spiders also have segmentation like the legs. Using the microscope, count the number of the segments and claws in each pedipalp.

Part II. (10 points) Exploration of the spider abdomen.

Q22. (1 point) The abdomen and cephalothorax of a spider are connected by a thin waist called the pedicel, which allows the abdomen to move in all directions (see the diagram of spider in Figure 1).

Which of the following organ systems does not pass through the pedicel?

A	Nervous system
B	Respiratory system
C	Circulatory system
D	Digestive system
E	Integumentary system

Q23. The silk-spinning apparatus of the spider is located at the posterior end of the ventral abdomen. This apparatus is composed of three pairs of spinnerets. Generally, the spinnerets are arranged in two distinct rows; anterior and posterior. Anatomically, the inner pair of spinnerets is defined as medial, and the outer pair is lateral (Table 3). Accordingly, the position of a spinneret is defined using these two positional terms.

Q23.1. (1 point) Compare the external morphology of the spinnerets with the following diagram. Label each spinneret in the answer sheet using the codes given in Table 3.

Table 3. Spider spinnerets

Code	Position of spinneret
A	Anterior
AM	Anterior medial
AL	Anterior lateral
P	Posterior
PM	Posterior medial
PL	Posterior lateral

Q23.2. (1 point) Identify the structure posterior to the spinneret under the microscope .

A	Anus
B	Spermatheca
C	Spiracle
D	Copulatory organ
E	Spinneret

Q24. Spiders produce various kinds of silk fibers from the silk glands. There are seven gland types in the specimen provided, each producing a different type of silk (Table 4).

Table 4. Silk glands of the spider

Code of silk gland	Number of pairs	Connection to spinneret
A	Numerous	Middle & posterior
B	2	Posterior
C	1	Posterior
D	1	Anterior
E	1	Middle
F	Numerous	Anterior
G	3	Middle (1) & posterior (2)

Q24.1. (1 point) Dragline silk is produced by the largest silk glands of this spider (Figure 2). Use the codes in Table 4 to locate the largest silk gland.

Figure 2. The silk gland which produces dragline silk

Q24.2. (2 points) Dissect one complete silk gland which produces dragline silk from this spider. After dissecting the silk gland, place the organ in the vial labeled Silk gland.

Q25. (2 points) With reference to Figure 1, dissect the heart tube from the abdomen and place it in the vial labeled Heart.

Q26. (2 points) With reference to Figure 1, locate and dissect one complete book lung. Place the organ in the vial labeled Book lung.

PRACTICAL TEST 2

Answer Key

PHYSIOLOGY AND ANATOMY

Total Points: 49

Duration: 90 minutes

TASK I. (25 points)

Q1. (1 point)

A	B	C	D	E
	√			

Q2. (1 point = 0.5 x 2)

p	8
q	20

Q3. (1 point)

40	Hz

Q4. (2 points)

A	B	C	D	E
	√			

Q5. (1 point)

A	B	C	D	E
			√	

Q6. (1 point)

A	B	C	D	E
				√

Q7. (1 point)

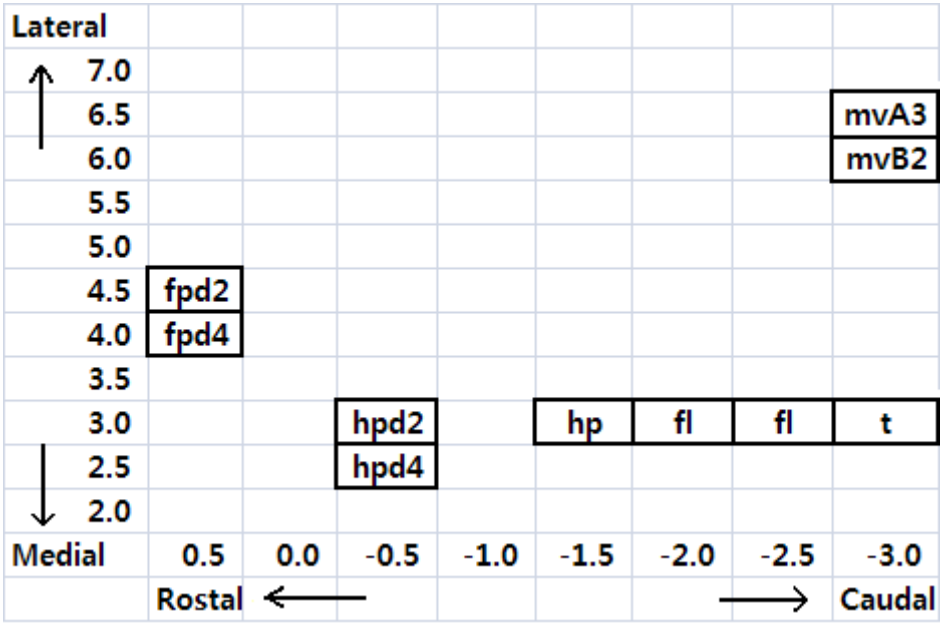
A	B	C	D	E

			√	

Q8. (2 points)

A	B	C	D	E
			√	

Q9. (5 points = 0.5 x 10)



Q10. (1 point)

A	B	C	D	E
√				

Q11. (1 point)

A	B	C	D	E
				√

Q12. (1 point = 0.5 x 2)

x	0

y	2.5

Q13. (4 points = 0.5 x 8)

