TEACHER GUIDE

This material was made to go along with the following companion video:
https://www.youtube.com/watch?v=xqC928Uoubc



It includes a viewing guide to go along with the video. It is meant to get them thinking more about eggs and the biology that helped our ancestors take over the planet.

There are also two labs that are meant to give students some hands-on time with egg research and a variety of “missions” that can be assigned as individual activities or as a larger packet.

Materials Required:

- *Lab 1: Mass | eggs, petri dishes, petroleum jelly, triple-beam balance scales (or electric scales)*
- *Lab 2: Microscopes | egg shells broken into small pieces, microscopes, slides, cover slips, tweezers, water droppers, food coloring, paper towels, cotton swabs, flashlight / phone light*
- *Missions: Graphing paper recommended for Mission 5*

HOW ONE EGG CHANGED LIFE FOREVER

BEFORE THE EPISODE

1. In this video they claim that the evolution of the amniotic egg - an egg with a shell - is one of evolution's most important innovations. Why do you think eggs with shells would be important for the evolution of life on Earth? There are no wrong answers, give your best guess!

DURING THE EPISODE

2. For the first 100+ million years of vertebrate (animals with backbones) evolution, those animals lived...

A. On land
B. In the atmosphere
C. In the water

3. What is one trait that vertebrates evolved that helped them live on land?

4. The amniotic egg first evolved around _____ million years ago.

5. Descendants of the early animals went on to become reptiles, dinosaurs, birds, mammals... and even _____.

6. True or False: The yolk in an ostrich egg is considered the largest single cell on Earth.

7. The chorion lets oxygen in and _____ _____ out.

8. As the bird develops, it pulls _____ from the shell and uses it to build the skeleton.

9. What is one way the Colossal Artificial Egg could help modern bird conservation?

10. More than _____ of all bird species are currently in decline.

AFTER THE EPISODE

---

11. Based on what you learned, explain why early vertebrates had to live near water and weren't able to expand across dry regions.

12. During the late Carboniferous, around 305 million years ago, the Earth's climate changed. Explain what happened and how it helped the amniotes (the group of animals that evolved eggs with shells).

13. How are the eggs of mammals and reptiles different?

14. Debate | The primary argument made in this video is that the amniotic egg was evolution's most important invention. Come up with an argument. Pick a different trait that you think was even more important and explain why.

HOW ONE EGG CHANGED LIFE FOREVER

BEFORE THE EPISODE

1. In this video they claim that the evolution of the amniotic egg - an egg with a shell - is one of evolution's most important innovations. Why do you think eggs with shells would be important for the evolution of life on Earth? There are no wrong answers, give your best guess!

A. **Eggs could leave the water.** Before shelled eggs, animals like fish and amphibians had to lay soft, jelly-like eggs in water or they'd dry out. A shell, plus the membranes inside, keeps the egg from drying out, so animals could lay eggs on dry land.
B. **Animals could spread out.** Once they didn't have to go back to water to lay eggs, animals could move inland and live in deserts, forests, and mountains, places that were empty before.
C. **Protection.** The shell protects the baby from predators, germs, bumps, and drying out.
D. **A built-in life-support system.** The egg holds its own food (yolk), water, a way to breathe through the shell's pores, and a place to store waste. The baby can grow on its own.

DURING THE EPISODE

2. For the first 100+ million years of vertebrate (animals with backbones) evolution, those animals lived...

A. On land
B. In the atmosphere
C. **In the water**

3. What is one trait that vertebrates evolved that helped them live on land?
SOME OPTIONS: The amniotic egg, stronger limbs, more robust skeletons, lungs / the ability to breathe air.

4. The amniotic egg first evolved around **340** million years ago.

5. Descendants of the early animals went on to become reptiles, dinosaurs, birds, mammals... and even **YOU**.

6. True or False: The yolk in an ostrich egg is considered the largest single cell on Earth

7. The chorion lets oxygen in and **CARBON DIOXIDE** out.

8. As the bird develops, it pulls **CALCIUM** from the shell and uses it to build the skeleton.

9. What is one way the Colossal Artificial Egg could help modern bird conservation?
Helping to rescue chicks with damaged shells, hatching birds that struggle to breed in captivity, cloning endangered birds without putting their mothers at risk

10. More than **HALF** of all bird species are currently in decline.

AFTER THE EPISODE

---

11. Based on what you learned, explain why early vertebrates had to live near water and weren't able to expand across dry regions.
They had to return to water to lay their eggs - their eggs could not survive outside of the water.

