PAGING DR. NAN O. BOT!

ROBOTS TO THE RESCUE?

The idea of armies of microscopic robots patrolling our bodies, cleaning and maintaining them has been a theme in futuristic science fiction for decades. The future is closer than you may think. These days nanobots in medicine are no longer just the realm of science fiction stories or movies like *Inner Space*, it's happening now.

Nanomachines may be tiny – 50,000 of them would fit across the diameter of a human hair – but they have the potential to pack a mighty punch in the fight against cancer and other diseases.

Different scientists are using different approaches in the fight against cancer. The powerful drugs (chemotherapy) that we use to kill cancer unfortunately also kill some healthy cells and cause nasty side effects and can cause permanent damage to our bodies. Of course, the good (saving lives) still outweighs the bad, so we continue to use powerful drugs to kill cancer. But with the latest technology, we can do better.

Cancer survival rates could be hugely improved if scientists are successful in developing microscopic medical weapons that obliterate cancerous cells. Some do this by delivering medicine directly where it is needed. Delivering medicine directly where it's needed not only minimizes side effects but also makes the drugs more effective. That's why researchers are designing tiny robots to precisely carry drugs to cancerous cells while leaving nearby healthy cells alone.

A TARGETED APPROACH

Other researchers are taking a different approach. A team of researchers from Montreal developed an alternative: natural nanobots are almost as good as artificial intelligent nanobots. They used nanotechnology to load bacteria with cancer-fighting drugs and guide them to the cancerous cells. Although the bacteria are quite effective, they can't be customized and controlled as well as a man-made robot.[1]

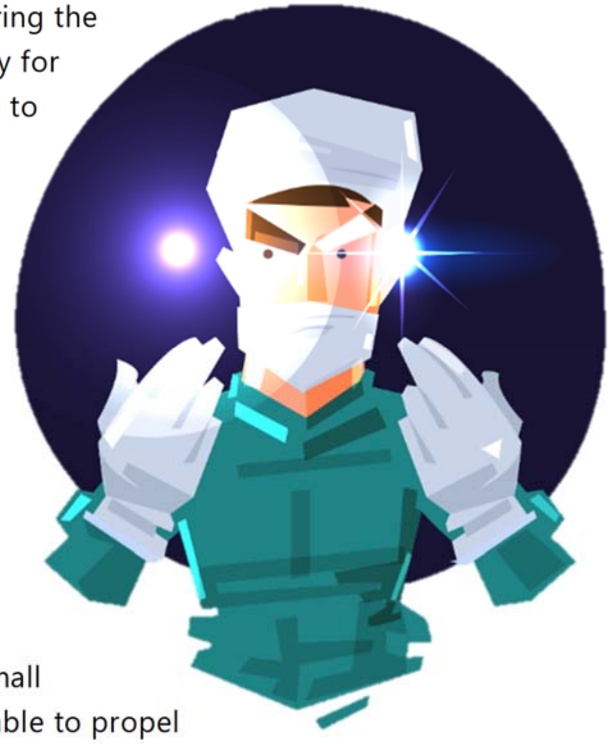
Researchers at Durham University in the UK have used nanobots to drill into cancer cells, killing them in just 60 seconds.[2]

Another clinical trial, done in mice had amazing results. Using a technique called DNA origami scientists from ASU and China programmed tiny robots to carry a blood-clotting enzyme to the blood vessels in tumors. These little biological weapons were able to deliver a dose of lifeblood-blocking, clot-inducing medicine to mice with human breast cancer tumors. Once they reached the surface of the blood vessels they sent the thrombin to the heart of the tumor. Within 24 hours they saw tissue damage on the tumor. Within three days they saw damage on all vessels in the tumor! But perhaps the most significant part of the tech is its precision, at least in the mouse models: The programmed DNA bots avoided causing any clotting or harm to healthy cells, the nanobots passed right by them.[3] That is an extremely important part of the experiment because thrombin can be really dangerous if delivered to the wrong spot in the body. For example, a patient might have a stroke if it was delivered to the brain.[4]

[1] Kelly McSweeney *Robotics* Retrieved from: https://www.zdnet.com/article/tiny-robots-attack-cancer/
[2] Sarah Knapton *The Telegraph* Retrieved from: https://www.telegraph.co.uk/science/2017/08/30/nanomachines-drill-cancer-cells-killing-just-60-seconds-developed/
[3] Sy Mukherjee *Fortune* Retrieved from: http://fortune.com/2018/02/13/dna-nanobots-cancer-tumors/
[4] Kristin Houser *Futurism* Retrieved from: https://futurism.com/nanobots-kill-tumors-blood-supply/

Inner Engineering

Cancer detection and eradication is one thing but tiny nanobots are big players in the future of medicine for other reasons. Scientists are exploring the use of nanobots for a number of healthcare uses, not only for fighting cancer, but also to unblock blood vessels in hard to reach areas, taking biopsies or measuring the level of certain chemicals in otherwise inaccessible areas of the body and going where a surgeon's hands can't reach.



Engineering the Future

A number of hurdles must be overcome, before surgical nanorobots will reach clinical trials. Getting the minuscule robots to travel to a precise site in the body and stay there long enough to carry out a procedure is a big challenge, given the speed and frequency of blood flow in the human body.

To deliver drugs to cancerous cells, nanobots must: be small enough to penetrate a tumor through blood vessels, be able to propel themselves and navigate while avoiding obstacles, have a mechanism for detecting oxygen levels (which indicate active cancer cells), be biocompatible, able to carry drugs, and have on onboard power source. Oh, and on top of all that, they have to be cheap to produce, since they are so tiny that it would take hundreds of millions of robots to deliver the right dosage of drugs. It's a long wish list that even the world's best scientists will struggle to complete. [5]

Welcome to the Team, Lab Rats!

They need your help! You've been invited to join an elite team of biomedical engineers who are striving to solve tomorrow's problems today by thinking up creative or clever solutions to

[5] Kelly McSweeney *Robotics* Retrieved from: https://www.zdnet.com/article/tiny-robots-attack-cancer/

complex medical problems.

Because biomedical engineers often act as a liaison between other types of engineers and physicians, they need good communication skills. They also should enjoy working independently, as well as in groups.

The Head Researcher (aka, the instructor) has handed down a few challenges to get you started as lab assistant. Be bold! Be brilliant! Your crazy idea might be the next great breakthrough!

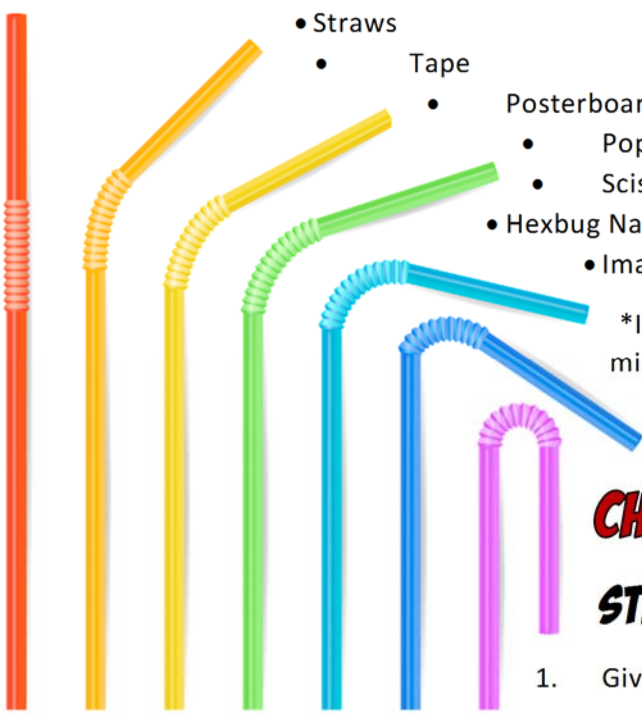
YOUR A-MAZE-ING BODY!

