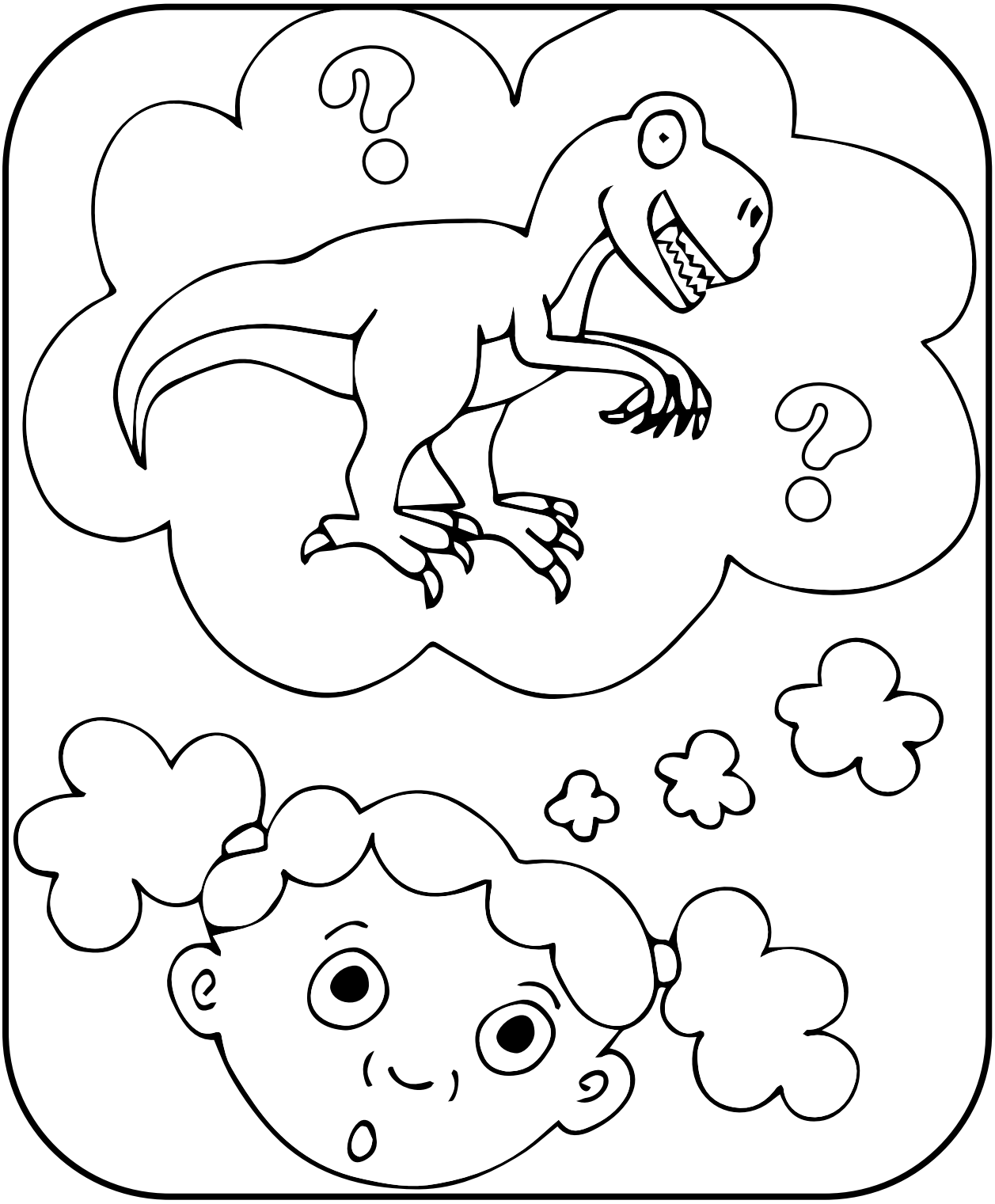
The K-Pg Extinction Coloring Book

Explore What Scientists Know and What Scientists are Debating about the K-Pg Extinction

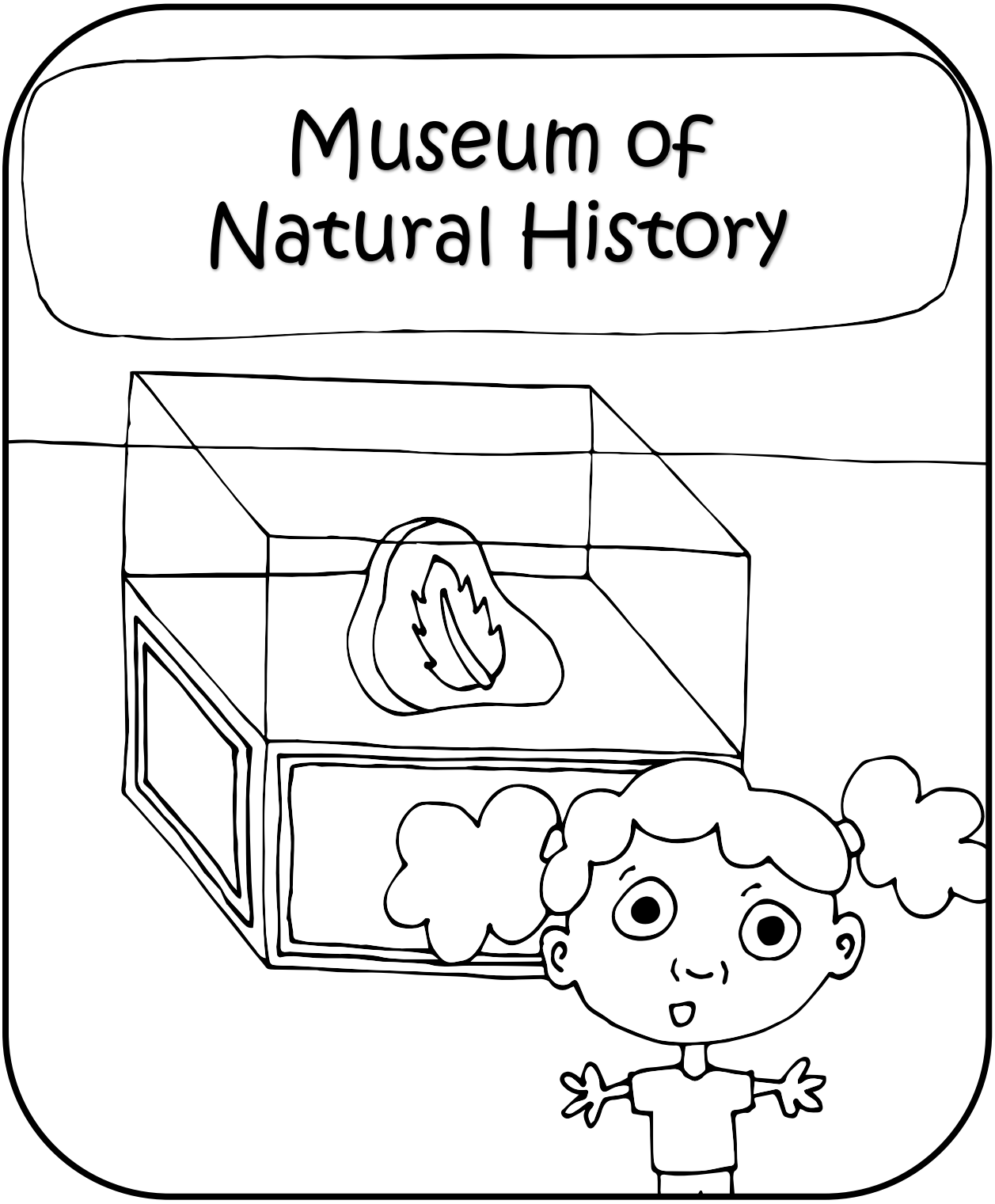
Introduction

In this coloring book, each page features a statement that provides information on the K-T extinction and either a related image to color or a related activity. The information in each statement is intended for a student in middle school to comprehend. At this age, most students are familiar with the extinction of the dinosaurs. Unfortunately, the media is providing this age group with inaccurate information. We wanted to address this issue. In addition, we wanted to create a fun, engaging way for young students to learn about science. We hope to promote an early interest in earth and environmental sciences.

