Jumping for Joy!

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Field(s) of Interest: Medicine, Physiology, Biology, Anatomy

Brief Overview:
Mentees will explore the cardiopulmonary system and how it relates to exercise and daily activity. By the end of the lesson, they will be able to identify key components of the respiratory and cardiovascular systems and how they work together.

Agenda:

- Introduction (5 min)
- Module 1: Just Keep Breathing (15-20 min)
- Module 2: Where does the blood go? (20-25 min)
- Module 3: Now you Jump! (10-15 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

- ➔ Respiratory system
- ➔ Lungs
- ➔ Air Pressure
- ➔ Cardiovascular system
- ➔ Arteries
- ➔ Veins
- ➔ Heart rate
- ➔ Heart/involuntary muscle

Background for Mentors

Module 1

- Respiratory System
- Lungs
- Diaphragm
- Trachea
- Ventilation
- Respiration

The **Respiratory System** is made up of the mouth, larynx, trachea, bronchi, lungs, and alveoli, the organs and structures that allow for gas exchange. In other words, oxygen in the air is brought into our bodies through the respiratory system.

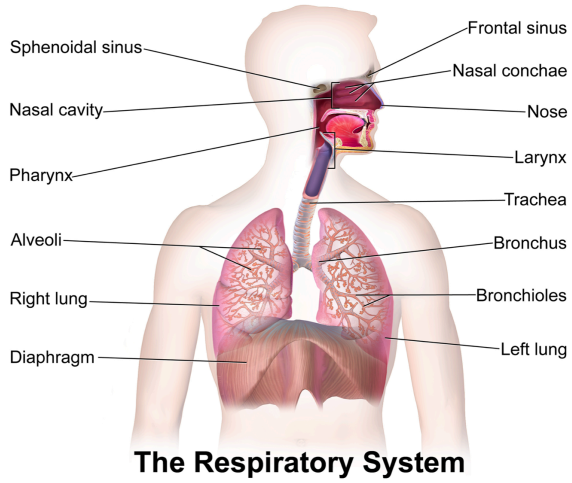


Figure 1: Anatomy of the respiratory system

Air is brought in from the outside environment, warmed, and humidified in the mouth. It then travels through pharynx and larynx (commonly referred to as the “voice box”). The larynx also contains the epiglottis which acts as a door between the pharynx and trachea. The **trachea** is a tube structure supported by rings of cartilage. The respiratory system then branches off into bronchi (larger), and later bronchioles (smaller), finally ending at the alveoli (small air filled sacs where gas exchange occurs between oxygen and carbon dioxide).

Lungs are the primary organ of the respiratory system, filling with air containing oxygen for use in the body, and removing carbon dioxide from it. They are made up of lobes, with two on the left and three on the right, due to the heart’s position in the chest cavity. The lungs don’t breathe on their own, rather they are supported by the relaxation (exhale) and contraction (inhale) of the **diaphragm,** a large muscle that reduces the air pressure inside the lungs compared to the outside, which draws air in through negative pressure.

Ventilation is the process of taking in air, and **respiration** is the actual process of gas exchange that allows oxygen to enter the bloodstream and carbon dioxide to leave it.

Module 2

- Cardiovascular system
- Pump
- Arteries
- Veins
- Heart chambers
  - Atria
  - Ventricles
- Blood pressure

The **cardiovascular system** is the infrastructure for circulating nutrients around the body. It is made up of the heart, which acts as a **pump** for blood (carrying nutrients absorbed from food and oxygen from the air throughout the body). Blood going away from the heart is carried in blood vessels called **arteries**, while blood going towards the heart is carried in **veins**. When the heart relaxes, it fills with blood. When it contracts, the blood is pushed out through blood vessels to the rest of the body.

This is a simplified view of the anatomy of the heart, made up of different chambers which allow for the flow of blood to be regulated. Blue blood vessels are deoxygenated (no oxygen), and red vessels are oxygenated. The gas exchange where oxygen is brought into the bloodstream takes place in tiny branches of the arteries and veins called capillaries. The lungs allow oxygen to enter and carbon dioxide to leave the bloodstream.

