



# DINOSAURS IN MOTION

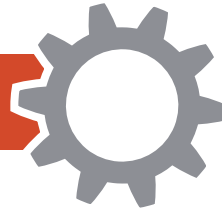
WHERE ART & SCIENCE MEET



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Exhibitions

**EDUCATOR GUIDE | GRADES 6-8**

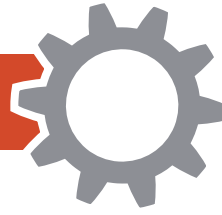
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**IN MOTION**

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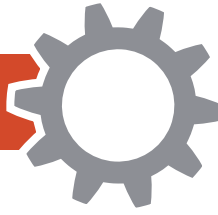
Forget everything you think you know about dinosaur exhibitions and start your imagination now! **DINOSAURS IN MOTION** is unlike anything you've seen before. It's the life's work of Asheville, NC artist John Payne who wanted not just to create accurate sculptures of dinosaurs, but also to infuse them with kinetics and creativity. **DINOSAURS IN MOTION** is more than an exhibition about dinosaurs. It is a showcase of the power of integrating Art, Science, and Innovation. The exhibition takes you on a journey through four studios, Beginner, Intermediate, Advanced, and Master, to showcase how technological, artistic, and scientific advances all contributed to the creation of these amazing sculptures. Visit [DINOSAURS IN MOTION ON THE WEB](#) for an overview of the exhibition.



### Included in This Guide

To engage with the exhibition you can choose what will best fit your students' needs and interests. Here's what the guide contains:

- A brief overview of each studio with a list of grade specific standards and activities you can do while visiting the exhibition.
- A 3-lesson unit to bridge your classroom and field trip experience.
- A Scavenger Hunt that challenges students to explore the exhibition using the Cross Cutting Concepts outlined in the Next Generation Science Standards.
- Additional ideas for activities to do before, during, and after your field trip!



We used the 6th - 8th grade Next Generation Science Standards (NGSS) to structure this guide because **DINOSAURS IN MOTION** and NGSS both embrace the concepts of innovation and integration. All of the activities in this guide are based on NGSS standards. The NGSS outlines 7 Cross Cutting Concepts that are present at all levels of science. Five of these concepts are clearly reflected in this exhibition. Below are the relevant cross cutting themes and questions to ponder as students walk through the exhibition. These are also the concepts used to structure the **DINOSAURS IN MOTION** Scavenger Hunt.



## NGSS Cross Cutting Concepts

### Cause and Effect

Are the effects of pushing and pulling on the dinosaurs casual or correlative?

### Scale, Proportion and Quantity

How are the dinosaurs' body proportions related to each other?  
How are they related to me?

### Structure and Function

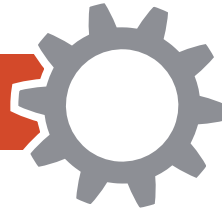
How are the parts of the dinosaurs, including their teeth, legs, jaws, and shapes different, and what are the functions of those parts?

### Systems and System Models

What role did the dinosaurs play in the larger ecosystem?  
What smaller systems lived within these dinosaurs?

### Energy and Matter; Flows, Cycles, and Conservation

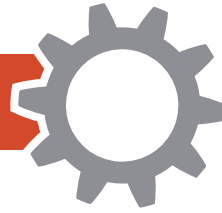
What different forms of energy are used to move these models?  
How is energy converted when you move the dinosaurs?



## Beginner Studio: Meet the Dinosaurs

In this studio, you will be exposed to the basic skills used to produce these amazing metal creations. Using dinosaurs as the medium, fascinating concepts are explored such as sketching as a way to study a subject, and treasure hunting in places like junkyards to find materials to build a masterpiece. Biomechanics and balance points are also explored to further animate the science behind creating these massive creatures. Emphasis in this studio is on sketching, found art, kinetic sculptures, anatomical movement, fossils, the biomechanics of jaws, balance, springs, and how paleontology accounts for missing information.

