SCIENCE THEATER
EXPLORE LESSON 28

Food and Agriculture Center for Science Education

Science Theater Teacher Directions

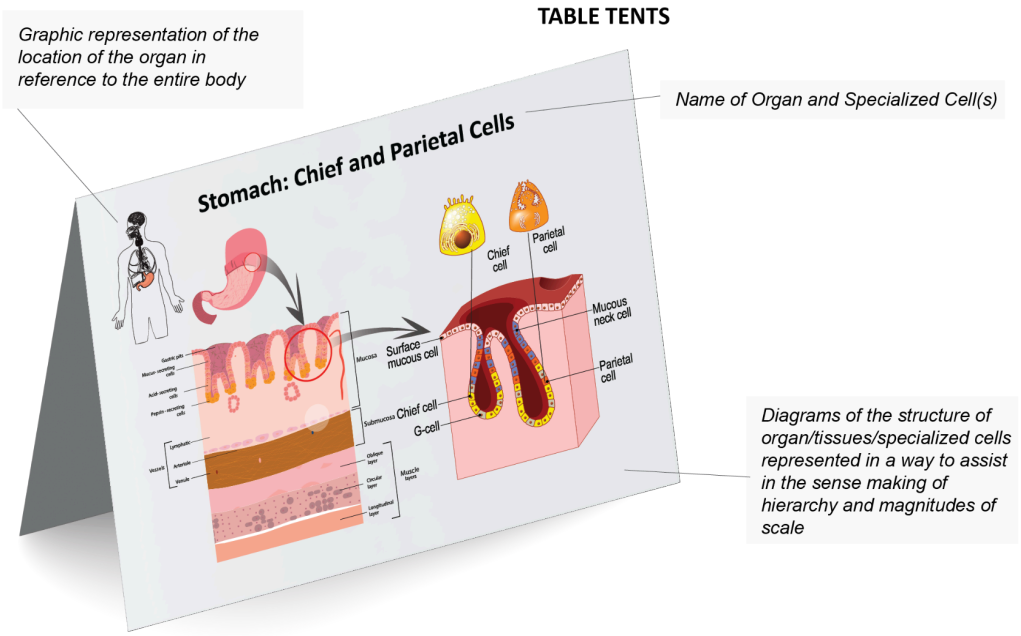
Key Outcomes

- Students experience the model from two points of view: an observer and a participant assigned to the role of an organ and/or specialized cell within an organ.
- Students cooperate to combine information about individual organs and cells to make sense of the pathways, processes, and purpose of muscle soreness and repair in the body post-exercise.
- Students physically transport and manipulate molecular models simulating the rearrangement of atoms during muscle recovery.

Materials

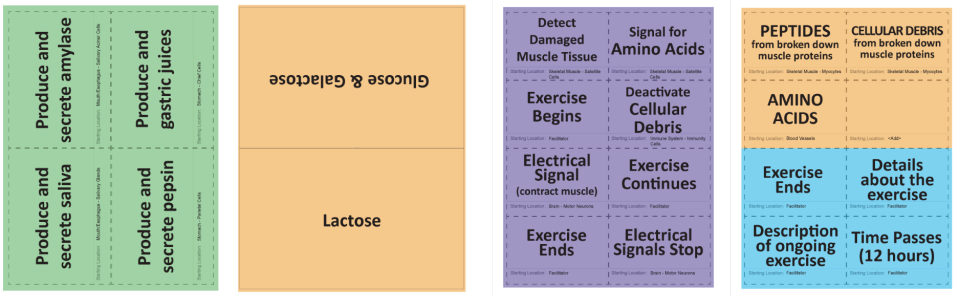
The following is a list of the printed materials in the student handout. There you will find:

Table Tents for each organ that depict the structure of the organ and the specialized cells it is composed of.



Tokens represent relevant nutrients, stimuli, processes, and responses that occur during the mechanism being modeled.

