One Small Bite for Man

Science, Technology, Engineering and Math Objectives:

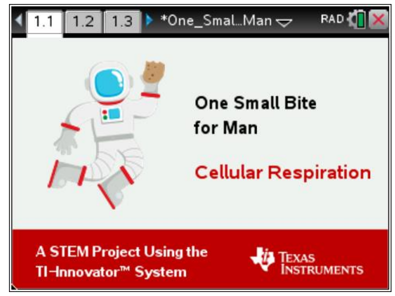
- Students will research science topics including:
  - Energy and material flow in cellular respiration.
  - Animal cell organelles.
  - The effects of Body Mass Index and activity level have on energy usage (calories consumed).
- Students will design and build a model of an astronaut to simulate energy consumption according to the BMI and activity level in a space-work environment.
- Students will use appropriate technology to evaluate their design, collaborate with colleagues and present their findings.
- Students will use mathematical processes of:
  - Area of a rectangle
  - Slope of a line
  - Interpreting graphs
  - Proportional reasoning

Vocabulary

- mitochondria
- cellular respiration
- calories
- Body Mass Index (BMI)

About the Lesson

- This is a project-based STEM activity that will engage your students in the engineering design process while using TI-Nspire technology.



Tech Tips:

- This activity includes screen captures taken from the TI-Nspire™ CX. It could also be used with the TI-Nspire CX Software.
- This activity will use the TI-Innovator™ Hub with TI LaunchPad™ Board.
- Watch for additional Tech Tips throughout the activity.

Suggested Grade Level: 6-8

Lesson Files:

Student Activity

- One_Small_Bite_For_Man_Student.doc
- One_Small_Bite_For_Man_Student.pdf
- One_Small_Bite_For_Man.tns

Activity Materials

- Styrofoam cups
- Pipe-cleaners
- Popsicle Sticks
- Straws
- Permanent Markers in assorted colors
- Googly eyes (optional)
- Tape
- Scissors

Technology Requirements

- TI-Nspire CX handheld
- TI-Innovator Hub with USB Cable
- TI-Innovator I/O Modules Pack Sensors:
  - Vibration Motor
  - White LED
  - Servo Motor
- TI-Innovator Battery Pack *

*Can alternatively plug in the TI-Innovator Hub to a power outlet using the TI Wall Adapter.

> **Teacher Tip:** The activity materials are listed as suggestions. The goal is to have a variety of materials available for the students to create the model greenhouse. Students should work in groups of two or three.

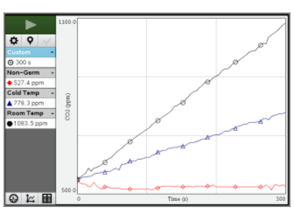
> **Teacher Tip:** If you are using the I/O Modules Pack for the first time, you will need to assemble both the LED and Servo Motor before distributing to students. For help with the initial assembly of these sensors, view the videos on education.ti.com/en/tisciencenspired/us/stem

Prerequisite Content Knowledge and Skills

> **Teacher Tip:** The use of this activity is designed to be flexible. It can be used as part of a project-based classroom or problem-based learning environment.

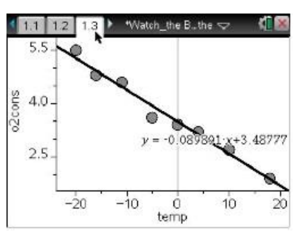
- Students will review the reaction for cellular respiration and animal cell structure and function.
- This activity incorporates many of process skills and crosscutting principles of the Next Generation Science Standards (NGSS).
- Related Science Nspired.com cellular respiration activities:

Vernier - Cell Respiration



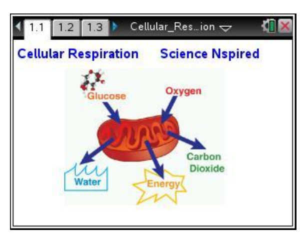
In this lesson, students will use a CO2 sensor to explore cell respiration and determine the effect of temperature on the rate of cell respiration.

Watch the Birdie Breath



In this lesson, students will analyze a graph of data representing the relationship between the environmental temperature and the resulting metabolism of an endothermic animal.

Cell Respiration



In this lesson, students will use different simulations to explore three pathways involved in cellular respiration.

Teacher Tip: Additional activities or student research might be necessary to supplement this activity to ensure students have a base-line knowledge of the process of cellular respiration.

The Situation

Your student is a horticultural engineer on the International Space Station (ISS), researching food production for extended space exploration missions.

Your students will be tasked with designing and building a model for investigating and experimenting with the food needs of the astronaut. They must use their model to investigate how Body Mass Index (BMI) and activity affect a person's daily food requirements.

STEM Career – Horticulture Engineer

Horticultural engineering blends agricultural engineering, plant science, computer science, and control theory to produce effective and efficient plant growing systems, whether in high-tech greenhouses or low-tech row cover systems. Degrees in Horticultural Engineering are available at many colleges and universities.