12. During the late Carboniferous, around 305 million years ago, the Earth's climate changed. Explain what happened and how it helped the amniotes (the group of animals that evolved eggs with shells).
The planet dried up and the animals that had evolved to lay eggs outside of the water suddenly had a large advantage over the other animals that were bound to water. this allowed the ancestors of today's amniotes to spread out and expand as the ancestors of amphibians were losing habitat.

13. How are the eggs of mammals and reptiles different?

Inside vs. outside: Reptiles lay their eggs, and the baby grows outside the mom's body. Most mammals keep the egg inside, and the baby grows in the mom's uterus until it's born.

Shell vs. no shell: Reptile eggs have a shell, either leathery (snakes, most lizards) or hard (crocodiles, some turtles). Most mammal eggs have no shell at all, because they never leave the mom's body.

Big yolk vs. tiny egg: A reptile egg has to pack all the food the baby will need, so it has a big yolk. A human egg cell is about 0.1 mm across, about the width of a hair, with almost no yolk, because the mom feeds the baby through the placenta.

What keeps the baby alive: In a reptile egg, the shell and membranes handle air, water, and waste. In mammals, the placenta does those jobs by connecting the baby to the mom's blood.

14. Debate | The primary argument made in this video is that the amniotic egg was evolution's most important invention. Come up with an argument. Pick a different trait that you think was even more important and explain why.

Photosynthesis: It made the oxygen in the air. Without it, almost nothing that breathes oxygen, including anything that lays an egg, could exist.

Mitochondria (the eukaryotic cell): Long ago, one cell swallowed a bacterium that became the mitochondria. That gave cells far more energy to work with, and every animal, plant, and fungus comes from that moment.

Multicellularity: Before cells teamed up, all life was single-celled. Without it there are no animals at all, egg-laying or not.

Jaws: Jaws turned fish from filter feeders into predators that could bite and chew. Almost every vertebrate alive today, us included, has them.

Limbs (legs): The egg let animals lay eggs on land, but legs got them there in the first place. Fish with sturdy fins came first.

Lungs: You can't live on land if you can't breathe air.

Seeds: These are basically the plant version of the amniotic egg. Seeds let plants spread away from water, and forests gave land animals food and shelter.

Flowers: They teamed up with insects and changed nearly every ecosystem on land.

Feathers or flight: Flight let animals cross oceans, escape predators, and spread across the whole planet. Birds, bats, and insects all evolved it.

Warm-bloodedness: It let mammals and birds stay active in the cold and at night, and survive the asteroid that wiped out the dinosaurs.

Big brains: One species with a big brain now changes the whole planet, and is even trying to bring extinct species back with an artificial egg.

LAB 1: CAN MASS GET THROUGH A SHELL? · TEACHER NOTES

Groups come up with their own way to test it first, then they run the same two-egg setup. One day to plan and set up, about 5 min a day to weigh for 7–10 days, then one day to graph and discuss.

> **HEADS UP**
> Use regular store eggs (not fertilized). If there's an embryo growing, its breathing throws off the mass loss.

Each group needs: 2 raw eggs, a scale that reads to 0.1 g, 2 petri dishes, and some petroleum jelly (the little containers work well).

DAY 1

1. Give the challenge: come up with a way to prove gas can get through an eggshell. Don't show materials yet.
2. Groups plan on Part 1 (10–12 min). Walk around and ask questions but don't fix their plans.
3. If a group is stuck, nudge in this order and stop once they get going: (1) If gas is leaving, the egg should change over time. What could you measure every day? (2) Set the materials out without explaining them. (3) What if you blocked the pores on purpose?
4. Each group shares their plan in a sentence. Talk through which ones would actually prove it and which ones we couldn't really do.
5. Show the two-egg setup. Point out the control, the one thing that changes, and measuring more than once.
6. Set up: cover egg B in petroleum jelly, leave egg A alone. Place each egg on its own petri dish and leave it there for the whole experiment. Each day, put the egg and its petri dish on the scale together.
7. Day 1 measurement: each person in the group finds the mass of each egg, so the group can double and triple check.

AFTER DAY 1

Weigh at the same time every day and record. On the last day, figure % lost, graph, and do the questions.

WHAT SHOULD HAPPEN

Egg A loses a little mass each day. Egg B barely changes and may not change at all. Changes are small at room temperature, so 10 days works better than 7. In the past, the experiment was kept going for over 30 days, with students returning to it periodically to collect more data. In the most recent trial, all the petroleum jelly eggs kept their mass, while the control eggs lost between 7% and 9.1% of their mass over the 30-day period.

Lab 1: Can Mass Get Through a Shell?