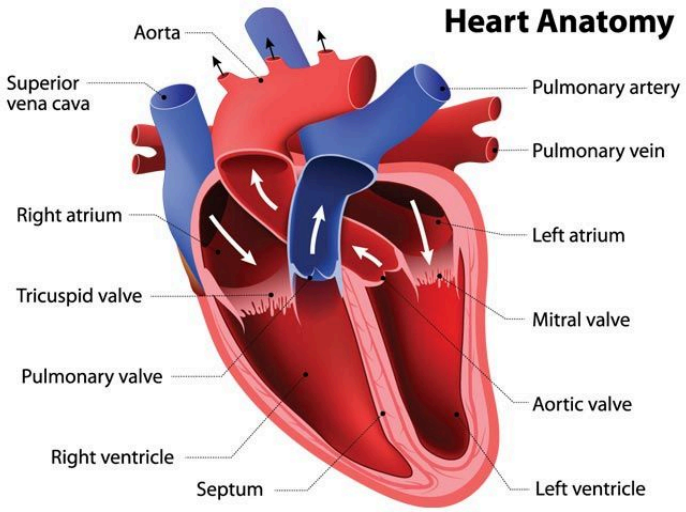


Figure 2: heart anatomy and circulation

The blood first comes in from the body through the vena cava (vein), into the right **atrium** (the first chamber), flows into the right **ventricle**, and is pumped into the lungs. Once the blood is filled with oxygen in the lungs, it moves to the left atrium, into the left ventricle, and out into the body through the aorta (main artery).

Blood pressure is the amount of force your heart uses to pump blood through your veins and arteries. It raises with stress in the short term and various health conditions in the long-term.

Module 3

- Heart rate
  - Cardiac output
- Cardiopulmonary system
- VO2 max
- Endurance
- Involuntary muscle
- Control group

Heart rate, measured in beats per minute, is the number of times your heart muscle contracts per minute, pumping blood throughout the body. **Cardiac output** is the volume of blood that is pumped by the heart per minute, typically about 5-6 Liters/min.

The **cardiopulmonary system** is the integration of the cardiovascular and respiratory systems. Through the cardiopulmonary system, blood is brought to the heart, pumped out to the lungs, oxygenated, returned to the heart, and finally pumped out to the body. This happens every time your heart beats. The oxygen gets into the lungs through inhalation into the lungs within the respiratory system. The two processes work together to deliver our bodies the essential oxygen that cells need to function.

CARDIO = heart
PULMONARY = lungs

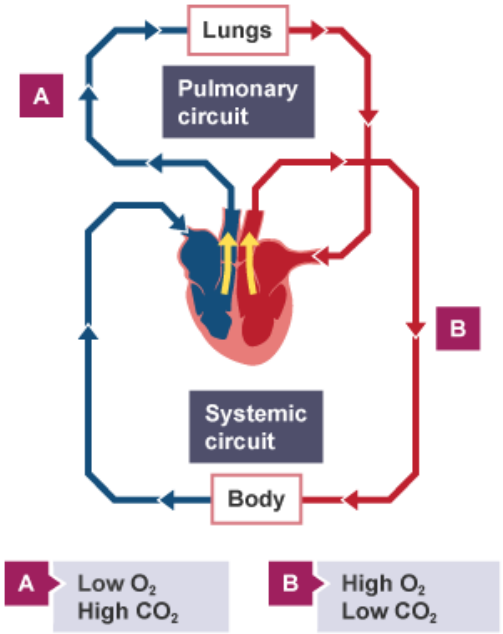


Figure 1: Blue = deoxygenated, Red = oxygenated

VO2 max is the maximum volume of oxygen that your body can absorb during exercise. A higher VO2 max indicated a strong heart and lungs, which are more able to fuel muscles during intense activity. It is also seen as a good indicator for overall health. To use a car analogy, a higher VO2 max

capacity (horsepower) leads to better ability to generate useful energy and drive fast. But unlike a car, you can teach your body to have a higher horsepower and move faster and longer through training.

Higher VO2 max is associated with better **endurance**, which is your body's ability to continue doing an activity for a long period of time. Regular physical activity, including endurance activity (brisk walking, jogging, dancing, biking, and more) has been shown to reduce the risk of many diseases.

