FACTORS AFFECTING THE CARDIAC CYCLE

MATERIALS NEEDED

Textbook
Physiological recording apparatus such as a kymograph or Physiograph
Live frog
Dissecting tray
Dissecting instruments
Dissecting pins
Frog Ringer's solution in plastic squeeze bottle
Thread
Small hook
Medicine dropper
Thermometer
Ice
Hot plate
Calcium chloride, 2% solution
Potassium chloride, 5% solution

For Learning Extension:

Epinephrine, 1:10,000 solution
Acetylcholine, 1:10,000 solution
Caffeine, 0.2% solution

SAFETY

- Wear disposable gloves when handling the frogs.
- Dispose of the frogs according to directions from your laboratory instructor.
- Wash your hands before leaving the laboratory.

Although the cardiac cycle is controlled by the S-A node serving as the pacemaker, the rate of heart action can be altered by various other factors. These factors include parasympathetic and sympathetic nerve impulses that originate in the cardiac center of the medulla oblongata, changes in body temperature, and concentrations of certain ions.

PURPOSE OF THE EXERCISE

To review the mechanism by which the heartbeat is regulated, to observe the action of a frog heart, and to investigate the effects of various factors on the frog heartbeat.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. Describe the mechanism by which the human cardiac cycle is controlled.
2. List several factors that affect the rate of the heartbeat.
3. Identify the atrial and ventricular contractions and determine the heart rate from a recording of a frog heartbeat.
4. Test the effects of various factors on the action of a frog heart.

PROCEDURE

1. Review the section entitled "Regulation of the Cardiac Cycle" in chapter 15 of the textbook.
2. Complete Part A of Laboratory Report 64.

GENERAL SUGGESTION

Try to become familiar with the content and organization of this lab before you pith a frog. If you work quickly, one pithed frog should last for all of the experimental steps.

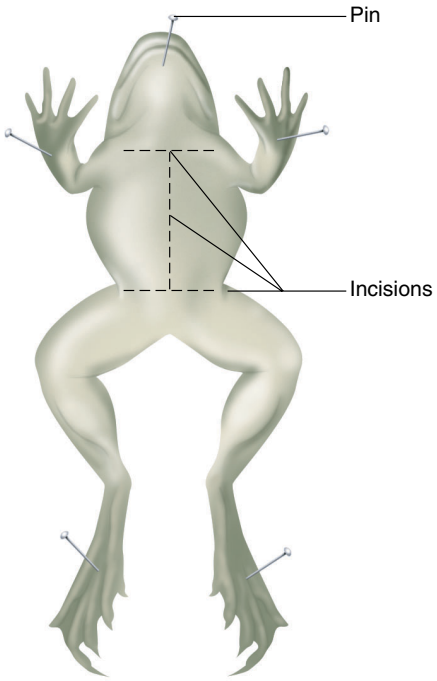
3. Observe the normal action of a frog heart. To do this, follow these steps:
   a. Obtain a live frog, and pith it according to the directions in Procedure C of Laboratory Exercise 62.

ALTERNATIVE PROCEDURE

An anesthetizing agent, tricaine methane sulfonate, can be used to prepare frogs for this lab. This procedure eliminates the need to pith frogs.

   b. Place the pithed frog in a dissecting tray with its ventral surface up, and pin its jaw and legs to the tray with dissecting pins.
   c. Use scissors to make a midline incision through the skin from the pelvis to the jaw.
   d. Cut the skin laterally on each side in the pelvic and pectoral regions, and pin the resulting flaps of skin to the tray (fig. 64.1).

Figure 64.1 Pin the frog to the dissecting tray and make incisions through the skin as indicated.



e. Remove the exposed pectoral muscles and the sternum, being careful not to injure the underlying organs.
f. Note the beating heart surrounded by the thin-walled pericardium. Use forceps to lift the pericardium upward, and carefully slit it open with scissors, thus exposing the heart.
g. Flood the heart with frog Ringer's solution, and keep it moist throughout this exercise.
h. Note that the frog heart has only three chambers—two atria and a ventricle. Watch the heart carefully as it beats, and note the sequence of chamber movements during a cardiac cycle.

