

SCIENTIFIC DECISION-MAKING

HEART: BASIC MEASUREMENTS



ABOUT THE PROJECT

Baylor
College of
Medicine

CENTER FOR
EDUCATIONAL
OUTREACH

The Scientific Decision-making curricular unit, produced as part of the project entitled AHRQ's Ischemic Heart Disease Products Translated for High School Populations, was funded by a grant (R18HS019248) from the Agency for Healthcare Research and Quality (AHRQ). The project's goal is to develop—and evaluate the effectiveness of—high school-level teaching materials focusing on evidence-based decision-making using examples related to cardiovascular health.

Activities described in this book are intended for middle or high school students under direct supervision of adults. The authors, Baylor College of Medicine and AHRQ cannot be held responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of BCM or the sponsoring agency.

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ISBN: 978-1-888997-84-2

BioEdSM

BioEdSM Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.

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ACKNOWLEDGMENTS

This project at Baylor College of Medicine has benefited from the vision and expertise of scientists and educators in a wide range of specialties. Our heartfelt appreciation goes to William A. Thomson, PhD, Professor and Director of the Center for Educational Outreach, and C. Michael Fordis, MD, Senior Associate Dean and Director of the Center for Collaborative and Interactive Technologies at Baylor College of Medicine, who have lent their support and expertise to the project.

We are especially grateful to the many classroom teachers in the Houston area who participated in the field tests of these materials and provided invaluable feedback.

All persons depicted in photographs throughout this guide are models and their images are used strictly for illustrative purposes only. The images are not intended to represent the model, nor any person living or deceased.

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HEART: BASIC MEASUREMENTS

Overview

Students are introduced to heart-related data, such as blood pressure and oxygen saturation, from the continuing stories of Arturo, Brian and Angela. They also learn basic information about the heart and circulatory system.

What Is in Blood?

Blood, the liquid inside the heart and blood vessels, is comprised of fluid plasma and several different kinds of cells. Red blood cells (erythrocytes) contain hemoglobin, a molecule that binds to and transports oxygen. White blood cells (leukocytes) are found in blood and the fluid in tissues. There are several kinds of white blood cells, each with a specific role in protecting the body from invading microbes and foreign materials. Blood platelets are fragments of bone marrow cells that help blood to clot. Many other substances are carried in blood: glucose, amino acids, vitamins, hormones, proteins and ions (such as sodium, bicarbonate and potassium).

To survive, human body cells must exchange gases (oxygen and carbon dioxide), receive nutrients (like glucose), and eliminate wastes. These processes require an efficient system to transport substances around the body. The lungs play a key role, enabling the body to obtain oxygen from the atmosphere and eliminate carbon dioxide waste. Meanwhile, the digestive system provides nutrients for survival and works with the liver and kidneys to remove waste products from the body. The transportation network for these gases and nutrients is our closed circulatory system, which, amazingly, consists of 60,000 to 100,000 miles of blood vessels.

All of this circulation begins with the unique pump in the chest, the heart. Weighing less than a pound and a little larger than a fist, this tireless organ beats approximately 100,000 times every day—nearly three billion times in a lifetime. Even at rest, the heart works twice as hard as the leg muscles of a person running a sprint.

Birds and mammals, including humans, have four-chambered hearts. Two chambers (atria) receive blood and the other two (ventricles) pump it out. The right side of the heart receives oxygen-poor blood from the body and sends it to the lungs to be re-oxygenated. The left

