



Metabolism:

Making the Diagnosis

Print Materials
(8.5" x 11")



© 2018 by The Regents of the University of California. All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage or retrieval system, without permission in writing from the publisher.



These materials are based upon work partially supported by the National Science Foundation under grant numbers DRL-1119584, DRL-1417939, ESI-0242733, ESI-0628272, and ESI-0822119. The Federal Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

These materials are based upon work partially supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A130610 to The Regents of the University of California. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.



Developed by the Learning Design Group at the University of California, Berkeley's Lawrence Hall of Science.



Amplify.
55 Washington Street, Suite 800
Brooklyn, NY 11201
1-800-823-1969
www.amplify.com

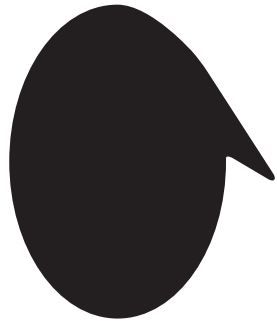
Metabolism
ISBN: 978-1-64333-162-1
AMP.NA18

KEY CONCEPTS AND
VOCABULARY HEADERS
2 CARDS



Key Concepts

Metabolism—Key Concepts—Lesson 1.2—AMP615583.21-MET
© The Regents of the University of California. All rights reserved.



Vocabulary

Metabolism—Vocabulary—Lesson 1.2—AMP615583.21-MET
© The Regents of the University of California. All rights reserved.

KEY CONCEPTS

11 CARDS

1. A functioning human body has molecules from food (glucose and amino acids) and molecules from air (oxygen) in its cells.

**2. Cells can only use
molecules that are small
enough to enter a cell.**

3. The respiratory system brings in oxygen molecules from the air. These oxygen molecules are already small enough to fit into cells.

4. The digestive system brings in food and breaks it down into smaller molecules, such as glucose and amino acids, that can fit into cells.

5. The circulatory system transports glucose, oxygen, and amino acid molecules to every cell in the body.

5a. Systems can work together to form a larger more complex system.

6. In a functioning human body, body systems work together to deliver glucose, oxygen, and amino acid molecules to the cells in the body.

7. A problem with a body system can result in fewer oxygen, glucose, and/or amino acid molecules getting to the body's cells.

**8. In order to release energy,
cells need both glucose and
oxygen molecules.**

9. Inside the cell, the atoms that make up glucose and oxygen can be rearranged to make different molecules. This chemical reaction is called cellular respiration and releases energy.

10. Cells can grow and repair themselves by combining amino acid molecules to form larger protein molecules. This growth and repair requires energy release from cellular respiration.

VOCABULARY
11 CARDS

metabolism

Metabolism—Vocabulary—Lesson 1.2—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

molecule

Metabolism—Vocabulary—Lesson 1.3—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

amino acid

Metabolism—Vocabulary—Lesson 1.3—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

glucose

Metabolism—Vocabulary—Lesson 1.3—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

oxygen

Metabolism—Vocabulary—Lesson 1.3—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

system

Metabolism—Vocabulary—Lesson 2.1—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

digestive system

Metabolism—Vocabulary—Lesson 2.2—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

respiratory system

Metabolism—Vocabulary—Lesson 2.2—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

circulatory system

Metabolism—Vocabulary—Lesson 2.2—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

energy

Metabolism—Vocabulary—Lesson 3.2—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

cellular respiration

Metabolism—Vocabulary—Lesson 3.3—AMP615583.17-MET
© The Regents of the University of California. All rights reserved.

EVIDENCE COMPARISON CARDS

2 CARDS

Evidence Card A

John observed his 14-year-old brother's sleep for one night. His brother slept for 10 hours. Based on this, John concluded that all 14-year-olds need 10 hours of sleep a night.

Metabolism—Evidence Comparison Cards—Lesson 1.3—AMP615583.04-MET
© The Regents of the University of California. All rights reserved.

Evidence Card B

Scientists observed the sleep of 2,000 healthy 14-year-olds every night for a month. The average number of hours the 14-year-olds slept was 9.4 hours. Based on this, the scientists concluded that 14-year-olds need about 9 hours of sleep a night.

Metabolism—Evidence Comparison Cards—Lesson 1.3—AMP615583.04-MET
© The Regents of the University of California. All rights reserved.

ELISA'S EVIDENCE CARDS
5 CARDS

Evidence Card A

Elisa's sleep journal shows that she has gotten, on average, 9 hours of sleep each night for the past month.

Metabolism—Elisa's Evidence Cards—Lesson 1.3—AMP615583.03-MET
© The Regents of the University of California. All rights reserved.

Evidence Card B

The night before she came back to the doctor's office, Elisa slept 7 hours.

Metabolism—Elisa's Evidence Cards—Lesson 1.3—AMP615583.03-MET
© The Regents of the University of California. All rights reserved.

Evidence Card C

Elisa was asked to keep a food journal for a month. Her journal shows that over that month, Elisa ate between 6 and 8 servings of food that contained starch every day. She ate between 2 and 4 servings of food that contained protein every day.

Metabolism—Elisa's Evidence Cards—Lesson 1.3—AMP615583.03-MET
© The Regents of the University of California. All rights reserved.

Evidence Card D

Elisa ate a lot of starch yesterday, but she still felt tired.