We chose a coloring book for our project because we want to present scientific information in a way that doesn't feel like learning. For example, when students go from coloring dinosaurs, the celebrities of the K-T extinction, to deciphering a maze that leads them to the iridium layer deep in the crust of the Earth, they might ask "What does this have to do with the dinosaurs?" Questions like this will motivate students to read the information provided on each page. Returning to our example, students will learn more about iridium and its relevance to the K-T extinction after reading the page's information. Curiosity rather than coercion will lead to learning.

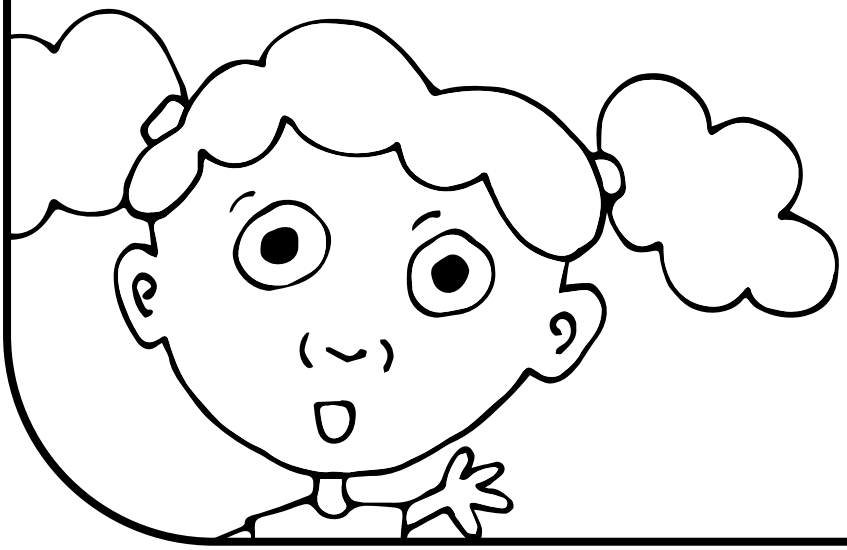


“Have you ever thought about the dinosaurs? What happened to them? Why did they go extinct? Let’s visit the local museum to find out!”



"There are a lot of fossils in the museum. Fossils are the remains of plants and animals. Scientists use these fossils to learn about events that happened millions and even billions of years ago!"

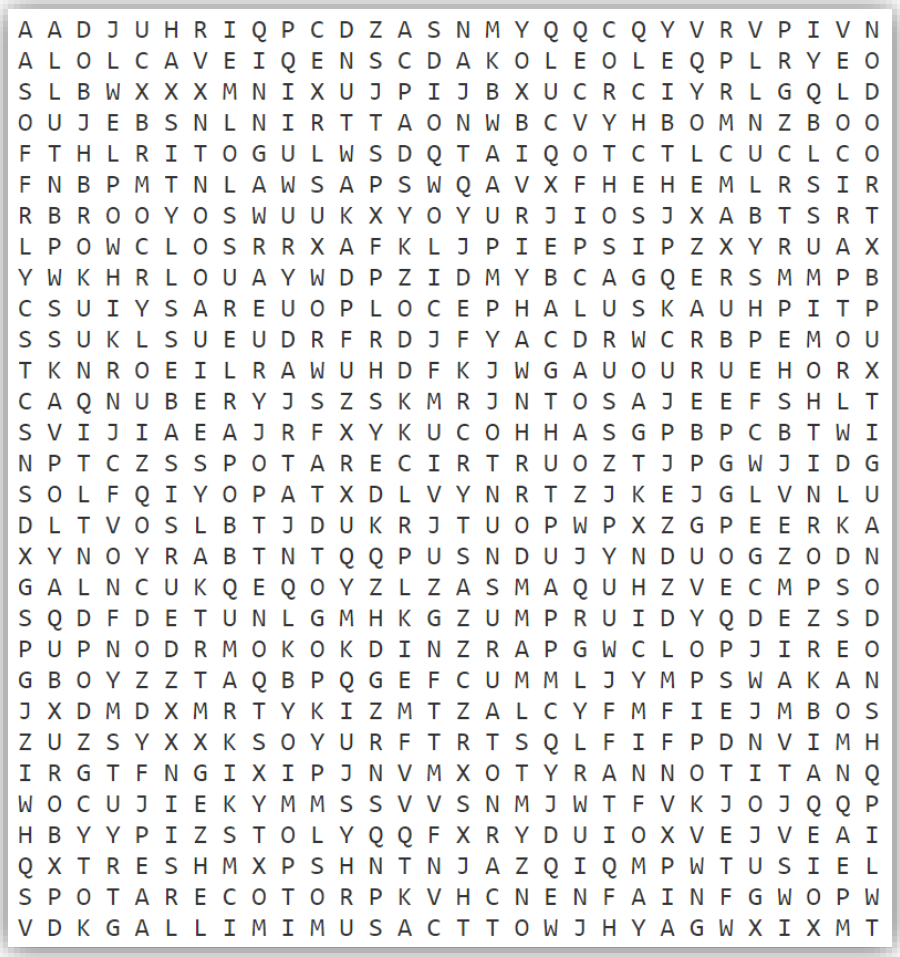
Period	Time Range	Events
Triassic	251 to 202 Million Years Ago	Evolution of dinosaurs and the first mammals
Jurassic	202 to 145 Million Years Ago	Evolution of giant herbivorous dinosaurs
Cretaceous	145 to 65 Million Years Ago	Evolution of large carnivorous dinosaurs, ends with extinction of dinosaurs
Paleogene	65 to 23 Million Years Ago	Extinction of dinosaurs 65 million years ago, available niches for mammals
Neogene	23 to 3 Million Years Ago	Expansion of grasslands, period of global cooling
Quaternary	3 Million Years Ago to Present	Considered the "Age of Humans," evolution of mammoths, bison, rhinos, and oxen



"We need to know when the dinosaurs went extinct. Then we can look at the right fossils. Here is a geologic time scale. We can use it to find out when the dinosaurs went extinct."

“It looks like we need to look at the fossils from the boundary between the Cretaceous period and the Paleogene period—the K-Pg boundary! Let’s go to the part of the museum that has fossils from that time.”

The Cretaceous Dinosaurs!