Name _____ Hour _____

Part 1: Make a Plan

Remember: Eggshells have thousands of tiny holes called **pores**. They're too small to see.

With your group, come up with an experiment to prove gas can get through an eggshell. You need something you can measure, not just "because it has pores."

1. What will you do to the egg?

_____

2. What will you measure?

_____

3. How will you know gas got through?

_____

Sketch your plan and label it.

Does your plan have these?

	Yes	No
Something to compare to		
Only one thing changed		
Measure more than once		

PART 2: TEST IT

Egg	What we did	My guess: loses MORE or LESS mass?
A	Nothing	
B	Petroleum jelly	

Data: weigh each egg (with its petri dish) at the same time every day.

Day	0	1	2	3	4	5	6	7	8	9	10
Egg A (g)											
Egg B (g)											

% lost = (Day 0 – last day) ÷ Day 0 × 100

	Egg A	Egg B
% lost		

Graph it: days on the bottom, mass on the side, one line per egg.

1. Which egg lost the most mass? Why?

2. What would the petroleum jelly do to a baby bird inside the egg? Explain your answer using the information you've gathered.

3. Colossal's artificial egg has to do the shell's job. What's one thing it has to get right?

LAB 2: WHAT DOES A SHELL LOOK LIKE UP CLOSE? · TEACHER NOTES

Students look at the outside of the shell, the inside of the shell, and the membrane under the microscope, then try to find and count pores. One class period. Do this a few days into the Lab 1 weigh-ins, once Egg A has started losing mass, or after Lab 1 is done.

Each group needs: a few dime-sized pieces of shell, a microscope, slide and cover slip, tweezers (optional), a dropper of water (optional), food coloring (dark colors work best), cotton swabs (Q-tips), and paper towels.

PREP

Crack the eggs, dump them out, rinse the shells, and break them into dime-sized pieces. Leave the membrane on. If you soak the pieces in water for a few minutes before class, the membrane peels off a lot easier.

WHAT TO EXPECT

The outside looks rough and bumpy, not smooth. The dyed pores show up as scattered dots, and how many students see depends on the piece and the dye. A chicken egg has somewhere around 7,000 to 17,000 pores total. The membrane looks like a mesh of threads, which is how gas can get through but bacteria mostly can't.

TIP

Try the dye step yourself first. Some eggs take the color better than others, and brown eggs are harder to see dots on than white ones.

STEPS

OUTSIDE OF THE SHELL

1. Break off a piece of shell small enough to sit flat on the slide.
2. Use your Q-tip to blot some food coloring onto the outside of the shell.
3. Let the food coloring sit for 30 seconds, then wipe it off with a wet paper towel. This should leave food coloring sitting in the pores.
4. Put the shell on the slide and observe it under the microscope.

INSIDE OF THE SHELL

1. Break off a piece of shell small enough to sit flat on the slide.
2. Look at the inside of the eggshell and observe how it looks different. If you can't see it well, add a little bit of food coloring.

> **HINT**
> Don't add too much food coloring. Light needs to pass through the eggshell so you can see the structures.

MEMBRANE

1. Pull the membrane away from the inside of the eggshell. It looks like a thin paper layer. If you can't find it, break a piece off the egg and see if the thin paper material is exposed, then gently pull it off the shell.

2. Put the membrane on a slide and try to see what the structures look like.

LAB 2: WHAT DOES A SHELL LOOK LIKE UP CLOSE?

Name _____ Hour _____

1. What do you think the shell will look like under the microscope?

_____

What did you see? Check all that apply.

	Outside of shell	Inside of shell	Membrane
Bumpy			
Smooth			
Holes / dots			
Threads			

Sketch what you saw. Write the magnification under each one.

Outside of shell	Membrane
Magnification: _____x	Magnification: _____x

How many dyed pores could you count in one view? _____

Final Questions

2. A chicken egg has thousands of pores. Why doesn't the egg just leak out?

_____

_____

3. Look at your Lab 1 data. Egg A is losing mass. How do the pores you saw today explain that?

MISSION 1: EGG OR NOT?

Some animals lay eggs. Some give birth to live babies. And some... well, it's complicated.

Round 1: Go with your gut. Check a column for each animal. No technology, no asking a friend... just your best guess.

Round 2: Now look each one up and check the real answer. Update the table.

Animal	Guess: Eggs	Guess: Live	Real: Eggs	Real: Live
Chicken				
Cat				
Platypus				
Ball Python				
Great white shark				
Seahorse				
Frog				
Boa constrictor				
Octopus				
Scorpion				
Echidna				
Aphid				
Kiwi				
Human				

1. Which animal surprised you the most? Explain what you found surprising about it.

2. Name a mammal that lays eggs and a reptile that does not.

MISSION 1: EGG OR NOT?