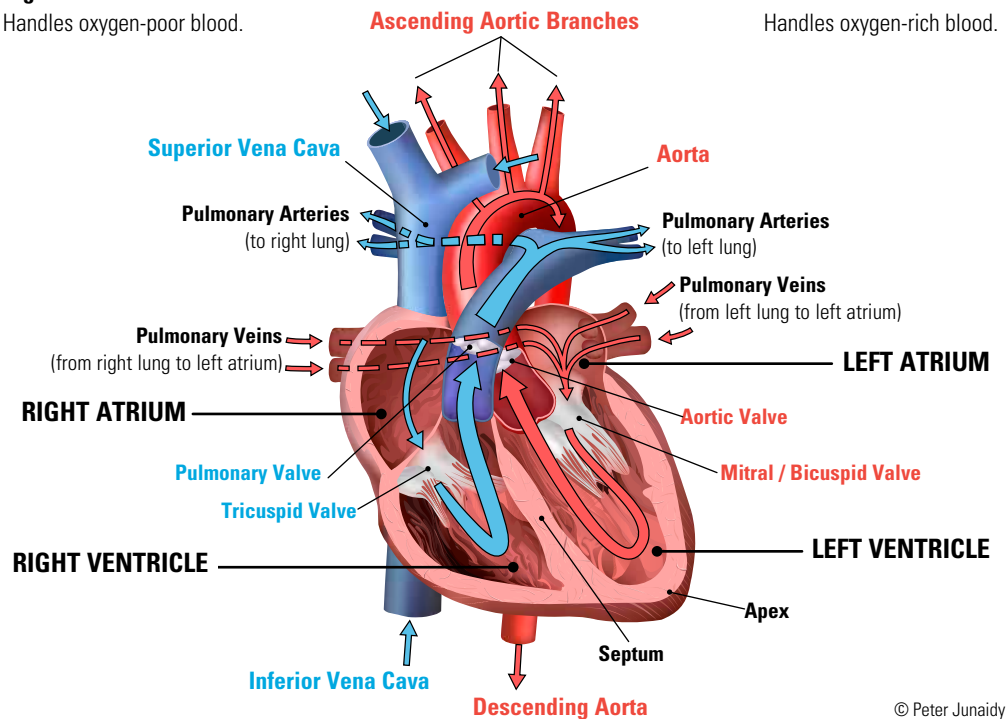
The Heart Pumps Blood In and Out

Right Side

Handles oxygen-poor blood.

Left Side

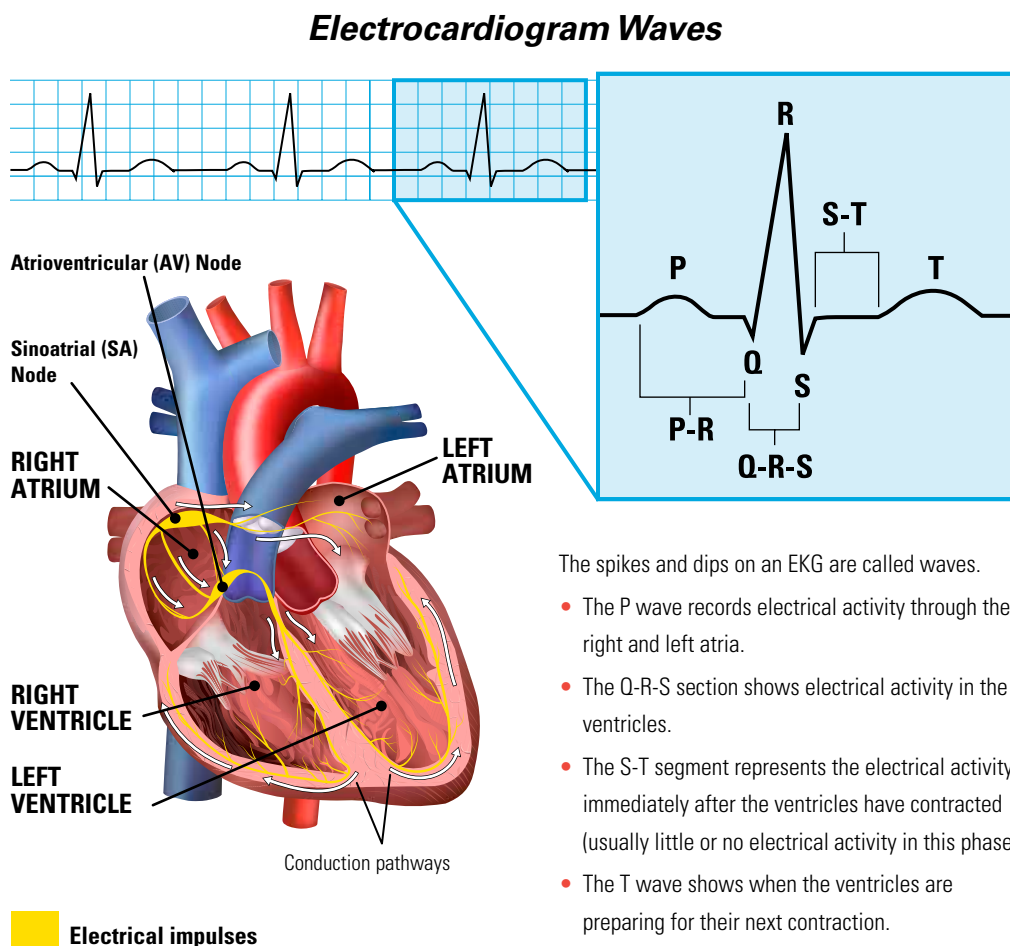
Handles oxygen-rich blood.



© Peter Junaidy

Fast Facts

According to the American Heart Association, possible risk factors for high blood pressure include: family history (high blood pressure runs in some families); advanced age; lack of physical activity; poor diet, especially one high in salt (sodium); being overweight or obese; and drinking too much alcohol.