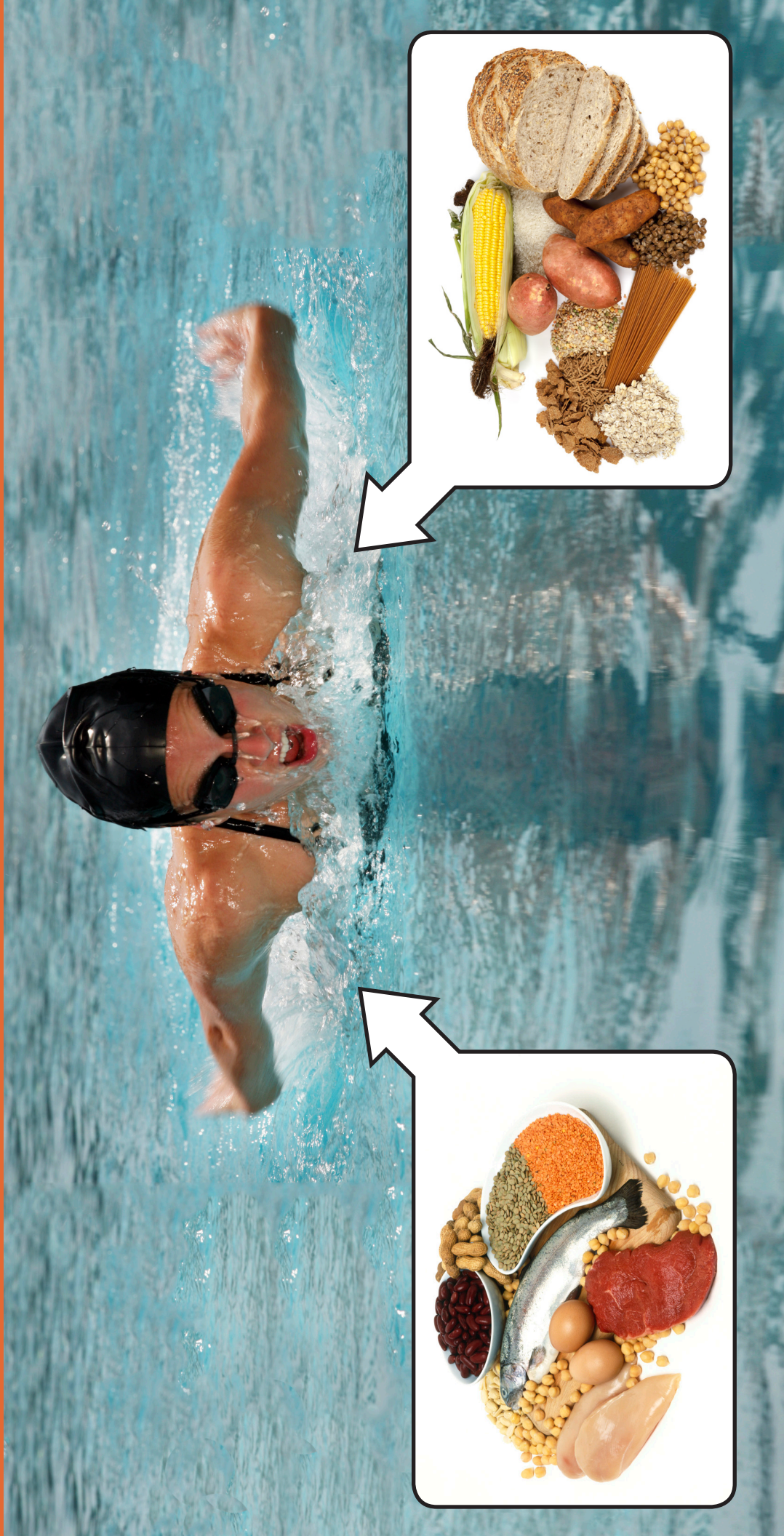
Metabolism—Elisa's Evidence Cards—Lesson 1.3—AMP615583.03-MET
© The Regents of the University of California. All rights reserved.

Evidence Card E

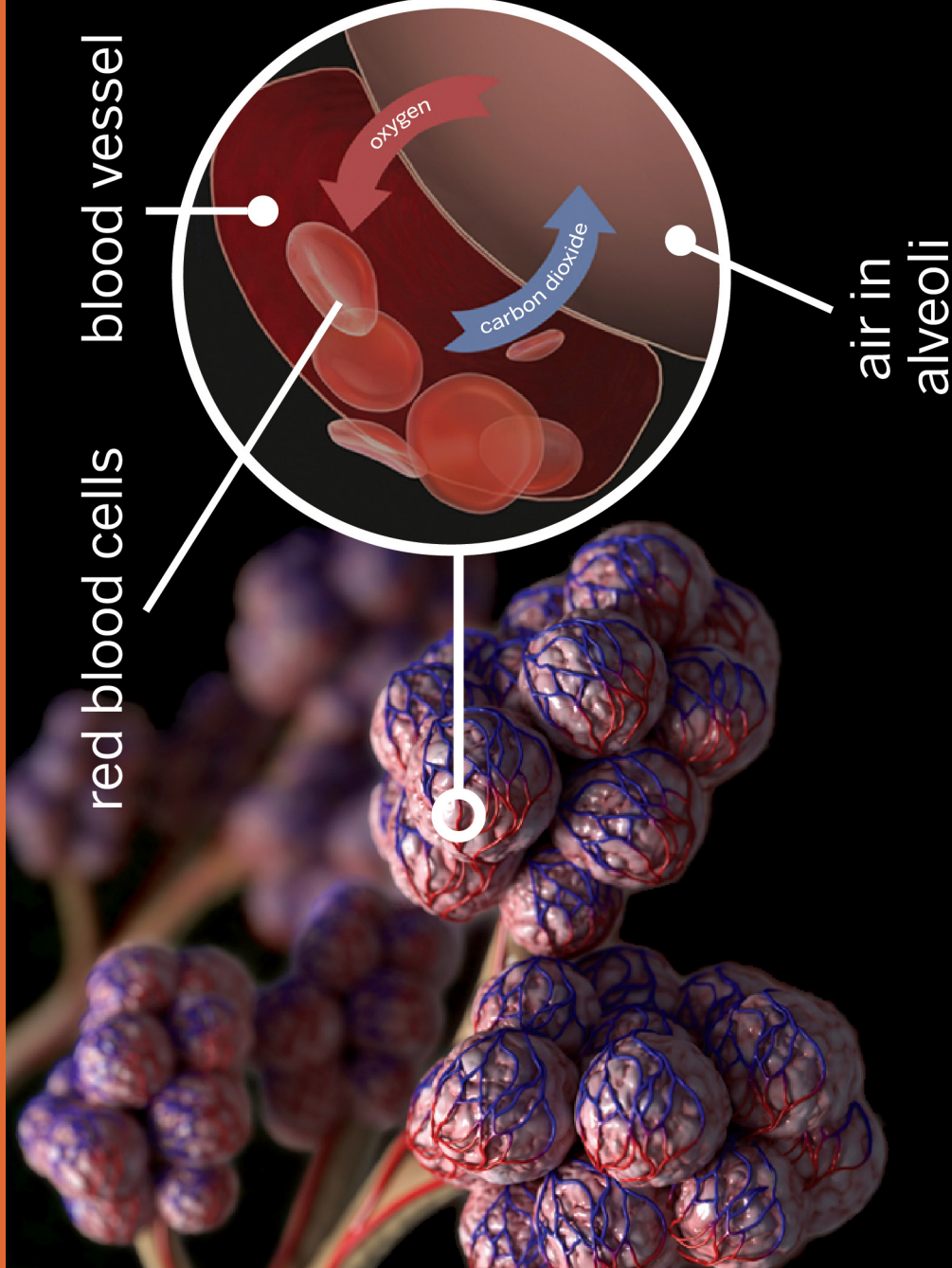
On the day before she started her food and sleep journals, Elisa said she always felt tired even though she ate well and slept a lot at night.