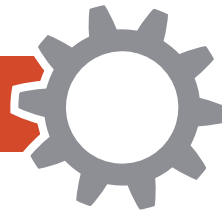
BEGINNER STUDIO	
<b>NGSS Physical Science</b>	<b>MS-PS2-1.</b> Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.
<b>Activity</b>	Push the tail of the <i>Ankylosaurus</i> and explain how this is a demonstration of Newton’s Third Law.
<b>NGSS Life Science</b>	<b>MS-LS1-4.</b> Use an argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
<b>Activity</b>	Observe and read about the <i>Tyrannosaurus rex</i> . Identify 3 characteristics of the <i>T. rex</i> that helped it survive and reproduce.
<b>NGSS Earth</b>	<b>MS-ESS3-3.</b> Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.
<b>Activity</b>	Try to identify the material used to construct the <i>Triceratops</i> and explain from where you think that material came and how much energy was used to manufacture it. <i>Bonus: Think of some materials that could be used to construct this dinosaur that have less of an impact on the environment.</i>



## Intermediate Studio: Mechanics Lab

This studio allows you to explore the next phase of John Payne’s work: dinosaurs with full-body movement. While the Beginner Studio also allowed manipulation and movement of the creatures, the Intermediate Studio intensifies these kinetic principles by adding additional axes of movement. It also explores concepts such as metalworking, puppetry, simple machines (pulleys), and color through patinas. Emphasis in this studio is on metal, metalworking, cables (wire ropes), connections, welding, patinas, puppetry, pulleys, and the biomechanics of speed.

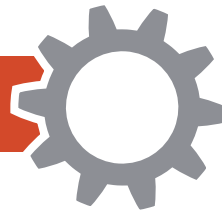
INTERMEDIATE STUDIO	
<b>NGSS</b>	<b>MS-PS2-5.</b> Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
<b>Activity</b>	Find the balance point on the <i>T. rex</i> . Now sketch the <i>Ouranosaurus</i> and indicate where you think its balance point is. Explain why you put the balance point where you did.
<b>NGSS</b>	<b>S-LS4-2.</b> Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
<b>Activity</b>	Read about the <i>Gastornis</i> and describe the similarities and differences you see between it and a chicken.
<b>NGSS</b>	<b>MS-ETS1-3.</b> Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
<b>Activity</b>	Manipulate all of the dinosaurs in this exhibit and explain how pulleys, cables, nuts, bolts, shackles, and crimps are used to help the models move. Sketch one of the dinosaurs in this studio and describe how these tools give the dinosaur the ability to move more.



## Advanced Studio: Robotics 101

In this studio, you are presented with an additional interactive level: robotics. Hands-on interactions guide you through the multiple ways in which motors can maneuver these giant metal creatures in life-like, natural shifts using such concepts as electric power, motors, and controllers. Emphasis in this studio is on robotics, animatronics, sound, discovering colors in fossils, the biomechanics of blood-flow in long-necked dinosaurs, electric power, electric motors, and controllers.

ADVANCED STUDIO	
<b>NGSS</b>	<b>MS-PS2-4.</b> Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of the interacting objects.
<b>Activity</b>	Manipulate all of the dinosaurs in this studio paying close attention to how they fall when the only force acting on them is gravity. From these observations identify which dinosaur has the most mass and explain why you think this.
<b>NGSS</b>	<b>S-LS4-2.</b> Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
<b>Activity</b>	The <i>Deinonychus</i> is one of the closest relatives of modern day birds. Identify 3 characteristics of the <i>Deinonychus</i> that are similar and 3 that are different than modern birds.
<b>NGSS</b>	<b>MS-ETS1-2.</b> Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
<b>Activity</b>	In this studio the models are more robotic. Select one dinosaur and explain how motors and electricity are used to control its movement. Describe why the use of motors is or is not a better design than the non-motorized designs of the dinosaurs in the Beginner and Intermediate studios.