Teacher Tip: Students might find it valuable to explore this STEM career after completing this activity.

Overview of the Activity

Your students will be tasked with designing and building a model for investigating and experimenting with the food needs of an astronaut. Then, the students must use their model to investigate how Body Mass Index (BMI) and activity affect a person's daily food requirements.

Move to pages 1.2-1.5 in TI-Nspire Document

In Problem 1, students are asked to read the storyline that sets the context of the tasks they are about to complete. Give students time to read this section, and you can follow up with a discussion on topics such as ISS, or food production.

Have students identify two experimental questions they want to investigate and record on "identify" question #2 on the student activity sheet.

Teacher Tip: If students have already completed the photosynthesis activity "*One Giant Leaf for Mankind*", they should begin at problem 2. It is recommended that students do both this activity and the "*One Giant Leaf for Mankind*" activity, as the storylines are connected. The reactions of photosynthesis and cellular respiration are complimentary processes because they are each other's products and reactants.

Move to pages 2.1-2.9 in TI-Nspire Document

In Problem 2, students are tasked with learning about cellular respiration within the cell and an overview of the chemical reactions and energy flow in these metabolic processes. Students will use the simulation of an animal cell on Page 2.2 to find the mitochondria as well as other cellular organelles. Students should answer Question #3 "Research" on their Student Activity Sheet. They are asked to draw a picture of the cell and answer questions from the .TNS file.

Teacher Tip: Students might want to look for additional resources online to learn further about the process of cellular respiration.

Teacher Tip: You can choose to have students compare and contrast a plant cell versus an animal cell.

Move to pages 3.1-3.7 in TI-Nspire Document

In Problem 3, students will investigate how much food (measured in yams) an astronaut needs to consume in 24 hours to support daily activity. The big idea for students is to understand that both Body Mass Index (BMI) and daily activity impact caloric expenditure.

In order to investigate these relationships, students will first build a model of an astronaut and then use it in conjunction with the simulation on Page 3.4 to model an astronaut's energy needs.

Task 1: Designing and Building the Avatar Model

In Problem 3, students will design and build their avatar. Students should review the available building materials and the engineering goal. Students will make a sketch in their student activity sheet of their proposed avatar model. Their avatar will use a Servo motor to simulate activity motion, an LED light that will represent "mental activity" i.e. analyzing data, and a vibration motor to simulate BMI.

Move to page 3.4 in TI-Nspire Document.

Connect input/output devices to the TI-Innovator Hub.

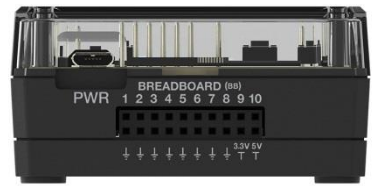
a. Connect the LED to *OUT1* on the TI-Innovator Hub.

b. Connect the vibration motor to *OUT2* on the TI-Innovator Hub.

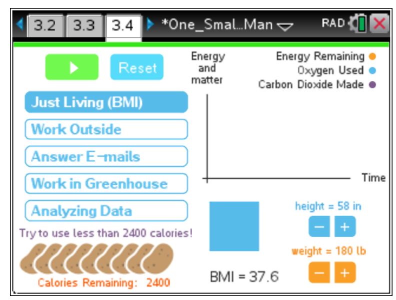
c. Connect the servomotor to *OUT3* on the TI-Innovator Hub.

d. Connect the power supply/battery pack to the TI-Innovator Hub where it says *PWR*.

e. Connect your TI-Innovator™ Hub to the TI-Nspire CX. Insert the "B" connector on the unit-to-unit cable into the DATA port at the bottom of the TI-Innovator™ Hub.

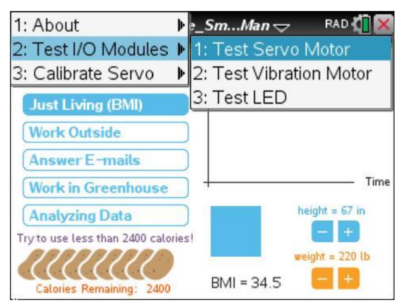


Note: You should see a green line at the top of TI-Nspire CX screen to show you are connected.



Before students design their model, they should test each sensor using **"Test Mode".** Go to **menu> Test I/O Modules> Test Servo Motor**, etc.

Encourage students to think about the movements, and how to best incorporate them into the design of their avatar.