Electrical impulses

Heart illustration © Peter Junaidy. Graphic from composite image © Healthwise, Inc.

side of the heart receives oxygen-rich blood from the lungs and pumps it out to the body. The “lub-dub” heartbeat you hear through a stethoscope corresponds to (1) the closing of one-way valves after blood has moved from the receiving chambers (atria) into the pumping chambers (ventricles); and (2) the closing of one-way valves at the base of the ventricles.

The heart pumps about once per second throughout our lifetimes. A resting adult circulates more than a gallon of blood throughout the body every minute; more than 2,000 gallons per day; nearly three-quarters of a million gallons each year. In a lifetime, our hearts will pump enough blood to fill three super tanker ships! The National Health Lung and Blood Institute offers an excellent animation of heart contraction and blood flow (<http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html>).

Electrocardiogram. We cannot directly observe contractions and movement of blood through the heart, but we can study the process indirectly by recording the heart’s electrical activity. With each heartbeat, an electrical signal spreads from the top of the heart to the bottom, causing the heart to contract and pump blood. This signaling process repeats with every heartbeat. An electrocardiogram (EKG or ECG) uses electrodes attached to the skin to collect information about these electrical signals, including their strength and timing when passing through each section of the heart. Information gathered from an EKG is presented

Blood Pressure Terms

Systole, the phase of heart contraction, is derived from the Greek word for “contract.” Diastole, the relaxation phase, is from the Greek for “dilation” or “lengthening.”

CATEGORIES FOR BLOOD PRESSURE LEVELS IN ADULTS⁵ (measured in millimeters of mercury, or mm HG)

Category	Systolic (top number)	Diastolic (bottom number)
Normal	<120	<80
Pre-hypertension	120–139	80–89
High Blood Pressure		
Stage 1	140–159	90–99
Stage 2	160+	100+

as a graph, which shows how fast the heart is beating and whether the rhythm is steady or irregular. The standard pattern of peaks and valleys in an EKG corresponds to alternating contractions and relaxation of the heart’s chambers. Visit the URL below to view an online animation demonstrating how an EKG translates activity of the heart into a readable graph (<http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/electrical.html>).

EKG/ECG is not the only way to observe or measure heart function and blood circulation. Additional methods are discussed below.

Pulse. Each time the heart beats, a surge of blood, known as a pulse, passes through the arteries. The pulse can be detected in specific locations, such as the wrist or neck, where arteries run near the surface of the skin. The number of pulses per minute provides a good estimate of heart rate. A normal resting heart rate in adults is 60–90 beats per minute.

Blood Pressure. When the heart pumps, moving blood generates pressure against artery walls. Blood pressure can be an indicator of one’s health or risk for certain diseases. It is measured at two different time points: when the heart is contracting and causing a surge of blood (systolic pressure); and when the heart is at rest between beats (diastolic pressure). Blood pressure usually is written as a ratio, with the systolic number above the diastolic number, such as 120/80 mm Hg. (The unit “mm Hg” refers to millimeters of mercury, a way of measuring pressure.)

The table at left shows healthy and unhealthy blood pressure values.

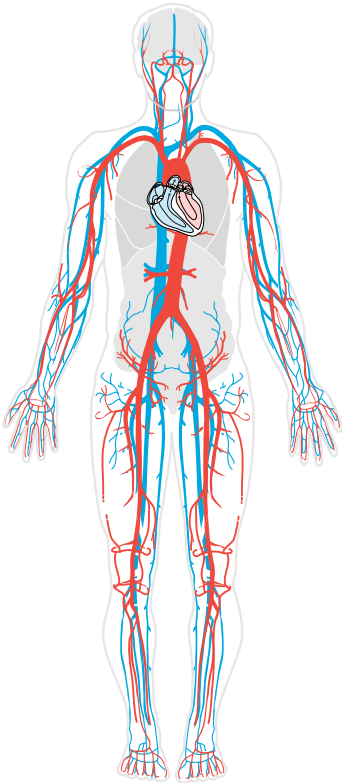
Oxygen Saturation. Oxygen saturation is a common diagnostic test used to determine whether the heart and lungs are supplying the body with enough oxygen. Pulse oximetry (“pulse ox”) uses a light sensor attached to a patient’s finger to estimate oxygen levels in the blood (based on absorption of different wavelengths of red light). Healthy blood oxygen saturation levels vary from 94% and 99% (i.e., oxygen occupies between 94% and 99% of the hemoglobin binding sites in the bloodstream). These values are affected by the amount of oxygen in air, which decreases at higher altitudes, so a person who lives at sea level might have a normal reading of 98% at home, but 95% when he or she is in a mountain village 5,000 feet above sea level.

Stroke Volume and Cardiac Output. Circulation begins with the heart, a complex pump that provides the initial force for blood flow through the body. The heart provides enough force to send blood to the toes and back in 16 seconds, thereby providing oxygen and nutrition for the body’s 75 trillion cells. Clearly, it is extremely important to maintain a healthy heart.