Some animals lay eggs. Some give birth to live babies. And some... well, it's complicated.

Round 1: Go with your gut. Check a column for each animal. No technology, no asking a friend... just your best guess.

Round 2: Now look each one up and check the real answer. Update the table.

Animal	Guess: Eggs	Guess: Live	Real: Eggs	Real: Live
Chicken			X	
Cat				X
Platypus			X	
Ball Python			X	
Great white shark				X
Seahorse			X	X
Frog			X	
Boa constrictor				X
Octopus			X	
Scorpion				X
Echidna			X	
Aphid			X	X
Kiwi			X	
Human				X

1. Which animal surprised you the most? Explain what you found surprising about it.

STUDENTS MIGHT BE SURPRISED TO LEARN SOME SNAKES LIKE BOA CONSTRICTORS GIVE BIRTH TO LIVE BABIES. SEA HORSES DO A LITTLE BIT OF BOTH... THE FEMALES LAY THE EGGS AND THE MALES HOLD THEM UNTIL THEY ARE READY TO HATCH... AN APHID WILL OFTEN GIVE BIRTH TO LIVE YOUNG (WITH NO MALES INVOLVED) AND SOMETIMES THOSE BABIES ALREADY HAVE BABIES DEVELOPING INSIDE OF THEM! THE PLATYPUS AND

ECHIDNA ARE BOTH EXAMPLES OF MONOTREMES - A GROUP OF MAMMALS THAT LAYS EGGS!

2. Name a mammal that lays eggs and a reptile that does not.

MAMMALS - PLATYPUS OR ECHIDNA. REPTILES - MANY EXAMPLES

MISSION 2: IS AN EGG A CELL?

> **Cell:** the smallest living unit. Animal cells have a **nucleus** (the control center), **cytoplasm** (the jelly-like inside), and a **cell membrane** (the outer layer).

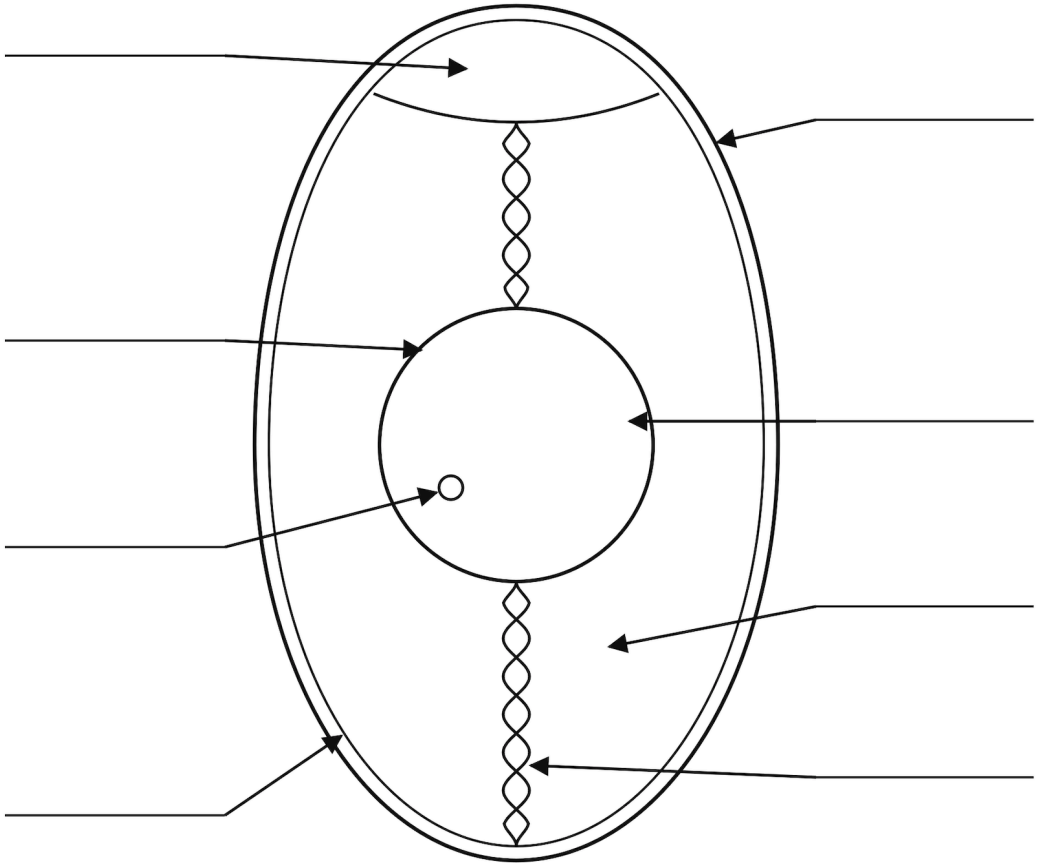
The yolk of a bird egg starts out as a single cell. That makes an ostrich yolk one of the largest cells on the planet. The egg white, the membranes, and the shell all get wrapped around it later, on its way out of the mother's body.