A A D J U H R I Q P C D Z A S N M Y Q Q C Q Y V R V P I V N
A L O L C A V E I Q E N S C D A K O L E O L E Q P L R Y E O
S L B W X X X M N I X U J P I J B X U C R C I Y R L G Q L D
O U J E B S N L N I R T T A O N W B C V Y H B O M N Z B O O
F T H L R I T O G U L W S D Q T A I Q O T C T L C U C L C O
F N B P M T N L A W S A P S W Q A V X F H E H E M L R S I R
R B R O O Y O S W U U K X Y O Y U R J I O S J X A B T S R T
L P O W C L O S R R X A F K L J P I E P S I P Z X Y R U A X
Y W K H R L O U A Y W D P Z I D M Y B C A G Q E R S M M P B
C S U I Y S A R E U O P L O C E P H A L U S K A U H P I T P
S S U K L S U E U D R F R D J F Y A C D R W C R B P E M O U
T K N R O E I L R A W U H D F K J W G A U O U R U E H O R X
C A Q N U B E R Y J S Z S K M R J N T O S A J E E F S H L T
S V I J I A E A J R F X Y K U C O H H A S G P B P C B T W I
N P T C Z S S P O T A R E C I R T R U O Z T J P G W J I D G
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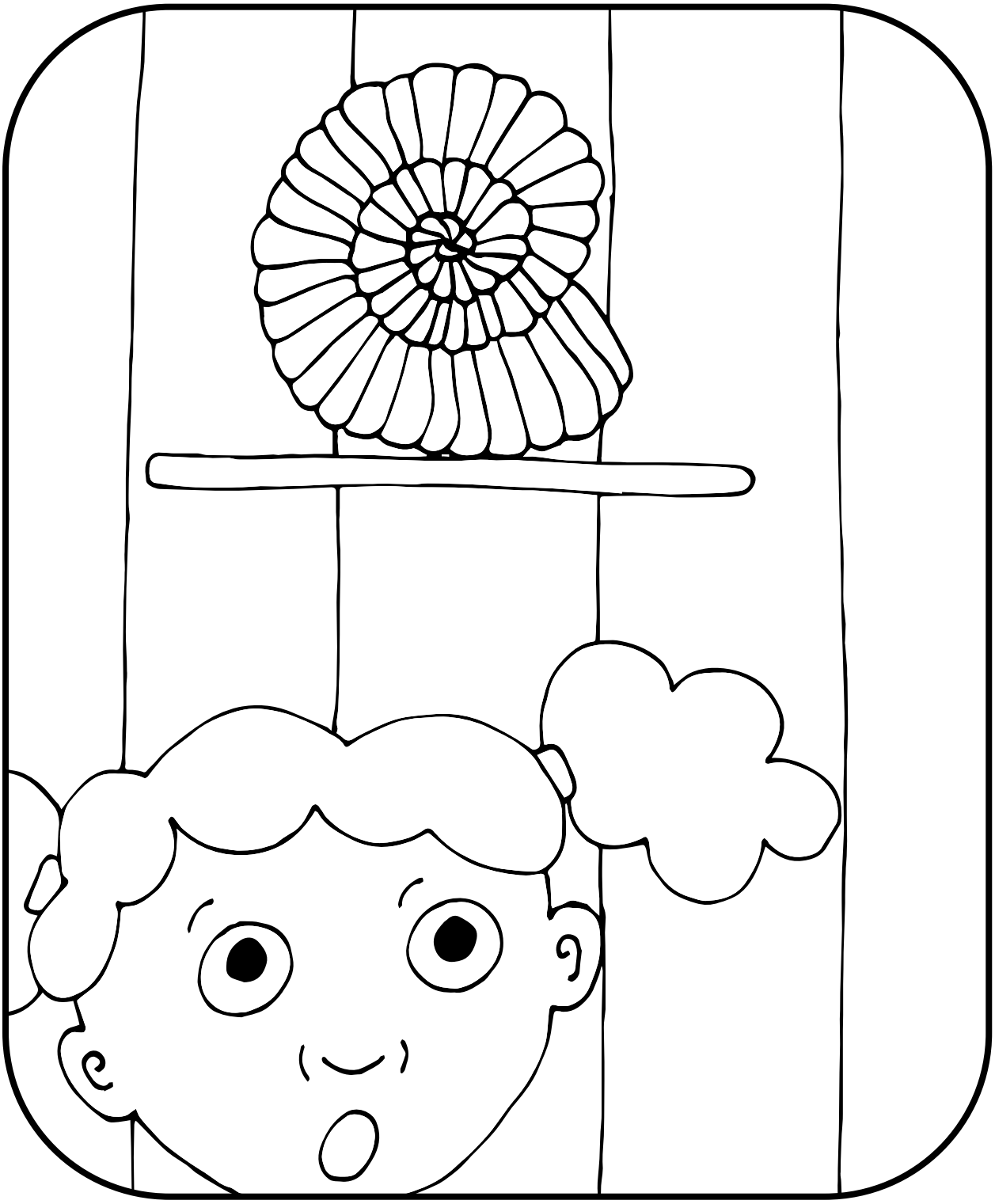
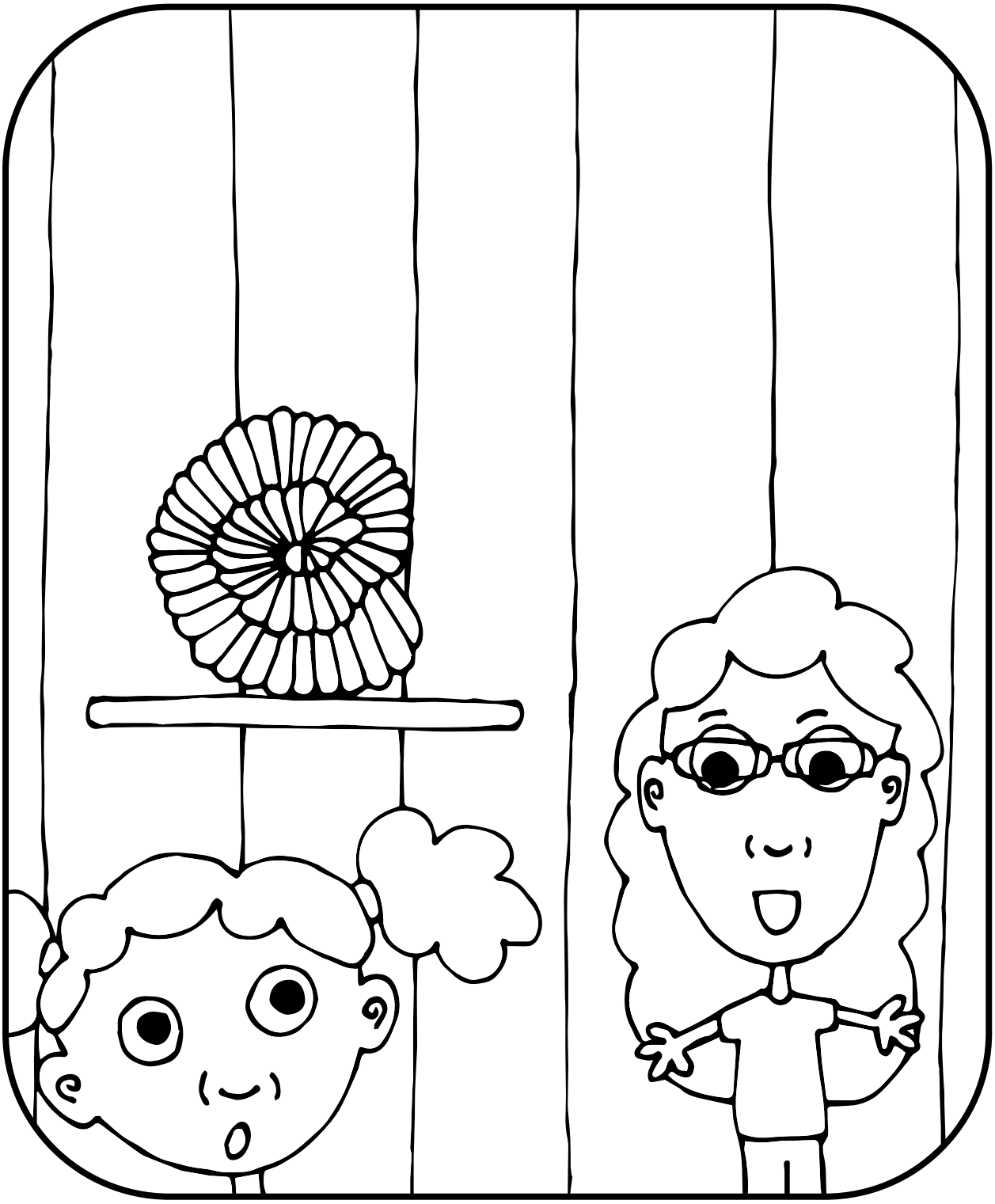
X Y N O Y R A B T N T Q Q P U S N D U J Y N D U O G Z O D N
G A L N C U K Q E Q O Y Z L Z A S M A Q U H Z V E C M P S O
S Q D F D E T U N L G M H K G Z U M P R U I D Y Q D E Z S D
P U P N O D R M O K O K D I N Z R A P G W C L O P J I R E O
G B O Y Z Z T A Q B P Q G E F C U M M L J Y M P S W A K A N
J X D M D X M R T Y K I Z M T Z A L C Y F M F I E J M B O S
Z U Z S Y X X K S O Y U R F T R T S Q L F I F P D N V I M H
I R G T F N G I X I P J N V M X O T Y R A N N O T I T A N Q
W O C U J I E K Y M M S S V V S N M J W T F V K J O J Q Q P
H B Y Y P I Z S T O L Y Q Q F X R Y D U I O X V E J V E A I
Q X T R E S H M X P S H N T N J A Z Q I Q M P W T U S I E L
S P O T A R E C O T O R P K V H C N E N F A I N F G W O P W
V D K G A L L I M I M U S A C T T O W J H Y A G W X I X M T