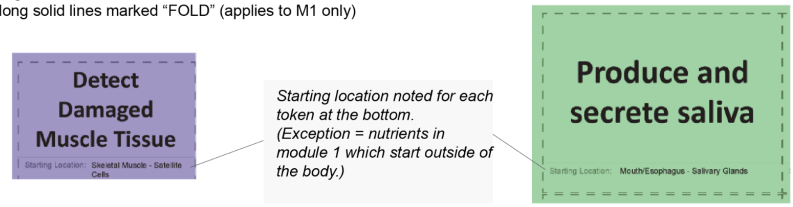
TOKENS



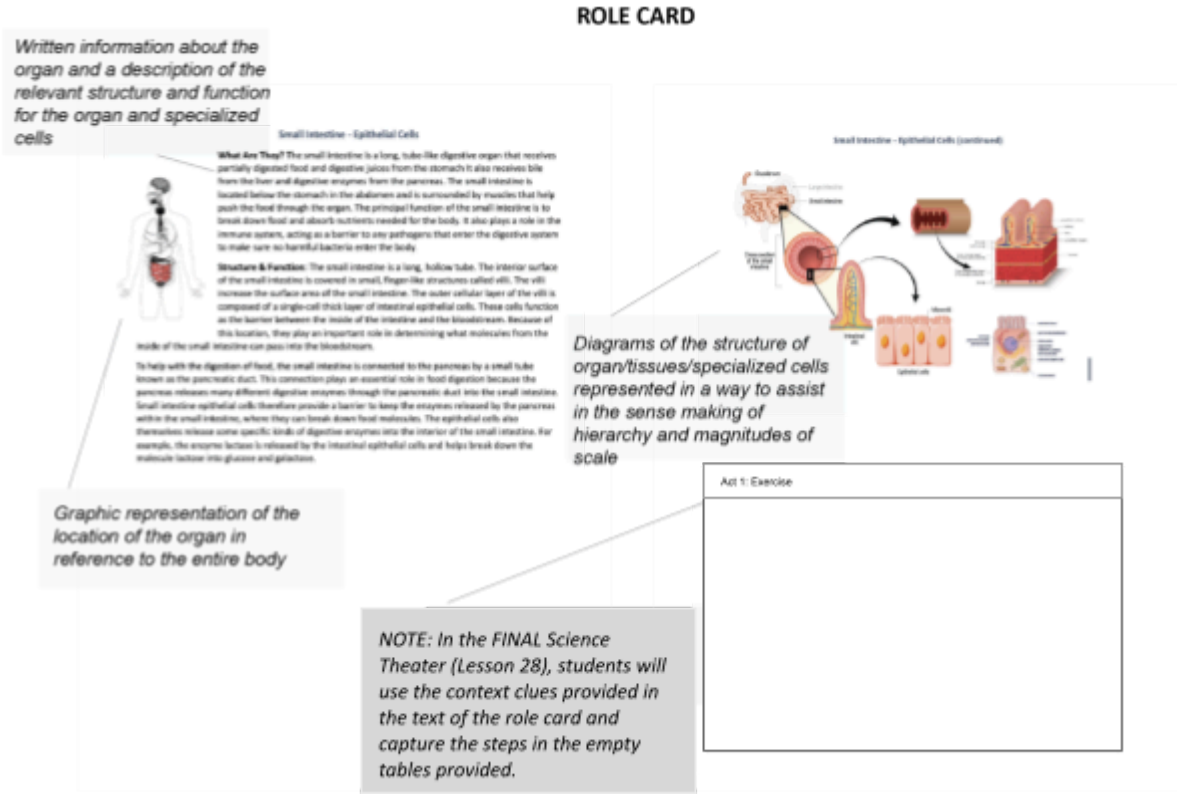
Above are a few examples from various Science Theater models throughout the unit.

Instructions after printing:

- Multiple tokens are located on a page.
- Cut along dotted lines.
- Fold along solid lines marked "FOLD" (applies to M1 only)