In this activity we'll use play materials you already have like Lego bricks, Magna-Tiles®, and even old wrapping paper and paper towel tubes or straws to create mazes and obstacles for the Hexbug Nano.

This activity is an absolute hit with kids and promotes all kinds of learning: planning, problem solving, engineering and building, creativity and more!

MATERIALS:

- Building toys and materials e.g., blocks, LEGO, Magna-Tiles, Marble run elements, Hexbug building elements, etc.
- Cardboard tubes
- Straws
- Tape
- Posterboard
- Popsicle sticks
- Scissors
- Hexbug Nanos*
- Imagination



*If you've never heard of Hexbugs, they are basically micro robots that are super fun to play with and provide all kinds of learning experiences. You can buy them as singles or in sets of five.

CHALLENGE IDEAS:

STRAW MAZE

1. Give each team one sheet of poster board.

2. Demonstrate how to attach straws to the poster board using tape. Bendy straws work especially well because they can be angled. Show the kids how to cut the straws to whatever lengths they need.
3. Invite teams to create mazes and/or obstacles for their Hexbugs using the provided materials. (Option: Also provide markers for the kids to use to add any details or illustrations to their human body/poster board, such as evil viruses, etc.)[6]

Block Mazes

- Invite your students to create mazes and structures for their Hexbugs nanobots using whatever building toys and materials you have, e.g., blocks, LEGO, Magna-Tiles, Marble run elements, Hexbug habitat building elements, cardboard tubes, etc., and meet the following goals for the research team

Sample Goal Levels:

Level One: Can students build a maze that their hexbug can successfully travel from one end to the other in order to 'apply its medicine' to the target?

Level Two: Can students build a/expand on/modify their maze and make sure that that their hexbug can successfully travel from one end to the other in order to successfully 'apply its medicine' without getting stuck a single time? If it gets stuck 'tissue' could be damaged by the medicine being delivered to the wrong spot!

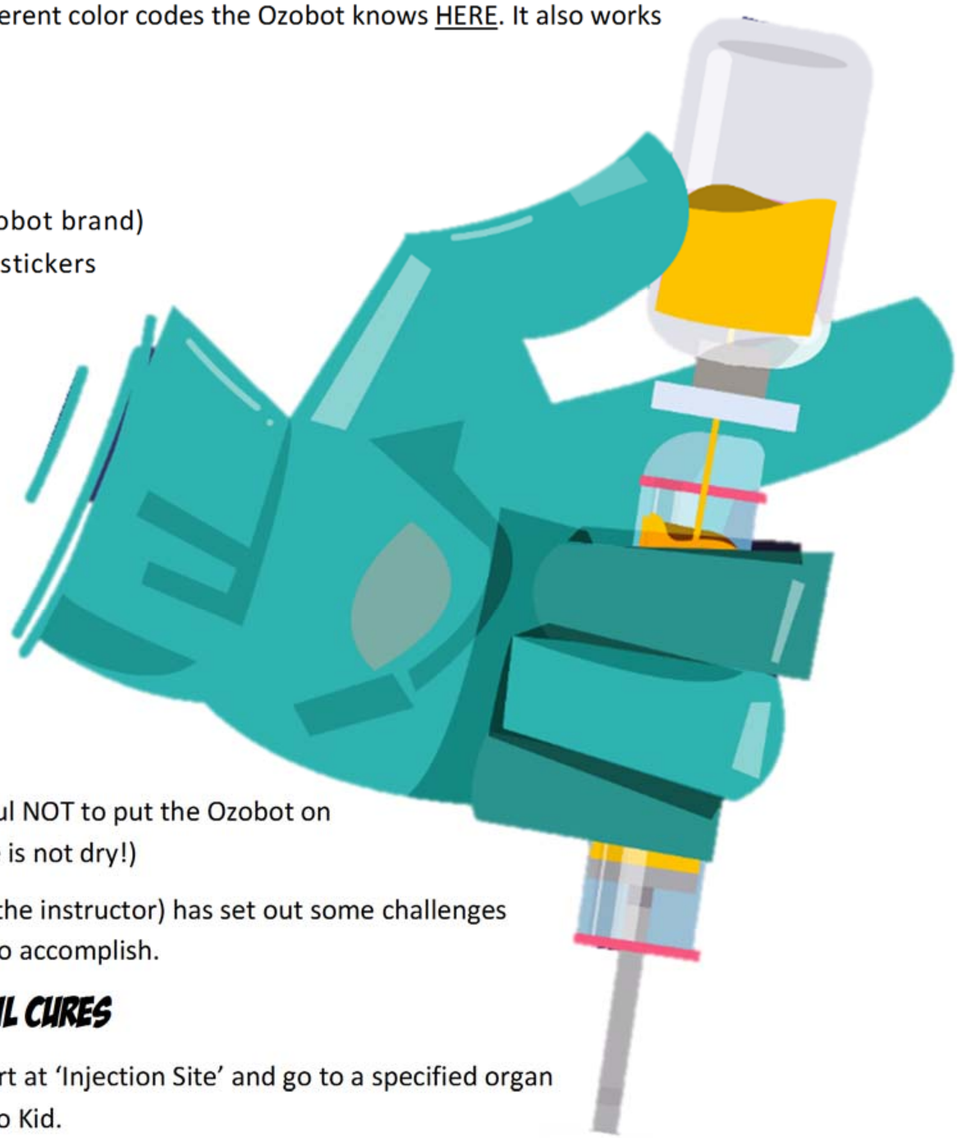
Level Three: Can students build a maze that demonstrates a special skill that their hexbug nanobot has?

[6] Chelsey *BuggyandBuddy* Retrieved from: https://buggyandbuddy.com/stem-challenge-for-kids-build-a-hexbug-maze-using-straws/

Curing Cardio Kid with Dr. Ozobot!

Color Coded Cures!

Ozobot reads lines and color combinations on a page, following them almost like a road or a path. Certain color combinations make the Ozobot do tricks, speed up, slow down, among other things. You can see all of the different color codes the Ozobot knows HERE. It also works as a great reference guide.



Materials:

- Ozocode handouts
- Markers (regular or Ozobot brand)
- Optional: Ozobot code stickers
- Paper
- Ozobots: Bit or Evo
- Cardio Kids organs printouts
- Thin cardboard, ex. From tissue boxes
- Markers
- Strips of white paper for "debugging" or "gauze"
- Scissors
- Clear tape
- Glue stick (be very careful NOT to put the Ozobot on the Cardio Kid if the glue is not dry!)

