

Part 1: Short Answer

Only answers written in space below questions will be considered.

If necessary, use blank sheets provided for calculations or draft answers.

1) In Lab 1, you learned proper pipette skills. Use the schematics of a pipette dial, shown below, to answer parts a and b.

P1000	P200
0	1
8	3
5	0
6	5

1a) What is volume (using correct units) of the P1000 pipette set to? (1)

856 μL

1b) What is the volume (using correct units) of P200 pipette set to? (1)

130.5 μL

2) In the Lab 1 protocol information was given that a pipette can be in 4 states. List these states in the space given below. (2; half mark for each response below)

i) Ready state

ii) 1ST STOP

iii) 2ND STOP

iv) Tip ejector

3) In Lab 1 you made serial dilutions using a pipette and tested your pipetting technique based on the linearity of your dilutions, as read by absorbance on the spectrophotometer. Imagine that your solution was glycerol (i.e., a solution with higher viscosity compared to water). In two sentences or less, what could be the **reasons** for the non-linearity of your serial dilutions? (2)

As indicated in the question: “reasons” indicates more than one reason.

Any combination of the following statements would be acceptable for marks:

- 1 mark: Not enough time given to fully aspirate glycerol
- 1 mark: Not all glycerol ejected
- 1 mark: Glycerol stuck to outside of pipette and was transferred to sample

4) In two sentences or less, define the concept of homeostasis. (2)

Any combination of the following statements would be acceptable for marks:

- 1 mark: mentioning **equilibrium** or **steady state** oscillation (or disturbance from equilibrium)
- 1 mark: mentioning **constant internal environment** or that the internal environment is different from the external environment
- 1 mark: mentioning stability is related to **negative feedback**

5) Can you think of a physiologic process that is **not** under the control of a homeostatic reflex mechanism? (1)

Growth of hair

Growth of nails

Aging (at least an argument can be made)

There is no advantage in using energy to regulate these processes. (The disadvantage is that they can grow very long and interfere with normal activities.)

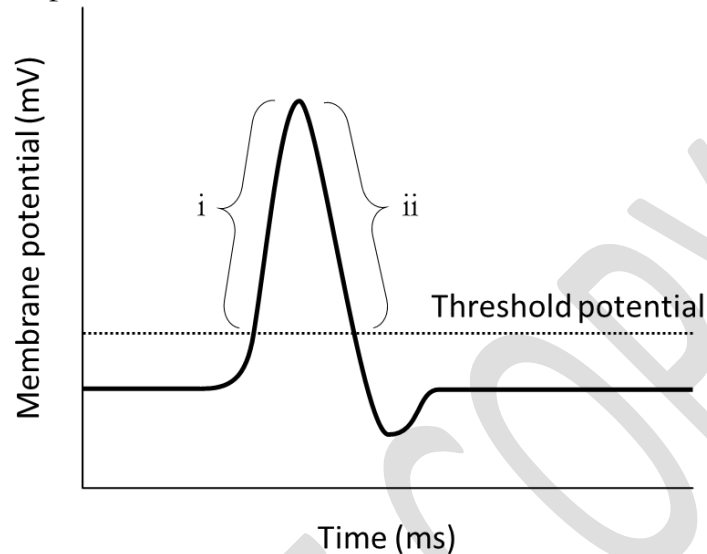
Therefore, the following are not acceptable answers as you could argue that they regulate the internal environment

- Salivation: there is an advantage to having salivation enzymes pre-digest food and this help regulate the internal environment
- Brain activity (unconscious): this would regulate internal environment
- Positive feedback loop: these would regulate internal environment

The following are not acceptable as you could argue that they don't necessarily apply to regulating the internal environment:

- Muscle movement
- Thinking or cognitive tasks

6) Shown below is typical representation of an action potential measured in a neuron. The braces are linked to two distinct phases (i and ii) of the action potential. Answer parts a, b, and d in one sentence or less.