Match each cell part with the egg part that does the same job.

Word bank: *yolk · germinal disc (the small white spot on the yolk) · yolk membrane*

Cell part	What it does	Matching egg part
Nucleus	Holds the DNA	
Cytoplasm	Fills the cell, holds food and supplies	
Cell membrane	Holds everything in, controls what goes in and out	

Label the diagram with: ***shell, shell membranes, air cell, egg white, yolk, yolk membrane, germinal disc, chalazae*** *(the twisted cords that keep the yolk centered).*



MISSION 2: IS AN EGG A CELL?

> **Cell:** the smallest living unit. Animal cells have a **nucleus** (the control center), **cytoplasm** (the jelly-like inside), and a **cell membrane** (the outer layer).

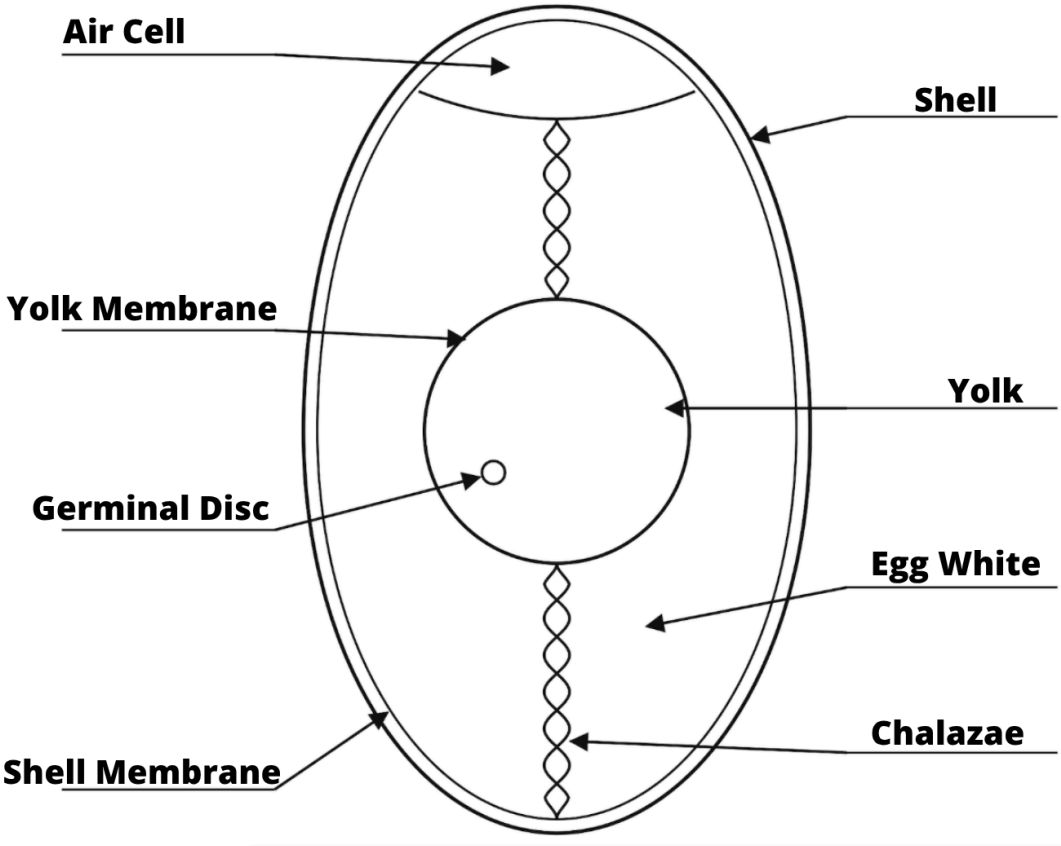
The yolk of a bird egg starts out as a single cell. That makes an ostrich yolk one of the largest cells on the planet. The egg white, the membranes, and the shell all get wrapped around it later, on its way out of the mother's body.

Match each cell part with the egg part that does the same job.

