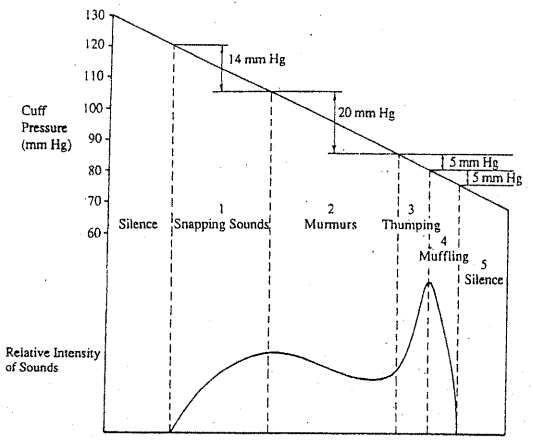
Laboratory 10: Physiology of the Circulatory System

*measure pulse rate
*measure blood pressure
*describe the relationship between changes in heart rate and blood pressure relative to changes in body position
*describe the relationship between changes in heart rate and exercise
*determine the "fitness index" for an adult human
*perform statistical analysis on class data
*define Q_{10}
*determine the Q_{10} of heart rate in a living organism such as *Daphnia*

Blood pressure tell one much about physiology; when the ventricles contract, blood pressure (directly dependent on amount of blood pumped per minute and the resistance to flow) is increased throughout the arteries. A sphygmomanometer allows you to temporarily cut off blood flow in the brachial artery, then listen through a stethoscope for Korotkoff's sounds. The first sound marks the point at which greatest force is being exerted = systolic pressure/ the last sound heart marks the point of lowest force = diastolic pressure.

The Five Phases of the Sounds of Korotkoff



During physical exertion, the cardiac rate (beats per minute) increases. You can measure this by pulse rate. Please note that physically fit individuals may have the same pulse rate as sedentary ones, but they will have higher stroke volume (milliliters delivered per beat) so their cells receive more oxygen. Under exertion, their rate will go up more slowly, and their rate return to "normal" more quickly.

An interesting test of fitness can be done by

(a) measuring two-minute reclining rate, then measure immediately upon standing; record the change in systolic pressure
(b) record pulse rate after two minutes of easy standing
(c) record pulse rate after reclining for five minutes
(d) measure the pulse rate immediately after standing from part c/ record the increase in pulse rate between the two
(e) do a step test on an 18-inch stool for 5 repetitions/ record pulse rate from 1-15 seconds, 16-30. 31-60. 61-90, and 91-120 seconds/ also record the time it takes for pulse to return to normal

Fitness Data

		Measurement	Points
Test 1.	Change in systolic pressure from reclining to standing	_____ mm Hg	_____
Test 2.	Standing pulse rate	_____ beats/min	_____
Test 3.	Reclining pulse rate	_____ beats/min	_____
Test 4.	Baroreceptor reflex Pulse rate increase on standing	_____ beats/min	_____
Test 5.	Step Test Return of pulse to standing rate after exercise	_____ seconds	_____
	Pulse rate increase immediately after exercise	_____ beats/min	_____

TOTAL SCORE _____

Total Score	Relative Cardiac Fitness
18-17	Excellent
16-14	Good
13-8	Fair
7 or less	Poor

Change in Systolic Pressure from Reclining to Standing

mm Hg	points
rise of 8 or more	3
rise of 2-7	2
no rise	1
fall of 2-5	0
fall of 6 or more	−1

Standing Pulse Rate

Beats/min	Points
60-70	3
71-80	3
81-90	2
91-100	1
101-110	1
111-120	0
121-130	0
131-140	−1

Reclining Pulse Rate

Beats/min	Points
50-60	3
61-70	3
71-80	2
81-90	1
91-100	0
101-110	−1

Reclining Pulse (beats/min)	Pulse Rate Increase on Standing (# beats)				
	0-10	11-18	19-26	27-34	35-43
	Points				
50-60	3	3	2	1	0
61-70	3	2	1	0	−1
71-80	3	2	0	−1	−2
81-90	2	1	−1	−2	−3
91-100	1	0	−2	−3	−3
101-110	0	−1	−3	−3	−3

