

# Exam KEY

## NROSCI/BIOSC 1070 and MSNBIO 2070

### Exam # 1

September 29, 2017

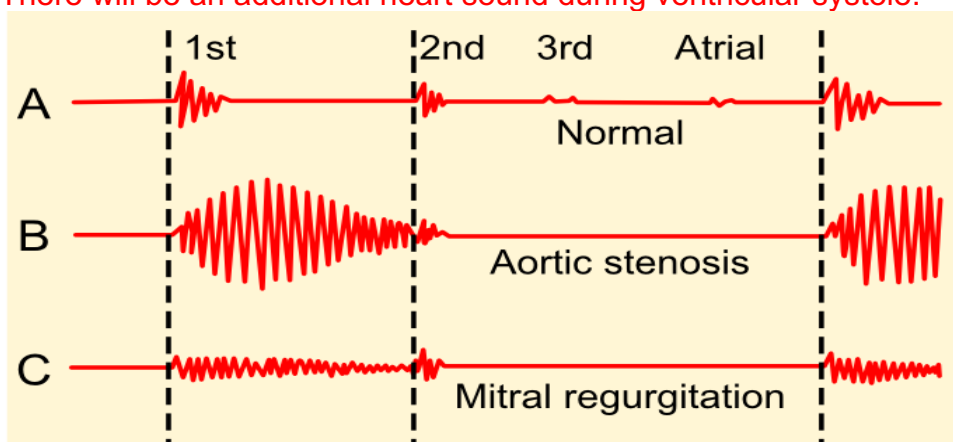
<b>Total POINTS: 100</b>	<b>20% of grade in class</b>
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- 1) Indicate whether the aortic and mitral valves would be open or closed during each of the following conditions? **(8 points)**.

<u>Condition</u>	<u>Mitral Valve</u>		<u>Aortic Valve</u>	
Atrial a-Wave	Open	Closed	Open	Closed
Isovolumetric Contraction	Open	Closed	Open	Closed
Third Heart Sound	Open	Closed	Open	Closed
Onset of ECG T-Wave	Open	Closed	Open	Closed

- 2) Echocardiography shows that a patient has regurgitation through the mitral valve. Describe differences in the heart sounds (if any) in this patient from a normal individual. Your answer should reflect whether the heart sounds occur during ventricular diastole or systole. **(2 points)**.

There will be an additional heart sound during ventricular systole.



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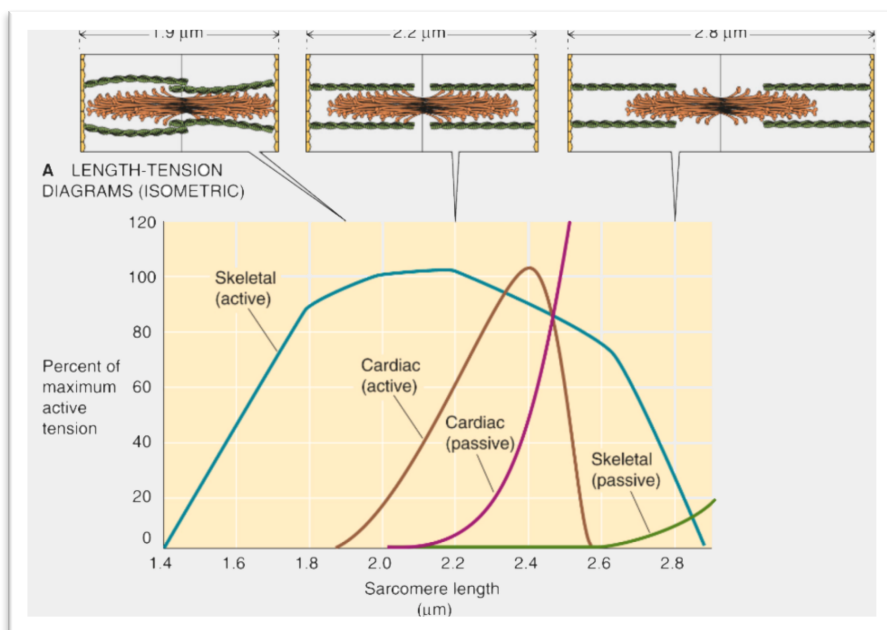
- 3) Digoxin, sold under the brand name Lanoxin among others, is a medication used to treat heart failure. Digoxin is an inhibitor for sodium-potassium ATPase. Briefly describe the mechanism through which an inhibitor for sodium-potassium ATPase acts to treat heart failure. **(5 points)**.