Word bank: *yolk · germinal disc (the small white spot on the yolk) · yolk membrane*

Cell part	What it does	Matching egg part
Nucleus	Holds the DNA	GERMINAL DISC
Cytoplasm	Fills the cell, holds food and supplies	YOLK
Cell membrane	Holds everything in, controls what goes in and out	YOLK MEMBRANE

*Label the diagram with: **shell, shell membranes, air cell, egg white, yolk, yolk membrane, germinal disc, chalazae** (the twisted cords that keep the yolk centered).*



MISSION 3: HISTORY OF THE EGG?

Frog and fish eggs are soft and jelly-like. Out of water, they dry up. For millions of years, that kept animals tied to the water. Fish were already laying eggs in water more than 400 million years ago.

Then, around 340 million years ago, something new showed up: the amniotic egg. Inside were membranes that held water, a sac for storing waste, and a way for gases to move in and out. Think of it as a pond packed inside a shell. For the first time, animals could lay eggs on dry land. Reptiles, birds, and mammals all come from these animals.

Dinosaurs laid amniotic eggs too, and scientists think the very first dinosaur eggs may have been soft and leathery, like a sea turtle's. The oldest dinosaur nests found so far are about 190 million years old. Early birds evolved from within a group of dinosaurs called the theropods around 150 million years ago and are still laying hard-shelled eggs today.

Mammals mostly went a different direction and switched to live birth. Only the platypus and echidnas still lay eggs.

A few giant birds didn't make it to today. Scientists think the dodo, the giant pigeon from Mauritious, went extinct around 330 years ago. New Zealand's moa disappeared about 600 years ago, and Madagascar's elephant bird about 1,000 years ago. Both laid some of the largest eggs ever.

Find each date in the reading. Then number the events from oldest (1) to newest (7).

Event	How long ago?	Order
Moa Extinction		
First amniotic eggs		
Fish laying eggs in water		
Dodo Extinction		
First birds		
Elephant Bird Extinction		

Event	How long ago?	Order
Oldest dinosaur nests		

MISSION 3: HISTORY OF THE EGG?

Frog and fish eggs are soft and jelly-like. Out of water, they dry up. For millions of years, that kept animals tied to the water. Fish were already laying eggs in water more than 400 million years ago.

Then, around 340 million years ago, something new showed up: the amniotic egg. Inside were membranes that held water, a sac for storing waste, and a way for gases to move in and out. Think of it as a pond packed inside a shell. For the first time, animals could lay eggs on dry land. Reptiles, birds, and mammals all come from these animals.

Dinosaurs laid amniotic eggs too, and scientists think the very first dinosaur eggs may have been soft and leathery, like a sea turtle's. The oldest dinosaur nests found so far are about 190 million years old. Early birds evolved from within a group of dinosaurs called the theropods around 150 million years ago and are still laying hard-shelled eggs today.

Mammals mostly went a different direction and switched to live birth. Only the platypus and echidnas still lay eggs.

A few giant birds didn't make it to today. Scientists think the dodo, the giant pigeon from Mauritious, went extinct around 330 years ago. New Zealand's moa disappeared about 600 years ago, and Madagascar's elephant bird about 1,000 years ago. Both laid some of the largest eggs ever.

Find each date in the reading. Then number the events from oldest (1) to newest (7).

Event	How long ago?	Order
Moa Extinction	**600 YEARS AGO**	**6**
First amniotic eggs	**340 MILLION YEARS AGO**	**2**
Fish laying eggs in water	**> 400 MILLION YEARS AGO**	**1**
Dodo Extinction	**330 YEARS AGO**	**7**
First birds	**150 MILLION YEARS AGO**	**4**
Elephant Bird Extinction	**1,000 YEARS AGO**	**5**

Event	How long ago?	Order
Oldest dinosaur nests	**190 MILLION YEARS AGO**	**3**

MISSION 4: MASS-IVE EGGS

1 kilogram (kg) = 1,000 grams (g). Going from g to kg? Divide by 1,000 (move the decimal 3 places left). Going from kg to g? Multiply by 1,000 (move the decimal 3 places right).

Fill in the table by first converting the measurements, and then rank the 15 animals in order of largest (1) to smallest (14). Then, answer the questions.