ALBERTOSAURUS	CORYTHOSAURUS	GIGANOTOSAURUS	ORNITHOMIMUS	STYRACOSAURUS
ANKYLOSAURUS	DEINONYCHUS	IGUANODON	PROTOCERATOPS	TRICERATOPS
BARYONYX	EDMONTOSAURUS	MAIASAURA	SAUROLOPHUS	TROODON
CARNOTAURUS	EUOPLOCEPHALUS	MINMI	SPINOSAURUS	TYRANNOTITAN
CERATOPS	GALLIMIMUS	NOTOCERATOPS	STEGOCERAS	VELOCIRAPTOR

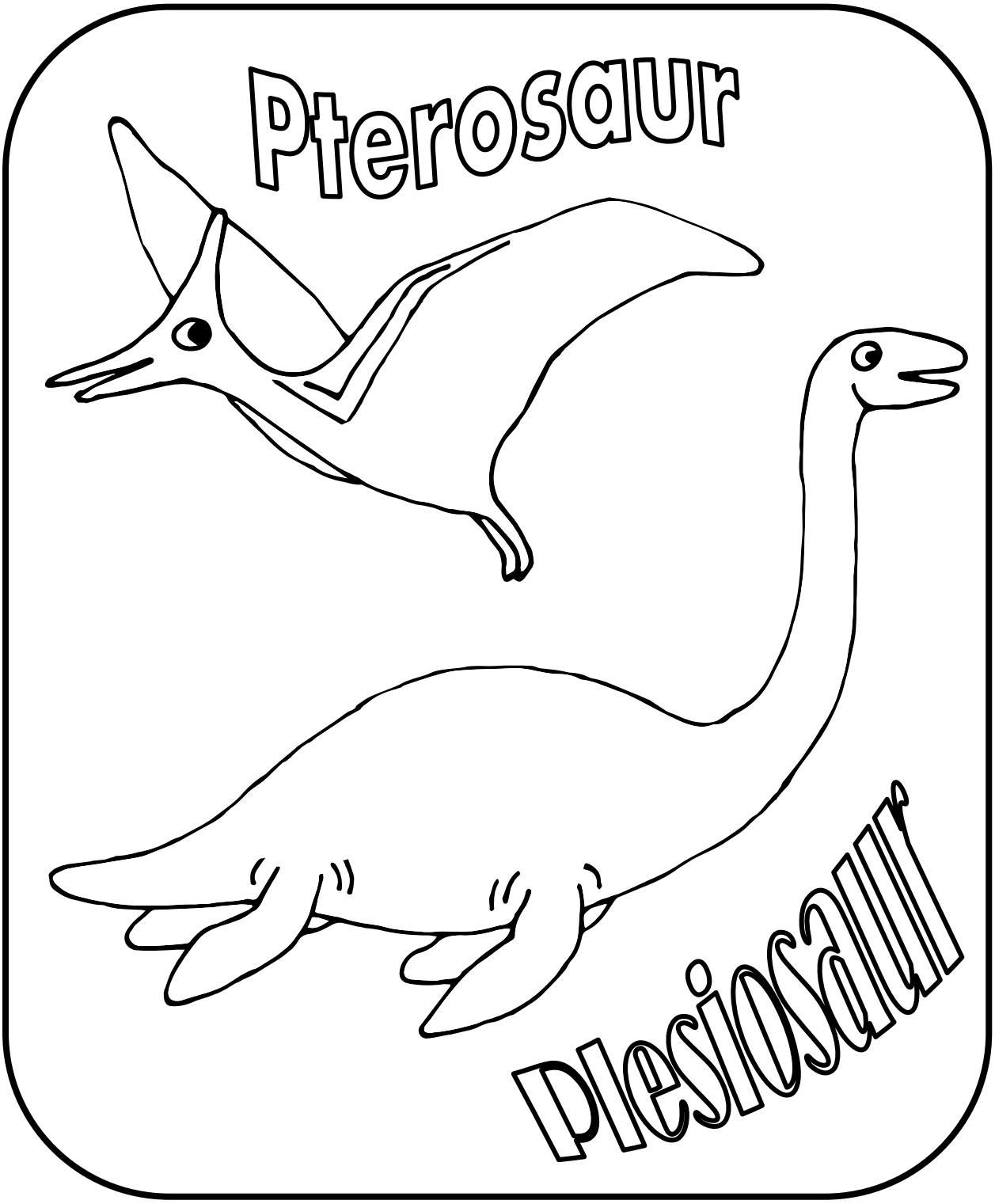
I can't wait to learn more about the dinosaurs of the Cretaceous period!



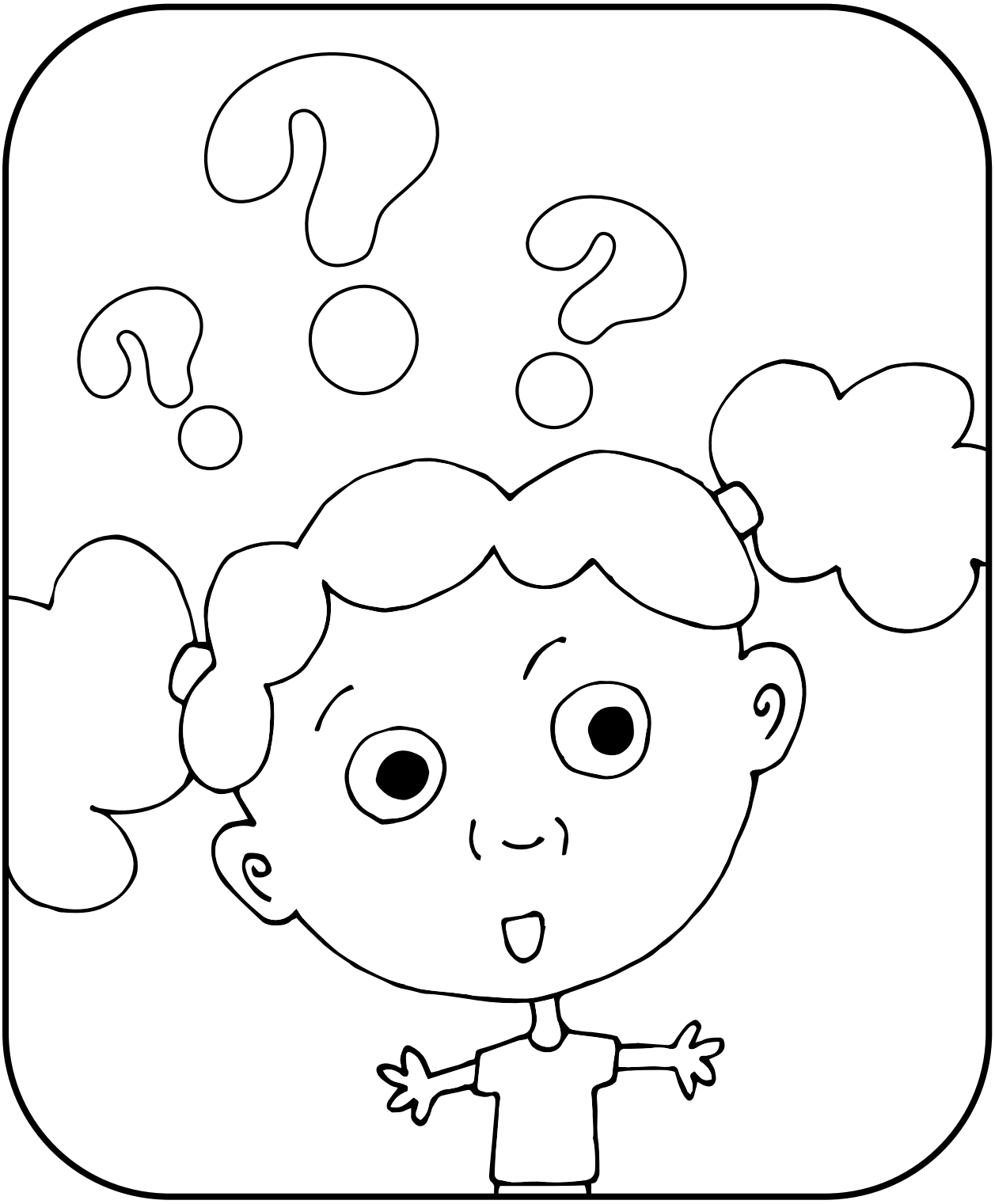
“Not all of these fossils look like they are from dinosaurs. Did other plants and animals go extinct with the dinosaurs?”



