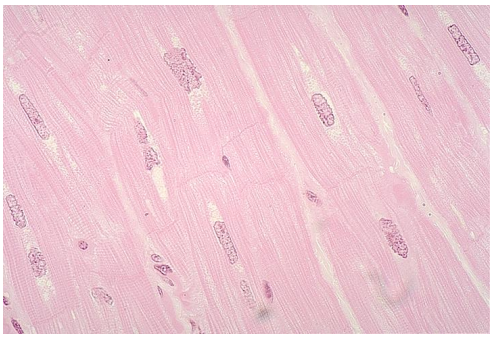
# KINES 330
# EXERCISE PHYSIOLOGY
# CARDIOVASCULAR
## Part 1: Introduction to Cardiac Function.

**Objectives:** To develop an understanding of the heart and its role in meeting the demands of physical activity.

**Process Objectives:** To improve information processing and critical thinking.

**Background Information:** The heart is a series of four pumps that move blood throughout the body. Blood is a liquid medium that transports oxygen, energy, metabolites, heat, and information. The heart and blood vessels are highly regulated and respond with an elegant level of precision.
Graded maximal exercise is a protocol in which the intensity of exercise is gradually increased by a pre-determined amount, at pre-determined intervals, until the exercising individual reaches volitional fatigue (maximum intensity).

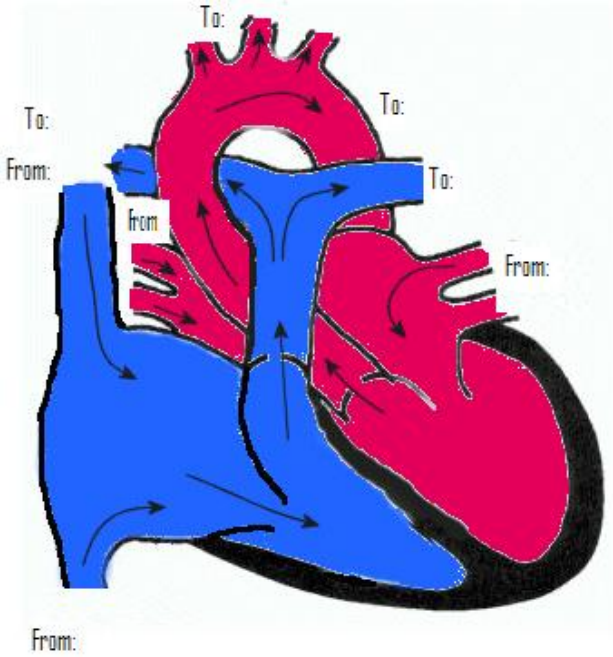
**Figure B1.** Light micrograph of a cardiac muscle.



**Instructions:** Use the figures and tables provided to answer the accompanying questions. Complete question 1 prior to coming to class. Do not complete any questions beyond #1 prior to coming to class.

1. *Review:* Figure 1 is schematic of the heart. Use your pre-existing knowledge of the heart to label the diagram and trace the flow of blood through the heart and lungs.

**Figure 1.** Heart schematic.




a. Aorta
b. Atrium (left)
c. Atrium (right)
d. Pulmonary artery
e. Pulmonary vein
f. Vena cava (inferior)
g. Vena cava (superior)
h. Ventricle (left)
i. Ventricle (right)
j. To:
   Body
   Head and upper extremities
   Lungs (x2)
k. From:
   Body
   Head and upper extremities
   Lungs (x2)

*Work with your group members to complete questions 2 – 12 during class time. Reach a consensus before you write down each answer.*

Table 1 contains information regarding the cardiac response to graded maximal treadmill exercise. Use the data provided to answer the following questions.