Some of the calcium is eliminated from ventricular myocytes by a  $\text{Na}^+\text{-Ca}^{2+}$  exchanger. This secondary active transport mechanism depends on the low intracellular  $\text{Na}^+$  generated by the  $\text{Na}^+\text{-K}^+$  ATPase. If  $\text{Na}^+\text{-K}^+$  ATPase is inhibited, then there is more  $\text{Na}^+$  inside the cell, and less driving force for secondary active transport to remove  $\text{Ca}^{2+}$ . The residual  $\text{Ca}^{2+}$  left inside the cell at the end of the contraction will permit more rapid saturation of troponin with  $\text{Ca}^{2+}$  during the next  $\text{Ca}^{2+}$ -induced  $\text{Ca}^{2+}$  release, and thereby more shortening and higher contractility.

Key points: digoxin leads to higher intracellular  $\text{Na}^+$  (1 point); this leads to higher intracellular  $\text{Ca}^{2+}$  (1 point) by affecting the efficacy of the cell-surface  $\text{Na}^+\text{-Ca}^{2+}$  exchanger (2 points). As a result, contractility increases (1 point).

- 4) Skeletal and cardiac muscle cells are isolated and placed in a tissue bath. Both types of cells are stretched identically. Which type of cell would generate the most amount of tension when stretched passively? Briefly indicate why stretch of this particular type of muscle cell would create extensive tension. Your answer should encapsulate the molecular differences between the muscle cells that lead to tension differences when they are stretched. **(5 points)**.

Cardiac muscle is much stiffer, and thus cardiac muscle cells generate more tension when stretched passively (3 points). This is mainly due to the isoform of titin in cardiac muscle cells (2 points).



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- 5) Congestive heart failure occurs when one ventricle does not pump out the same volume of blood per unit time as the other. However, in the vast majority of individuals, heart failure does not occur. Briefly describe the mechanism through which cardiac output from both ventricles is always balanced. Your answer should include a discussion of how cardiac output imbalances from the two ventricles are quickly corrected. **(7 points)**.

This is mainly due to the Frank-Starling Law. If one side lags the other, then end diastolic volumes will increase in the lagging side, leading to stronger contractions.

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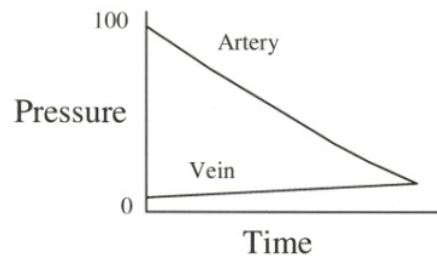
- 6) In the table below, circle which type of blood vessel corresponds to each property described. **(12 points; 2 each question).**

Property	Type of Blood Vessel			
Highest Surface Tension	Large Artery	Arteriole	Capillary	Vein
Slowest Velocity Blood Flow	Large Artery	Arteriole	Capillary	Vein
Contains the Most Blood (all vessels of type combined)	Large Artery	Arteriole	Capillary	Vein
Highest Compliance	Large Artery	Arteriole	Capillary	Vein
Least Amount of Smooth Muscle in Wall	Large Artery	Arteriole	Capillary	Vein
Largest Pulse Pressure	Large Artery	Arteriole	Capillary	Vein

## Exam KEY

- 7) A cuff is inflated around the upper arm to a pressure greater than systolic pressure. Prior to cuff inflation the mean arterial pressure is 100 mmHg and the venous pressure in the arm is 5 mmHg. If venous compliance in the forearm is 20 times greater than the arterial compliance, what will the final equilibrium pressure be on complete cessation of blood flow? **(15 points)**.

At a cuff pressure greater than systolic pressure both arteries and veins will be occluded and the arterial and venous pressures in the arm will equilibrate as blood shifts from the arterial to venous compartments.



Let  $C_A$  = arterial compliance  $\Delta P_A$  = change in arterial pressure  
 $C_V$  = venous compliance  $\Delta P_V$  = change in venous pressure  
 $\Delta V_A$  = change in arterial volume  $X$  = final equilibrium pressure  
 $\Delta V_V$  = change in venous volume

$$C_V = 20C_A$$

$$C_A = \Delta V_A / \Delta P_A$$

$$C_V = \Delta V_V / \Delta P_V$$

$$\Delta P_A = 100 - X$$

$$\Delta P_V = X - 5$$

In a closed system  $\Delta V_A = \Delta V_V$

$$C_A \Delta P_A = C_V \Delta P_V$$

$$C_V / C_A = 20 = \Delta P_A / \Delta P_V$$

$$(100 - X) / (X - 5) = 20 \quad \text{or} \quad 20X - 100 = 100 - X$$

$$21X = 200$$

$$X = 9.5 \text{ mmHg}$$

## Exam KEY

- 8) The drug Ditropan (oxybutynin) has been used to treat patients with an overactive bladder. The main side effect of the drug is a dry mouth, but patients taking Ditropan are advised to avoid exercise in a hot environment, as the drug increases the possibility of having a heat stroke. Briefly describe why Ditropan makes a patient more susceptible to heat stroke. **(6 points)**.