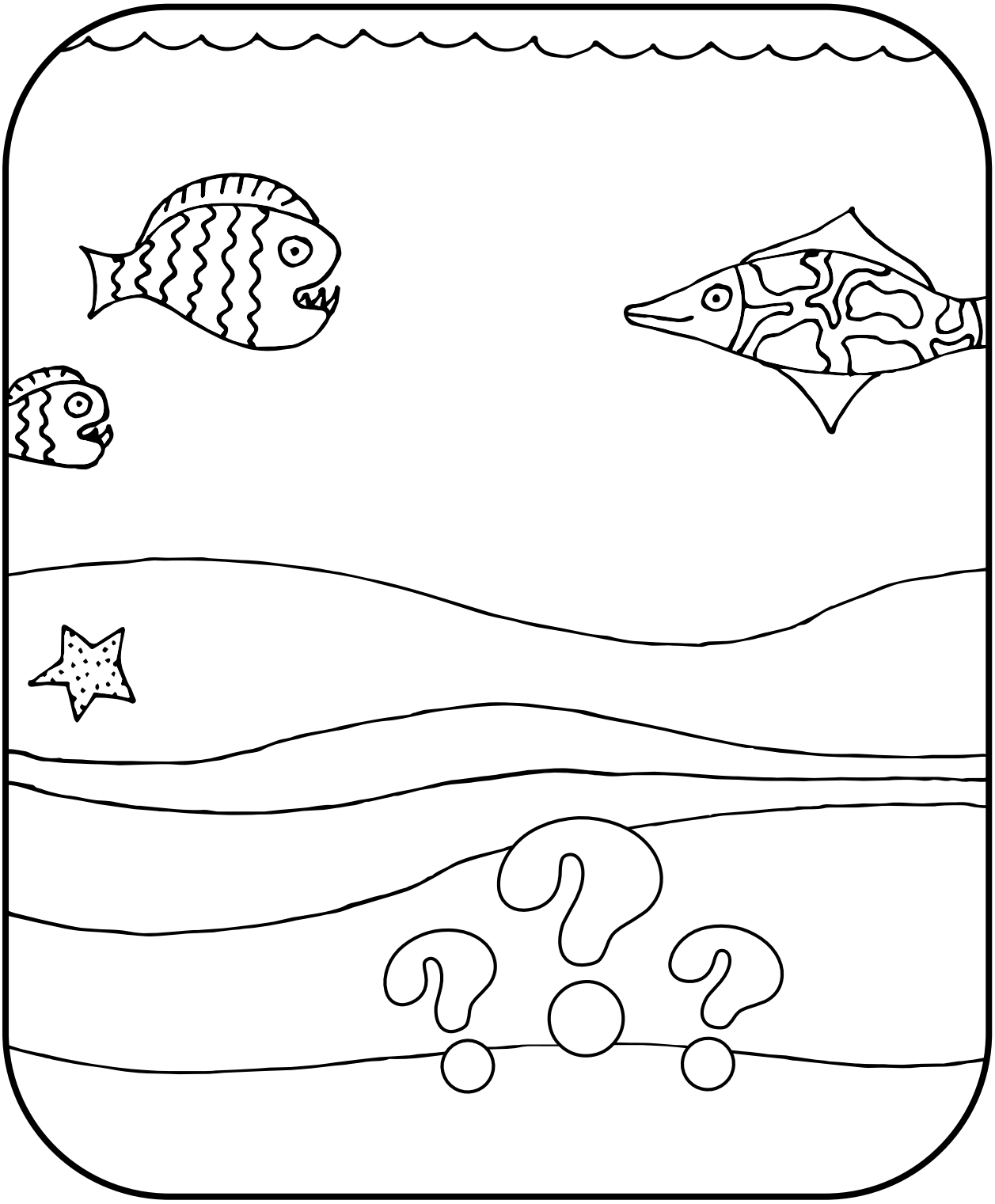
“Hello! My name is Larissa. I saw you admiring my exhibit, and I overheard your question. This is an ammonite fossil. Ammonites went extinct with the dinosaurs.”



“The K-Pg boundary marks the extinction of eighty percent of all plant and animal species on Earth. Here are just some of the species that went extinct!”



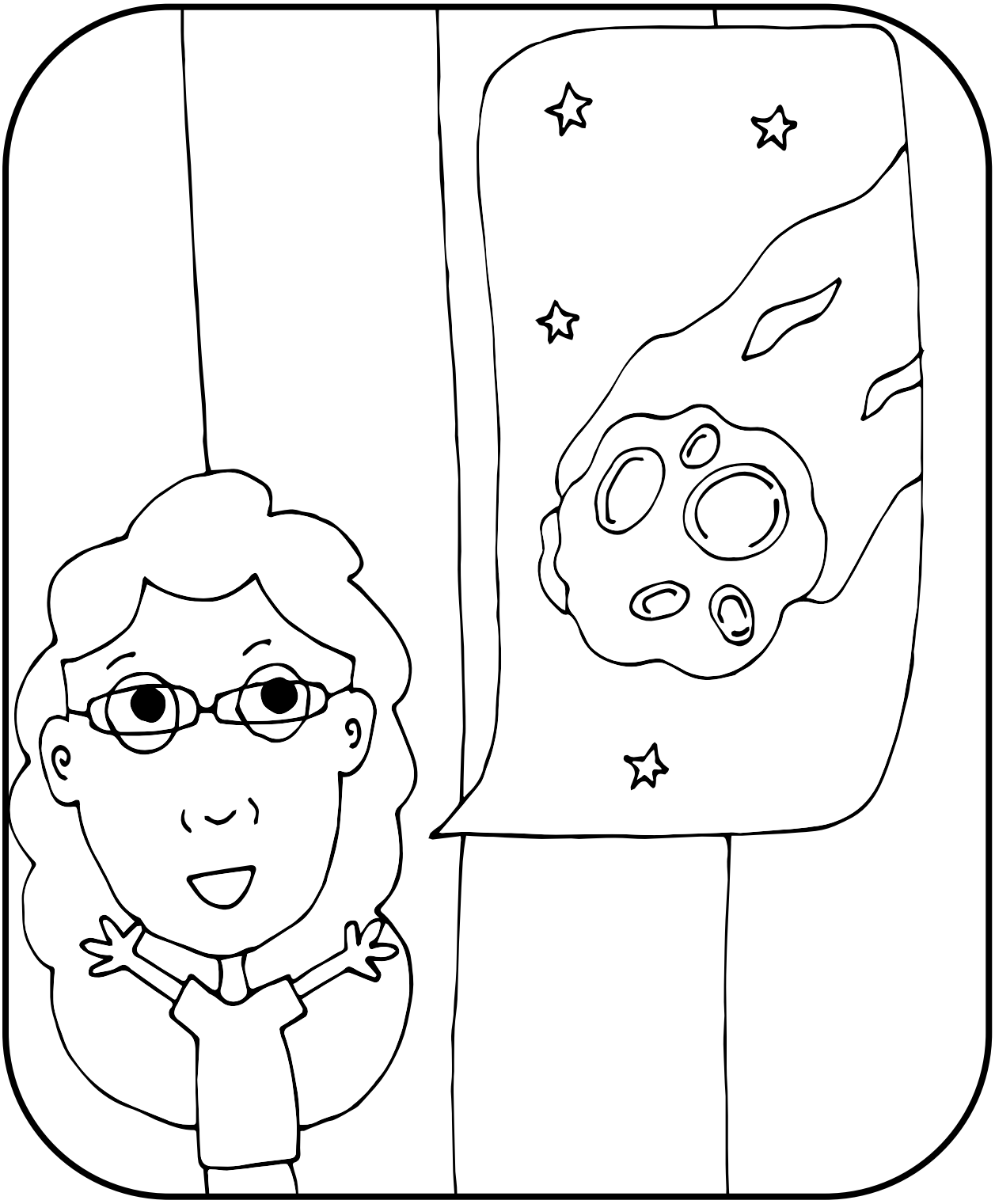
“You seem like you know a lot about the K-Pg extinction event! Why did the dinosaurs and other species go extinct?”