STATION SIGNS
6 CARDS

Environment Station



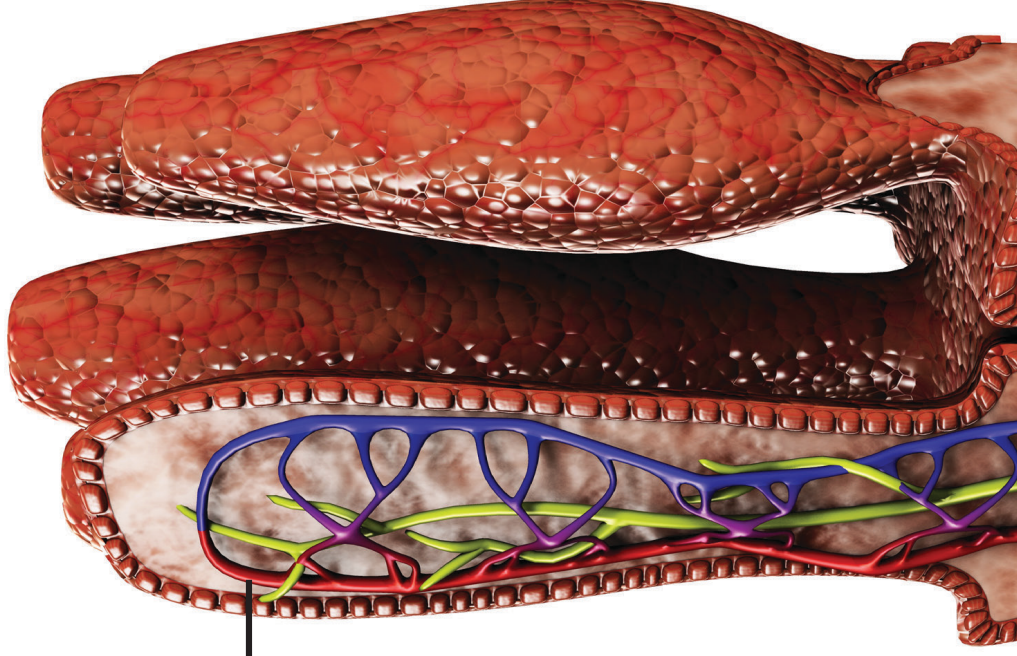
Lungs Station



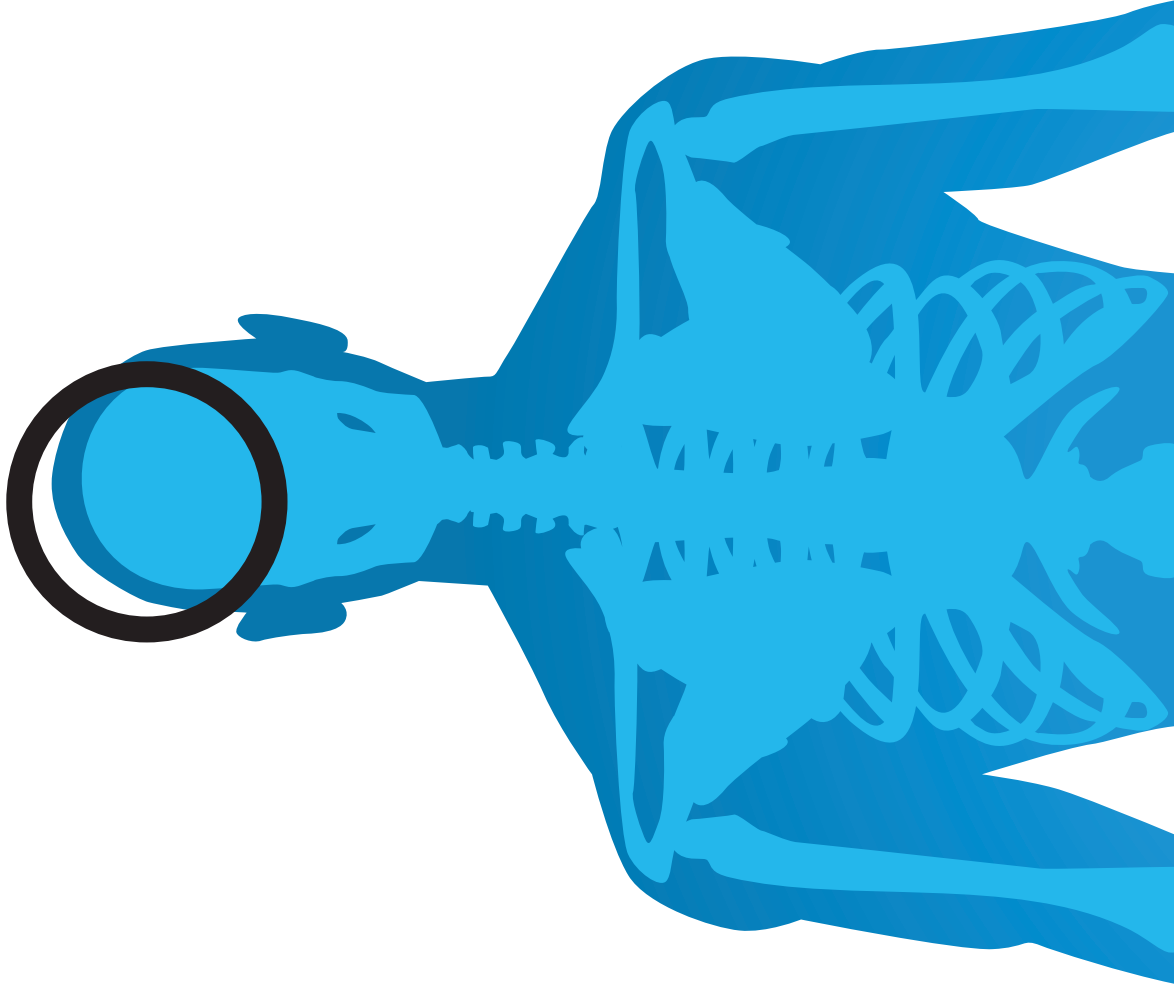
Small Intestine Station

villi

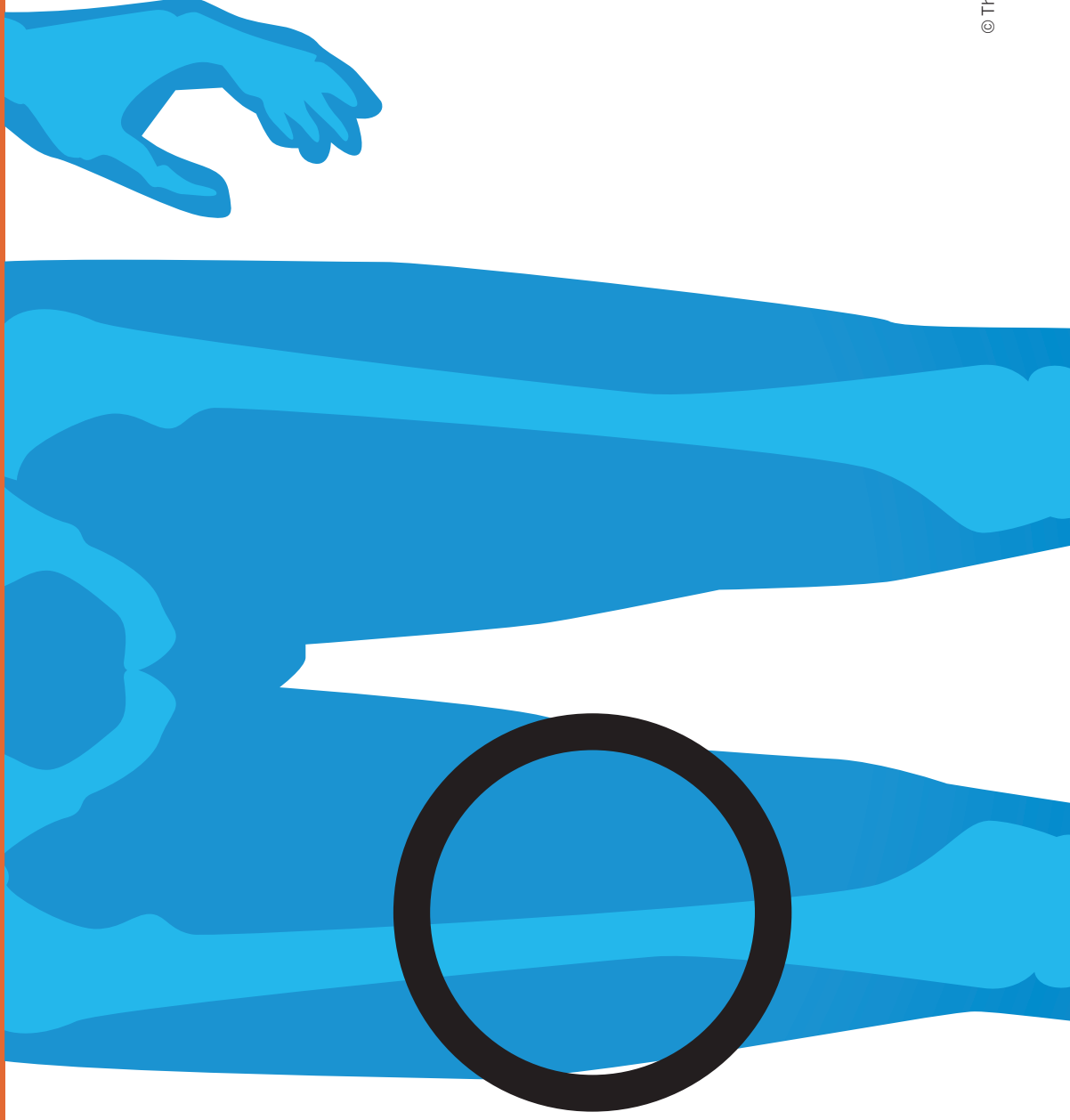
capillaries



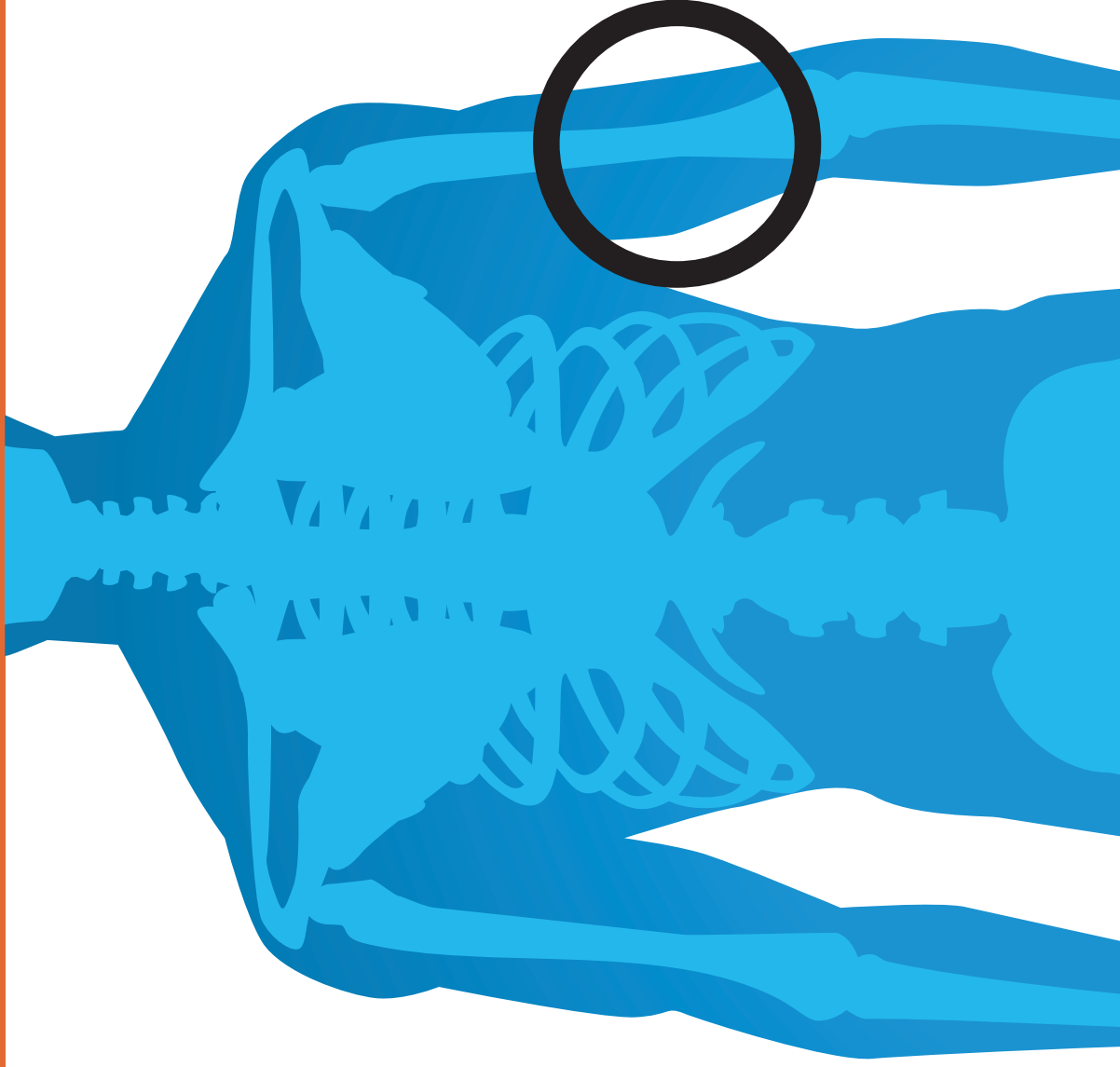
Brain Cell Station



Leg-Muscle Cell Station



Injured Arm-Muscle Cell Station



HEART FAILURE CARDS

6 CARDS

HEART FAILURE!

The patient represented in the model is now in heart failure, which means there is not enough blood flowing through his body. **To represent this in our model, please STOP participating in the model and sit down at your desk.** Observe the model carefully for the next few minutes to see what happens to the patient.

Metabolism—Heart Failure Cards—Lesson 2.1—AMP615583.05-MET
© The Regents of the University of California. All rights reserved.

HEART FAILURE!