6a) What is the cause of the phase labeled as i? (1)

Influx of Na^+ or Movement of Na^+ into cell
(need more than just: depolarization)

6b) What is the cause of the phase labeled as ii? (1)

Efflux of K^+ or Movement of K^+ out of cell
(need more than just: repolarization)

6c) What is the typical resting membrane potential of a neuron? (1)

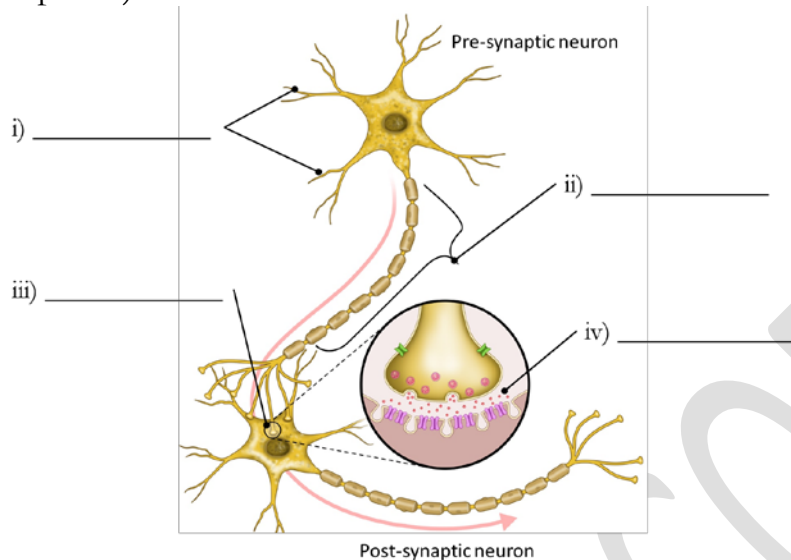
-70 mV

6d) What is a major contributing factor to the resting membrane potential? (1)

Potential acceptable answers:

- Relative intracellular and extracellular concentration gradients of several ions
- Na^+/K^+ pump that creates concentration gradient
- Permeability of membrane to each ion species
- Outcome of Goldman-Hodgkin-Katz equation

7) Enter the correct labels for the structures listed below. (2; half mark for each response)



i) Dendrites

ii) Axon (myelin sheath is also acceptable)

iii) Axon terminal or button / synaptic terminal / synaptic knob / synapse

iv) Neurotransmitter (release) or synaptic cleft (Synapse would not be appropriate here as iii would encompass the synapse as a whole)

8) Consider the following example: a neurotransmitter such as GABA or glycine opens (Cl^-) channels on a postsynaptic neuron. (Extracellular Cl^- concentrations $[\text{Cl}^-]_{\text{out}} = 110 \text{ mM}$; intracellular Cl^- concentration $[\text{Cl}^-]_{\text{in}} = 5 \text{ mM}$; membrane potential $V_m = -65 \text{ mV}$). To answer part a and b, use this version of the Nernst equation: where Z = the valance of the Chloride ion

$$E_{\text{ion}} = \frac{61.5}{Z} \log_{10} \frac{[\text{ion}]_{\text{out}}}{[\text{ion}]_{\text{in}}}$$

8a) What is the equilibrium potential of the Cl^- ion (rounded to the nearest whole number)? (1)

-83 mV

8b) What will happen to the postsynaptic neuron (in terms of polarization)? (1)

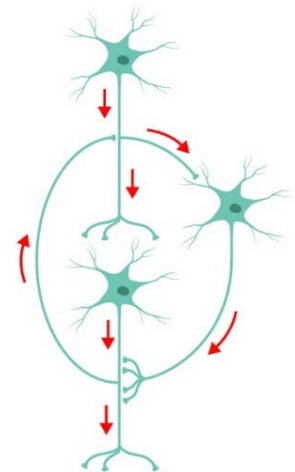
Hyperpolarize

9) During normal conditions in the whole body, the approximate potassium concentrations in the extracellular and intracellular fluid is: $[K^+]_{out} = 4.5 \text{ mM}$ and $[K^+]_{in} = 120 \text{ mM}$. In two sentences or less, describe how hypokalemia (low extracellular potassium) might change the normal function of the nervous system. (2)

“(Low potassium outside the cell would create **an increase** in the concentration gradient.)

This would make potassium's equilibrium potential more **negative** (since **more** potassium ions would be leaving the cell), and create a more **hyperpolarized** membrane potential. This would make neurons **less excitable**.”

10) Neuronal circuits allow certain functions in the body to be achieved. Use the schematic shown to the right to provide a descriptive label for the circuit and in two sentences or less, describe what the function could be and give an example of that function in the body. (3; 1 mark for each response)



10a) Descriptive label: **Rhythm-generating circuit**
Or **positive feedback loop**,

10b) Function:

(A rhythm-generating circuit has a chain of interconnected neurons, in which the incoming stimulus travels along from each cell in the circuit.)

