The Spark of Life

Medtronic Spark Explore Pre Curriculum Teacher Guide

The Spark of Life is an immersive, two-part pre-experience that transitions students from passive learners to active biomedical problem-solvers. In the first phase, students explore the heart as a rhythmic electrical system, identifying the **Sinoatrial (SA) Node** as the body's natural conductor and the **four-chambered pump** as the mechanical engine. By framing the heart as a system of inputs and outputs, students gain the vocabulary and conceptual framework necessary for high-level hands-on tech.

In the second phase, students participate in **"Steady the Beat,"** a high-stakes team activity where students role-play the parts of the heart, the pacemaker, and the patient. Over three rounds of gameplay, students must maintain "homeostasis" while facing system disruptions such as sinus node disorder (irregular heart rate).

TIMING

Ideally, this activity should occur a few days to one week prior to the mobile experience to ensure that students can recall the pre-activity and its content while in the mobile space.

LEARNING OUTCOMES

Students will know:

- The SA Node acts as the electrical trigger for the heart's mechanical pump.
- Irregular rhythms, such as sinus node disorder, cause the heart to beat inconsistently and disrupt oxygen delivery to the body.

Students will understand:

- The heart is a system of inputs and outputs, gaining the vocabulary necessary for high-level hands-on tech.

How engineers study natural systems, like the heart's SA node, to create technologies that help the body function more effectively.

Students will be able to:

- Demonstrate how system disruptions like slow heart rates affect the body.
- Compare the roles of natural biological systems versus engineered medical interventions.

MATERIALS PREPARATIONS

Materials are per group of 4 students.

Print and cut out student role cards. These are the main roles used in the simulated portion of the activity. The cards should be printed double-sided with the Quick Science Terms to Know on the back. There should be one of each of the following:

- Heart
- SA Node
- Pacemaker
- Body

Blood Tokens: 20-30 small items per group (e.g., dried beans, marbles)

Containers: Three bins per group labeled "Atria," "Ventricle," and "Organs."

Timing Device: Stopwatch, Metronome App set to 60 BPM.

LESSON PLAN

PART 1: The Briefing (15 minutes)

- Before the simulation begins, students must understand the biological machinery they are about to encounter.
- Using the provided slide deck, share:
    - **Anatomy of the Heart** - An overview of the heart as a mechanical pump driven by electrical signals.
        - Four Chambers: **Atria** (loading docks) and **Ventricles** (shipping centers).
        - **Valves**: One-way doors that prevent backflow.
        - **Sinoatrial (SA) Node** (the natural pacemaker): The body's original "Spark" that tells the muscles when to squeeze.
- Before moving on to the simulation, ensure students understand the base vocabulary and physiology with some of the following questions:
    - Which chambers of the heart are responsible for pushing blood out of the heart into the body?
        - Ventricles
    - What structure is responsible for setting the rhythm of the heartbeat?
        - SA Node

- What general path does blood take through the heart before leaving to the body?
  - Atria→Ventricles→Body
  - Or more detailed, Right Atrium→ Right Ventricle→ Lungs→ Left Atrium→ Left Ventricle→ Aorta→ Body
- Which part of the system ensures blood moves in a single direction?
  - Valves

PART 2: Simulation: "Steady the Beat" Relay (20 Minutes)

- Organize students into **Medical Response Teams** of four. Arrange the classroom into stations where groups have enough space to line up four chairs or stand in a row to represent the flow of the system:
  - **SA Node:** Positioned at the start of the line with visibility to the metronome. Their main role is to tap the Heart on the shoulder each time the metronome sounds.
  - **Heart:** Positioned in the middle with the Atria and Ventricle bins in front of them, side by side. Their main role is to move one token from the atria bin to the ventricle bin every time the SA Node taps their shoulder.
  - **Body**: Positioned at the end of the line to receive tokens to place in the organ bin. Their main role is to take one token from the ventricle bin every 3 seconds and move it to the organs bin.
  - **Pacemaker:** Positioned to the side to observe and eventually intervene. Their main role is to observe what happens in each role as the simulation takes place and to intervene in later rounds to maintain stability.
- Review each role and ensure students understand functionally what to do.

Round 1: Homeostasis

- Reiterate student roles if needed.
  - **SA Node:** Every time the metronome sounds, they tap the Heart on the shoulder.
  - **Heart:** Every time they are tapped, they move one token from the atria bin to the ventricle bin. They can only pick up one token at a time.
  - **Body:** Every three seconds, they move one token from the ventricle bin to the organ bin. They can take a token as often as 1 per second if it is available in the ventricle bin but must aim to get at least 1 token every three seconds.
  - **Pacemaker:** They observe the system and keep note of what is working and what is not.
- Ensure that the atria bin has about 20 tokens inside and that all other bins are empty.
- Set the metronome to 60 BPM in a 6/4 time signature and have students run the simulation for 30 seconds to 1 minute.

- Have a class discussion about how the system worked with some of the following questions:
    - What does each token represent in the system?
        - Blood, containing oxygen and nutrients needed for body function
    - What path does a token take through the system from start to finish?
        - Atria→ Ventricle→ Body
    - What triggered the heart to move a token?
        - SA node firing (tapping)
    - Which role controlled the speed of the entire system?
        - SA node
    - Did the system feel stable or unstable during this round? Why?
        - Stable, the heart could easily move the pieces when tapped and the body always had a supply of tokens in the ventricle to pull from every three seconds.
    - If the SA Node stopped tapping consistently, what do you think would happen?
        - There might be fewer tokens in the ventricle for the body to take from. The body might not have the nutrients it needs for its functions.