The Head Researcher (aka, you, the instructor) has set out some challenges for the students/Lab Assistants to accomplish.

Level One: Coding Colorful Cures

1. The Ozobot needs to start at 'Injection Site' and go to a specified organ or 'tumor' on your Cardio Kid.
2. There should be at least three working codes
3. There should be at least one cool move among those codes.

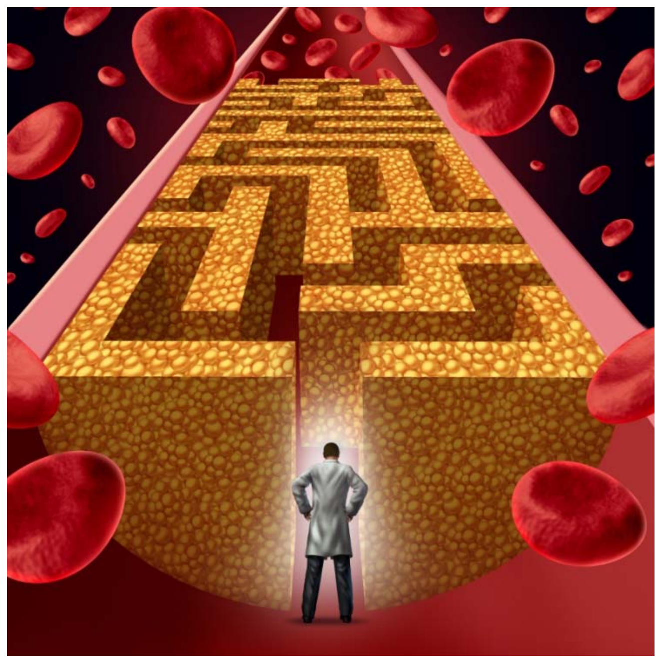
Level Two: Human Trials

At this stage Lab Assistants are ready to incorporate more engineering design thinking. We will still keep all the challenges from the first level, but you'll add in more challenges:

4. The bot must spin to deliver its medicine once it reaches its destination.
5. Build an arterial bypass a.k.a. a bridge or ramp the Ozobot can travel over on your Cardio Kid's circulatory system, preferably near the heart. (Note: the Ozobot is not very powerful so the incline must be very smooth and low. Watch to see if students deduce that if Ozobot has enough momentum, it can navigate the bridge better. They might add a "turbo boost" code just before the ramp.)
6. Create a tunnel tall and wide enough for the Ozobot to pass through somewhere on the body.

Level Three: Going with the Flow

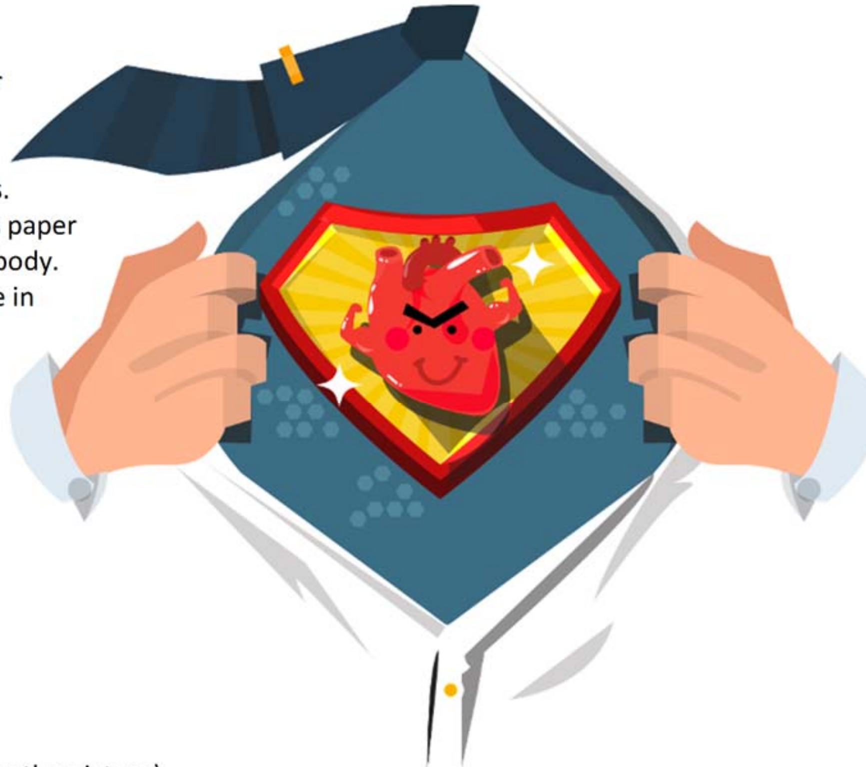
7. Challenge students to create a route that has the bot follow the circulatory system flow in the correct order and direction from the injection site, to the heart, through the body, and/or around the circulatory system.
8. Have the bot 'apply medicine' at multiple spots in the body along the route.



Tip: Demonstrate that to edit codes students can use pieces of white paper to stick over any errors or areas they want to debug or improve. If you use sentence strips in writing, you could compare these to them and perhaps call them "debugging strips" or "gauze strips".

Note: After mastering color coding, kids and teens can advance with Ozobot apps and OzoBlockly, Ozobot's block-based programming language. The Ozobot website has tons of OzoBlockly games and STEM activities for Bit.