- 1) Each cell then stimulates the previous cell through a positive feedback manner (a rare example of physiological positive feedback in the body).
- 2) A rhythm-generating circuit is turned off only when the cells become exhausted or inhibited by an outside source.

10c) Example:

- 1) Many of these circuits are known as central-pattern-generating (CPG) circuits, which are capable of producing patterns of activities.
- 2) Activities like breathing, walking, and so on

11) You are at home cooking and you turn on the electric element on the stove to boil some water. After some time, the element is red hot and the water is boiling. In your haste you accidentally burn your finger on the stove. In this scenario, **draw** and **label** the 5 major components of a simple reflex pathway that triggers your upper arm to move your forearm in response to pain. (6; half mark for each part of the drawing and corresponding label)

Major components are:

1 mark: receptor

1 mark: Afferent pathway

1 mark: Integrating centre in spinal cord (1 excitatory interneuron; 1 inhibitory interneuron)

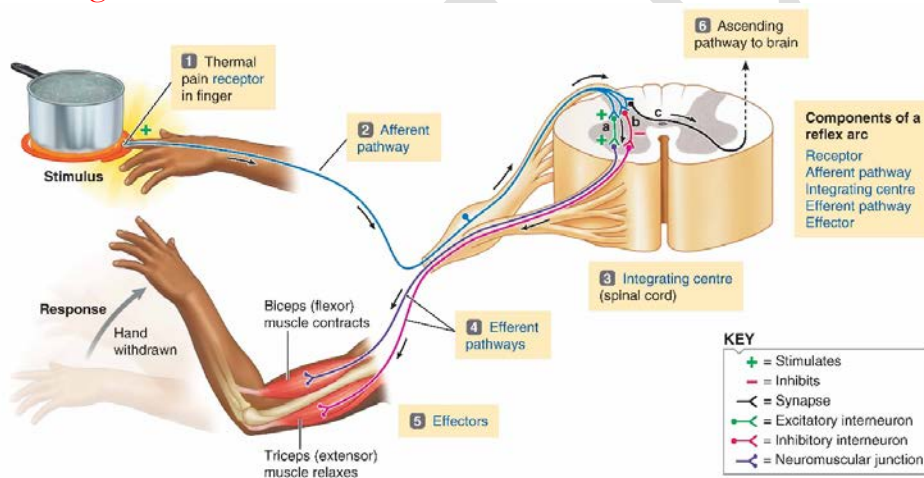
1 mark: efferent pathway to bicep

0.5 mark: bicep effector

1 mark: efferent pathway to triceps

0.5 mark: triceps effector

Drawing should look like:



12) Botulism toxin affects the neuromuscular junction. People exposed to botulism toxin usually die as a result of respiratory failure because of the inability to contract respiratory muscles. In two sentences or less, propose a mechanism by which botulism toxin might be acting. (2)

Botulism toxin might be affecting nerve stimulation at the NMJ. Skeletal muscle is responsible for the contraction of the diaphragm, which is required for respiration. The toxin likely binds or interferes with ACh binding to its receptor.

13) In response to sensory input, the regulation of voluntary movement is controlled by the somatic nervous system and the regulation of involuntary movement is controlled by the autonomic nervous system. Shown below is a template of this comparison with the example of comparing somatic and autonomic regulation already filled in. From the list of other properties given, choose only two to compare the somatic and autonomic nervous systems. (4; 1 mark for each box)

- Only two properties will be marked.
- If a student answered more than two, mark the first two complete comparisons, as they appear top to bottom
- If a student answered more than two, mark the two complete comparisons that they have indicated they want to be marked.