The patient represented in the model is now in heart failure, which means there is not enough blood flowing through his body. **To represent this in our model, please STOP participating in the model and sit down at your desk.** Observe the model carefully for the next few minutes to see what happens to the patient.

Metabolism—Heart Failure Cards—Lesson 2.1—AMP615583.05-MET
© The Regents of the University of California. All rights reserved.

HEART FAILURE!

The patient represented in the model is now in heart failure, which means there is not enough blood flowing through his body. **To represent this in our model, please STOP participating in the model and sit down at your desk.** Observe the model carefully for the next few minutes to see what happens to the patient.

Metabolism—Heart Failure Cards—Lesson 2.1—AMP615583.05-MET
© The Regents of the University of California. All rights reserved.

HEART FAILURE!

The patient represented in the model is now in heart failure, which means there is not enough blood flowing through his body. **To represent this in our model, please STOP participating in the model and sit down at your desk.** Observe the model carefully for the next few minutes to see what happens to the patient.

Metabolism—Heart Failure Cards—Lesson 2.1—AMP615583.05-MET
© The Regents of the University of California. All rights reserved.

HEART FAILURE!

The patient represented in the model is now in heart failure, which means there is not enough blood flowing through his body. **To represent this in our model, please STOP participating in the model and sit down at your desk.** Observe the model carefully for the next few minutes to see what happens to the patient.

Metabolism—Heart Failure Cards—Lesson 2.1—AMP615583.05-MET
© The Regents of the University of California. All rights reserved.

HEART FAILURE!