Time Required for Return of Pulse Rate to Standing Level after Exercise

Seconds		Points
0-30		4
31-60		3
61-90		2
91-120		1
121+		1
1-10	beats above standing pulse rate	0
11-30	beats above standing pulse rate	−1

Pulse Rate Increase after Exercise

Standing Pulse (beats/min)	Pulse Rate Increase Immediately after Exercise (# beats)				
	0-10	11-20	21-30	31-40	41+
	Points				
60-70	3	3	2	1	0
71-80	3	2	1	0	−1
81-90	3	2	1	−1	−2
91-100	2	1	0	−2	−3
101-110	1	0	−1	−3	−3
111-120	1	−1	−2	−3	−3
121-130	0	−2	−3	−3	−3
131-140	0	−3	−3	−3	−3

The relationship between heart rate and temperature can be represented graphically and/or by the calculation of a value known as Q_{10} . This value is an exponential expression of the effect of temperature change. Q_{10} is a value representing the effect of raising the temperature 10° C. For example, a Q_{10} of 2 indicates the raising the temperature 10° will cause the rate being studied to double.

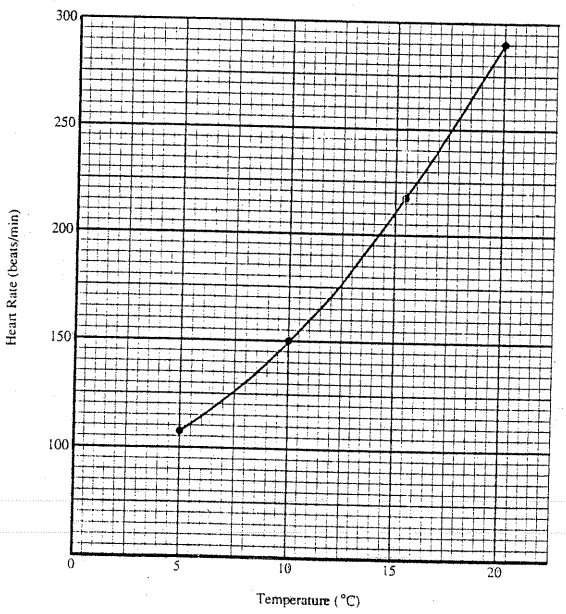
The general formula is:

t_2 = higher temperature
t_1 = lower temperature
k_2 = rate at temperature t_2
k_1 = rate at temperature t_1

Immobilize a *Daphnia* by placing it in a small section of capillary tube and sealing it at both ends. Place in a bowl of room temperature water and record the number of heartbeats for 10 seconds (multiply by 6 for beats / minute). Move the capillary tube to a bowl at 0-5° stable temperature, and let stabilize for 1 minute. Record the heart rate. Add warm water until the temperature is 5° higher, record the rate and so on until you get back to room temperature. Determine a Q_{10}.

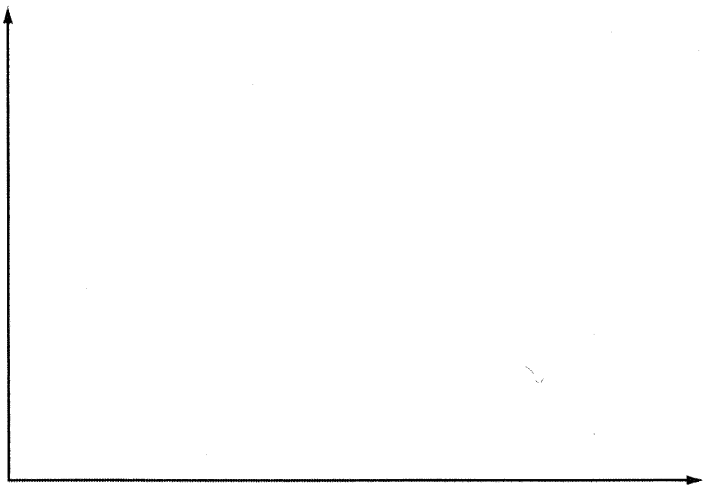
Temperature (°C)	*Daphnia Heart Rate (beats/min)*
5	108
10	152
15	211
20	290

Heart Rate and The Effect of Temperature



Lab 10
Circulation/Respir.