Normal

lateral

2.8				
2.6				
2.4	hpd4	hpd4	hpd4	hpd4
2.2				
(mm)	−0.6	−0.8	−1.0	−1.2

→ caudal

hpd4 amputated

lateral

2.8				
2.6				
2.4	hpd5	hpd5	hpd3	hpd3
2.2				
(mm)	−0.6	−0.8	−1.0	−1.2

→ caudal

Q14. (1 point)

A	B	C	D	E
			√	

Q15. (2 points)

A	B	C	D	E
			√	

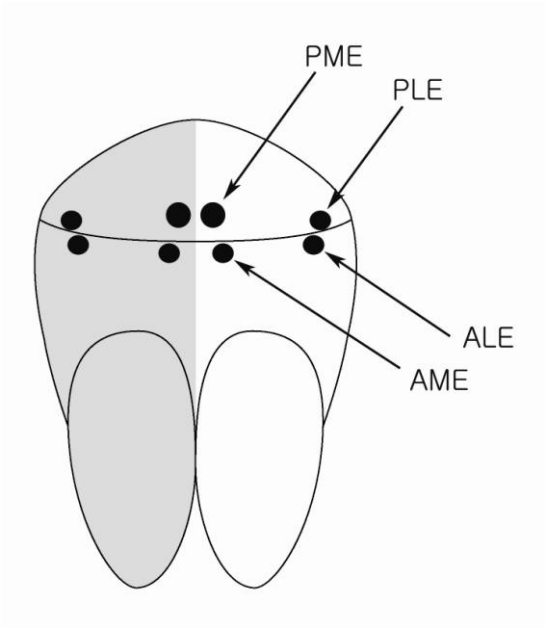
TASK II. (24 points)

Part I. (14 points)

Q16.1. (2 points = 1 × 2)

Type of eye	Total number of eye
Compound eye	0
Ocellus	8

Q16.2. (2 points)



Frontal view of the head.

1. 1 point will be given if you draw 4 pairs of eyes at proper position.
   1 point to the 4 correct codes (1 point = 0.25 × 4).
2. 1 point will be given if you draw 4 pairs of eyes at proper position without correct codes or with incorrect codes.
3. 0 point will be given if you draw incorrect number of eyes.

Q17.1. (1 point)

A	B	C	D	E
			√	

Q17.2. (1 point)

A	B	C	D	E
		√		

Q18. (1 point)

①	②	③	④

√			

Q19.1. (2 points)

(Place the organ in the provided vial, labeled **Venom gland** in English)

1. 2 points will be given if you dissect out a pair of venom glands with or without chelicerae.
2. 1 point will be given if you dissect out the chelicerae with one venom gland.
3. 0 point will be given if you dissect incorrect organ.

Q19.2. (1 point)

A	B	C	D	E
		√		

Q20. (2 points = 0.5 × 4)

	1^{st} leg	2^{nd} leg
Number of segments	7	7
Number of claws	3	3

Q21.1. (1 point)

Sex of the spider provided	
Male	Female
	√

Q21.2. (1 point = 0.5 × 2)

Number of the segments	6

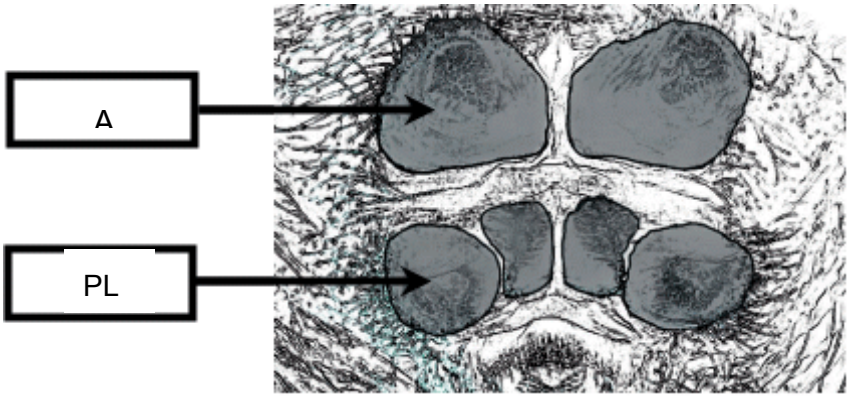
Number of claws	1

Part II. (10 points)

Q22. (1 point)

A	B	C	D	E
	√			

Q23.1. (1 point = 0.5 × 2)



Q23.2. (1 point)

A	B	C	D	E
√				

Q24.1. (1 point)

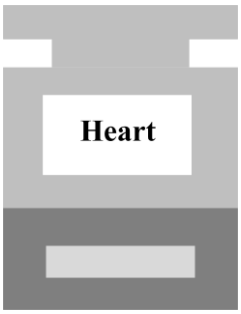
Code of silk gland	D

Q24.2. (2 points)

(Place the organ in the provided vial, labeled **Silk gland** in English.)

1. 2 points will be given if you dissect proper silk gland with both regions of ampulla and tail.
2. 1 point will be given if you dissect proper silk gland with ampulla region only.
3. 0 point will be given if you dissect incorrect silk gland.

Q25. (2 points)



(Place the organ in the provided vial, labeled **Heart** in English.)

Q26. (2 points)

(Place the organ in the provided vial, labeled **Book lung** in English.)