Usually when we think of muscle, we think of skeletal muscle, that we can tell what to do. This is called voluntary muscle. The heart is made up of **involuntary muscle**, so we don't have to consciously tell our heart to beat. It is controlled by an automatic electrical conduction system, which creates the rhythmic pump that is essential to keep us alive.

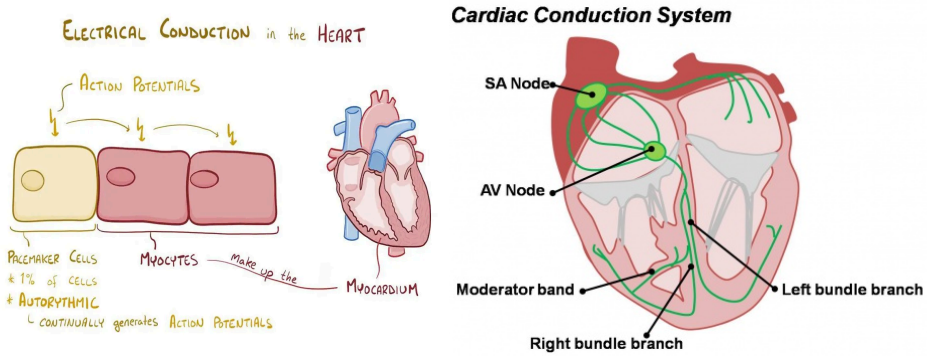


Figure 2: Overview of electrical conduction in the heart

A **control group** is an experimental group that is not given a treatment, as a baseline to compare with another group that was given a treatment. In this case, the control is before the mentees exercise, while the treatment group is after they exercise. In the second part, we can compare mentees who do not jump (control) to ones who do, and compare heart rates.

Introduction

Concepts to Introduce	**Questions to Pique Interest**
● Cardiovascular system: highway analogy where the blood is the delivery trucks, taking nutrients and oxygen all throughout your body, and the blood vessels are the road ● Respiratory system: organs that bring oxygen from the air into our bodies ● Ventilation is like walking into a kitchen, and Respiration is like actually cooking ● VO2 max: How much oxygen your body can take in to fuel your heart and lungs while you exercise, like the fuel that car engines can use to drive fast	● Why do you think your chest moves when you breathe? ● Do you think the lungs breathe by themselves, or do they have help? ● Have you ever run really fast and had to stop to catch your breath? ● Do you remember a time you were playing outside and could hear your heart beating really loud? ● Why can you feel your heartbeat in your wrist if your heart is in your chest?
Scientists, Current and Past Events	**Careers and Applications**
● William Harvey discovered the **circulation of blood** by looking at transparent cold blooded fish. ○ https://www.helencowan.co.uk/heart-hero-who-discovered-heartbeat ● **Physical activity** improves academic performance, heart and lung health, brain health, and helps with disease prevention in many ways ○ https://www.cdc.gov/physical-activity-basics/health-benefits/children.html	● Medicine ○ Sports ○ Cardiovascular ○ Emergency ● Physical therapy

Module 1: Just Keep Breathing

Mentees will model the function of lungs through a small group demo with water bottles and balloons.

Teaching Goals

1. **Respiratory System:** The organs and structures that bring oxygen from the air into our bodies.
2. **Lungs**: The organ in the body that fills with air, where oxygen and carbon dioxide exchange, allowing us to breathe.
3. **Diaphragm**: A large muscle that contracts to draw air into the lungs.
4. **Respiration**: Intake of oxygen and removal of carbon dioxide.
5. **Ventilation**: Moving air in and out of the body.

Materials

- Cut plastic water bottles (1 bottle per mentor)
- Balloons (2 per demo)
- knife/scissors

Different Methods for Teaching

1. **Start with real life connection:** Ask mentees to take a deep breath and notice how their chest or abdomen moves.
2. **Lungs vs Diaphragm:** When you pull a syringe plunger back, you create more space for air inside. When your diaphragm moves down, it creates more space in your chest and pulls air into your lungs.
    a. The bottom balloon with the knot represents the diaphragm, and the top represents a lung.
3. **Ventilation** is like walking into or out of a kitchen (air moving in and out of your lungs), and **respiration** is like actually cooking a dish (useful gas exchange).