CARDIOVASCULAR KID

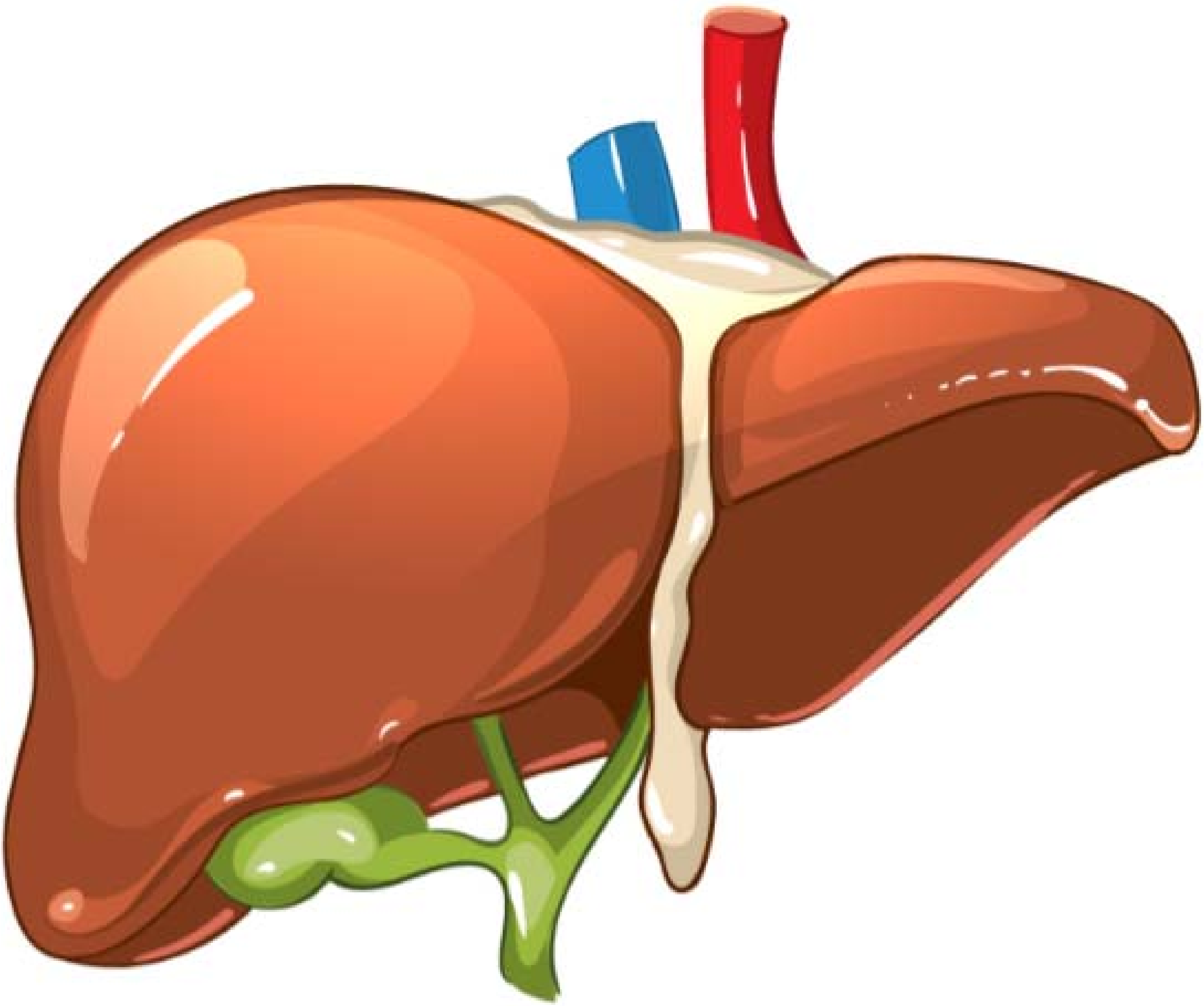


It's a bird, it's a plane....no it's Cardiovascular Kid! Get a large piece of butcher paper - large enough for a student to lie down on. Divide your students into two or more teams. In each team have a student lie down on this paper and have another student outline his or her body. Now have the two teams hang up the outline in front of the room. Working together the teams must race to fill-in their outline with parts of the cardiovascular system and the pictures of the organs supplied below. The students must find the correct label for each of the structures that are drawn or added onto their picture and add it to their Cardiac Kid.

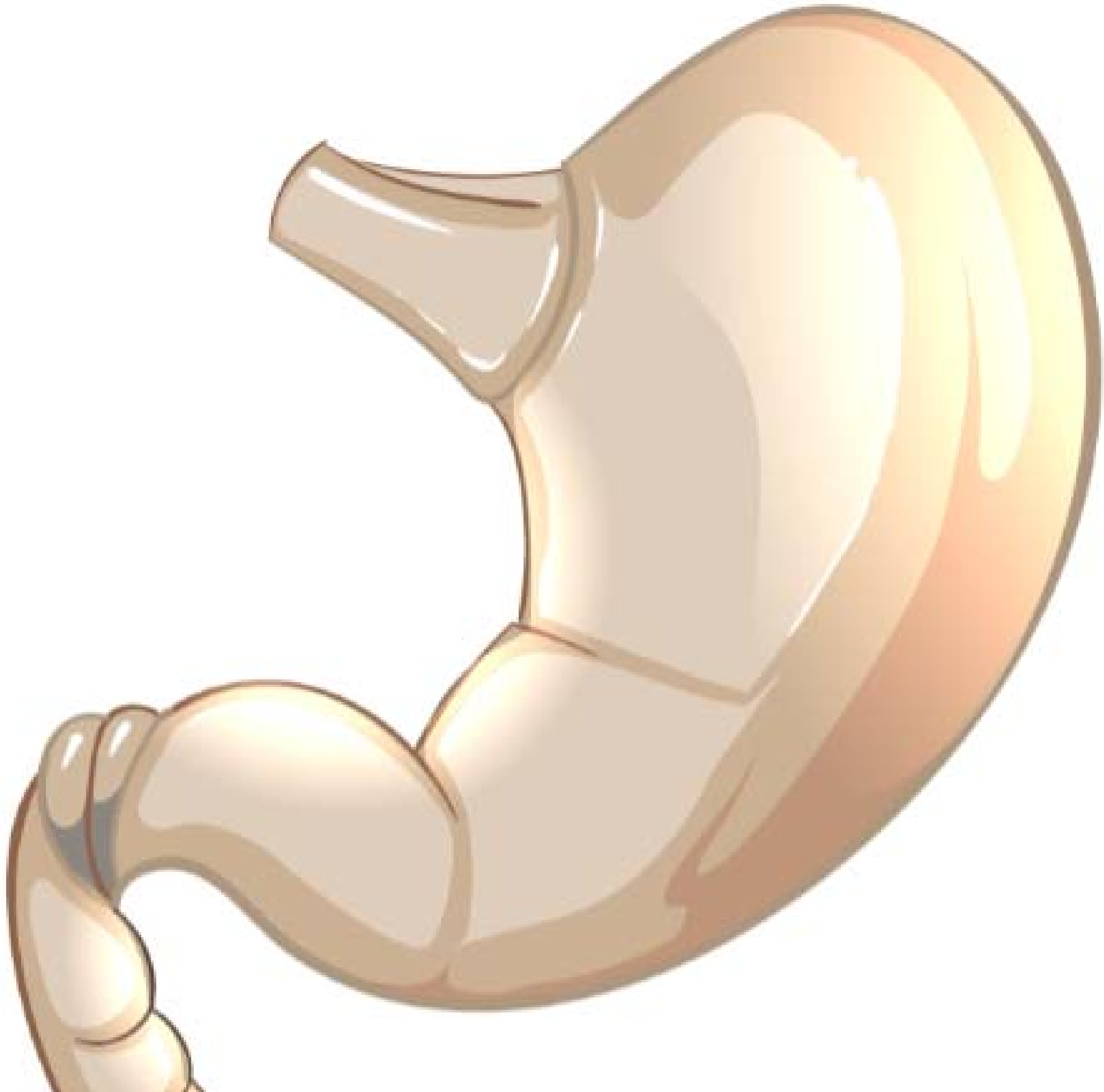
Materials:

- Butcher paper (roll of white paper)
- Markers/crayons (to outline and color the picture)
- Pens and pencils (to label the structures and draw blood vessels & arteries)
- Several sets of pictures and labels of internal organs cut out and put in separate sets (one for each team).

