STUDENT GUIDE
ELABORATE LESSON 6

Food and Agriculture Center for Science Education

Part 1: Our Motivation

Record what we were trying to figure out that led to this investigation.

We know that the molecules in milk have been broken down into amino acids, fatty acids, and sugar molecules. We wonder where these molecules go from the small intestine because they do not leave the body.

Example student questions:

- Where are molecules going next?
- How do the molecules get to the rest of the body to help in recovery?
- How are these molecules flowing throughout the body?
- Are some molecules used differently than others?
- Do molecules get used at the same time?

Part 2: Observing the Structure of the Small Intestines

What do you notice (or wonder) about the shape and structure of the interior specialized structures within the small intestine? How might this help get nutrients to the rest of the body?

- There are many wavy structures on the interior surface of the small intestine.
- There are very small folds in the surface of the small intestine.
- Why are these structures shaped in these ways?
- Do these cells absorb amino acids, fatty acids, and sugar molecules?

Part 3: Use Models to Observe What Happens to Nutrients in the Small Intestine

Identify the scales that each model of the "Body System Models" focuses on. Place an X in each box that shows the scale each model represents.

	m	cm	mm	um	nm
Model 1		x			x
Model 2					x
Model 3					x
Model 4	x	x	x	x	
Model 5			x		

Based on the table above, describe how orders of magnitude can help you understand how the scale of one model relates to the scale of another model.

Orders of magnitude help me understand how one model relates to another and the relative size of different units of length shown in the different models. For example, Model 4 shows the entire gastrointestinal tract to be between three and five meters in length. Model 1 shows the intestinal villus within the gastrointestinal tract carrying nutrients such as amino acids which can be as small as 0.7 nm.

Use each of the models on the "Body System Models" handout to observe how nutrients are absorbed from the small intestines. Record the merits and limitations of each model as you observe them.

Model	Merits	Limitations

1	• Shows the overall absorption process and includes multiple organs. • Shows how different molecules take different pathways (blood vessels vs lymph). • Shows that all molecules end up in the bloodstream.	• Does not show cells • Does not show the scale for all components (only liver 7-10 cm and amino acid 0.7 nm)
2	• Shows how different molecules cross through the epithelial cells in different ways.	• Does not show where the molecules go after they enter the hepatic portal vein. • Does not show the scale for all components (only shows Na^+ 0.95 nm)
3	• Shows how the different molecules in the small intestine pass through the epithelial cells and into the bloodstream.	• Does not show the different ways that the molecules enter the epithelial cells. • Does not show the scale for all components (only shows brush border on microvilli 50-550 nm and triglycerides +/- 10 nm)
4	• Shows the structure of the small intestine at different scales. • Shows how the epithelial cells are arranged on the villi. • Shows scale of all components of gastrointestinal tract (GI tract 3-5 m in length, small intestine 1-3 cm wide, intestinal lining fold 2-4 mm thick, villi 0.5-1 mm in length, epithelial cell 10-20 um thick)	• Does not show where the blood vessels go after leaving the villi.
5	• Shows where all the arteries and veins are in the body.	• Does not show the small intestine in detail. • Does not show scale for length only diameter (carotid 4..3-7.7 mm diameter and femoral 6-7 mm diameter)

Using ideas from all models, summarize **how** molecules move from the small intestine to the rest of the body. In your response, be sure to:

- Identify how the function of specialized cells helps move amino acids, fatty acids, and sugars from the small intestine to the rest of the body.
- State which model(s) most clearly helped you understand which ideas.

As shown best by Model 4, the epithelial cells that line the villi are only one cell thick, so nutrient molecules like amino acids, fatty acids, and sugars from the small intestine can move through them. The molecules in the small intestine cross the epithelial cells in a variety of ways depending on what type of molecule it is, which is clear in Model 2. Then, as Model 1 shows, glucose, amino acids, and water move directly into the bloodstream. Fats are put into chylomicrons and move into the lymph vessels, which later move into the bloodstream. The arteries and blood vessels can carry the blood to the rest of the body, as shown in Model 5.

Part 4: Revising a Model of How Milk is Digested

Using all the evidence gathered, brainstorm revisions to our Class Consensus Model from Lesson 5 that answer our Module Question, *How is milk digested after it is consumed?* Include zoom-ins as necessary.

- We should add the bloodstream since that is where the nutrient molecules end up.
- We should add the epithelial cells of the small intestine because the nutrients pass through these cells to enter the hepatic portal vein.
- We should add the relative sizes of the structures in the bloodstream.
- We should add the interactions of the circulatory system and the digestive system through the epithelial cells.

Record the new class consensus model we create in the space below.