Ditropan must block muscarinic receptors, as this would reduce bladder contractions while also resulting in a dry mouth (as an effect of diminishing parasympathetic influences on these tissues). Sympathetic nerve fibers that control sweating release acetylcholine, which binds to muscarinic receptors on sweat glands. Thus, Ditropan blocks sweating, a principal mechanism for body cooling. Thus, patients taking the drug are susceptible for heat stroke.

## Exam KEY

- 9) Blockers of L-type  $\text{Ca}^{2+}$  channels are often used to treat angina, cardiac pain that occurs when the heart is overworked. Actions of such drugs on three distinct types of cells contribute to their efficacy in treating angina. List each of these cell types, and the mechanisms through which the actions of  $\text{Ca}^{2+}$ -channel blockers on these cells reduces myocardial oxygen consumption. **(15 points).**

### Cell Type 1

Vascular smooth muscle cells. L-type calcium channels are a principal mechanism for  $\text{Ca}^{2+}$  entry into most vascular smooth muscle cells. Thus,  $\text{Ca}^{2+}$  channel blockers cause peripheral vasodilation and a decrease in afterload. High afterload raises the workload on the heart considerably.

3 points for vascular smooth muscle cells; 2 points for decreased afterload.

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### Cell Type 2

Autorhythmic cells. L-type  $\text{Ca}^{2+}$  channel blockers extend the length of the pacemaker potential, thereby lowering heart rate.

3 points for autorhythmic cells; 2 points for decreased heart rate.

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### Cell Type 3

Myocardial cells. L-type  $\text{Ca}^{2+}$  channel blockers delay the  $\text{Ca}^{2+}$ -induced  $\text{Ca}^{2+}$  release, and the saturation of troponin with  $\text{Ca}^{2+}$ . Hence, the drugs diminish myocyte shortening, leading to a decline in contractility.

3 points for myocardial cells; 2 points for decreased contractility.

## Exam KEY

- 10) A pharmaceutical company is in search of a chemical male contraceptive.
- a. Would a GnRH receptor antagonist eliminate sperm production in men? Briefly provide the rationale for your answer. **(4 points)**.

Yes: would block FSH production; FSH is necessary to stimulate spermatogenesis

- b. Would the GnRH receptor antagonist produce any undesired side effects? Briefly explain your answer. **(4 points)**.

Yes: would block LH production; LH is necessary to stimulate testosterone production. Loss of testosterone would have many negative side effects (loss of sex drive, loss of muscle mass, etc).



## Exam KEY

- 11) A patient with a mild case of myasthenia gravis is prescribed the drug Pyridostigmine, which blocks the actions of acetylcholinesterase. The patient accidentally takes two tablets of the drug, instead of one (as prescribed by their neurologist). Discuss the effects of the drug overdose on the following physiological responses. **(2 points each; 10 points total).**

Myasthenia gravis results from destruction of nicotinic receptors, mainly those at the neuromuscular junction. Pyridostigmine prolongs the effects of acetylcholine at both nicotinic and muscarinic synapses. Thus, muscarinic mechanisms can be overstimulated in patients taking Pyridostigmine.

- a. Would the pupils be dilated, constricted, or normal?

Constricted: Parasympathetic effects on the eye are exacerbated, resulting in pupillary constriction.

- b. Would salivation be normal, excessive, or diminished (dry mouth)?

Excessive: Due to parasympathetic overstimulation of salivary glands.

- c. Would bronchial secretions be normal, reduced, or enhanced?

Enhanced: Due to parasympathetic overstimulation of bronchial glands.

- d. Would sweating be normal, reduced, or enhanced?

Enhanced: Due to overstimulation of sweat glands by cholinergic sympathetic fibers.

- e. Would tearing be normal, reduced, or enhanced?

Enhanced: Due to overstimulation of tear glands by the parasympathetic nervous system.

## Exam KEY

- 12) Because of the potential side effects of taking Pyridostigmine, elaborated in your answers to question 11, this drug is usually combined with a second drug that diminishes these unwanted effects. How would such a drug act to diminish the side effects? **(4 points)**.

Block muscarinic receptors (e.g., atropine)

- 13) Contraction of skeletal muscle entails a variety of molecular and biochemical events. Which of these events is the slowest, and thus the “rate limiting” step of muscle contraction? **(3 points)**.

Myosin ATPase speed (speed at which the high energy bond of ATP is severed in the myosin head).