**Table 1.** Cardiac responses to graded maximal treadmill exercise.

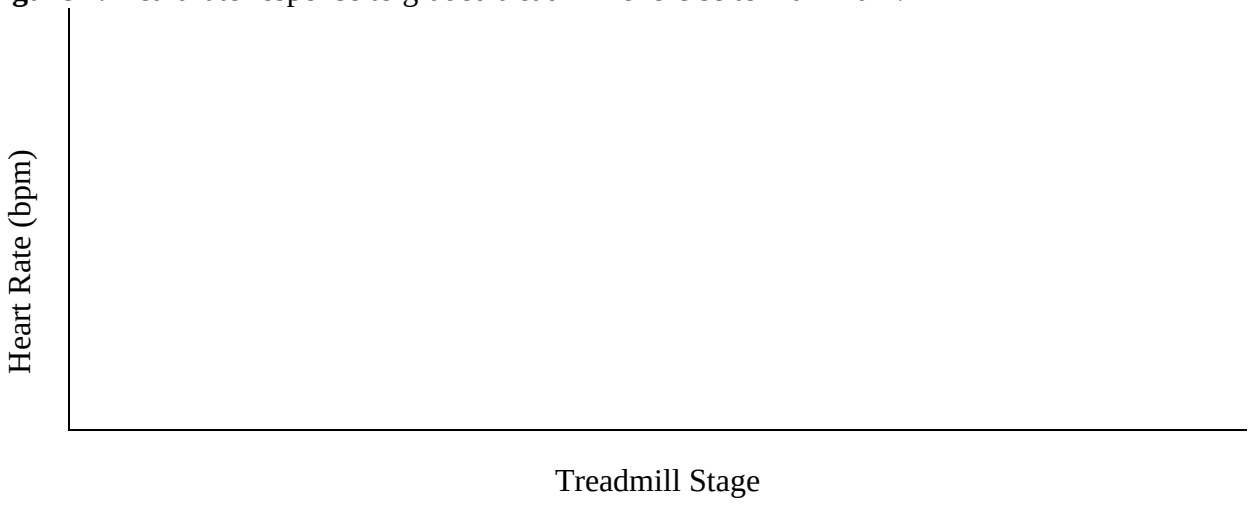
| Stage | Heart Rate (bpm) | Stroke volume (mL/beat) | Cardiac Output (L/min) |
|---|---|---|---|
| *Rest* | 72 | 76 | 5.47 |
| *1* | 124 | 99 | 12.28 |
| *2* | 149 | 100 | 14.90 |
| *3* | 174 | 101 | 17.57 |
| *Max* | 185 | 103 | 19.06 |
| *Recovery 2 min* | 123 | 99 | 12.18 |
| *Recovery 5 min* | 90 | 87 | 7.83 |

2. What do we mean when we use the term heart rate?

   a. What are the units for heart rate?

   b. Use figure 1 to graph heart rate across the stages of the treadmill exercise depicted in table 1.

**Figure 1.** Heart rate response to graded treadmill exercise to maximum.




   c. What happens to heart rate during graded maximal exercise?

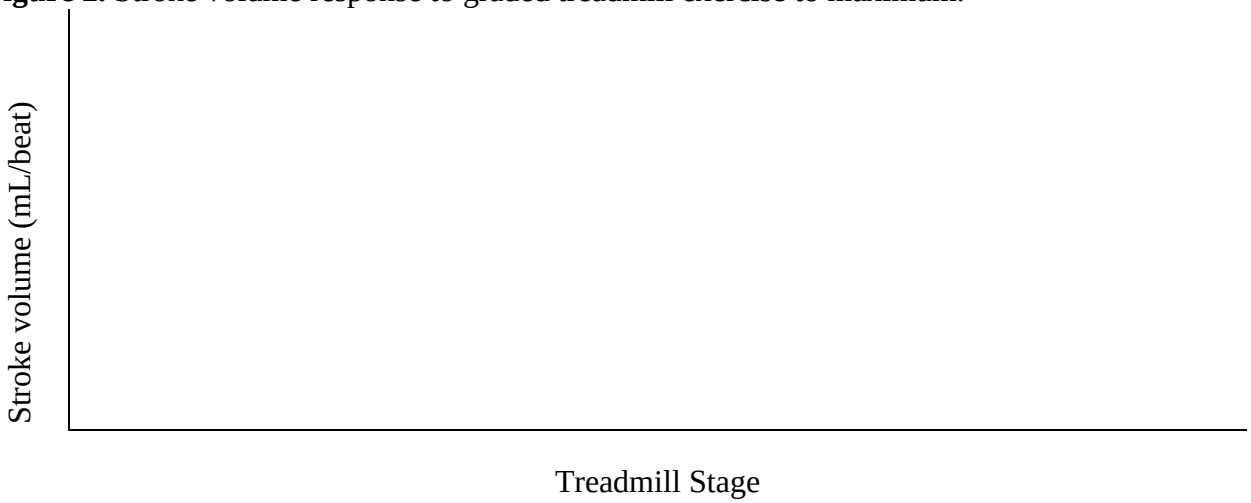
   d. What is the relative (%) change in heart rate from rest to maximum?