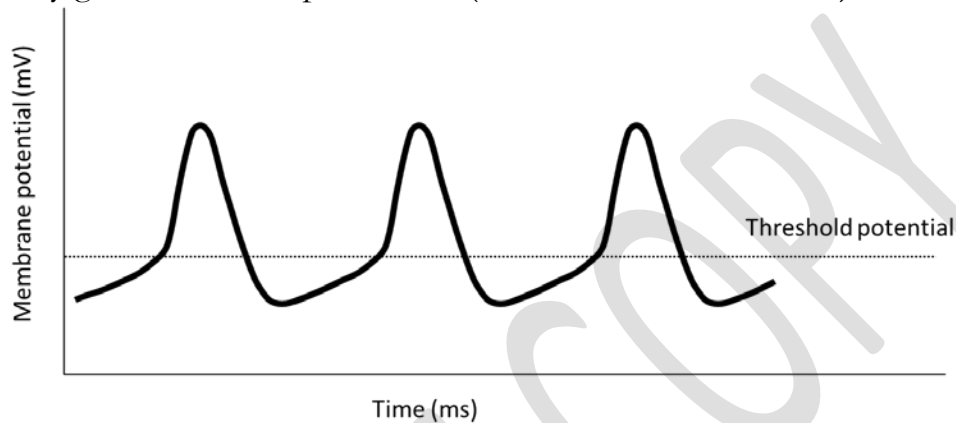
Property	Somatic nervous system	Autonomic nervous system
Regulation	Voluntary/conscious	Involuntary/unconscious
Origin	Motor cortex, medulla, or dorsal horns of the spinal cord	Brain stem nuclei or varying regions of the spinal cord
Myelination	Yes	Preganglionic myelinated; postganglionic are not. (need to state postganglionic are not for full mark)
Neurotransmitter	ACh	ACh, NorEpi, Epi [need to state all three; otherwise half mark]
Target tissue	Skeletal	Any one or all of the following: Smooth and/or cardiac muscle; kidneys; lungs; blood vessels; GI tract; liver; bladder; eyes; salivary and sweat glands
Receptor subtype	Nicotinic	Nicotinic, muscarinic, alpha and beta adrenergic (or just adrenergic is acceptable) [Need to state all types of receptors for full mark; otherwise half mark]

14) Sort the steps (in no particular order: **dissociate; power stroke; reactivate; cross-bridge**) in the sliding filament theory in order of occurrence. (2; half mark for each response)

No explanation is necessary

Order	Step
1	Cross-bridge
2	Power stroke
3	Dissociate
4	Reactivate

15) Cardiac pacemaker cells are the sole source of cardiac autorhythmicity and a typical pacemaker action potential is shown below. The most striking feature of the pacemaker waveform is the glaring absence of a stable resting membrane potential. (as shown in the diagram below). Using one sentence per example, what are three ways in which pacemaker cells can **decrease** the rate at which they generate action potentials? (3 total; 1 for each answer)



15a) Mechanism related to depolarization: (1)

Decrease rate of depolarization

15b) Mechanism related to diastolic potential: (1)

Decrease minimum resting membrane potential

15c) Mechanism related to threshold: (1)

Increase threshold potential

Part 2: Multiple Choice

Each question is worth 1 point

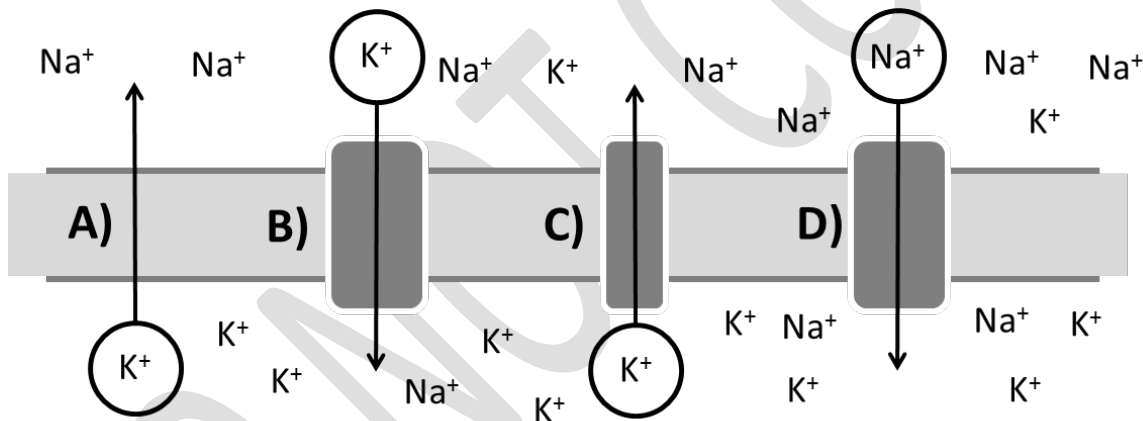
Each question has only one answer (i.e., a, b, c, or d)

Answers must be filled out on bubble sheet on last page

1) Which of the following statements is **false**?