Animal	Egg Mass (g)	Egg Mass (kg)	Rank
Ostrich		1.4	
Bald eagle	125		
Vervain hummingbird	0.365		
Emu		0.6	
Chicken (large)	57		
Elephant bird *(extinct)*		9	
Japanese quail	10		
Emperor penguin		0.45	
Little blue penguin	52		
Giant moa *(extinct)*		4	
Cassowary	650		
Brown kiwi	450		
Rhea		0.5	

Animal	Egg Mass (g)	Egg Mass (kg)	Rank
Ostrich		1.4	
Bald eagle	125		
Vervain hummingbird	0.365		
Emu		0.6	
Chicken (large)	57		
Elephant bird *(extinct)*		9	
Japanese quail	10		
Emperor penguin		0.45	
Little blue penguin	52		
Giant moa *(extinct)*		4	
Cassowary	650		
Brown kiwi	450		
Tyrannosaurus rex *(extinct)*	3,700		

1. A carton of eggs has 12 large chicken eggs inside. What is the total mass of the 12 eggs?

a. _____ grams
b. _____ kilograms

2. Scientists think that one adult T. rex may have laid between 20 and 30 eggs.

a. A small clutch of 20 eggs would have a mass of _____ kg.
b. A large clutch of 30 eggs would have a mass of _____ kg.

3. Compare the mass of the moa egg to the ostrich egg. How many kg heavier was the moa egg?

4. The Emperor Penguin and the Kiwi both lay eggs that are about the same size. What do you think that suggests about the size of these birds as adults?

5. Use your technology to research the kiwi and the emperor penguin. Was your guess about their adult size correct? What did you learn?

MISSION 4: MASS-IVE EGGS

1 kilogram (kg) = 1,000 grams (g). Going from g to kg? Divide by 1,000 (move the decimal 3 places left). Going from kg to g? Multiply by 1,000 (move the decimal 3 places right).

Fill in the table by first converting the measurements, and then rank the 15 animals in order of largest (1) to smallest (14). Then, answer the questions.

Animal	Egg Mass (g)	Egg Mass (kg)	Rank
Ostrich	**1,400**	1.4	**11**
Bald eagle	125	**0.125**	**5**
Vervain hummingbird	0.365	**0.000365**	**1**
Emu	**600**	0.6	**9**
Chicken (large)	57	**0.057**	**4**
Elephant bird (extinct)	**9,000**	9	**14**
Japanese quail	10	**0.01**	**2**
Emperor penguin	**450**	0.45	**6 or 7**
Little blue penguin	52	**0.052**	**3**
Giant moa (extinct)	**4,000**	4	**13**
Cassowary	650	**0.65**	**10**
Brown kiwi	450	**0.45**	**6 or 7**
Rhea	**500**	0.5	**8**
Tyrannosaurus rex	3,700	**3.7**	**12**

1. A carton of eggs has 12 large chicken eggs inside. What is the total mass of the 12 eggs?

2. **684** grams
3. **0.684** kilograms

2. Scientists think that one adult T. rex may have laid between 20 and 30 eggs.

c. A small clutch of 20 eggs would have a mass of **74** kg.
d. A large clutch of 30 eggs would have a mass of **111** kg.

3. Compare the mass of the moa egg to the ostrich egg. How many kg heavier was the moa egg?

2.6 kg

4. The Emperor Penguin and the Kiwi both lay eggs that are about the same size. What do you think that suggests about the size of these birds as adults?

Prediction - so anything is fine... but I always expect students to assume the adults would be roughly the same size.

5. Use your technology to research the kiwi and the emperor penguin. Was your guess about their adult size correct? What did you learn?

The brown kiwi is about the same size as a chicken... between 2 and 3 kg. Emperor penguins are massive, standing over 1 meter tall and weighing up to 40 kg.

MISSION 5: DATA ANALYSIS | NESTS

In people and chickens, chromosomes decide whether a baby is male or female. In sea turtles, the **temperature of the nest** decides.

A mother sea turtle crawls up the beach at night, digs a hole, lays around 100 eggs, covers them with sand, and heads back to the ocean. She never comes back. From then on, the sun heats the sand and the sand heats the eggs.

While the babies develop, the temperature flips them toward male or female. Cooler sand means more males. Warmer sand means more females. And if the sand gets too hot, a lot of the eggs never hatch.

THE DATA

This example data follows the same pattern scientists find in real sea turtle nests.

Nest temp (°C)	(°F)	Female babies (%)	Eggs that hatch (%)
26	79	0	80
27	81	5	85
28	82	20	85
29	84	50	85
30	86	80	80
31	88	95	75
32	90	100	65
33	91	100	40
34	93	100	20

GRAPH IT: Make a line graph of % female. Nest temperature (°C) on the x-axis, % female on the y-axis.

(This works best with graphing paper, if it isn't available use the space below or a new piece of paper.)

DATA ANALYSIS: Use your graph to answer the questions below.