## Master Studio: Art + Science = Innovation

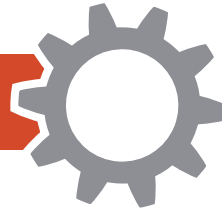
Some paleontologists think that modern birds are living dinosaurs because of key similarities in their skeletons. Our mentor and master craftsman John Payne followed this evolutionary progression with his art, starting with dinosaurs and continuing to his last and most intricate creations—modern birds.

Great craftsmanship and skills are necessary to create metal birds with movement. Apprentices in the Master Studio will experience the grace and beauty of these sculptures and learn about John Payne’s most exquisite pieces. Emphasis in this studio is on complex and advanced metalworking techniques, the exploration of different materials, and the evolution of non-avian dinosaurs into birds.

MASTER STUDIO	
<b>NGSS</b>	<b>MS-PS4-2.</b> Develop and use a model to describe that sound waves are reflected, absorbed, or transmitted through various materials.
<b>Activity</b>	Manipulate the <i>Whooping Crane</i> and notice all of the various sounds that are generated by its movements. Sketch the bird and describe how sound is absorbed, reflected or transmitted through all of the various materials on the model.
<b>NGSS</b>	<b>MS-LS4-1.</b> Analyze and interpret data to find patterns in the fossil record that document the existence, diversity, extinction, and changes of life forms throughout the history of life on Earth under the assumption that natural laws operate the same way today as they did in the past.
<b>Activity</b>	Observe and read about the <i>American Crow</i> and the <i>Whooping Crane</i> . Compare the factors that influence their lives today with those of the dinosaurs in the previous studios. Compare and contrast.
<b>NGSS</b>	<b>MS-ESS3-3.</b> Apply scientific principles to design a method for monitoring and minimizing a human’s impact on the environment.
<b>Activity</b>	Read about the near extinction of the <i>Whooping Crane</i> and design a plan for how you think humans can continue to help preserve them.



# SCAVENGER HUNT



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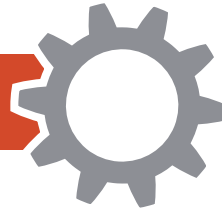
## Cause and Effect

*In grades 6-8, students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. Students also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability!*

### IS IT CAUSAL OR CORRELATIONAL?

The dinosaurs in this exhibition move and make noise for a variety of reasons. Your challenge is to determine both the causal (direct) and correlational (parallel) effect of performing several actions. Find the dinosaurs on which you can perform the following actions and describe the causal and correlational effects.

ACTION (CAUSE)	DINOSAUR	CAUSE EFFECT	CORRELATIONAL EFFECT
<b>Push</b>			
<b>Pull</b>			
<b>Press a button</b>			
<b>Move a joystick</b>			
<b>Optional action: You choose!</b> <hr/>			

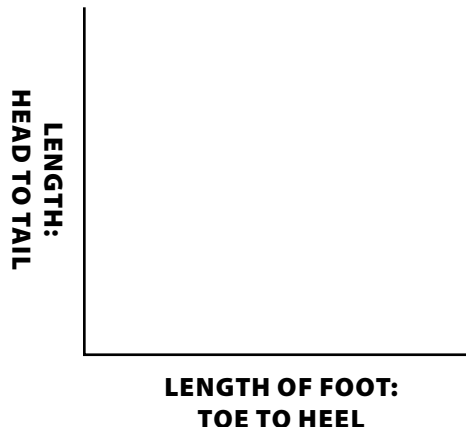


## Scale, Proportion, and Quantity

*In grades 6-8, students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small to be directly observed. They understand that phenomena observed at one scale may not be observable at another scale, and that the functions of natural and designed systems may change with scale. Students use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes and represent scientific relationships through the use of algebraic expressions and equations.<sup>1</sup>*

Choose any 3 dinosaurs in the exhibit and measure their total length (head to tail) and the length of their foot (toe to heel). Record the data and plot the data on a graph. Determine if there is a relationship between foot and body length. Measure your height and foot length and put that data on the graph. How do you fit in?