Two measurements that help to determine heart health are stroke volume and cardiac output. Stroke volume is the amount of blood pumped by the left ventricle with each beat. Cardiac output is the amount of blood pumped by the left ventricle every minute. These values can be estimated based on an individual’s body size. Actual values are determined by a diagnostic procedure, called an echocardiogram. Comparisons of the estimated and actual values make it possible to determine the amount of heart muscle damage caused by disease or a heart attack.

Various disease states of the heart can reduce cardiac output so much that the heart becomes unable to supply enough blood flow (oxygen and nutrients) to meet the needs of the body cells. This condition, known as heart failure or cardiac insufficiency, is costly, disabling and potentially deadly.

The Circulatory System



Modified illustration by M.S. Young © Williams & Wilkins. All rights reserved.

MATERIALS

Teacher

- Set of Heart Facts Cards, printed on card stock and pre-cut to create a class set of cards
- Set of Heart Basics Station Cards, including Nomogram for Estimating Body Surface Area
- Computer and projector, interactive white board or overhead projector
- Automatic blood pressure cuff (arm or wrist)
- Finger pulse oximeter
- Digital thermometer and disposable tips
- Tape measure (feet and inches)
- Bathroom scale
- Wall clock with second hand, or small timers, or stop watches at stations C and D

Per Student

- Copy of "Heart Basics/Personal Data Sheet" (PDS)

SETUP

Print or copy the Heart Facts Cards on card stock and pre-cut the cards to create a classroom set. Make copies of the Heart Basic Station cards on card stock and cut each sheet in half to separate the two cards. Make a copy of "Heart Basics/Personal Data Sheet" for each student. Set up one or more of each of the following stations around the classroom.

- **Station A:** Body Temperature card and a digital thermometer, plus disposable thermometer tips
- **Station B:** Blood Pressure card and a digital blood pressure cuff for arm or wrist (available at most drug stores for \$15–\$60)
- **Station C:** Heart (Pulse) Rate card and timer or clock with a second hand
- **Station D:** Respiration (Breathing) Rate card and timer or clock with a second hand
- **Station E:** Oxygen Saturation card and finger pulse oximeter (available at most drug stores for \$35–\$50)
- **Station F:** Electrocardiogram (EKG) card and computer with Internet access set for students to view the following page: <http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/electrical.html>
- **Station G:** Heart Stroke Volume card, and copy of "Nomogram," page, tape measure attached to a wall, 12-inch ruler, bathroom scale
- **Station H:** Cardiac Output card

Conduct the first part of the activity as a class discussion. For the second part, have students work in teams of two or four, and rotate through each diagnostics station. Some teachers prefer to set up two stations for each measurement.

An answer key for the statements on the Heart Facts cards is provided on page 31.

PROCEDURE

1. Remind students of the previous class session, during which they learned of three health emergencies. Students also learned about lifestyle choices and behaviors that can contribute to poor cardiovascular health. Tell students that now they will investigate the heart and circulatory system further, and learn more about the tests used by emergency medical personnel who treated Arturo, Brian and Angela.
2. Distribute one Heart Facts Card to each student. Tell students that not all of the "facts" on the cards are true. Have each student read his or her card aloud. The rest of the class should raise their hands if they believe the statement to be true.

Heart Contraction and Blood Flow



<http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html>

Image courtesy of the National Heart, Lung, and Blood Institute, National Institutes of Health.

Information Resources

- **American Heart Association**
<http://www.heart.org>
- **National Heart, Lung and Blood Institute**
<http://www.nhlbi.nih.gov>
- **Mayo Clinic**
<http://www.mayoclinic.com>

3. Initiate a short discussion by asking, *Were you surprised by any of the facts? Which ones and why?* Tell students that they will learn more about how to measure heart function.
4. Ask, *Why did most of the tests performed on Arturo, Brian and Angela relate to heart function?* Encourage students to discuss the tests, and lead them to understand that the heart is essential because it pumps blood throughout the body. Blood carries vital oxygen and nutrients to all cells and every body system (digestive, excretory, respiratory, muscular, etc.). It also transports and removes carbon dioxide and other waste products from every body system. We cannot live without blood circulation, and blood cannot circulate without the heart.

If students are unfamiliar with the heart and circulatory system, show the following animation, Heart Contraction and Blood Flow, at the National Heart, Lung, and Blood Institute's website (<http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html>).