- A) Cell volume can be altered by solute concentration differences
- B) Osmosis is the diffusion of water through a semipermeable membrane
- C) Animal cells shrink in size when they are placed in a hypertonic solution
- D) An animal cell placed in a hypotonic solution will shrink

2) Which of the following scenarios demonstrates active transport?



ANSWER: B

3) Complete the following sentence: Voltage-gated sodium channels are found in _____

- A) The neuronal cell body (excluding the hillock)
- B) The postsynaptic membrane
- C) The axon
- D) All epithelial cells

4) The absolute refractory period is the time span during an action potential when another action potential cannot be initiated. The absolute refractory period occurs during which stage or stages?

- A) Hyperpolarization stage
- B) Depolarization stage
- C) Depolarization and repolarization stages
- D) Repolarization and hyperpolarization stages

5) Complete the following sentence: Excitable cells _____

- A) Are found in all tissue types
- B) Only send messages to other cells
- C) Have no nucleus
- D) Can generate an action potential in response to a graded potential

6) The information to and from the brain travels through the network of neurons. The packets of messages, also known as the action potentials, travel down a single neuron in the following order: ____, ____, ____, and then get transferred to another neuron by _____. This process is repeated for many other neurons along the network, which guarantees the transfer of information from one part of the body to another.

- A) cell body, axon, axon terminal; dendrites
- B) axon, cell body, axon terminal; synapse
- C) dendrites, axon hillock, axon terminal; neurotransmitters
- D) cell body, axon, axon hillock; neurotransmitters

7) The minimal number of cells in a polysynaptic spinal cord reflex arc is:

- A) 1
- B) 2
- C) 3
- D) 4

8) When considering the “*Fight or Flight*” response, which of the following is a false statement?

A) It is also known as the acute stress response.

B) It is controlled by the parasympathetic system.

C) It shunts blood away from nonessential tissues.

D) Is a result of the combination of neural activity and hormones in the bloodstream.

9) When you suddenly stand up after sitting for an extended period of time, there is a good chance that your blood pressure (BP) will be reduced. Baroreceptors in the heart and carotid artery detect the change in BP. The brain stem instructs the peripheral blood vessels to contract in order to increase total vascular resistance and shunt blood toward the brain. The BP goes back to being normal. Which of the following correctly describes this homeostatic feedback loop in terms of the stimulus; receptor; control; and effector?

A) Stimulus: sensors in heart & carotid artery; Receptor: standing up; Control: brain stem; Effector: heart

B) Stimulus: brain stem; Receptor: heart; Control: standing up; Effector: sensors in heart & carotid artery.

C) Stimulus: standing up; Receptor: sensors in heart & carotid artery; Control: brain stem; Effector: heart

D) Stimulus: standing up; Receptor: sensors in heart & carotid artery; Control: brain stem; Effector: skeletal and abdominal organ blood vessels

10) Complete the following sentence: An endocrine cell _____.

A) Secretes hormones into blood

B) Can be a neuron

C) Is found within endocrine organs

D) All of the above

11) Complete the following sentence: The primary physiological effect of Insulin secretion is _____

- A) To increase blood glucose content
- B) To decrease blood glucose content
- C) To stimulate the release of ghrelin from the stomach
- D) To stimulate the release of digestive enzymes from the pancreas

12) Where is the neuronal cell body for a parasympathetic neuron located?

- A) Chain ganglia along the length of the spinal column
- B) The brain stem and sacral region of the spinal cord
- C) The thoracic and lumbar region of the spinal cord
- D) The brain stem and lumbar region of the spinal cord

13) Once an action potential excites the sarcolemma, a series of actions take place in order to produce a muscle contraction. The process of muscle contraction primarily includes which of the following ions?

- A) ATP
- B) Ca^{2+}
- C) Potassium
- D) Sodium

14) Who were the primary inventors/contributors of the first artificial external pacemaker?

- A) Earl Bakken and Dr. C. Walton Lillehei
- B) John Hopps and Dr. Wilfred Bigelow
- C) Rune Elmqvist and Dr. Åke Senning
- D) Dr. Michel Mirowski and Dr. Morton Mower