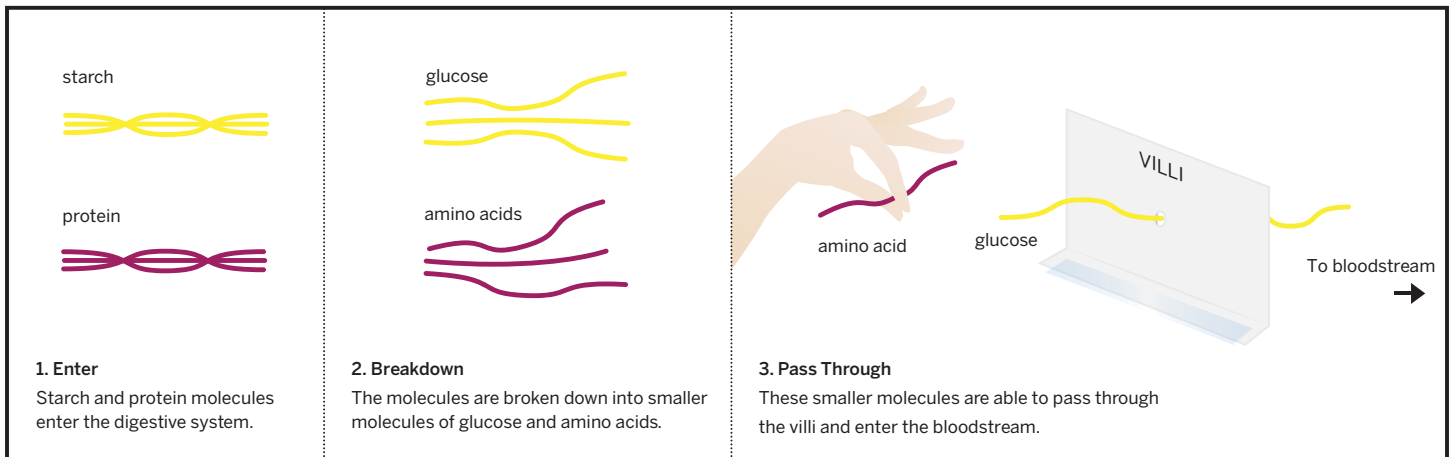
The patient represented in the model is now in heart failure, which means there is not enough blood flowing through his body. **To represent this in our model, please STOP participating in the model and sit down at your desk.** Observe the model carefully for the next few minutes to see what happens to the patient.

Metabolism—Heart Failure Cards—Lesson 2.1—AMP615583.05-MET
© The Regents of the University of California. All rights reserved.

ROLE CARDS
6 CARDS

Role: Digestive System

Your job in the model is to represent the digestive system. The cells of the body need glucose and amino acids that come from the food taken in and broken down by the digestive system.

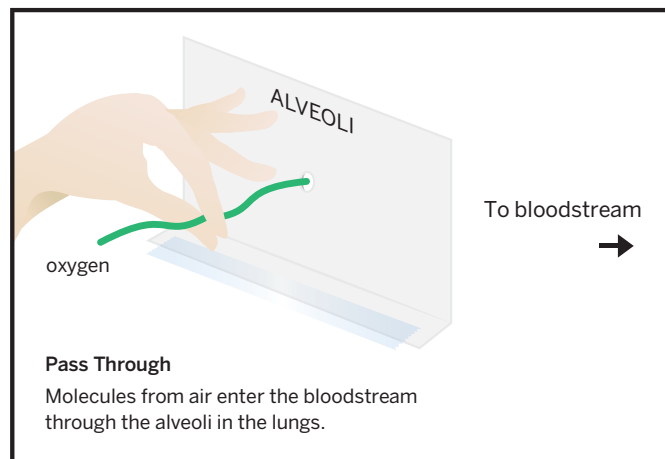


1. Take one food molecule from the Environment Station.
2. Once you've selected a starch molecule or a protein molecule, untwist the pipe cleaners to provide glucose molecules or amino acid molecules for the cell.
3. At the Small Intestine Station, thread the single glucose or amino acid pipe cleaners through the hole in the Villi card so the pipe-cleaner molecules can enter the bloodstream.
4. Repeat steps 1–3 to get more molecules for the cell.

Metabolism—Role Cards—Lesson 2.1—AMP615583.10-MET
© The Regents of the University of California. All rights reserved.

Role: Respiratory System

Your job in the model is to represent the respiratory system. The cells of the body need oxygen that comes from the air taken in from the environment by the respiratory system.

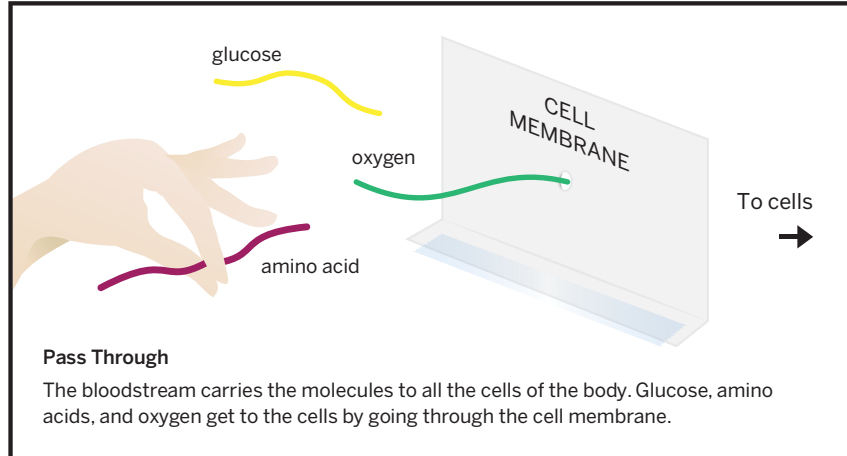


1. Take one oxygen molecule pipe cleaner from the Environment Station.
2. Thread the single oxygen molecule pipe cleaner through the hole in the Alveoli card at the Lungs Station so the pipe-cleaner molecule can enter the bloodstream.
3. Repeat steps 1–2 to get more oxygen molecules for the cell.

Metabolism—Role Cards—Lesson 2.1—AMP615583.10-MET
© The Regents of the University of California. All rights reserved.