5. Tell students that they will visit stations set up around the room to gather statistics similar to those obtained for Arturo, Brian and Angela. Point out the instruction card at each location, and demonstrate how to use the equipment and collect information at each station. Note that Station H requires data collected at Stations C and G, and that students must complete those Stations before going to Station H.
6. Distribute copies of the "Heart Basics/Personal Data Sheet," and have students work in teams of two to four as they circulate through each station. If a station they need to visit is occupied, instruct students to wait in their seats until it is available.

Briefly discuss the importance of protecting patient confidentiality, emphasizing that information on the Personal Data Sheet is not to be shared. Explain that students are responsible for protecting their personal data.
7. If students are concerned about any of their personal readings (for example, high blood pressure), suggest that they visit the school nurse to receive new, possibly more accurate measures.
8. Conclude the activity by discussing students' observations about their vital signs. Their investigations of resting and active pulse rates, respiration and cardiac output should enable students to understand that our bodies' cells require more oxygen and nutrients at times of increased pulse or respiration rates (during exercise, for example).
9. Tell students to keep their personal data sheets for use with the activity, "Calculating Coronary Artery Disease Risk."

EXTENSIONS OR HOMEWORK

One out of three Americans has high blood pressure. Often, the causes are unknown, but it possible to identify, and sometimes treat, risk factors for high blood pressure. Have students visit one or more of the websites listed in "High Blood Pressure Information Resources" (left sidebar), and find at least four different factors that increase a person's risk for high blood pressure. Students should list the factors, write one or two sentences describing the associated risks, and provide the name and URL of the website from which the information was obtained.

⁵ National Heart, Lung and Blood Institute (<http://www.nhlbi.nih.gov/hbp/detect/categ.htm>).

TEACHER ANSWER KEY

FOR HEART FACTS CARDS

The following statements from the Heart Facts Cards (identified by number below) are FALSE. Correct answers are given in italics.

1. Each day, the adult human heart beats approximately 10,000 times.
The heart beats 100,000 times each day.

10. A common test uses a light sensor attached to the finger to estimate the level of CO₂ in the blood.
A common test uses a light sensor to estimate the level of oxygen (O₂) in the blood.

11. It takes only one minute for blood to travel from the heart, to the brain and back to the heart.
It only takes eight seconds for blood to travel from the heart, to the brain and back to the heart.

15. Reptiles, birds and mammals all have 5-chambered hearts.
Reptiles, birds and mammals all have 4-chambered hearts.

16. Blood accounts for about 15% of your total body weight.
Blood accounts for about 7–8% of your total body weight.

17. An electrocardiogram, or EKG, creates a graph of the electrical activity within the brain.
An EKG creates a graph of the electrical activity within the heart.

18. Too much sleep can cause irregular jumping heartbeats, called premature ventricular contractions (PVCs).
Prolonged lack of sleep can cause irregular jumping heartbeats.

20. A man's heart typically beats faster than a woman's heart.
A woman's heart typically beats faster than a man's.

26. Blood pressure is the force exerted by moving blood against the walls of the veins.
Blood pressure is the force exerted by moving blood against the walls of the arteries.

29. Hardening of the arteries results from the buildup of cholesterol and iron inside blood vessels.
Hardening of the arteries results from the buildup of cholesterol and fat.

31. Blood flows in both directions within arteries and veins.
Blood flows in one direction. Arteries carry blood away from the heart; veins carry blood toward the heart.

HEART FACTS CARDS

1

Each day the adult human heart beats approximately 10,000 times.

2

A faucet would need to be open with the water running for at least 45 years to equal the amount of blood pumped by the heart in an average lifetime.

3

The adult heart is a little larger than your fist.

4

Every day, the heart uses enough energy to drive a truck twenty miles. In a lifetime, that's equivalent to driving to the moon and back.

5

Adults have almost 60,000 miles of blood vessels.

6

Because the heart has its own electrical impulses, it can continue to beat outside of the body.

7

Each day the adult human heart pumps more than 2,000 gallons of blood through the body.

8

The heart pumps enough oxygen and nutrients to maintain the 75 trillion cells of the human body.

9

During an average lifetime, the heart will pump enough blood to fill 200 train tank cars.

10

A common test uses a light sensor attached to the finger to estimate how much CO₂ is being carried in blood.

11

It takes only one minute for blood to go to the brain and back to the heart.

12

It takes only 16 seconds for blood to reach the toes and return to the heart.

13

Fish have a 2-chambered heart.

14

Frogs and salamanders (amphibians) have 3-chambered hearts.

15

Reptiles, birds, and mammals all have 5-chambered hearts.

16

About 15 percent of your total body weight is blood.

17

An electrocardiogram or EKG creates a graph of the electrical activity of the brain using information from electrodes attached to the skin.

18

Too much sleep can cause irregular jumping heartbeats called premature ventricular contractions (PVCs).

HEART FACTS CARDS

19 "Atrium," the upper chambers of the heart, is Latin for "entrance hall," and "ventricle," the lower chambers of the heart, is Latin for "little belly."