4. Tie a piece of thread about 45 cm long to a small metal hook, and insert the hook into the tip (apex) of the ventricle without penetrating the chamber (fig. 64.2). The laboratory instructor will demonstrate how to connect the thread to a physiological recording apparatus so that you can record the frog heart movements. The thread should be adjusted so that there is no slack in it, but at the same time, it should not be so taut that it pulls the heart out of its normal position (fig. 64.3).
5. Record the movements of the frog heart for 2–3 minutes. Identify on the recording the smaller atrial contraction waves and the larger ventricular contraction waves. Also, determine the heart rate (beats per minute) for each minute of recording, and calculate the average rate. Enter the results in Part B of the laboratory report.

Figure 64.2 Attach a hook and thread to the tip of the ventricle.

6. Test the effect of temperature change on the frog's heart rate. To do this, follow these steps:
   a. Remove as much as possible of the Ringer's solution from around the heart, using a medicine dropper.
   b. Flood the heart with fresh Ringer's solution that has been cooled in an ice water bath to about 10°C (50°F).
   c. Record the heart movements, and determine the heart rate as before.
   d. Remove the cool liquid from around the heart, and replace it with room temperature Ringer's solution.
   e. After the heart is beating at its normal rate again, flood it with Ringer's solution that has been heated on a hot plate to about 35°C (95°F).
   f. Record the heart movements, and determine the heart rate as before.
   g. Enter the results in Part B of the laboratory report.
7. Complete Part B of the laboratory report.
8. Test the effect of an increased concentration of calcium ions on the frog heart. If the frog heart from the previous experiment is still beating, replace the fluid around it with room temperature Ringer's solution, and wait until its rate is normal. Otherwise, prepare a fresh specimen, and determine its normal rate as before. To perform the test, follow these steps:
   a. Flood the frog heart with 2% calcium chloride. (This solution of calcium chloride will allow ionization to occur, providing Ca^{++}.)

b. Record the heartbeat for about 5 minutes, and note any change in rate.
c. Flood the heart with fresh Ringer's solution until heart rate returns to normal.

9. Test the effect of an increased concentration of potassium ions on the frog heart. To do this, follow these steps:
   a. Flood the heart with 5% potassium chloride. (This solution of potassium chloride will allow ionization to occur, providing K^+.)
   b. Record the heartbeat for about 5 minutes, and note any change in rate.
10. Complete Part C of the laboratory report.

LEARNING EXTENSION

Plan an experiment to test the effect of some additional factor on the action of a frog heart. For example, you might test the effect of epinephrine, acetylcholine, caffeine, or some other available substance. If the laboratory instructor approves your plan, perform the experiment and record the heart movements. What do you conclude from the results of your experiment?

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Figure 64.3 Attach the thread from the heart to the recording apparatus so that there is no slack in the thread.

Laboratory Report 64

Name _____

Date _____

Section _____

Factors Affecting the Cardiac Cycle

PART A

Complete the following statements:

1. The primary function of the heart is to _____ .
2. The _____ normally controls the heart rate.
3. Parasympathetic nerve fibers that supply the heart make up part of the _____ nerve.
4. Endings of parasympathetic nerve fibers secrete _____ , which causes the heart rate to decrease.
5. Sympathetic nerve fibers reach the heart by means of _____ nerves.
6. Endings of sympathetic nerve fibers secrete _____ , which causes the heart rate to increase.
7. The cardiac control center is located in the _____ of the brainstem.
8. Baroreceptors (pressoreceptors) located in the walls of the aorta and carotid arteries are sensitive to changes in _____ .
9. If baroreceptors (pressoreceptors) in the walls of the venae cavae are stimulated by stretching, the cardioaccelerator center sends _____ impulses to the heart.
10. Rising body temperature usually causes the heart rate to _____ .
11. Of the ions that affect heart action, the most important ions are calcium and _____ .

PART B

1. Describe the actions of the frog heart chambers during a cardiac cycle.

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2. Attach a short segment of the normal frog heart recording in the following space. Label the atrial and ventricular waves of one cardiac cycle. Enter the average heart rate beneath the recording.

3. Temperature effect results:

Temperature	Heart Rate
10°C (50°F)	
Room temperature	
35°C (95°F)	

4. Summarize the effect of temperature on the frog's heart action that was demonstrated by this experiment. _____

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PART C

Complete the following:

1. Describe the effect of an increased calcium ion (Ca^{++}) concentration on the frog's heart rate._____

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2. Describe the effect of an increased potassium ion (K^{+}) concentration on the frog's heart rate. _____

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Critical Thinking Application

In testing the effects of different ions on heart action, why were chlorides used in each case?

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