Role: Circulatory System

Your job in the model is to represent the bloodstream in the circulatory system. The cells of the body need glucose and amino acid molecules that come from the food taken in and broken down by the digestive system. The cells also need the oxygen molecules that come from the air that the respiratory system takes in from the environment. The bloodstream carries these molecules from the digestive and respiratory systems to all the cells of the body.



1. At the Small Intestine Station or Lungs Station, take one molecule that the cell needs. You may need to communicate with a cell station to find out which molecules the cell needs.
2. Carry one pipe cleaner at a time to a cell station.
3. Thread the single pipe cleaners through the hole in the Cell Membrane card so the cell can get the molecules it needs.
4. Return to the Small Intestine Station or Lungs Station to get more molecules for the cell.

Metabolism—Role Cards—Lesson 2.1—AMP615583.10-MET
© The Regents of the University of California. All rights reserved.

Role: Leg-Muscle Cell

Your job in the model is to represent a leg-muscle cell in the body. You send signals to the body systems to get the molecules you need to move and build muscle. You only allow the molecules you need to pass through the cell membrane.

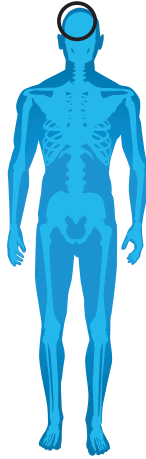


1. Your goal is to collect 20 amino acid molecule pipe cleaners, 4 glucose molecule pipe cleaners, and 24 oxygen molecule pipe cleaners for the needs of your leg-muscle cell.
2. Signal to the circulatory system which pipe-cleaner molecules you need and allow only those molecules to enter the cell through the Cell Membrane card.
3. As you collect molecules, re-twist your glucose molecule and amino acid molecule pipe cleaners into starch molecules and protein molecules.
4. Repeat steps 2–3 until you've reached your goal.

Metabolism—Role Cards—Lesson 2.1—AMP615583.10-MET
© The Regents of the University of California. All rights reserved.

Role: Brain Cell

Your job in the model is to represent a brain cell in the body. You send signals to the body systems to get the molecules you need in order to send signals to other brain cells and keep yourself healthy. You only allow the molecules you need to pass through the cell membrane.



1. Your goal is to collect 10 glucose molecule pipe cleaners and 60 oxygen molecule pipe cleaners for the needs of your brain cell.
2. Signal to the circulatory system which pipe-cleaner molecules you need and allow only those molecules to enter the cell through the Cell Membrane card.
3. As you collect molecules, re-twist your glucose molecule and amino acid molecule pipe cleaners into starch molecules and protein molecules.
4. Repeat steps 2–3 until you've reached your goal.

Metabolism—Role Cards—Lesson 2.1—AMP615583.10-MET
© The Regents of the University of California. All rights reserved.

Role: Injured Arm-Muscle Cell

Your job in the model is to represent an injured arm-muscle cell in the body. You send signals to the body systems to get the molecules you need to repair damage from an injury. You only allow the molecules you need to pass through the cell membrane.



1. Your goal is to collect 30 amino acid molecule pipe cleaners, 1 glucose molecule pipe cleaner, and 6 oxygen molecule pipe cleaners for the needs of your injured arm-muscle cell.
2. Signal to the circulatory system which pipe-cleaner molecules you need and allow only those molecules to enter the cell through the Cell Membrane card.
3. As you collect molecules, re-twist your glucose molecule and amino acid molecule pipe cleaners into starch molecules and protein molecules.
4. Repeat steps 2–3 until you've reached your goal.

Metabolism—Role Cards—Lesson 2.1—AMP615583.10-MET
© The Regents of the University of California. All rights reserved.

PURPLE GROUP CARDS
4 CARDS

A. A patient had to be hooked up to a heart–lung machine during surgery.

- Model what is happening in a patient's body when she is hooked up to a heart–lung machine during surgery.

Metabolism—Purple Group Cards—Lesson 2.6—AMP615583.08-MET
© The Regents of the University of California. All rights reserved.

B. Sonya ate a meal containing starch molecules, protein molecules, and fat molecules.

- Model what would happen in Sonya's body and cells after eating this meal.

Metabolism—Purple Group Cards—Lesson 2.6—AMP615583.08-MET
© The Regents of the University of California. All rights reserved.

C. Jose held his breath for almost 60 seconds. Earlier, Jose had eaten a lunch of a chicken sandwich on wheat bread.

- Model what would happen in Jose's body and in all his cells. Include carbon dioxide and any other molecules that might be affected.

Metabolism—Purple Group Cards—Lesson 2.6—AMP615583.08-MET
© The Regents of the University of California. All rights reserved.

D. Rachel was in the hospital and wasn't able to eat. She was given an IV needle, which injected into her circulatory system. This needle is connected to an IV bag filled with glucose and amino acids.

- Model what Rachel's body and cells would look like if she were getting these molecules from an IV.

Metabolism—Purple Group Cards—Lesson 2.6—AMP615583.08-MET
© The Regents of the University of California. All rights reserved.

BLUE GROUP CARDS
4 CARDS

A. Jose held his breath for 30 seconds.

Earlier, Jose had eaten a lunch of a chicken sandwich on wheat bread.

- Model what would happen in Jose's body and in all his cells.

Metabolism—Blue Group Cards—Lesson 2.6—AMP6J5583.01-MET
© The Regents of the University of California. All rights reserved.

B. Lily is not digesting her food well. Some proteins and starches are not breaking down. Earlier in the day, Lily ate rice and beans.

- Model what would happen in Lily's body and in all her cells.

Metabolism—Blue Group Cards—Lesson 2.6—AMP6J5583.01-MET
© The Regents of the University of California. All rights reserved.

C. Rachel was in the hospital and wasn't able to eat. She was given an IV needle, which injected into her circulatory system. This needle is connected to an IV bag filled with glucose and amino acids.