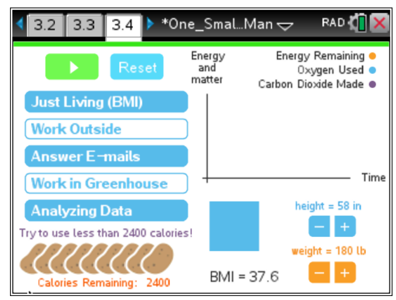
Teacher Tip: Over time, the Servo Motor may not operate correctly and will need to be recalibrated. Go to **menu> Calibrate Servo> Calibrate Servo**. If the Servo does not move, then it's already calibrated, If the servo is moving, use a screwdriver to move the potentiometer in the back of the motor until it stops. If you need more assistance, contact Customer Support [education.ti.com/support.](education.ti.com/support)

Teacher Tip: Students should make a detailed sketch of their model with appropriate labels and material lists before they begin construction. This is a good checkpoint to ensure students are on task. If students are struggling with their designs, pose the following questions:

- Where should you place the motor to maximize movement?
- How will your design allow the model to move freely without the wires getting in the way?
- What feature of the LED should change to demonstrate the astronaut is thinking?
- Which materials are critical to the model?
- How might the size of your model impact the experiment?

Teacher Tip: Although the avatar is essentially an "astronaut avatar," remind students they do not need to try to build a traditional astronaut.

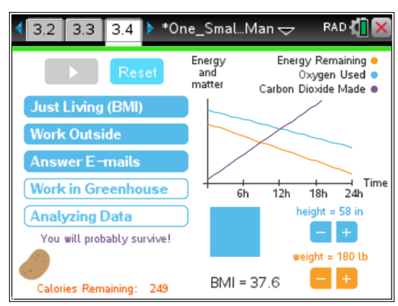
Task 2: Investigate Relationships Using the Model



Students will now use their model to conduct a simple experiment using the scientific method. The simulation is designed to help students understand the material and energy flows in cellular respiration. Oxygen is used while carbon dioxide is produced.

As the simulation runs, the astronaut avatar uses energy produced from eating the yams allocated to their energy budget of 2400 calories. The goal is to have the astronaut use no more than 2400 calories (per day): 3 plants x 800 calories per plant.

Have students identify the controlled, measured, and constant variable of the experiment.



Students should adjust the BMI and choose different combinations of astronaut activities, then run the simulation. Use the reset button to have students test other combinations of BMI and astronaut activities.

Students should record at least 3 trials on their student activity sheets in Question #7. After each trial, students should go to Page 3.7 to analyze the data.

Additional Background on BMI: Students need to understand what BMI is and how the formula relates to the area of a square. **This is not included in the TNS file or student activity sheet**.

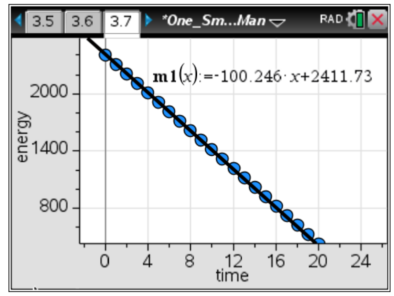
$$BMI = \frac{weight(lbs)}{(height(in))^2} \times 703$$

The height squared in this formula represents the surface area of the body while the weight represents the body's volume, while the 703 is a constant of proportionality based on the use of US imperial measurement units.

The ratio of volume to surface area is an important biological concept and is captured in the body's BMI. A person's BMI is used to judge obesity. In this simulation, it also informs the basal metabolic rate (BMR) of the astronaut.

Teacher Tip: Students might want to look for additional resources online to learn further about Body Mass Index (BMI).

Analyzing Data to Make Conclusions



The objective is to find the relationship between activity and energy used and also the relationship between BMI and energy used. On Page 3.7, students will see a graph of the energy produced from cellular respiration. They will add a moveable line (**menu> Analyze> Moveable Line**) and find the slope. After each trial as they adjust different combinations of the BMI and activities, they will return to page 3.7 to analyze the data.

> **Teacher Tip:** The graph can also plot oxygen used or carbon dioxide produced during cellular respiration. The calories/time stat plot is displayed by default. To analyze the other data points, change the variable displayed in the y-axis.

On pages 4.1 through 4. 5, there are questions to help students analyze the data and draw conclusions. Questions and answers are included on the student activity sheet answer key.

> **Teacher Tip:** Additional discussion questions to help guide student conclusions:
>
> - What does the slope of your graph tell you about the astronaut?
>   **Answer**: The rate of energy usage (calories consume)
> - Why are the slopes of the energy graphs negative?
>   **Answer**: Energy is being consumed not produced.
> - What are the units of the slope of the graph?
>   **Answer**: Calories/hour
> - What effect does BMI have on the energy usage?
>   **Answer**: The greater the BMI the faster energy is consumed.
> - What effect activity levels have on energy usage?
>   **Answer**: The greater the greater the activity the faster energy is use.
>   Students may want to look for additional resources online to learn further about Body Mass Index (BMI).

Assessment

Students will complete the Student Activity sheet which will contain design sketches, data analysis, answers to the questions included in the TNS file, and finally their conclusions.

You can also have students prepare a brief presentation explaining their design and findings using a dry erase board, poster board, or multimedia. They should include pictures of their design and findings from their experiment.

- Formative assessment consists of questions posed to students throughout the design process to determine if they understand the concepts presented in the lesson.
- Summative assessment will consist of the overall quality of the design and student explanation of their model and findings.