DINOSAUR NAME	LENGTH: HEAD TO TAIL	LENGTH OF FOOT: TOE TO HEEL
<b>YOU!</b>		



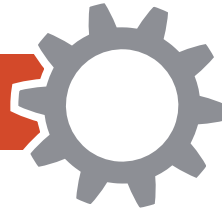


## Structure and Function

*In grades 6-8, students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. Students design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.<sup>1</sup>*

Find two models that move their necks. Observe how they move and sketch how the neck is connected to both the head and the body. Use the resources in the exhibition and your deductive skills to explain how and why the necks are similar and different in these models.

<p><b>1</b> _____ <b>DINOSAUR NAME</b></p>	<p><b>2</b> _____ <b>DINOSAUR NAME</b></p>
<p>Sketch</p>	<p>Sketch</p>
<p>Similarities:</p>	
<p>Differences:</p>	
<p>Reasons for similarities and differences:</p>	

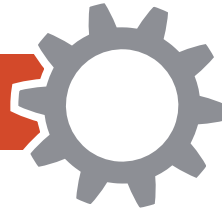


## Systems and System Models

*In grades 6-8, students can understand that systems may interact with other systems; they may have sub-systems and can be a part of larger complex systems. Students can use models to represent systems and their interactions—such as inputs, processes and outputs, as well as energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.*

Millions of years ago these dinosaurs were all part of the natural ecosystem, however, in this exhibition they are seen out of their environment. Your challenge is to try to recreate the system the dinosaurs were in when they were alive. Choose one dinosaur, sketch it and add in all the other components that impacted its life. You should label all the components as either inputs or outputs. For example, an input is the oxygen the dinosaur breathes in and an output is the carbon dioxide it breathes out. Use your understanding of animals and their needs along with the information in the exhibition panels to help inform your drawing.

**A Dinosaur's Ecosystem:**

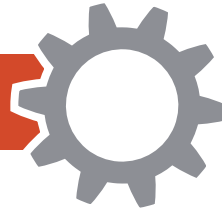


## Energy and Matter; Flows, Cycles, and Conservation

*In grades 6-8, students learn that matter is conserved because atoms are conserved in physical and chemical processes. They also learn that within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.<sup>1</sup>*

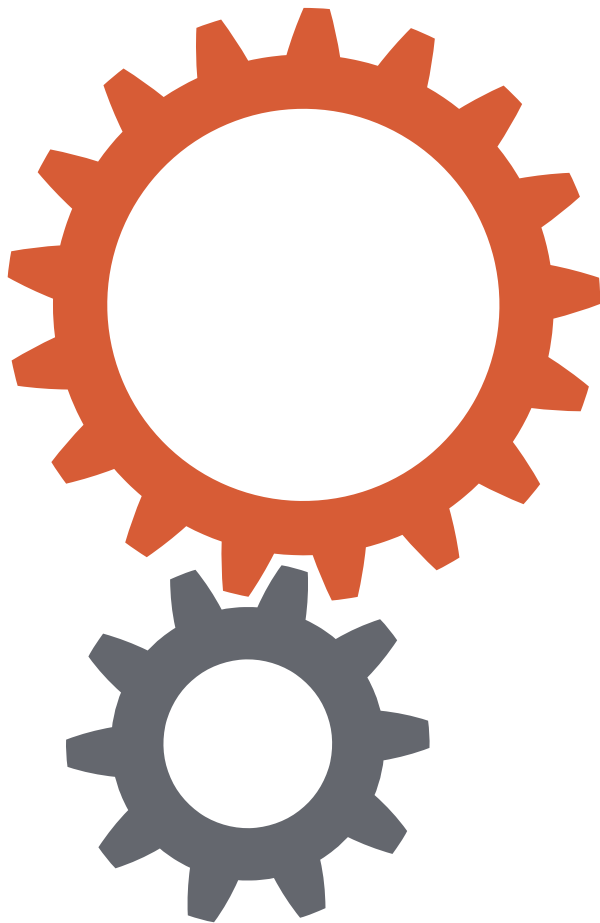
Find a dinosaur model that converts electrical energy into motion and draw that model labeling all the different forms of energy that are used. Be sure to think about how the energy is stored, how sound is generated, and where mechanical energy (the motor) is used. Your diagram should include arrows and list a minimum of 3 different types of energy.