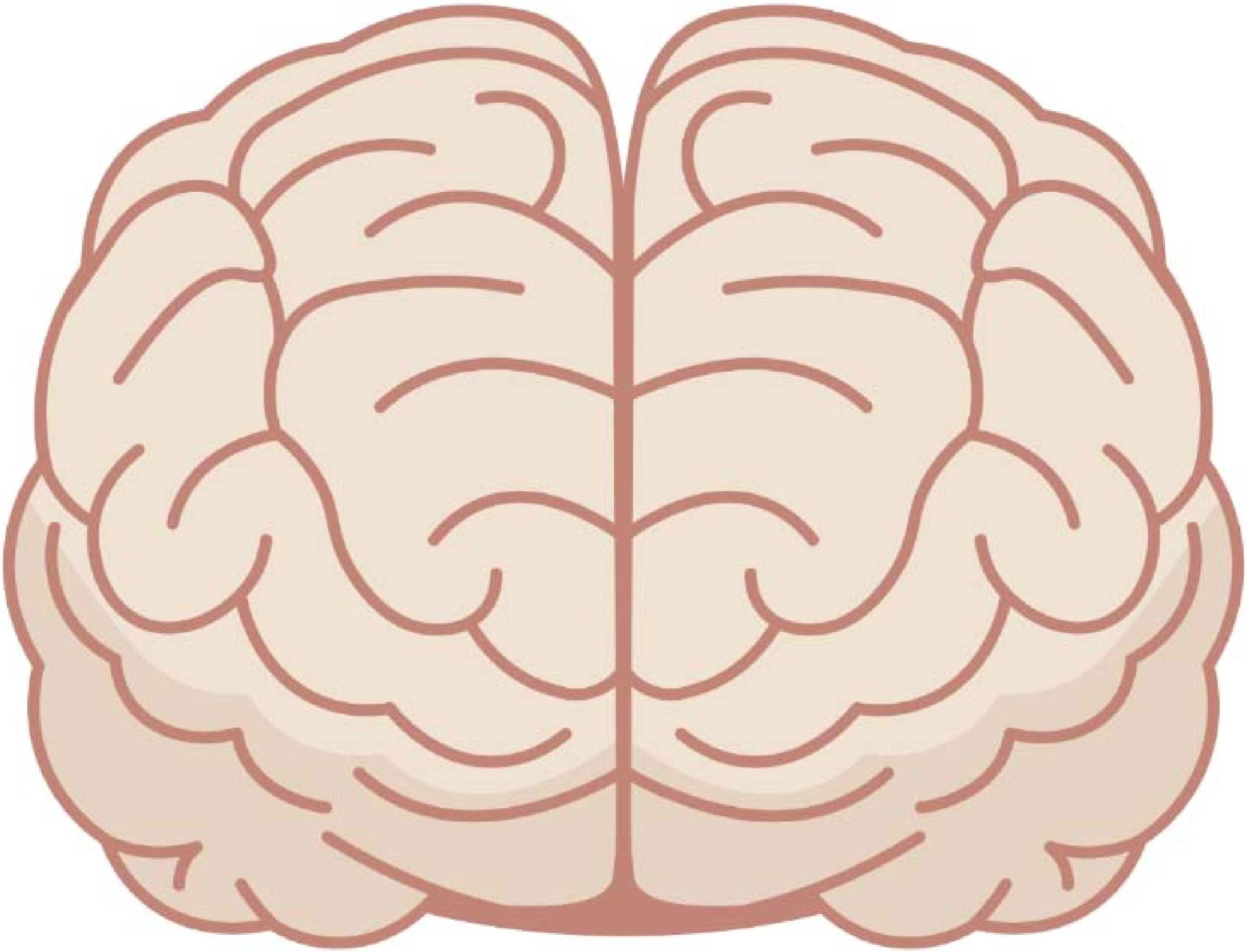
Eyes, Mouth, Nose, Ears



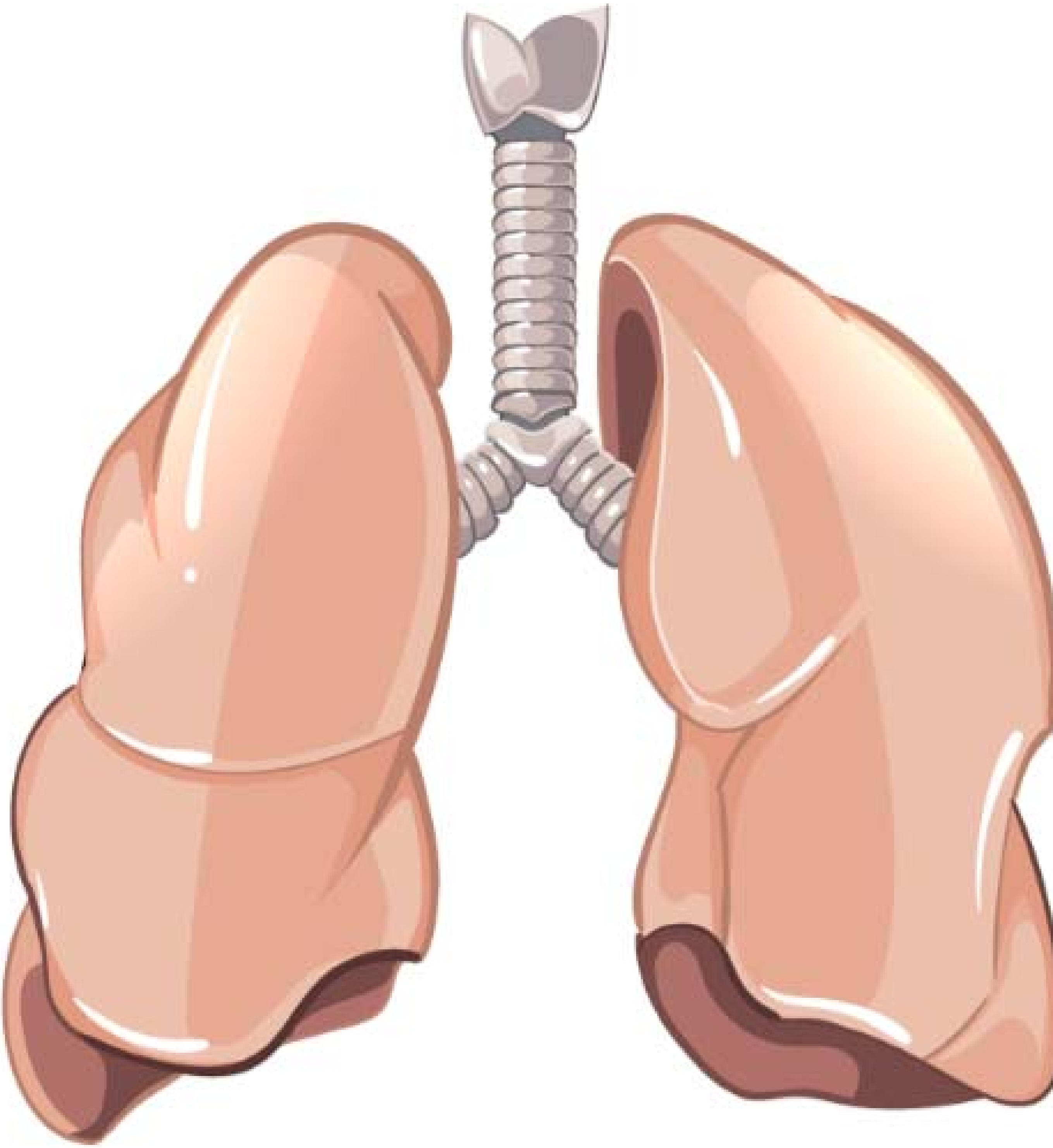
LIVER



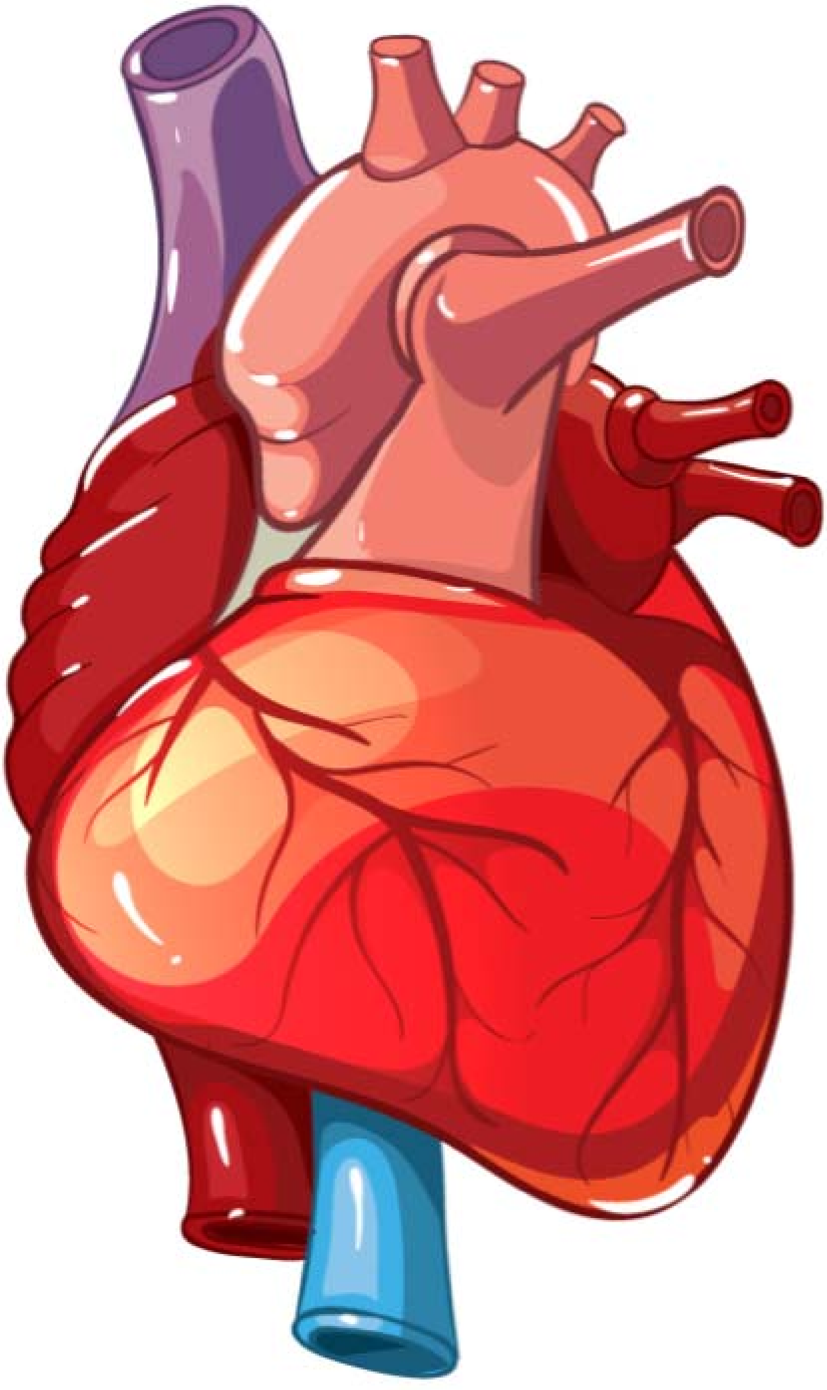
STOMACH



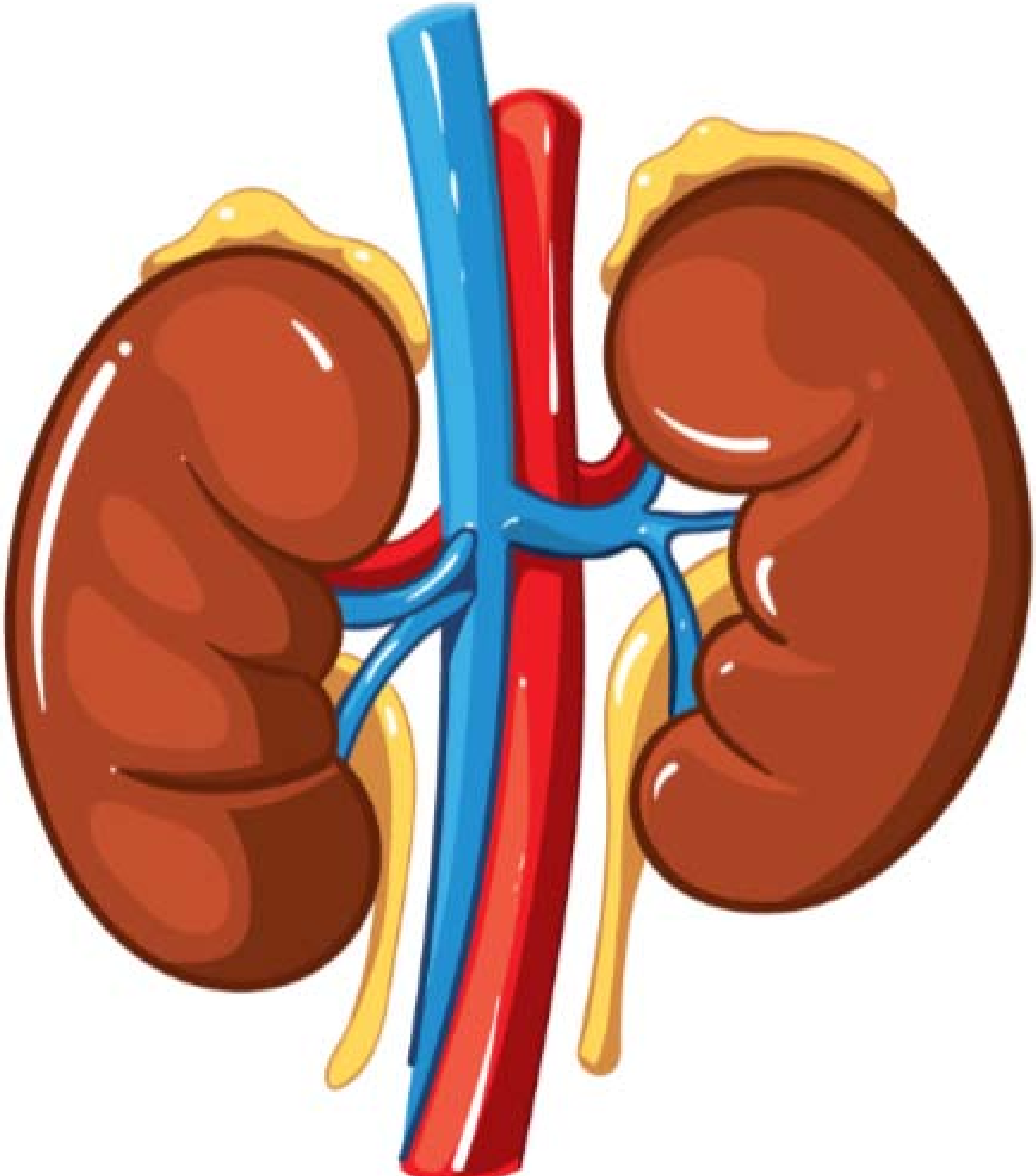
BRAIN



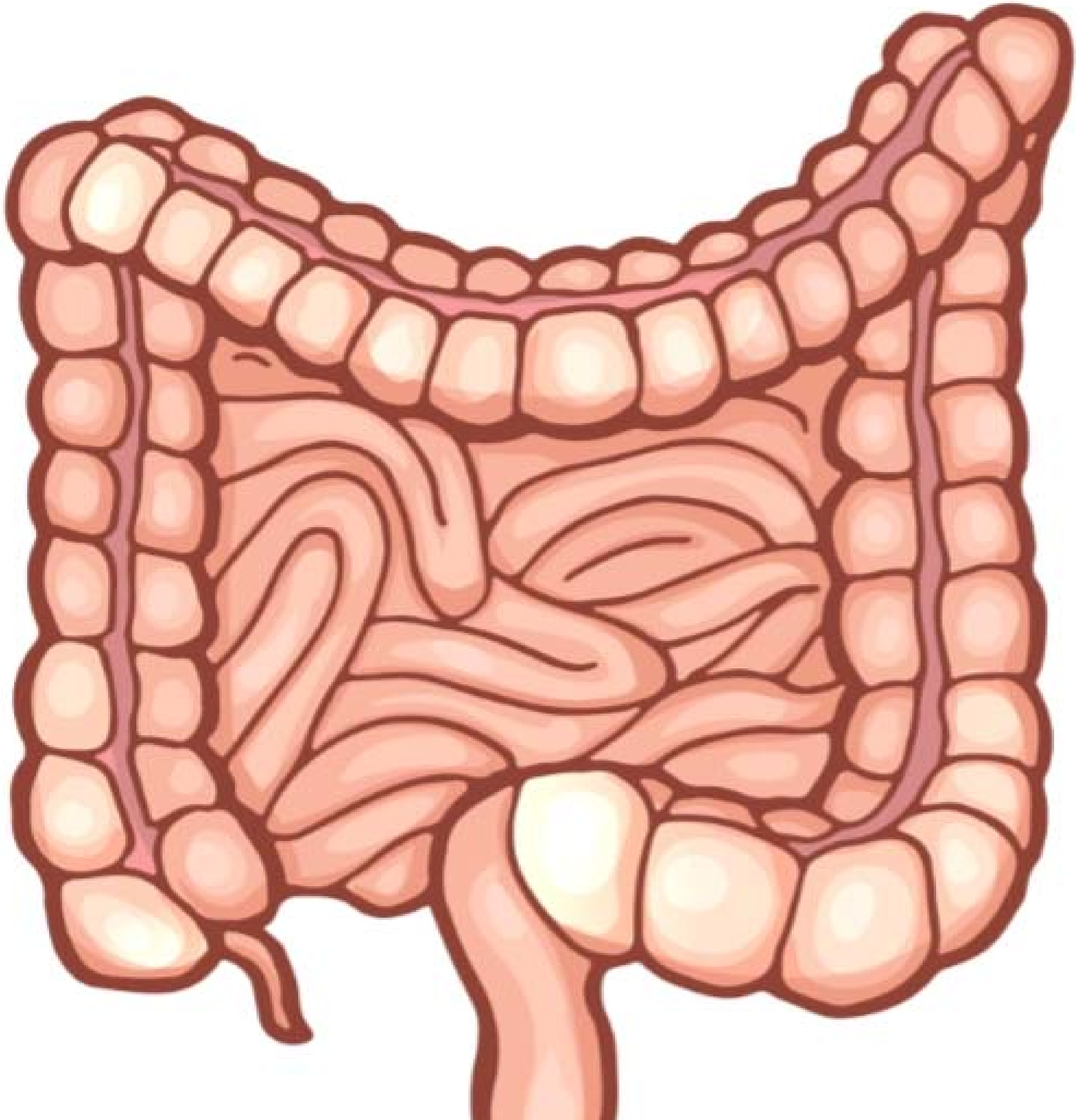
LUNGS



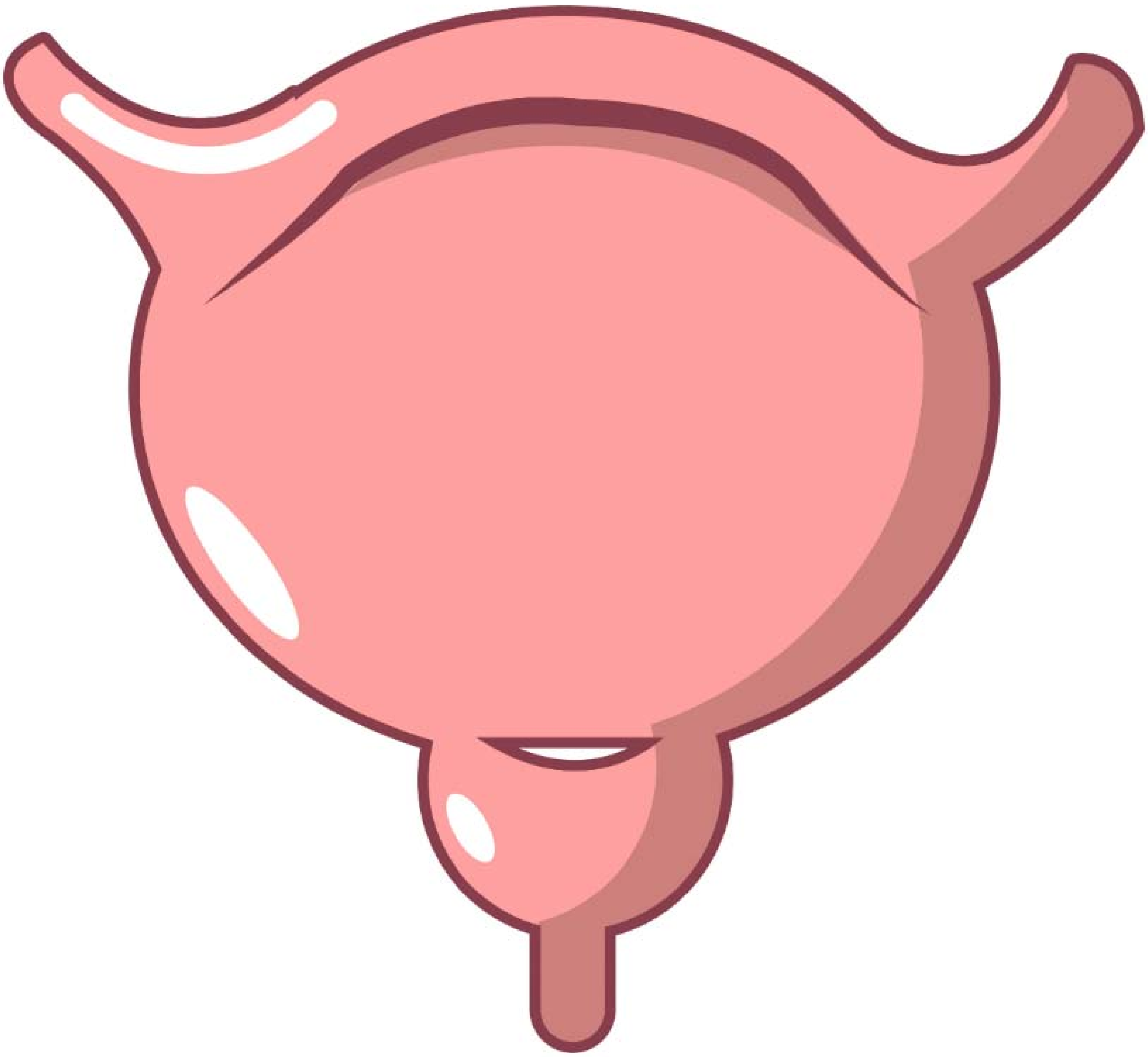
HEARTS



KIDNEY



SMALL & LARGE INTESTINES



BLADDER

Paging Dr. Nan O. Bot Activities Supply List

Your A-Maze-Ing Body

- Building toys and materials e.g., blocks, LEGO, Magna-Tiles, Marble run elements, Hexbug building elements, etc.
- Cardboard tubes
- Straws
- Tape
- Posterboard
- Popsicle sticks
- Scissors
- Hexbug Nanos*
- Imagination

Color-Coded Cure

- Ozocode handouts
- Markers (regular or Ozobot brand)
- Optional: Ozobot code stickers
- Paper
- Ozobots: Bit or Evo
- Cardio Kids
- Thin cardboard, ex. From tissue boxes
- Markers
- Strips of white paper for “debugging” or “gauze”
- Scissors
- Clear tape
- Glue stick (be very careful NOT to put the Ozobot on the Cardio Kid if the glue is not dry!)

Cardiovascular Kid!

- Butcher paper (roll of white paper)
- Markers/crayons (to outline and color the picture)
- Pens and pencils (to label the structures and draw blood vessels & arteries)
- Several sets of pictures and labels of internal organs cut out and put in separate sets (one for each team).

Samples of Academic Standards that can be reinforced during 'Paging Dr. Nan O. Bot' activities

K

7.T/E.2 Invent designs for simple products.

7.T/E.3 Use tools to measure materials and construct simple products.

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

7.2.1 Recognize that some things are living and some are not.

7.11.1 Explore different ways that objects move.

7.11.1 Use a variety of objects to demonstrate different types of movement. (e.g., straight line/zigzag, backwards/forward, side to side, in circles, fast/slow).

7.1.3 Take apart an object and describe how the parts work together.