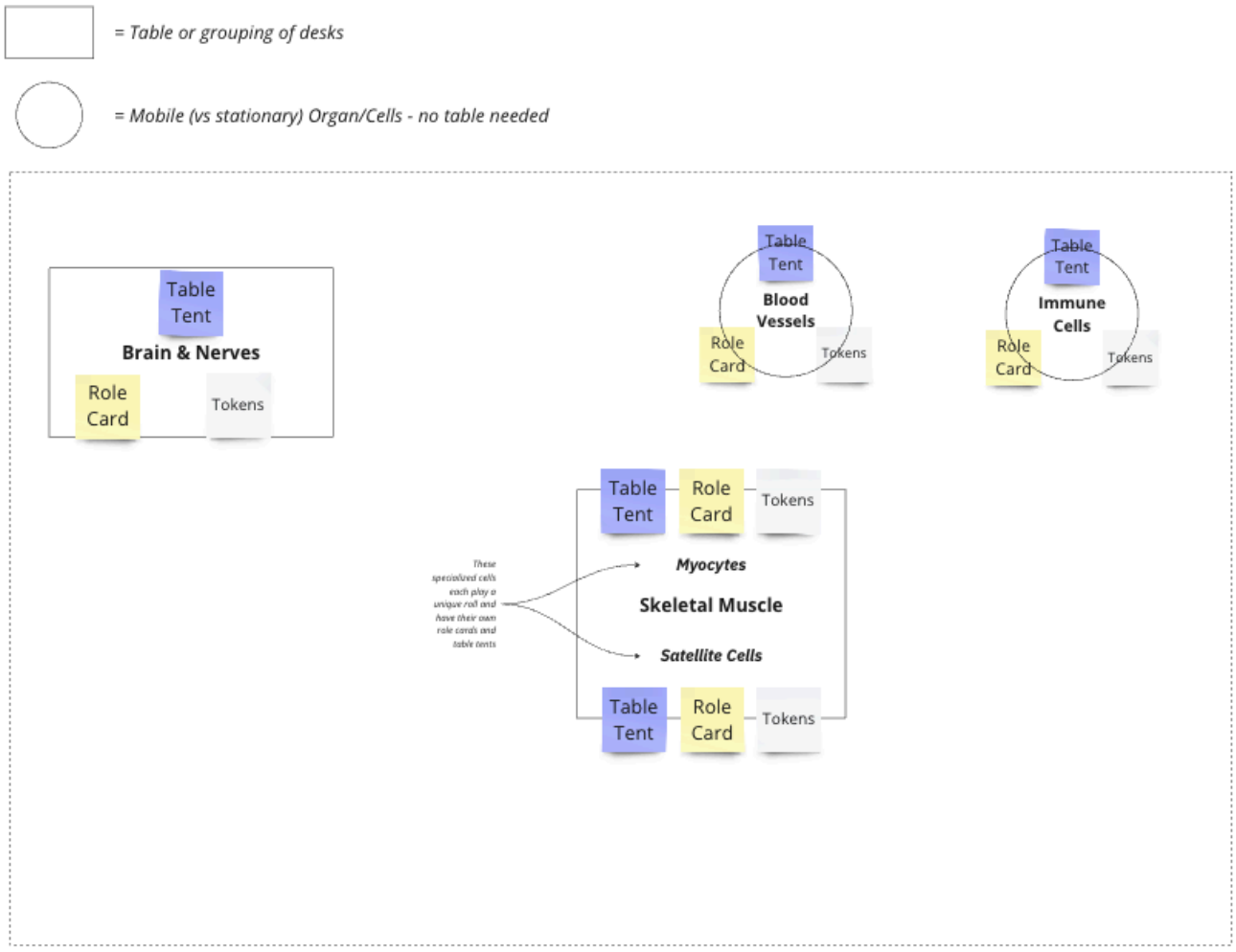


Role Cards for each organ (including any specialized cells) that describe the function of each organ and its specialized cells, as well as instructions for how students will engage in the model.



Physical Classroom Setup

Set up and label the layout of the classroom as shown below so that a table (or grouping of desks) represents each organ. Ensure each organ has the corresponding visual poster where it is visible. Students will stand or sit at each table as they represent the cells of each organ. Molecule cards will be "moving" from one organ to another.



Below is a table listing the initial locations for each token:

Organ	**Tokens**
Brain & Nerves	● Initial electrical signal (contract muscle) ● Continuous electricals signals ● Increased amount of electrical signals ● Electrical signals stop
Skeletal Muscle - Satellite Cells	● Formation of new myocytes ● Repair of damaged myocytes ● Functional myocytes ● Return to dormant state ● Deactivate cellular debris ● Detect damaged muscle tissue ● Signal for amino acids
Skeletal Muscles - Myocytes	● Contracted muscle ● Continuous muscle contractions ● Increased amount of muscle cells contracting ● Myocytes with microtears ● Muscle soreness ● Peptides from broken-down muscle proteins ● Cellular debris from broken-down muscle cells ● Increase levels of protein synthesis ● Muscle fatigue and myocytes with microtears
Blood Vessels	● Amino Acids
Immune Cells	● Detect peptides from broken-down muscle cells ● Deactivate cellular debris ● Migrate back to blood vessels
Facilitator	● Exercise begins ● Resistance is added, and pedaling continues for 45 minutes ● Exercise ends ● Time passes (12 hours)