Procedure

1. Break into small groups, each led by a mentor.
2. Attach one balloon to the top of the plastic bottle, with the balloon extending inside.
3. Cut the top ~⅓ off of a second balloon
4. Tie a knot at the bottom of the second balloon.
5. Stretch the balloon over the bottom of the bottle.
6. The Demo:
    a. Pull on the knot in the bottom balloon (gently) and watch the top balloon inflate
    b. Careful not to pull too hard, plastic



Figure 1: *Attach balloons to the cut water bottle.*

bottle edges may be sharp.	 **Figure 1:** *Pull down on the bottom balloon to inflate the top one.*

Classroom Notes

Make sure mentees don't pull too hard on the bottom of the lung demo and expose potentially sharp cut plastic edges. Feel free to poke a hole in **ONE** (demos are reused) of your site's balloons to show what might happen if a lung wasn't working properly.

Module 2: Where does the blood go?

Mentees will create their own cardiovascular system complete with a heart, and blood vessels on a coloring page.

Teaching Goals

1. **Cardiovascular system:** Like a highway where the blood is the delivery trucks, taking nutrients and oxygen all throughout your body, and the blood vessels are the road.
2. **Pump:** When the heart relaxes, it fills with blood. When it contracts, the blood is pushed out through blood vessels to the rest of the body.
3. **Arteries:** Take blood away from the heart.
4. **Veins**: Bring blood towards the heart.
5. **Heart chambers**
    a. **Atria:** Upper chambers of the heart, where the blood comes in.
    b. **Ventricles**: Lower chambers of the heart, where the blood leaves from.
6. **Blood pressure**: The amount of force your heart uses to pump blood through your veins and arteries.

Materials

- 1 coloring page per mentee
- Blue and red yarn
- Glue sticks
- Markers
- Scissors

Different Methods for Teaching

1. **Cardiovascular system** as a **highway**, where the **blood** acts as **delivery trucks** taking nutrients and oxygen **“packages”** all throughout your body.
2. Trees branch off from the **trunk** (arteries and veins close to the heart) into **tiny branches** (blood vessels in fingers and toes).
3. We can compare the heart to a train station. The **atria** are the arrival platforms of the train station where people come in (blood coming into the heart), and the **ventricles** are the departure platforms where people leave (like sending blood back out).

Procedure

1. Distribute outline pages to mentees.
2. Instruct them to draw a heart in the chest that is going to be the central pump for the body.
3. Glue blue yarn (veins) and red yarn (arteries) to the paper
    a. Make sure that they connect to the heart, so that it can pump blood to the whole body!
4. Get creative!

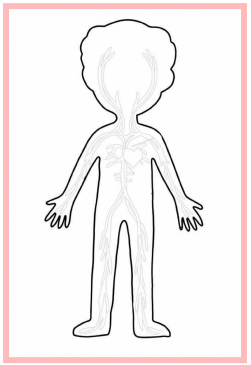


Figure 1: *Distribute these pages to the mentees, and get creative!*

a. Have the mentees connect the yarn in branching patterns through the whole outline.
b. If time, mentees can decorate/add labels like “hand” “ear” or “elbow” to their 3D diagram.

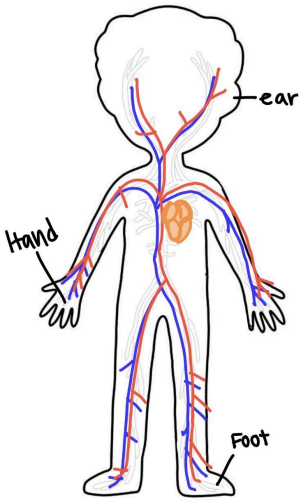


Figure 2: *Example craft page.*

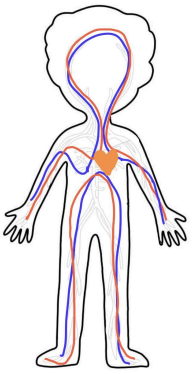


Figure 3: *Simpler alternative.*

Classroom Notes

Let the mentees have fun with their yarn patterns, and try to get the ‘blood vessels’ to reach every part of the body.