7.1.2 Use building materials to create a whole from the parts.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

1

7.T/E.2 Invent designs for simple products.

7.T/E.3 Use tools to measure materials and construct simple products.

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.1a Explain how tools (ex. like robots), technology, and inventions are used to extend the senses, make life easier, and/or solve everyday problems.

7.T/E.1b Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

7.11.1 Use familiar objects to explore how the movement can be changed.

7.11.2 Investigate and explain how different surfaces affect the movement of an object.

7.11.1 Investigate how forces (push, pull) can move an object or change its direction.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

2

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.1 Explain how simple tools are used to extend the senses, make life easier, and solve everyday problems.

7.T/E.1b Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

7.12.1 Determine that objects can move without being touched.

7.11.2 Describe the sounds produced by different types of vibrating objects.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

3

7.T/E.1 Describe how tools, technology, and inventions help to answer questions and solve problems.

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

7.T/E.2 Recognize that new tools, technology, and inventions are always being developed.

7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.

7.11.2 Demonstrate how changing the mass or weight affects a balanced system.

7.11.1a Explore how the direction of a moving object is affected by unbalanced forces. (Note: **Unbalanced forces** always cause a change in motion. They are not equal and opposite. Forces occur in pairs and can be either balanced or unbalanced. **Balanced forces** do not cause a change in motion. They are equal in size and opposite in direction so they cancel each other out and no motion happens. If motion is happening then there are unbalanced forces.)