**Energy Model:**



## Design Challenge: Unit Overview

This 3-part unit gives students the opportunity to design, construct, and test their own models of dinosaurs. Students will experience a design process similar to **DINOSAURS IN MOTION** sculptor, John Payne's, by designing and constructing a simple, and later, a more complex model. Students begin this unit by visiting **DINOSAURS IN MOTION** and making notes on how John Payne used simple machines (springs, gears, and pulleys) to enhance his models. In the second lesson, students design and construct their models using one of the simple machines. As a class, students will then develop a process to test the models and identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. The final lesson challenges students to create an improved, movable, 3-D model based on their collective learning from their experience at **DINOSAURS IN MOTION**.



### Essential Question:

- How can I use data to improve a model?

### Objective:

- Students will develop a process to quantitatively evaluate and refine their models.

### NGSS Standards Addressed:

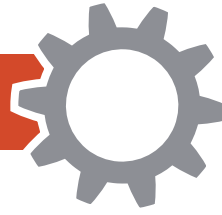
Middle School Engineering Design

#### ■ MS-ETS1-2.

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

#### ■ MS-ETS1-3.

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.



## Lesson 1: At the Exhibition

### Materials:

- Clipboards
- Science Notebooks
- Simple Machines Handout

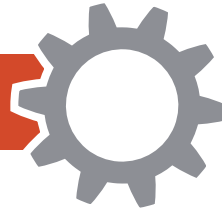
### Procedure:

1. Give students an overview of the unit. Tell them they will be challenged to build, test, and refine their own models of dinosaurs but, before they begin, they will need to investigate John Payne's models.
2. Give students 30 minutes to explore the entire exhibition, asking them to make notes on their observations.
3. After 30 minutes, regroup as a class and tell students that they need to go back into the exhibition to further explore, but this time they should look for some specific features. Pass out the "Simple Machines" handout and tell the students that they will be looking for 3 design features: pulleys, levers, and springs. Have students go through the exhibition again and look to see if levers, pulleys, or springs are used on each dinosaur. On the handout, have students identify how they are being used and what purpose they serve.

### Debrief:

1. Ask students to share their handouts and to look for patterns. Ask questions like, "Are springs always used for one purpose?" or "Is there an advantage of using a lever instead of a pulley?"
2. Tell students that they will get to develop a model using one of these simple machines when they return to the classroom. Ask them to think about which simple machine they would like to use and why.

# SIMPLE MACHINE HANDOUT



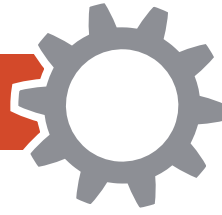
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As you go through the **DINOSAURS IN MOTION** exhibition, choose five models and look for the use of simple machines—pulleys, levers, or springs, in each. Sketch the dinosaur model, label its simple machines and describe what it is doing.

<b>Dinosaur Name:</b>	Sketch a dinosaur and label the simple machines it uses. Include a description of what actions the simple machines are performing.
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<b>Dinosaur Name:</b>	Sketch a dinosaur and label the simple machines it uses. Include a description of what actions the simple machines are performing.





## Lesson 2: Initial Design

### Materials:

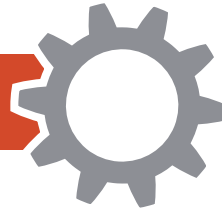
- Springs
- Pulleys
- String
- Aluminum foil
- Popsicle sticks
- Assorted arts and craft materials

### Procedure:

1. Reflect on the students' experiences at the exhibition and revisit their "Simple Machine Handout."
2. Tell students that they will have 30 minutes to design and construct a model of a dinosaur that uses ONE simple machine (either a lever, pulley, or spring). The machine should help the model move (it can move anything - its jaw, legs, neck, etc.).
3. Have groups of students sketch their designs indicating which type of simple machine they will use. Once the teacher approves the design, the students will be given all necessary materials.
4. After students have constructed their models, ask them "how can we determine which of these models works best?" Help students identify that they need to design a fair test that quantifiably measures something to determine which models work best.
5. Have each group present and test their model based on the class criteria. Record all of the data on a large poster in front of the class.