20 A man's heart typically beats faster than a woman's heart.

21 Blood is considered to be a connective tissue of the body.

22 Blood pressure is measured at two time points: when the heart contracts, causing a surge of blood, and when the heart rests between beats.

23 French physician Rene Laennec (1781-1826) invented the stethoscope when he felt it was inappropriate to place his ear on large-bosomed female patients' chests.

24 William Harvey, an English physician, concluded that there was a fixed amount of blood in the body and that it circulated in one direction.

25 Cocaine affects the heart's electrical activity and causes spasms of the arteries—which can lead to a heart attack or stroke, even in healthy people.

26 An adult woman's heart weighs about 16 ounces, a man's heart weighs about 32 ounces.

27 The aorta, which is the largest artery in the body, is about the same diameter as a garden hose.

28 The heart is located near the center of the chest, not on the left side.

29 Hardening of the arteries results from the buildup of cholesterol and iron inside blood vessels.

30 Beating of the heart is controlled by electrical signals.

31 Blood flows in both direction in the arteries and veins.

32 It takes 10 capillaries to equal the thickness of a human hair.

33 A heart attack happens when the flow of blood to the heart muscle itself becomes blocked.

34 Squid have three hearts: Two hearts to feed the gills for oxygen exchange, and one heart to pump blood around the body.

HEART BASICS

PERSONAL DATA SHEET (PDS)

PRIVACY NOTICE

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) requires that you maintain the confidentiality of personal health information. It is your responsibility to keep your personal data confidential. Do not write your name on this document. If you prefer, you may leave some of the spaces blank, but you must remember the numbers for calculation purposes.



Station A: Body Temperature

Your temperature. _____ °F



Station B: Blood Pressure (mm Hg)

Diastolic pressure: _____ mm Hg

Systolic pressure: _____ mm Hg

Pulse rate (if given by meter): _____ beats/minute



Station C: Heart (Pulse) Rate

Measurement 1: _____ beats/15 seconds

Measurement 2: _____ beats/15 seconds

Measurement 3: _____ beats/15 seconds

Average: _____ x 4 = _____ **beats/minute**

Exercise rate: _____ x 4 = _____ **beats/minute**



Station D: Respiration Rate

Normal rate: _____ breaths/minute

Exercise rate: _____ breaths/minute



Station E: Oxygen Saturation (Pulse ox)

Percentage of oxygen in your blood. _____ %



Station F: Electrocardiogram (EKG)

Use the back of this sheet for notes.



Station G: Heart Stroke Volume (SV)

Height: _____ ft/in. Weight: _____ lbs

Body Surface Area (BSA): _____ m²

Heart Stroke Volume: _____ x 42.5 = _____ mL



Station H: Cardiac Output (CO)

You need the results from Stations C and G for this Station.

Resting rate: _____ x _____ = _____ mL

Exercise rate: _____ x _____ = _____ mL

Why do you think cardiac output increases with exercise? Write a short paragraph explaining your answer on the back of this sheet of paper.

MAKE AN INSIDE FOLD HERE TO KEEP YOUR DATA PRIVATE.

STATION CARDS



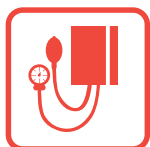
STATION A: BODY TEMPERATURE

Temperature in degrees Fahrenheit.

1. Prepare the digital thermometer by covering the tip (probe) with a plastic probe cover. The cover is a thin plastic sheath found within the bandage-size paper wrapper. Slide the probe tip between the two layers of the paper cover until it stops. Remove the paper from both sides. The thermometer is ready to use.
2. Press the small button next to the window to turn the thermometer on. The number 188.8 °F will appear, followed by the last temperature measured. After two seconds, the window will clear.
3. Insert the probe, with cover in place, into your mouth under your tongue. Wait 60 seconds and read the temperature. You may hear a beep when ready. Record your temperature on your PDS.
4. Discard the cover.
5. Proceed to the next station.



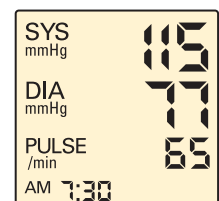
© Yuliyana Velchev



STATION B: BLOOD PRESSURE (MM Hg)

Pressure exerted by blood flow on the walls of the arteries.

1. Sit down and relax for 30 seconds.
2. Review the operating instructions for the blood pressure monitor. It will be a device either placed on your wrist or wrapped around your upper arm, just above the elbow. The inflatable part of the monitor is the cuff.
3. If you are wearing a heavy shirt or sweater, roll up your sleeve to make better contact with the cuff.
4. Sit calmly and turn on the monitor. The monitor will inflate the cuff to provide pressure on your wrist or arm. Gradually, the cuff will deflate as it records your systolic (heart stroke) pressure and diastolic (heart rest) pressure. The monitor may also measure your pulse rate.
5. When the monitoring cycle is complete, write your numbers on your PDS.
6. Proceed to the next station.