2. In mammals, heart rate during periods of exercise is linked to the intensity of exercise.
   (a) **Discuss** the interactions of the respiratory, circulatory, and nervous systems during exercise.
   (b) **Design** a controlled experiment to determine the relationship between intensity of exercise and heart rate.
   (c) On the axes provided below, **indicate** results you expect for both the control and the experimental groups for the controlled experiment you described in part B. Remember to label the axes.



3. The physical form of cells and organisms is often influenced by special structural polymers. Choose **one** polymer from **each** of the following three pairs of polymers:

   Pair 1: tubulin . . myosin

   Pair 2: cellulose . . chitin

   Pair 3: messenger RNA . . transfer RNA

   For each of the three polymers you have chosen, **describe** its
   (a) structure, and
   (b) role in a cell or organism.

4. A triploblastic animal is one in which three germ layers form during embryonic development. Triploblastic animals include acoelomate, pseudocoelomate, and coelomate (eucoelomate) organisms.
   (a) **Identify** the three germ layers of a triploblastic embryo and **discuss** the fates of these germ layers in embryonic development.
   (b) **Describe** acoelomate, pseudocoelomate, and coelomate body plans. **Identify** an animal that is representative of **each** of these types of body plan.
   (c) **Compare and contrast** the digestive systems of an acoelomate and a coelomate organism.

END OF EXAMINATION

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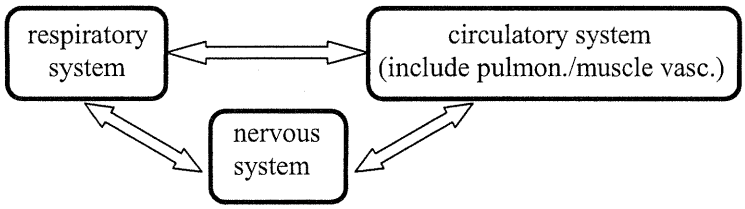
2002 SCORING GUIDELINES (Form B)

Question 2

2. (a) **Discuss** the interactions of the respiratory, circulatory, and nervous systems during exercise. (**4 points maximum**)

Note: Must have a "detail" on one side or the other of the interaction
non-inclusive list of possible examples . . .



nervous system medulla oblongata ANS/sympathetic, adrenalin chemosensory neurons (pH, O_2, CO_2, etc.)	← *interacting with* →	respiratory system diaphragm/ intercostals bronchodilation
respiratory system alveoli (small, thin air sacs)	← *interacting with* →	circulatory system capillaries, erythrocytes, hemoglobin
circulatory system blood containing O_2 /glucose	← *interacting with* →	exercising muscle produces ATP using O_2/glucose anaerobic – lactic acid
nervous system accelerator nerve ANS, sympathetic neurons chemosensory neurons (pH, O_2, CO_2, etc.)	← *interacting with* →	circulatory system SA/AV node (heart rate) vasodilation/vasoconstriction stroke volume

2. (b) **Design** a controlled experiment to determine the relationship between intensity of exercise and heart rate. (**4 points maximum**)

- hypothesis statement/prediction of results
- correctly describe the concept of a "control" group (baseline, resting)
- specify matched subjects (age, sex, fitness, twins, etc.)
- describe parameters of the exercise protocol
- describe how the heart rate will be measured (e.g., pulse, EKG, etc.)
- specify all other conditions stay the same (only one independent variable)
- statistical analysis
- large sample size/repetition (reliability)

Question 2 (cont'd.)