### Debrief:

1. Give students 5 minutes to look at the class data and write down their interpretations.
2. As a class, have students share their reflections and discuss which models were successful and why. Be sure to ask if there were characteristics of the different types of simple machines that made the models more or less successful.



## Lesson 2: Model Refinement

### Materials:

- Springs
- Pulleys
- String
- Aluminum foil
- Popsicle sticks
- Assorted arts and craft materials
- Simple Machine Rubric

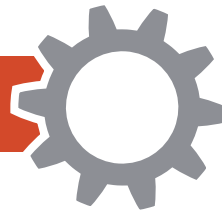
### Procedure:

1. Have students look back and analyze the class data they collected and ask for comments.
2. Tell students that they now need to build a new model that uses two different simple machines. Pass out the 3-D Model Rubric and go over the criteria as a class. Students should think about how they are going to change and refine their models based on the class data. Tell them they will be asked to share this information when they present their new model.
3. Give students 30 minutes to design and build a new model that incorporates two of the simple machines and moves in at least two places.
4. Have groups of students sketch their designs indicating which two types of simple machines they will use. Once the teacher approves the design, the students will be given all necessary materials.
5. Have students present their new models and explain how they used the data to refine their design. Students should score themselves using the "3-D Model Rubric."

### Debrief:

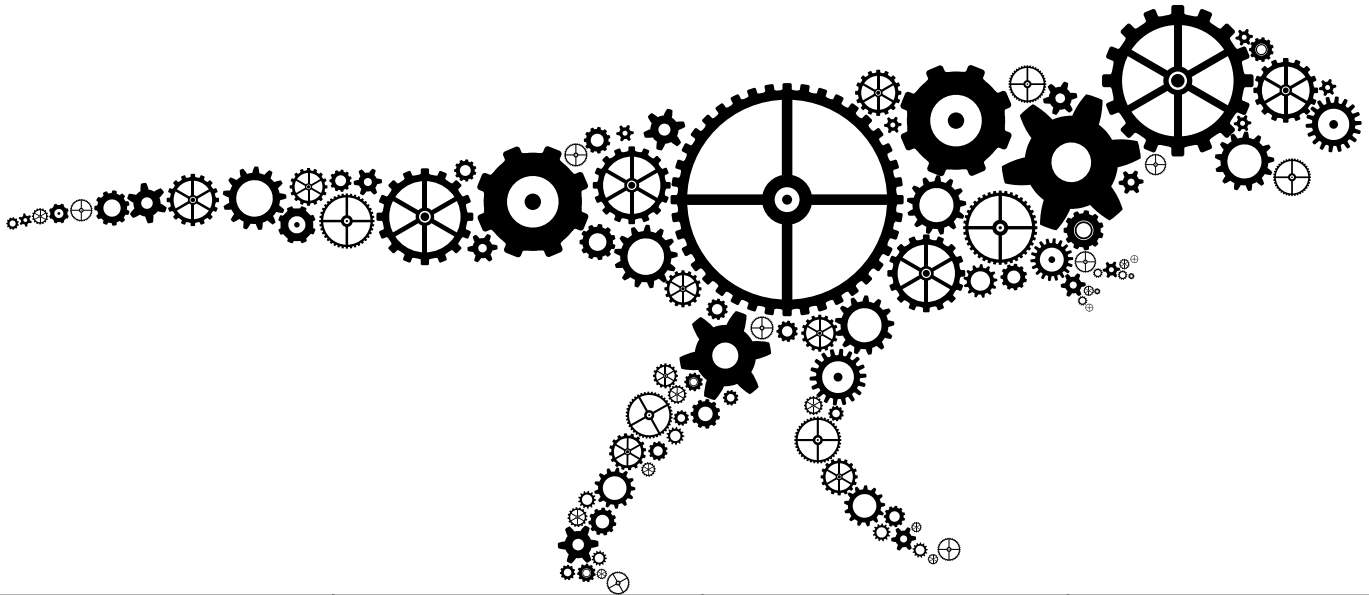
1. Give students 5 minutes to reflect on the unit. Ask them to think about how looking at models, designing and testing models and refining models based on data helped them to improve their design.
2. Have students share their reflections with the class.