**Typical face
on a digital
blood pressure
monitor**

STATION CARDS



STATION C: HEART (PULSE) RATE

Number of heartbeats occurring in one minute.

1. Sit down and relax for 30 seconds.
2. Locate the radial pulse point on one of your wrists. This is a point just below the palm on the thumb side. Place two fingers on this point and feel for the rhythmic pulsing of your heart. You may have to adjust your finger position and pressure slightly to feel the pulse.
3. Watch a clock with a second hand and count the number of pulses you feel for 15 seconds. Record this number on your PDS.
4. Repeat the process and measure your pulse rate twice more. Record your results.
5. Total your three measurements and divide by three to obtain an average. Multiply the average by four to get your pulse rate per minute.
6. Run in place for 60 seconds, and repeat and record your pulse measurement.
7. Proceed to the next station.



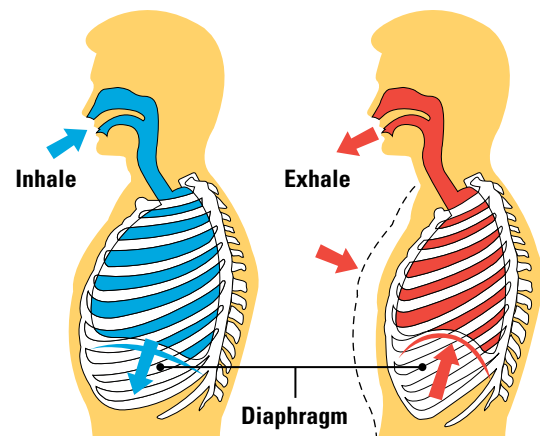
© Andrii Kovalenko



STATION D: RESPIRATION (BREATHING) RATE

Number of breaths taken in one minute.

1. Sit down and relax for 30 seconds. If you have just finished Station C, give yourself two minutes to return to a resting rate.
2. Using a clock with a second hand or a stopwatch as a reference, count the number of times you breathe for one minute. One complete breath consists of an inhale and an exhale. Record your results on your PDS.
3. Run in place for 60 seconds, and repeat and record your breathing rate measurement.
4. Proceed to the next station.



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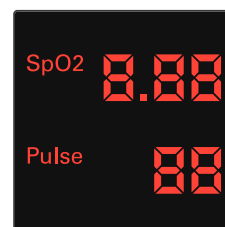
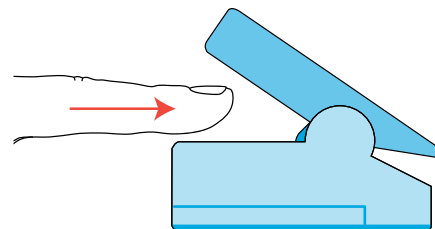
STATION CARDS



STATION E: OXYGEN SATURATION (PULSE OX)

How much oxygen the blood is carrying, expressed as a percentage of the maximum it could carry.

1. Pick up the pulse oximeter and squeeze the upper ends together with the fingertips of one hand. This will open the lower end where the sensor is located.
2. While holding the oximeter open, insert one of your index fingers all the way into the opening.
3. Release your grip on the oximeter. It will close on your fingertip and automatically begin monitoring your oxygen saturation. Wait for the readings to appear.
4. Record the percentage of oxygen in your blood on your PDS.
5. The oximeter also will display your pulse rate. Record this rate and compare it to your pulse rate, as determined by Station C.
6. Proceed to the next station.



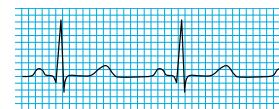
Typical face on a pulse oximeter



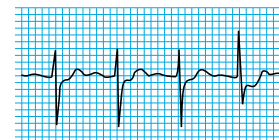
STATION F: ELECTROCARDIOGRAM (EKG)

Graph of electrical signals produced by contraction in different sections of the heart.

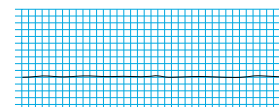
1. Enter this address on the computer to bring up an animated diagram explaining Your Heart's Electrical System.
<http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/electrical.html>
2. This presentation demonstrates the relationship between the heart's activity and the graph lines in an electrocardiogram.
3. Take notes as needed on your PDS. Use the back of this sheet if more space is needed.
4. Compare the three electrocardiograms to the right.
5. Proceed to the next station.



Normal EKG



Abnormal EKG



Flat Line

STATION CARDS



STATION G: HEART STROKE VOLUME (SV)

Amount of blood pumped out to the body with each beat of the heart's left ventricle.