Science Theater Actions By Role

- Brain and Nerves (Neurons)
    - Muscle fibers expand and contract during exercise. The brain sends an electrical impulse signal through the nerves to the neuromuscular junction. The nerve signal causes the muscle fibers to contract. Continued signals from the brain and nerves stimulate the muscle cells throughout exercise.
- Skeletal Muscles (Myocytes)
    - Muscle fatigue and microtears occur in the structure of the muscle fibers as exercise continues.
    - Damaged muscle fibers begin to break down and release small fragments of muscle proteins into the bloodstream.
- Skeletal Muscles (Satellite Cells)
    - Satellite cells, located in the muscle tissue, detect nearby damaged muscle fiber cells.
    - Satellite cells move to the site of the muscle fiber damage.
    - Satellite cells begin to undergo cell division and form new muscle fiber cells that are incorporated into the damaged muscle fibers. Satellite cells also fuse into the damaged muscle fiber cells to reform their structure.
- Blood Vessels
    - Within damaged or newly created muscle fiber cells, levels of protein synthesis increase. Amino acids in the bloodstream move into the actively repairing muscle cells. These cells used the amino acids to build new proteins, which creates additional muscle fibers and repairs damaged muscle fibers.
- Immune Cells
    - These small fragments of proteins are detected by the immune system. Immune cells move through the bloodstream to move toward the site of the damaged muscle fiber proteins.
    - The immune cells begin to assist the muscle fibers in removing and breaking down damaged muscle fiber proteins and other damaged parts of the muscle fiber cells.
    - After muscle fibers are repaired, immune cells leave the site of the damaged muscle fiber cells and return to the bloodstream and lymph. Satellite cells return to their dormant state in the muscle tissue.

Science Theater Actions in Sequence

Act 1 - During Exercise

1. (Facilitator) Exercise begins
2. (Brain & Nerves - Motor Neurons) Send initial electrical signal (contract muscle) through nerves to Skeletal Muscle Myocytes
3. (Skeletal Muscle - Myocytes) Initiate muscle contraction
4. (Brain & Nerves) Continued signals from the brain and nerves stimulate the muscle cells throughout exercise.
5. (Skeletal Muscle - Myocytes) Continuous muscle contractions.
6. (Skeletal Muscle - Myocytes) Microtears occur in the structure of the muscle fibers as exercise continues.
7. (Skeletal Muscle - Myocytes) Protein fragments from broken-down myocytes released into blood vessels
8. (Blood Vessels) Receive protein fragments from broken-down myocytes
9. (Skeletal Muscle - Myocytes) Cellular debris from damaged myocytes remains in skeletal muscles

Act 2 - During Recovery

1. (Facilitator) Twenty-four hours have passed since the end of the workout, and the skeletal muscles are experiencing soreness.
2. (Immune System - Immune Cells) Detect protein fragments from broken-down muscle proteins in the bloodstream are detected by the immune system.
3. and migrate to damaged muscle cells via the bloodstream (Blood Vessels)
4. (Immune Cells @ Myocytes) Cellular debris is removed by the immune cells
5. (Skeletal Muscles - Satellite Cells) Detects protein fragments from broken-down muscle cells in the bloodstream.
6. (Skeletal Muscles - Satellite Cells) Migrate within the skeletal muscle to broken-down myocytes.
7. (Skeletal Muscles - Satellite Cells) Send a signal to the blood vessels that amino acids will be needed to repair damaged cells.
8. (Blood Vessels) Deliver amino acids to skeletal muscles.
9. (Skeletal Muscles - Myocytes) Amino acids are received from the bloodstream.
10. (Skeletal Muscles - Satellite Cells) Use amino acids to increase the levels of protein synthesis, which are put to use in building new proteins.
11. (Skeletal Muscles - Satellite Cells)) New proteins create additional muscle fibers and repair damaged myocytes. (Myocytes)
12. (Skeletal Muscles - Satellite Cells) - Return to a dormant state in muscle tissue.