2. (c) On the axes provided below, **indicate** results you expect for both the control and the experimental groups for the controlled experiment you described in part B. Remember to label the axes. (**3 points maximum**)

- axes labeled with continuous scalar values and correct unit
- independent variable on X axis, dependent (results) on Y axis
- plots indicate correct relationship between control and experimental group

Q2-A
p.1 of 2

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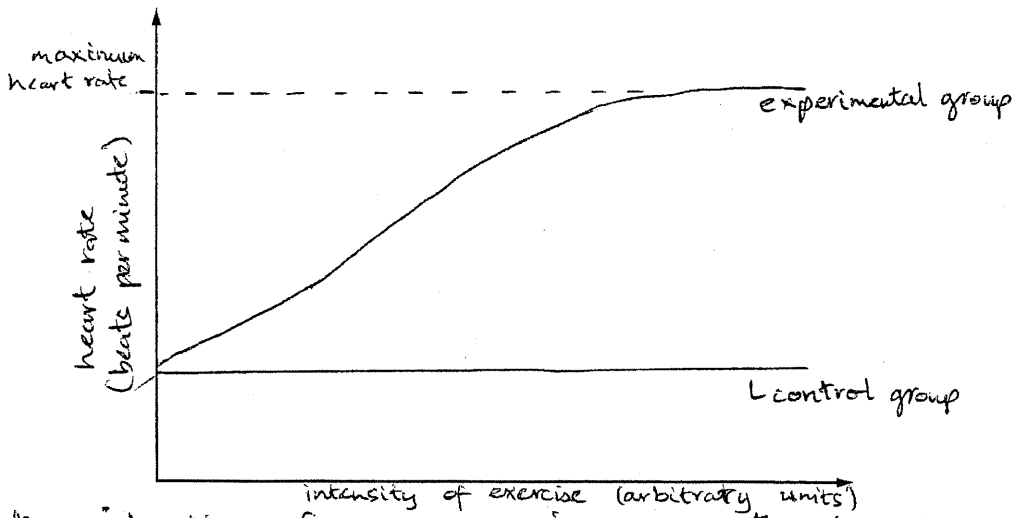

a) As the intensity of exercise increases, the heart rate increases in order to provide oxygen for respiring muscle cells and to remove carbon dioxide and heat. ~~The~~ Chemoreceptors and barroreceptors in the carotid bodies and aorta measure CO_2 concentrations and blood pressure. The breathing rate and depth of breathing increases. Ventilation in the lungs increases. The sympathetic nerves of the autonomic nervous system stimulate the sinoatrial node of the heart. There is faster depolarization and so the rate of heartbeat increases. There is an increased blood flow to the muscle cells. This provides them with more oxygen for aerobic respiration. ~~Expr~~ Respiration releases energy, in the form of ATP, for muscle contraction. The hypothalamus is also involved. If CO_2 concentrations rise above normal, the hypothalamus stimulates the heart to beat faster.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

b)

b) The independent variable is the intensity of exercise while the dependent variable is the heart rate. ~~The intensity of exercise can be measured~~ Ask someone to step onto a treadmill and connect wires to his body that allow his heart rate to be measured. The heart rate is measured in beats per minute. Change the speed and inclination of the treadmill to alter the intensity of exercise. The control, in this experiment, is another person of the same age, gender and state of health, sitting down and exerting no physical effort.

Take readings of the heart rate at different levels of exercise intensity. Plot a graph of the results. Repeat the experiment with a different person. Again this person should be of the same age, gender and state of health. The results should concur. Take the average of the results and hypothesize. The experiment shows that as intensity of exercise increases, the heart rate increases. There is a direct relationship between the two variables. The results also show that the experimental group reach a certain maximum heart rate beyond which there is no increase, no matter what the level of exercise intensity is. In addition, the control group should show virtually no change in heart rate. The graph for the control group remains fairly constant. This is known as the resting heart rate.