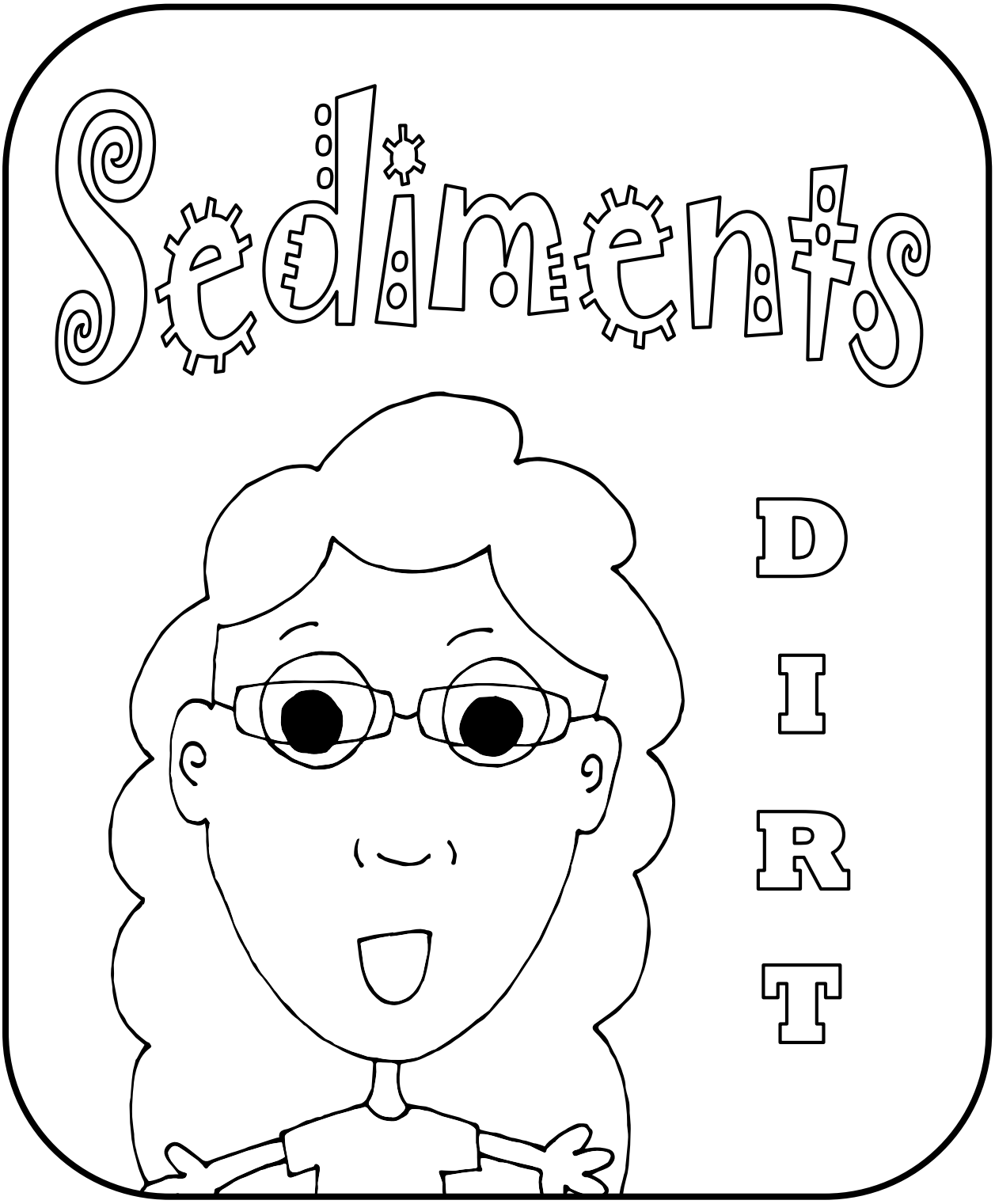
“Well, scientists didn’t have much of an answer until about 30 years ago when they discovered something deep in the Earth’s crust."

“They found lots and lots of iridium!” (Alvarez et al., 1990).

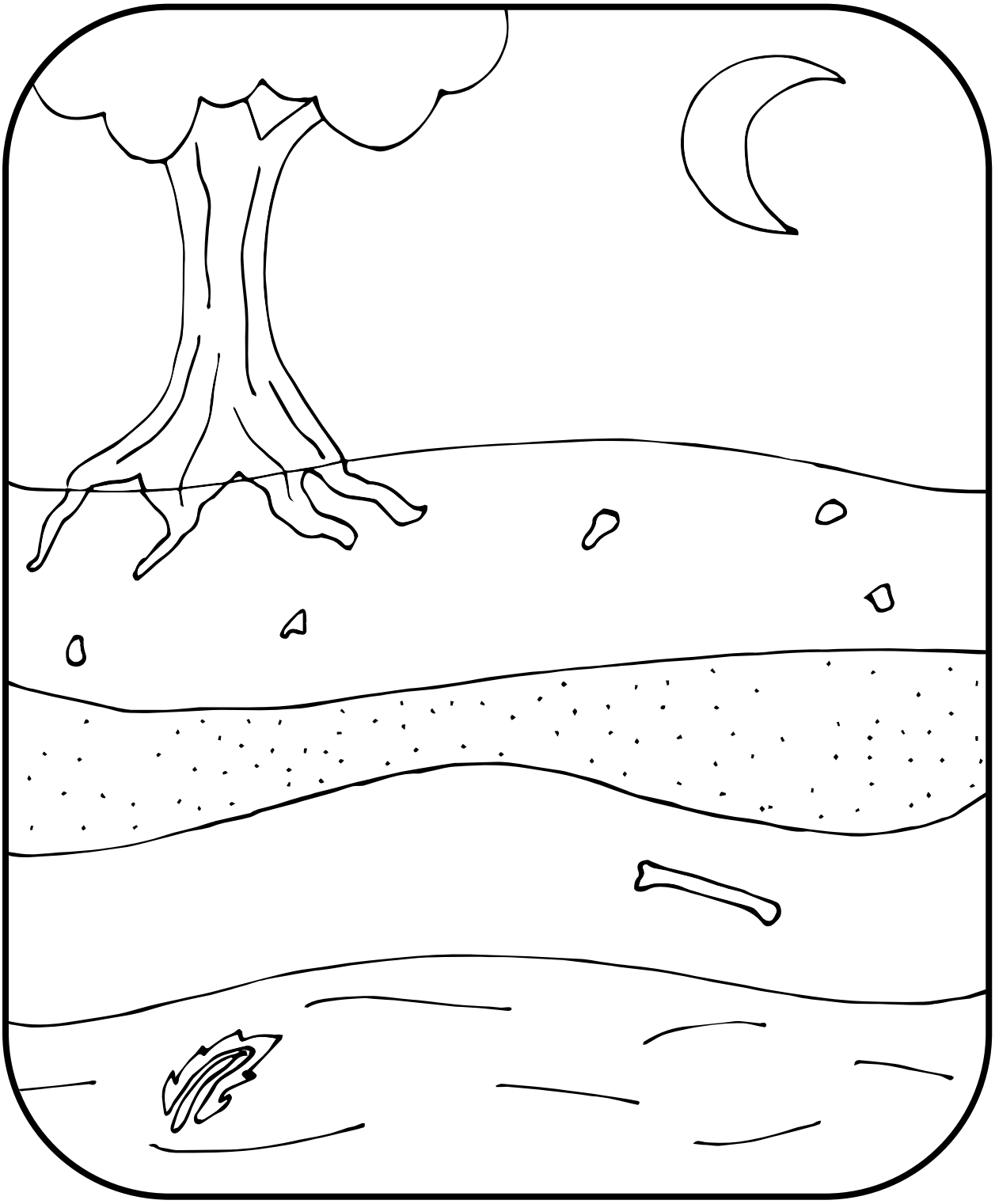
“What is iridium?”