- Model what Rachel's body and cells would look like if she were getting these molecules from an IV.

Metabolism—Blue Group Cards—Lesson 2.6—AMP6J5583.01-MET
© The Regents of the University of California. All rights reserved.

D. Levi ate fish for dinner.

- Model what would happen in Levi's body and cells just after he ate this meal.

Metabolism—Blue Group Cards—Lesson 2.6—AMP6J5583.01-MET
© The Regents of the University of California. All rights reserved.

GREEN GROUP CARDS
4 CARDS

A. Julia just ran one kilometer without getting tired.

- Model what molecules could be in Julia's cells.

Metabolism—Green Group Cards—Lesson 2.6—AMP615583.06-MET
© The Regents of the University of California. All rights reserved.

B. John didn't eat breakfast and is feeling very tired.

- Model what molecules could be in John's cells.

Metabolism—Green Group Cards—Lesson 2.6—AMP615583.06-MET
© The Regents of the University of California. All rights reserved.

C. Levi ate fish for dinner.

- Model what would happen in Levi's body and cells just after he ate this meal.

Metabolism—Green Group Cards—Lesson 2.6—AMP615583.06-MET
© The Regents of the University of California. All rights reserved.

D. For dinner, Lily ate rice and potatoes. She ate no protein at this meal.

- Model what her cells would look like when the molecules from this meal got to her cells.

Metabolism—Green Group Cards—Lesson 2.6—AMP615583.06-MET
© The Regents of the University of California. All rights reserved.

PURPLE, BLUE AND GREEN GROUP KEYS
3 CARDS

Purple Group Key

- A. Model what happens to the circulatory and respiratory systems while a patient is hooked up to a heart–lung machine during surgery.
- B. Model how molecules get to the cells of the body when a person eats a meal of starch, protein, and fat.
- C. Model what happens to the body when a person holds his breath for a long time.
- D. Model what Rachel’s body and cells would look like if she were getting an IV injection of glucose and amino acids.

Metabolism—Purple Group Key—Lesson 2.6—AMP615583.09-MET
© The Regents of the University of California. All rights reserved.

Blue Group Key

- A. Model what Jose’s cells would look like after he held his breath.
- B. Model what would happen in Lily’s body and in all her cells since she is not digesting starches and proteins well, and she just ate a meal with rice and beans in it.
- C. Model what Rachel’s body and cells would look like if she were getting an IV injection of glucose and amino acids.
- D. Model what would happen in Levi’s body and cells just after he ate a meal of fish for dinner.

Metabolism—Blue Group Key—Lesson 2.6—AMP615583.02-MET
© The Regents of the University of California. All rights reserved.

Green Group Key

- A. Model what molecules could be in Julia's cells just after she ran.
- B. Model what molecules could be in John's cells since he didn't eat breakfast.
- C. Model what would happen in Levi's body and cells just after he ate a meal of fish for dinner.
- D. Model what Lily's cells would look like after she ate rice, potatoes, and no protein.

LARGE SCIENCE SEMINAR EVIDENCE CARDS
15 CARDS

Evidence Card A

Jordan Jones said, “I placed tenth in my last race, which was six months ago. I’m going to win all my next races.”

Evidence Card B

Jordan Jones was tested for blood doping two years ago, just before a big race. Compared to the 70 other cyclists in the race, he did not have a high number of old red blood cells in his blood sample at that time.

Evidence Card C

Jordan Jones read a study of 20,000 athletes showing that eating more starch made them perform better in long-distance races because there was more glucose available for cellular respiration. He changed his pre-race meal about a year ago, and now he eats more starch before a race.

Evidence Card D

Jordan Jones goes on a long, fast practice bike ride once every week as part of his training for real races. Before each practice bike ride, he ate the same pre-race meal he ate before the competition in which he placed first. In the eight long practice rides before the race, he got faster each time.

Evidence Card E

In an interview, Jordan Jones said that he felt really good and had a lot of energy three days before winning the American Cycling Classic.

Evidence Card F

Jordan Jones started high-altitude training. After two days of training in the mountains, he had one very slow practice ride.

Evidence Card G

Jordan Jones's blood sample had a higher number of old red blood cells than the average number found in the samples from the other 100 cyclists participating in the race.

Evidence Card H

A research study conducted on 1,000 athletes showed that high-altitude training increases the number of red blood cells in an athlete for 10–20 days after they returned to a lower altitude.

Evidence Card I

Jordan Jones trained at a higher altitude for one month.

Evidence Card J

Blood doping increases the number of red blood cells in an athlete's body.

This increases the amount of oxygen entering his cells, which increases energy released through cellular respiration.

Evidence Card K

Twelve days before the race, Jordan Jones left his high-altitude training center for the low-altitude city where the race was located.

Evidence Card L

Hemoglobin carries oxygen in red blood cells and is used to detect blood doping. If an athlete has a hemoglobin level that is 10–14% higher on the day of a race than it was the week before, officials might suspect that the athlete is blood doping. If the athlete's hemoglobin level is 15% or more higher, the athlete would likely be disqualified from that race for blood doping.

Evidence Card M

On the day of the race, Jordan Jones had a hemoglobin level that was 11% higher than it was a week before.

Evidence Card N

Jordan Jones’s Pre-Race Meals

	Pre-Race Meal
Last Year’s Race	2 Corn, 4 Sandwiches
This Year’s Race	4 Corn, 2 Fish

Evidence Card O

Results from Simulation Tests
of Jordan Jones's pre-race meals

Glucose absorbed by cells at time 100	
Last Year	Trial 1: 56 molecules
	Trial 2: 62 molecules
	Trial 3: 51 molecules
This Year	Trial 1: 58 molecules
	Trial 2: 49 molecules
	Trial 3: 65 molecules

EVALUATING EVIDENCE CRITERION CARD 1 CARD

Evidence is higher quality when it is based on more data because there can be more confidence in the patterns seen in the data.