7.11.1b Identify how the direction of a moving object is changed by an applied force. (Any force could be considered to be an applied force, but applied force usually stands for a force applied by a person or an action which directly pushes or pulls on a system.)

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

4

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

7.T/E.5 Apply a creative design strategy to solve a particular problem

7.T/E.2 Recognize that new tools, technology, and inventions are always being developed.

7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.

7.11.2 Design a simple investigation to demonstrate how friction affects the movement of an object.

7.11.2 Identify factors that affect the speed and distance traveled by an object in motion.

7.11.2 Identify factors that influence the motion of an object.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

5

7.T/E.4 Evaluate an invention that solves a problem and determine ways to improve the design.

7.T/E.5 Apply a creative design strategy to solve a particular problem

7.T/E.2 Recognize that new tools, technology, and inventions are always being developed.

7.T/E.1 Explain how different inventions and technologies impact people and other living (and non-living) organisms.

7.T/E.1c Study a tool, technology, or invention that was used to solve a human problem.

7.12.2 Identify the force that causes objects to fall to the earth.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

6

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

7.T/E.1 Explore how technology responds to social and economic needs.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

7.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

7.10.3 Recognize that energy can be transformed from one type to another.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

7

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

7.T/E.1 Explore how technology responds to social, political, and economic needs.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

7.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

7.T/E.5 Develop an adaptive design and test its effectiveness.

7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

7.11.4 Recognize how a net force [the overall force acting on an object] impacts an object's motion.

7.11.4 Investigate how Newton's laws of motion explain an object's movement.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.

8

7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

7.T/E.1 Explore how technology responds to social, political, and economic needs.

7.T/E.3 Explore how the unintended consequences of new technologies can impact society.

7.12.7 Explain how the motion of objects is affected by gravity.

7.T/E.5 Develop an adaptive design and test its effectiveness.

7.12.5 Recognize that gravity is a force that controls the motion of objects.

These standards will be met and reinforced as students learn about and use models of nanobot robots (ozobots and hexbugs) and understand their purposes and functions, as well as how they help humans more easily accomplish tasks. Then students will be tasked to incorporate the capabilities of each robot into their design for each of the challenge levels.

As they encounter challenges or setbacks students will be reminded of the steps in the engineering design process and encouraged to think creatively in order to solve the problem, reimagine uses for 'everyday objects,' and overcome challenges.

Students will be encouraged to build upon their designs and think of ever more complex and creative (functional) additions to their mazes. They will have to demonstrate their solutions to the challenges and explain their design and thought processes.