“Iridium is a chemical element that is not usually found on Earth. However, it’s commonly found in asteroids and meteors. So what does this discovery mean?”

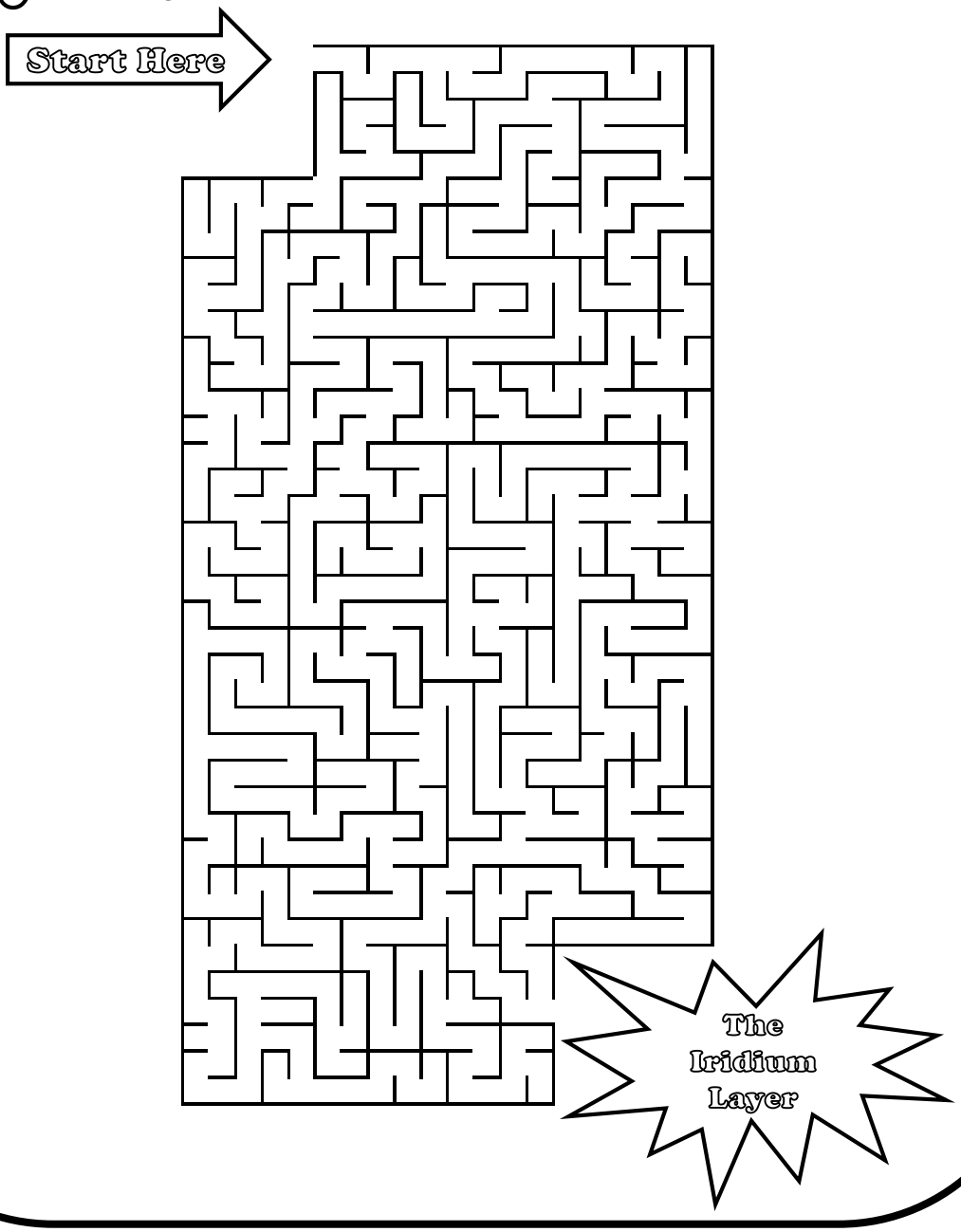


"Well, let's learn a little bit more about how scientists gather information about Earth's history. Scientists can use dirt to figure out what happened millions of years ago."



“Over time, dirt is compacted and then covered with more dirt! Scientists use these layers of dirt as a record of the past.”

