TEACHER VERSION
Lesson Two

LESSON 2: GRAPHING & DATA INTERPRETATION

Dr. Se-Jin Lee from The Jackson Laboratory sent his mice into space in order to study the effects of microgravity on muscle and bone loss. Both the Mighty Mice lacking the myostatin gene (called Mstn -/- mice) as well as non-engineered mice (called wildtype mice) spent one month in space aboard the International Space Station (ISS). The mice have returned to Earth, and now Dr. Lee invites you to be a part of his research team and help him analyze a portion of the data from these experiments.

PART 1: MUSCLE MASS

Dr. Lee's research team measured the muscle mass of non-engineered mice (wildtype) and mice lacking the myostatin gene (*Mstn* -/-) before their journey to the ISS. The tables below show the data Dr. Lee's team of scientists collected from the mice.

Calculate the average for each group of mice, and graph the muscle mass data. Label the title, each genotype, and the x and y axes of your graph.

Condition	Animal	Muscle mass (g)	Average (g)
Before stay on ISS	wildtype 1	11.8	12.8
	wildtype 2	12.3	
	wildtype 3	13.1	
	wildtype 4	11.5	
	wildtype 5	14.0	
	wildtype 6	13.7	
	wildtype 7	13.7	
	wildtype 8	12.0	

Condition	Animal	Muscle mass (g)	Average (g)
Before stay on ISS	*Mstn* -/- 1	17.9	17.4
	Mstn -/- 2	15.7	
	Mstn -/- 3	20.0	
	Mstn -/- 4	17.4	
	Mstn -/- 5	17.1	
	Mstn -/- 6	15.8	
	Mstn -/- 7	17.0	
	Mstn -/- 8	18.5	

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PART 2: ANALYSIS

Interpret your results by answering the following questions.

1. Why do different animals with the same genotype have different muscle masses? Why calculate the average muscle mass for each group?

   A: Inter-individual differences account for small differences in animals of the same genotype. Differences in sleeping, eating, movement, etc. can all affect an individual's muscle mass. Taking the average helps to neutralize the variability.

2. Compare the muscle mass between the wildtype mice and *Mstn* -/- mice before their stay on the ISS. Are they different? Provide an explanation for the results you have observed.

   A: The Mstn -/- mice have higher muscle mass compared to the wildtype mice because they lack the myostatin gene. Without this negative regulator of muscle growth, muscles grow more than they would normally.

3. Was the difference in muscle mass between wildtype and *Mstn* -/- mice what you expected? Were you expecting a larger change, a smaller change, or something else?

   A: The difference between wildtype and Mstn -/- mice is 4.7 grams. This may not seem like a lot, but it is nearly 40% of the wildtype muscle mass, which is a relatively large amount of mass to gain for a small mouse.

PART 3: DISCUSSION

In Lesson 1, you learned about myostatin, Dr. Lee's Mighty Mice, and how loss of muscle mass can occur both in space and on Earth. You also made predictions about the results of the Mice in Space experiment. Now that you have analyzed some of the real data from the Mice in Space experiment, summarize the work that has been done and think about the significance of these studies and the impact of this research on human health.

1. In your own words, describe the genetic and phenotypic differences between the two genotypes of mice used in the Mice in Space experiment.

   A: Wildtype mice are the non-engineered mice who have their entire genome intact. There is no disruption of muscle growth in these mice and the mice display typical muscle mass for their age and sex. Mstn -/- mice are the engineered, myostatin-mutant mice who lack the myostatin gene with all other genes intact. Without myostatin, muscle growth is not regulated, and so the mice display about two times the muscle mass of a typical mouse.

2. What was the purpose of sending these mice into space?

   A: The microgravity environment of space allows for a natural way to limit limb usage without being restrictive or harmful. Periods of little limb use lead to loss of muscle mass and bone density, especially seen in astronauts in space as well as individuals on Earth who are immobile due to injury, age, or disease. Conducting this experiment in space allows for an acute, natural environment of weightlessness to study muscle and bone.

3. State one hypothesis from the Mice in Space experiment.
4. Do your original predictions from Lesson 1 match your observations and analysis of the experimental data from Lesson 2? Explain.
5. Dr. Lee's research team will analyze the muscle mass of the wildtype mice after their stay on the ISS. Do you predict the muscle mass will be the same or different from the pre-flight muscle mass you calculated for the wildtype mice? Provide an explanation for your prediction.

   A: The muscle mass of wildtype mice will likely decrease after their stay on the ISS, because of their lack of limb use in the microgravity environment of space.

6. Dr. Lee's research team will analyze the muscle mass of the *Mstn -/-* mice after their stay on the ISS. Do you predict the muscle mass will be the same or different from the pre-flight muscle mass you calculated for the *Mstn -/-* mice? Provide an explanation for your prediction.

   A: The muscle mass of Mstn -/- mice will likely decrease after their stay on the ISS, because of their lack of limb use in the microgravity environment of space.

7. Dr. Lee's research team will next compare the muscle mass of the wildtype mice and *Mstn -/-* mice after their stay on the ISS. Do you predict the muscle mass will be different between the two groups? Provide an explanation for the result you have observed.

   A: While both mice will likely lose muscle mass after their stay in space, the Mstn -/- mice will likely have more muscle after space than the wildtype. This is because they started with more muscle mass than the wildtype mice.

8. Imagine you are a scientist researching methods to combat loss of muscle mass and bone density. Given the results from the Mice in Space experiment, what could you do to help astronauts traveling in outer space avoid losing muscle mass and bone density?

   A: Given that myostatin works to block muscle growth, and Mstn -/- mice had more muscle after space travel than the wildtype had before space travel, I would find a way to block myostatin in the astronaut during space travel. This would allow the astronaut's muscles to grow bigger, combating the muscle loss that will occur from being in space, and the astronaut should return to Earth with little to no muscle loss.

9. Imagine you are a physician treating patients with weakened muscles and bones due to disuse. Given the results from the Mice in Space experiment, what could you do to help patients who experience muscle and bone loss?

   A: Given that myostatin works to block muscle growth, and Mstn -/- mice had more muscle after space travel than the wildtype had before space travel, I would find a way to block myostatin in the patients. This would allow the patient's muscles to grow bigger, which should help them become stronger and prevent further injury or recover from their current illness or injury.