1. With the help of a partner, measure your height in feet and inches. Stand with your back against the measuring sticks taped to the wall. Look straight ahead while your partner places a ruler on the top of your head. The ruler should be level and your partner will read your height. Record the number on your personal data sheet (PDS). Assist your partner in measuring his or her height.
2. Measure your weight in pounds. Record the number on your PDS.
3. Use the nomogram to determine your body surface area in square meters. Find your height in column A and your weight in column B. Place the straight edge of a ruler across these two points. Find your body surface area in square meters where the ruler edge crosses column C. Record your answer.
4. Calculate your heart stroke volume by multiplying your body surface area times 43.5. The answer is the volume of blood pumped with each stroke. Record your answer.
5. Proceed to your next station.



STATION H: CARDIAC OUTPUT (CO)

Amount of blood pumped from the left ventricle of the heart per minute.

You will need the data from Stations C and G before beginning.

1. Cardiac output is the volume of blood pumped by the heart in one minute. Determine your resting cardiac output by multiplying your stroke volume (Station G) by your resting pulse rate (Station C). Record your answer on your PDS.
2. Determine your exercise cardiac output by multiplying your stroke volume (Station G) by your exercise pulse rate (Station C). Record your answer.
3. Proceed to your next station.



STATION C: HEART (PULSE) RATE

Number of heartbeats occurring in one minute.

1. Sit down and relax for 30 seconds.
2. Locate the radial pulse point on one of your wrists. This is a point just below the palm on the thumb side. Place two fingers on this point and feel for the rhythmic pulsing of your heart. You may have to adjust your finger position and pressure slightly to feel the pulse.
3. Watch a clock with a second hand and count the number of pulses you feel for 15 seconds. Record this number on your PDS.
4. Repeat the process and measure your pulse rate twice more. Record your results.
5. Total your three measurements and divide by three to obtain an average. Multiply the average by four to get your pulse rate per minute.
6. Run in place for 60 seconds, and repeat and record your pulse measurement.
7. Proceed to the next station.



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STATION G: HEART STROKE VOLUME (SV)

Amount of blood pumped out to the body with each beat of the heart's left ventricle.

1. With the help of a partner, measure your height in feet and inches. Stand with your back against the measuring sticks taped to the wall. Look straight ahead while your partner places a ruler on the top of your head. The ruler should be level and your partner will read your height. Record the number on your personal data sheet (PDS). Assist your partner in measuring his or her height.
2. Measure your weight in pounds. Record the number on your PDS.
3. Use the nomograph to determine your body surface area in square meters. Find your height in column A and your weight in column B. Place the straight edge of a ruler across these two points. Find your body surface area in square meters where the ruler edge crosses column C. Record your answer.
4. Calculate your heart stroke volume by multiplying your body surface area times 43.5. The answer is the volume of blood pumped with each stroke. Record your answer.
5. Proceed to your next station.

NOMOGRAM

FOR ESTIMATING BODY SURFACE AREA (BSA)

EXAMPLE

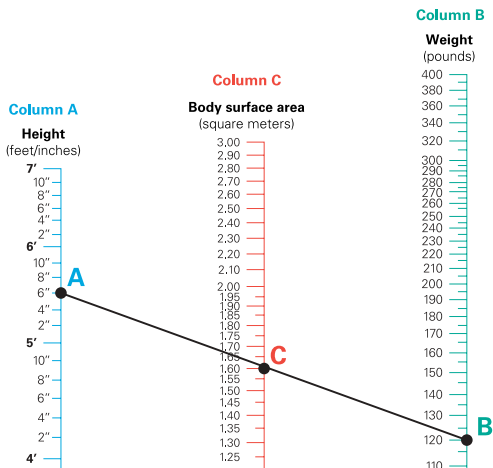
In the nomogram below, the subject is 5 ft, 6 in., in height (A) and weighs 120 lb (B).

Body surface area (BSA) is revealed by connecting the dots with a line (see below).

Heart Stroke Volume in mL is determined by multiplying BSA x 43.5.

In this example, the equation and result are as follow.

$$1.6 \text{ m}^2 \times 43.5 \text{ mL/m}^2 = 69.6 \text{ mL}$$



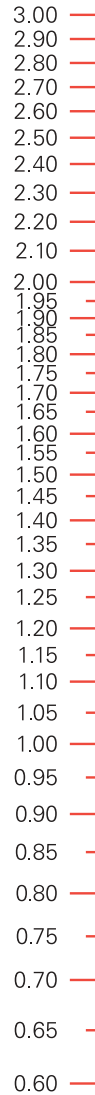
Column A

Height (feet/inches)



Column C

Body surface area (square meters)



Column B

Weight (pounds)