3. If we consider each beat of the heart to be the same as the stroke of a pump (after all, the heart is simply a pump), what do we mean when we use the term stroke volume?

   a. What are the units for stroke volume?

   b. Use figure 2 to graph stroke volume across the stages of the treadmill exercise depicted in table 1.

**Figure 2.** Stroke volume response to graded treadmill exercise to maximum.




   c. What happens to stroke volume during graded maximal exercise?

   d. What is the relative (%) change in stroke volume from rest to maximum?

4. Which factor, heart rate or stroke volume, changes more in response to graded exercise?

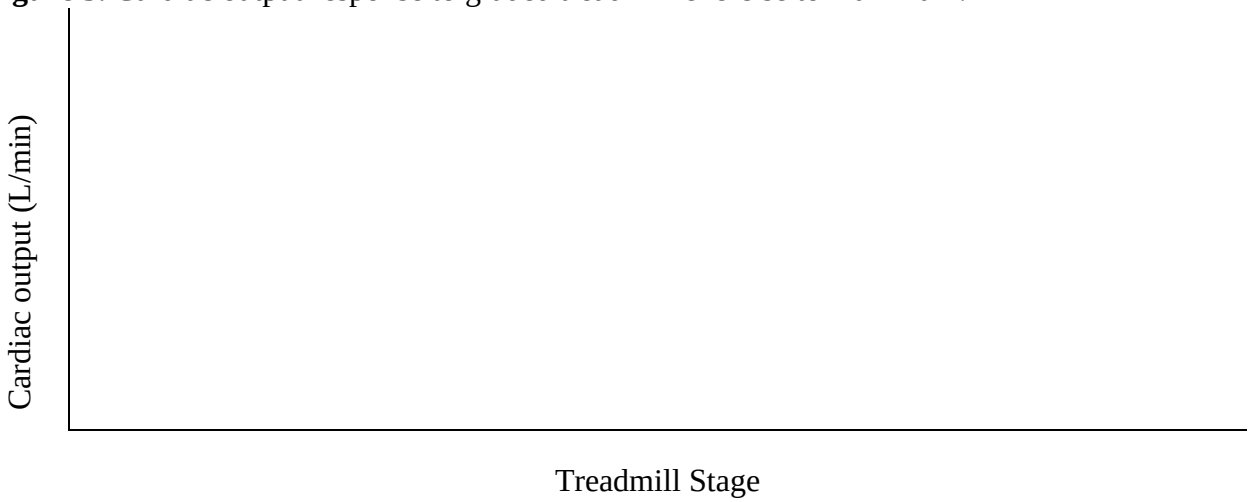
5. Look at table 1. What are the units for cardiac output?

   a. How would you mathematically combine heart rate and stroke volume to determine cardiac output? (Hint: let the units lead the way.)

   b. Using the equation that you just developed, and the units for cardiac output, how would you define cardiac output?

c. Use figure 3 to graph cardiac output across the stages of the treadmill exercise depicted in table 1.

**Figure 3.** Cardiac output response to graded treadmill exercise to maximum.




d. What happens to cardiac output during graded maximal exercise?

e. What is the relative (%) change in cardiac output from rest to maximum?

f. Which factor, heart rate or stroke volume, plays a greater role in the change in cardiac output from rest to maximum exercise?

g. What does this change in cardiac output mean for the exercising body?

6. Use the information in table 2 to calculate cardiac output at rest and during maximal exercise for sedentary individuals and for trained endurance athletes.

**Table 2.** Comparison of heart rate, stroke volume, and cardiac output at rest and during maximal exercise for sedentary and trained individuals.

| | **Heart Rate (bpm)** | | **Stroke Volume (mL/beat)** | | **Cardiac Output (L/min)** | |
|---|---|---|---|---|---|---|
| | *Sedentary* | *Trained* | *Sedentary* | *Trained* | *Sedentary* | *Trained* |
| *Rest* | 72 | 45 | 69 | 110 | | |
| *Maximum* | 180 | 180 | 150 | 220 | | |

a. How does cardiac output compare at rest for the sedentary and trained individuals?

b. How does cardiac output compare at maximum for the sedentary and trained individuals?

c. Based on the information found in table 2, what accounts for a trained individual's lower resting heart rate?