1. At what temperature would you get a population of babies that is about ½ male and ½ female?

2. What happens to the babies as the nest gets warmer?

FIELD REPORT: RAINE ISLAND

Raine Island, on Australia's northern Great Barrier Reef, is one of the biggest green sea turtle nesting beaches in the world. Its beaches have been warming. In 2018, scientists checked young turtles that came from these warm northern beaches. About 99% of them were female.

1. Use your graph. How warm do you think those nests were getting?

2. If almost every baby is female, what problem would this population have over the next 30 years?

PLOT TWIST

Alligators also have their sex set by temperature, but backwards: warmer nests make more males. Chickens don't work this way at all, but their eggs still have to stay right around 37.5 °C (99.5 °F) for about 21 days or the chick won't develop right.

1. Using what you learned in this part, why does temperature control matter so much for a Colossal Artificial Egg?

YOUR CALL: SHOULD WE STEP IN?

Conservation groups can help hot turtle nests by shading them, sprinkling them with water to cool them, or moving the eggs to a shaded hatchery. Should people change the temperature of sea turtle nests?

CLAIM YOUR ANSWER	
EVIDENCE FROM THE DATA, YOUR GRAPH, OR RAINE ISLAND	
REASONING WHY YOUR EVIDENCE SUPPORTS YOUR CLAIM	

MISSION 5: DATA ANALYSIS | NESTS

In people and chickens, chromosomes decide whether a baby is male or female. In sea turtles, the **temperature of the nest** decides.

A mother sea turtle crawls up the beach at night, digs a hole, lays around 100 eggs, covers them with sand, and heads back to the ocean. She never comes back. From then on, the sun heats the sand and the sand heats the eggs.

While the babies develop, the temperature flips them toward male or female. Cooler sand means more males. Warmer sand means more females. And if the sand gets too hot, a lot of the eggs never hatch.

THE DATA

This example data follows the same pattern scientists find in real sea turtle nests.

Nest temp (°C)	(°F)	Female babies (%)	Eggs that hatch (%)
26	79	0	80
27	81	5	85
28	82	20	85
29	84	50	85
30	86	80	80
31	88	95	75
32	90	100	65
33	91	100	40
34	93	100	20

GRAPH IT: Make a line graph of % female. Nest temperature (°C) on the x-axis, % female on the y-axis.

(This works best with graphing paper, if it isn't available use the space below or a new piece of paper.)

Students should get an S-shaped curve. It's flat near 0% female at 26–27 °C, climbs steeply between 28 and 31 °C, and flattens out at 100% from 32 °C up. Check that temperature is on the x-axis, % female is on the y-axis (0–100), and the axes are labeled.

DATA ANALYSIS: Use your graph to answer the questions below.

1. At what temperature would you get a population of babies that is about ½ male and ½ female?

About 29 °C (84 °F).

2. What happens to the babies as the nest gets warmer?

As the nest gets warmer, more of the babies are female. By 32 °C, they're all female. Hatching stays high (80–85%) up to about 30 °C, then drops fast: only 65% hatch at 32 °C and just 20% at 34 °C.

FIELD REPORT: RAINE ISLAND

Raine Island, on Australia's northern Great Barrier Reef, is one of the biggest green sea turtle nesting beaches in the world. Its beaches have been warming. In 2018, scientists checked young turtles that came from these warm northern beaches. About 99% of them were female.

3. Use your graph. How warm do you think those nests were getting?

About 31 °C or warmer, since that's where the graph reaches about 95–100% female.

4. If almost every baby is female, what problem would this population have over the next 30 years?

There won't be enough males to mate with all the females, so fewer eggs will get fertilized, fewer babies will hatch, and the population could shrink.

PLOT TWIST

Alligators also have their sex set by temperature, but backwards: warmer nests make more males. Chickens don't work this way at all, but their eggs still have to stay right around 37.5 °C (99.5 °F) for about 21 days or the chick won't develop right.

5. Using what you learned in this part, why does temperature control matter so much for a Colossal Artificial Egg?

Temperature controls whether an embryo develops properly at all, and for some reptiles it even decides male or female. Just a few degrees too hot or cold can kill the embryo, and with no parent sitting on the egg, the machine has to get it right every minute for weeks.

YOUR CALL: SHOULD WE STEP IN?

Conservation groups can help hot turtle nests by shading them, sprinkling them with water to cool them, or moving the eggs to a shaded hatchery. Should people change the temperature of sea turtle nests?

CLAIM YOUR ANSWER	
EVIDENCE FROM THE DATA, YOUR GRAPH, OR RAINE ISLAND	

REASONING WHY YOUR EVIDENCE SUPPORTS YOUR CLAIM	