Module 3: Now You Jump!

Mentees will apply their knowledge to exercise, and how the cardiopulmonary system makes this happen.

Teaching Goals	**Materials**
1. **Heart rate**: Measured in beats per minute, is the number of times your heart muscle contracts per minute. a. **Cardiac output**: Volume of blood that is pumped by the heart per minute 2. **Cardiopulmonary system**: Word for the cardiovascular and respiratory systems working together 3. **VO2 max**: Maximum volume of oxygen your body can use during exercise. 4. **Endurance**: The ability to continue doing an activity for a long period of time 5. **Involuntary muscle**: Muscle that contracts without us thinking about it. 6. **Control group**: experimental group that is not given a treatment, as a baseline to compare with another group that was given a treatment.	• 1 mentee • Stopwatch

Different Methods for Teaching

1. To pique the mentees' interest about **involuntary muscles**: say "Try to flex your heart," then ask them to compare the action of flexing your heart to the action of flexing your arm muscles.
2. **Connect back to real life:** Think of a time when you exercised. Think about how fast and hard you were breathing and how much oxygen you were taking in. If you were really out of breath really fast, that indicates a **low VO2 max**, and if you weren't out of breath that indicates a **high VO2 max**.
    a. Higher VO2 max is like how a car with high horsepower can generate useful energy and drive fast. But unlike a car, you can teach your body to have a higher horsepower and move faster and longer through training.
3. Compare **heart** to a delivery truck. The **heart rate** is the number of trips it makes each minute, and the **cardiac output** is the total amount of packages the truck can deliver a minute.

Procedure

1. Head outside, or clear space in the classroom, mentees will be moving around!
2. Part 1: Measure Heart Rate
    a. Have the mentees put their index and middle finger against their wrists to feel a pulse.
        i. If mentees struggle, they can also count heartbeats using the artery in their necks.
    b. One mentor begins the stopwatch/timer for 30 seconds and says to start counting beats
    c. Mentees count how many times they feel a beat in those 30 seconds
    d. Multiply that number by 2 to get beats per minute (BPM)
    e. See this video for tips on finding a radial pulse (wrist): https://www.youtube.com/watch?v=XqA4Vc8RaRo
        i. And carotid pulse (neck): https://www.youtube.com/watch?v=bB7j0lvso7Q
3. Part 2: Get Moving
    a. Break out into small groups, each led by a mentor.
    b. Do movements with the mentees for 1 minute.
        i. What is your favorite kind of dance?
        ii. What kind of animal jumps? Move like a Kangaroo!
        iii. Switch it up, keep it interesting!
    c. Set a 30 second timer and ask everyone to count how many times they feel a beat, then double that number → BPM
4. Part 3: Control vs Experimental
    a. Divide the classroom into 2 groups.
    b. One group does jumping jacks for 30



Figure 1: *The mentees playing outside.*



Figure 2: *Jumping jacks will increase heart rate compared to baseline.*

seconds, the other one sits down. c. Repeat the heart rate procedure above and have everyone report their heart rates to the class. d. Compare numbers from the control (sitting) to the experimental (jumping) groups.	

Classroom Notes

Wear something comfortable to site and try to engage the mentees through your own participation and enthusiasm!

Conclusion

Tie the activity in Module 3 back to the anatomical structures that make it possible. How do their lungs and heart work together to let them run and play?

References

- Module 1 activity inspired by: https://www.mombrite.com/balloon-lung-model/
- Module 3 more info about the cardiac conduction system: https://my.clevelandclinic.org/health/body/21648-heart-conduction-system

Summary Materials Table

Material	**Amount per Site**	**Expected $$**	**Vendor (or online link)**
Cut plastic water bottles	5 (1 per mentor)		
Balloons	10 (2 per bottle)	$10	Amazon
Coloring Sheet	1 per mentee		
Blue Yarn	~18in per mentee	$10	Amazon
Red Yarn	~18in per mentee	$10	Amazon
Glue sticks	1 per 3 mentees	$16	Amazon
Markers	n/a		
Stopwatch/Timer (phone)	1 per mentor		