7. Summarize the resting efficiency and responses to graded maximal exercise for sedentary and aerobically trained individuals.

8. Infants have a fixed stroke volume. What does this mean for how infants will control their cardiac output?

9. Older adults have a lower resting heart rate than younger adults, yet their cardiac output is equal. How do older adults accomplish this?

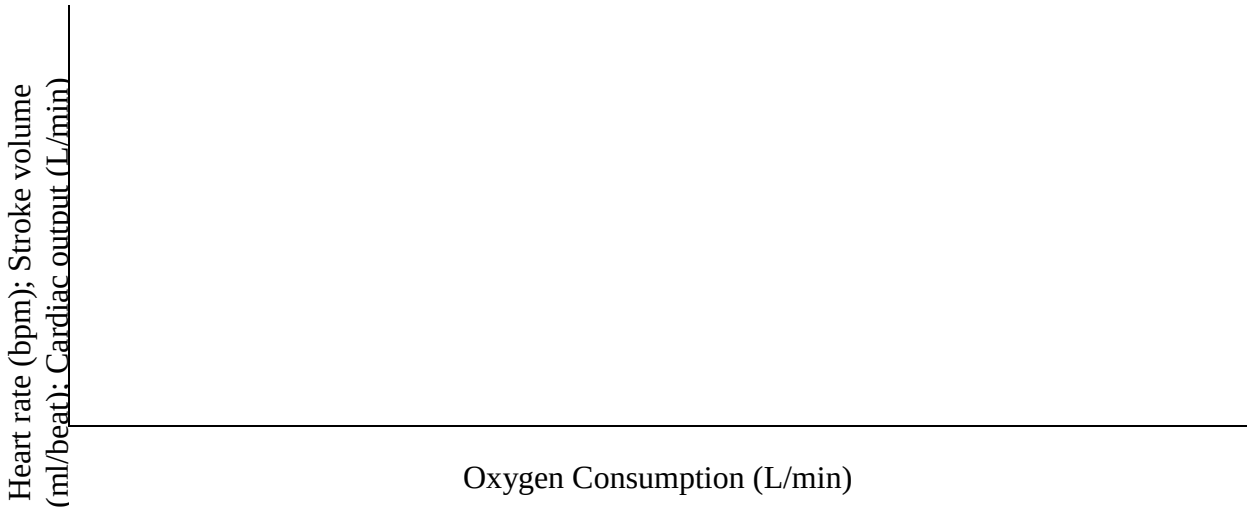
10. Fill in the missing information in table 3 using the data provided to check your answer to number 9.

**Table 3.** Cardiac output ($\dot{Q}$) across treadmill workloads for adults, children, and older adults.

| Workload (Oxygen Consumption, l/min) | Heart Rate (HR, bpm) | | | Stroke Volume (SV, mL/beat) | | | Cardiac Output ($\dot{Q}$, L/min) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Adult | Child | Elderly | Adult | Child | Elderly | Adult | Child | Elderly |
| 0.4 | 64 | | 60 | 72 | 48 | | | 3.94 | 4.61 |
| 0.5 | 80 | | 66 | 75 | 49 | | | 5.02 | 6.00 |
| 0.7 | 92 | | 73 | 80 | 50 | | | 6.41 | 7.36 |
| 0.9 | 102 | | 82 | 92 | 51 | | | 8.17 | 9.38 |
| 1 | 116 | | 93 | 96 | 52 | | | 10.41 | 11.14 |
| 1.5 | 132 | | 106 | 100 | | | | | 13.20 |
| 2 | 152 | | 122 | 101 | | | | | 15.35 |
| 3 | 180 | | | 104 | | | | | |
| 3.5 | 182 | | | 108 | | | | | |

a. Use figure 4 to graph heart rate, stroke volume, and cardiac output across the workloads depicted in table 3.

**Figure 4.** Heart rate, stroke volume, and cardiac output responses to graded treadmill exercise to maximum.




11. What conclusion can you draw about the mechanisms to control cardiac output from infancy to old age? How do they change?

12. What questions do you have about the heart at this time? In other words, of what you have covered so far, what is unclear to you and/or what contradictions do you find?