# 3-D MODEL RUBRIC



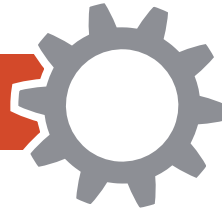
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	0	1	2
DESIGN	My design does not incorporate simple machines	My design incorporates one simple machine	My design incorporates two different simple machines
APPLICATION	My model does not move	My model uses simple machines to move in one place	My model uses two different simple machines to move in multiple places
REFINEMENT	I did not use the data to help refine my model	I used the data to refine my model but did not clearly explain how	I clearly used and explained how I used the data to refine my model

## ADDITIONAL ACTIVITIES



### Pre Field Trip Activities:

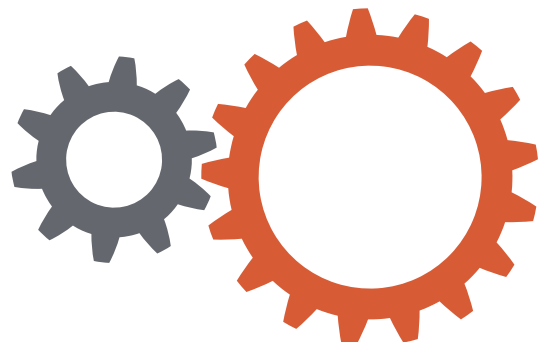
- Make a model in which a dinosaur's jaw opens and closes using a pulley.
- Show pictures of various dinosaurs' feet and have students predict the type and size of the dinosaur to which they belong.

### Activities During Field Trip:

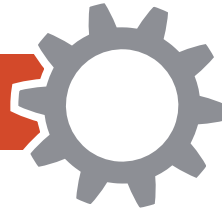
- Adaptation Scavenger Hunt  
Have students identify adaptations on the dinosaurs and ask them to describe how the adaptations helped the dinosaur survive.
- Cause and Effect  
In each studio, have students identify the initiating force and the effect it had on the dinosaur's motion.
- Find Patterns  
Look for patterns among the dinosaurs. Do they all have the same shaped eyes? Are their heads shaped the same? Have the students share their findings with a partner.
- Suggest that students mimic their favorite dinosaur model and have a partner try to guess which dinosaur they are pretending to be.
- Sketch a dinosaur model and label how energy is converted as it moves through the model.

### Post Field Trip Activities:

- Correlation Activity  
Have students compare and contrast different dinosaurs, add the information to a chart, and make correlations based on the data. For example, are all of the dinosaurs that stand on two legs carnivores?
- As a class or individually, have students create their own story related to the exhibition using creative writing skills. Explore connections to literature or even develop your own exhibition on the topic!
- Defend or refute the idea that these models are like real dinosaurs.



# APPENDIX 1



NGSS Standards Addressed:

## PHYSICAL SCIENCE

- MS-PS2-1.** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.\*
- S-PS2-2.** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- S-PS2-3.** Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
- MS-PS2-4.** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of the interacting objects.
- MS-PS2-5.** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- MS-PS4-2.** Develop and use a model to describe that SOUND waves are reflected, absorbed, or transmitted through various materials.

## LIFE SCIENCE

- MS-LS1-4.** Use an argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- MS-LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4.** Construct an argument supported by empirical evidence that suggests that changes to physical or biological components of an ecosystem affect the ecosystem's populations.
- MS-LS4-1.** Analyze and interpret data to show patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as they did in the past.
- S-LS4-2.** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

## EARTH SCIENCE

- MS-ESS3-2.** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human's impact on the environment.  
\* RECYCLED MATERIAL

## ENGINEERING

- MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

# QUESTIONS?

## CONTACT

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