Round 2: Arrhythmia

- What happens when flow of blood through the heart is slowed?
    - **Sinus Node Disorder**: An irregular or dangerously slow heartbeat that can cause chaos in the body.
    - Discuss how the SA node can sometimes create slow or irregular heartbeats and have students predict how it will affect the body as a whole.
- Discuss that they will run the simulation again to see this effect in action, but with some changes. To keep all students participating, it is recommended to have students rotate roles within their groups.
- In this round, they will model what happens when the SA node doesn't beat consistently.
- Review the roles that change:
    - **SA Node:** Instead of tapping with every sound of the metronome, they can only tap on the first and fifth sound of the metronome, then only the first beat, then only the fifth beat. Then this pattern repeats. Explain how to use the visualized metronome to know which beat is which. You can practice this as a class before the round starts.
    - **Heart:** Can only move tokens when they are tapped. If no tap is received, they move nothing.

    - **Body**: Still needs to get at least one token every 3 seconds from the ventricle bin for the organ bin. If 3 seconds pass without a token say "Heartbeat is Irregular!". If more than 5 seconds pass without a token, say " I need help!" and stop the simulation.
    - **Pacemaker:** They observe the system and keep note of what is working and what is not.
- Ensure that the atria bin has about 20 tokens inside and that all other bins are empty.
- Set the metronome to 60 BPM in a 6/4 time signature and have students run the simulation for 30 seconds to 1 minute.
- Have a class discussion about how the system worked with some of the following questions:
    - Was the SA Node signal consistent or inconsistent?
        - Inconsistent, it fired unreliably and felt unpredictable to the Heart.
    - What happened to token movement when the SA Node skipped beats?
        - Fewer tokens were moved to the ventricle and it meant the body often had to wait longer than it was supposed to in order to get its required token for the organs.
    - If fewer blood tokens move out of the heart, how do you think that would affect the organs?
        - They might not be able to fully do their job without enough oxygen or nutrients. The person might feel tired, lethargic, or even lightheaded.
    - If someone was experiencing this, what could be done to help?
        - Use a tool to cover the SA Node pauses.

Round 3: The Innovation

- Mechanical Solution: the **pacemaker**—a bridge between engineering and medicine that takes over when the SA node isn't working properly.
    - Describe how the pacemaker helps to identify when the heart needs help and provides a pulse, similar to that of the SA node.
    - Have students predict how the use of a pacemaker will affect the body as a whole.
- Discuss that they will run the simulation again to see this effect, but with some changes. To keep all students participating, it is recommended to have students rotate roles within their groups.
- In this round, they will model what happens when the SA node doesn't beat consistently but a pacemaker has been added to the system.
- Review the roles that change:

    - **SA Node:** Same as round 2, they can only tap on the first and fifth sound of the metronome, then only the first beat, then only the fifth beat. Then this pattern repeats. Explain how to use the visualized metronome to know which beat is which. You can practice this as a class before the round starts.
    - **Heart:** Can only move tokens when they are tapped. If no tap is received, they move nothing.
    - **Body:** Still needs to get at least one token every 3 seconds from the ventricle bin for the organ bin. If 3 seconds pass without a token say "Heartbeat is Irregular!" If more than 5 seconds pass without a token, say " I need help!" and stop the simulation.
    - **Pacemaker:** They provide a tap along with the metronome but only if the SA Node doesn't provide it. They should watch the SA node and the metronome and tap with the metronome when the SA node doesn't.
- Ensure that the atria bin has about 20 tokens inside and that all other bins are empty.
- Set the metronome to 60 BPM in a 6/4 time signature and have students run the simulation for 30 seconds to 1 minute.
- Have a class discussion about how the system worked with some of the following questions:
    - What was different about system behavior before the pacemaker and after it was added?
        - The flow of tokens was more stable and reliable.
    - What stayed the same even after the pacemaker was added
        - The heart and body still acted the same. Even the SA Node continued to tap irregularly, but the pacemaker filled in the gaps to provide a reliable signal.
    - What controlled the timing of the Heart in this round?
        - The SA Node AND the Pacemaker
    - How does the Pacemaker know when to intervene?
        - It looks to see if the SA Node acted and if not, it fills in the gap knowing the correct rhythm to maintain.

PART 3: Student Survey (10 Minutes)

- After the simulation, students will complete a brief pre-survey to assess their baseline understanding of health tech careers and their view of themselves as innovators.
- This survey should be administered individually.
- Teachers should emphasize that responses are not graded and will be revisited after the mobile lab experience to measure changes in their understanding and view of themselves.

- Reinforce that the upcoming Medtronic Spark Explore mobile lab experience will further explore how a pacemaker can effectively regulate the heart.

ALIGNMENT TO STANDARDS

Standard Code	Standard Title	Application in Activity
MS-LS1-3	**Body Systems**	Students model the heart as a subsystem of specialized cells working together to sustain the larger organism.
MS-PS3-5	**Energy Transfer**	Students provide evidence that kinetic energy from heart motion can be transferred to power a pacemaker.
MS-ETS1-1	**Engineering Design**	Students define the constraints of a medical device (battery life, size, reliability) and solve for energy "income" vs "cost."
MS-LS1-1	**System Interactions**	Students observe how a failure in one part of the system (the electrical signal) causes a failure in the whole system (blood flow).

MS - Middle School; LS - Life Science; PS - Physical Science; ETS - Engineering