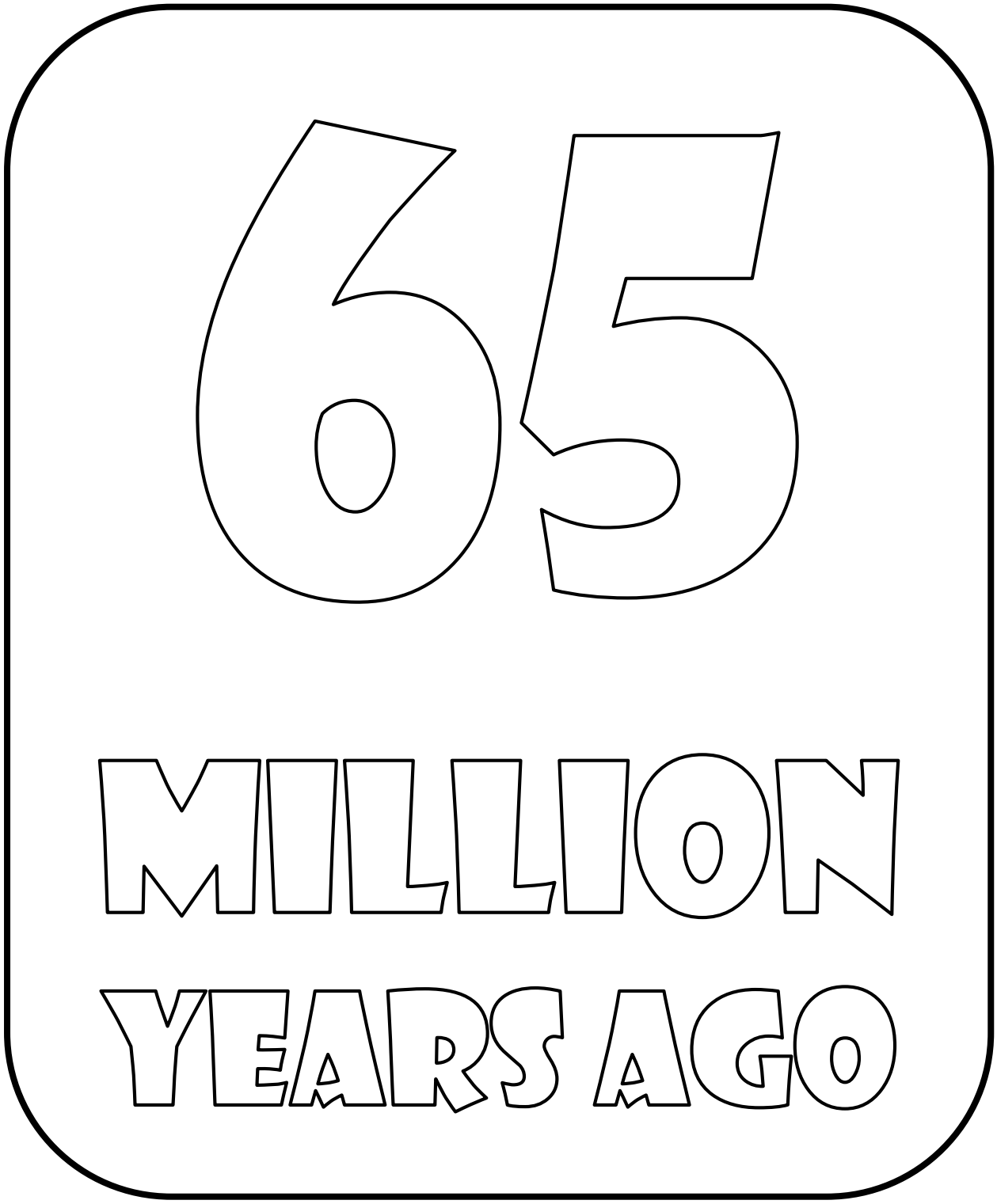
Dig Deep to Find the Iridium Layer



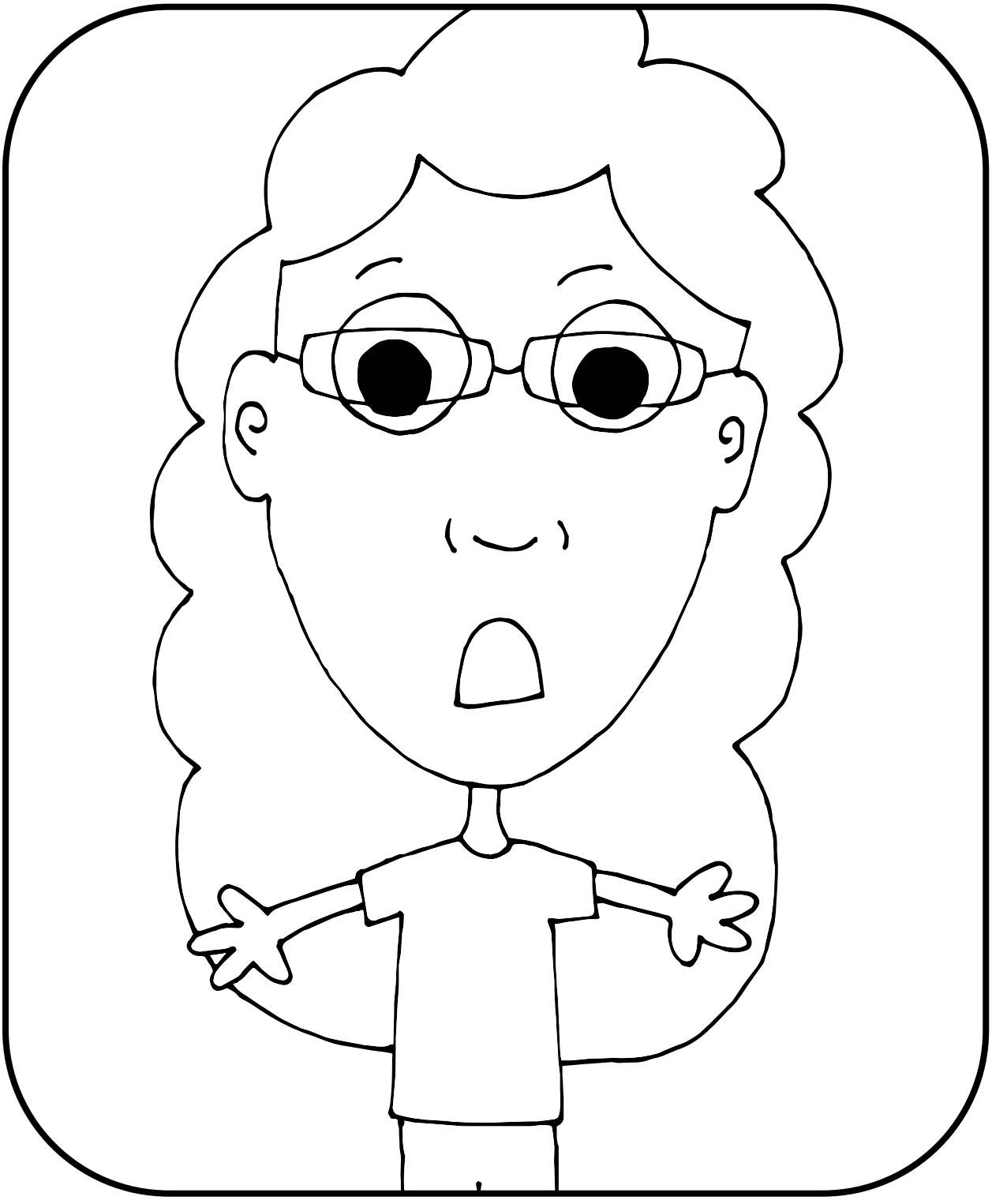
"By studying a sample of dirt from one of these layers, scientists can learn more about what happened when that dirt layer was formed. That's why the discovery of iridium in the Earth's crust was so important!"

“Scientists found this unusually large amount of iridium in a layer of dirt that formed between 71.5 and 61.5 million years ago,” (Alvarez et al., 1990), “and scientists already had evidence that the dinosaurs went extinct around 65 million years ago.”

“What if an asteroid hitting Earth caused the dinosaurs’ extinction!?”



“It makes sense! Asteroids have lots of iridium in them. Around 65 million years ago, there was a lot of iridium present on the Earth’s surface. Also around 65 million years ago, the dinosaurs and many other species of plants and animals went extinct.”



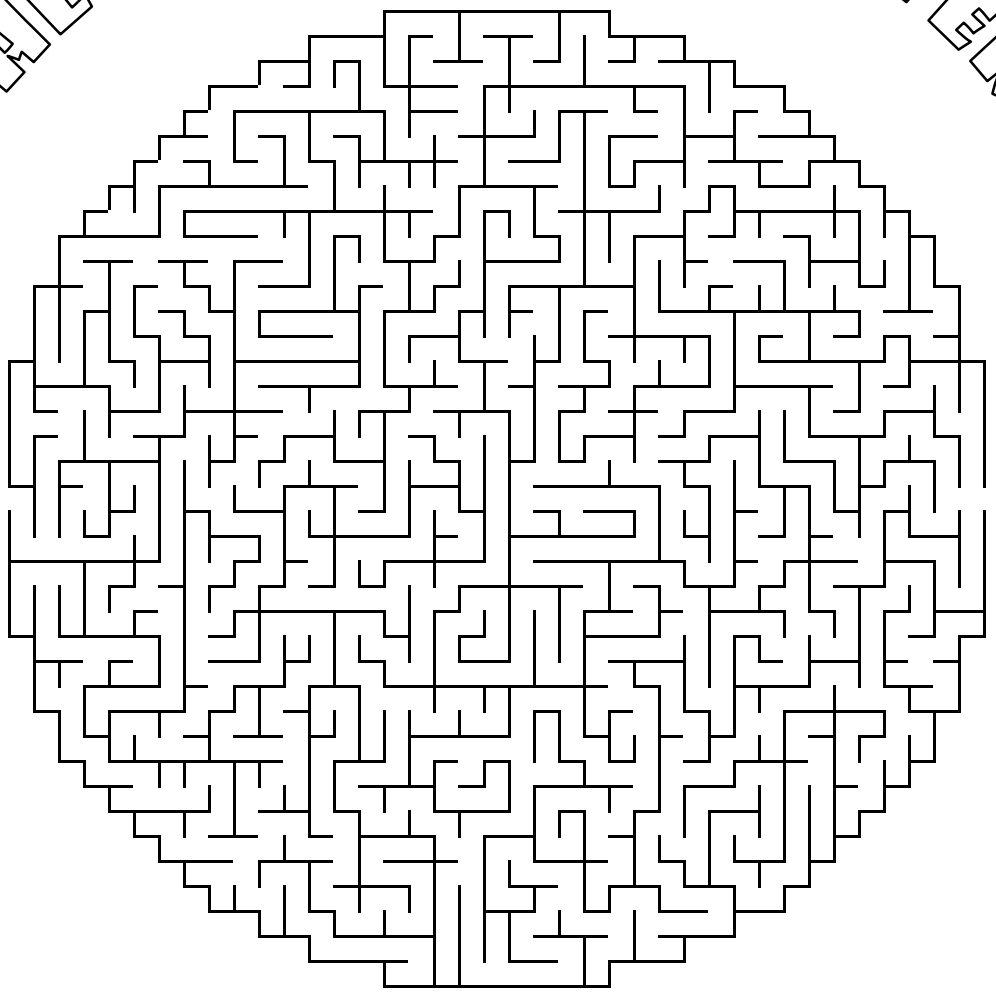
“Exactly! Unfortunately, scientists had no real evidence to support their claim of an asteroid impact other than the layer of iridium . . .”

". . . until scientists made a new discovery—a MASSIVE crater located near the Gulf of Mexico!"

THE CHICXULUB CRATER

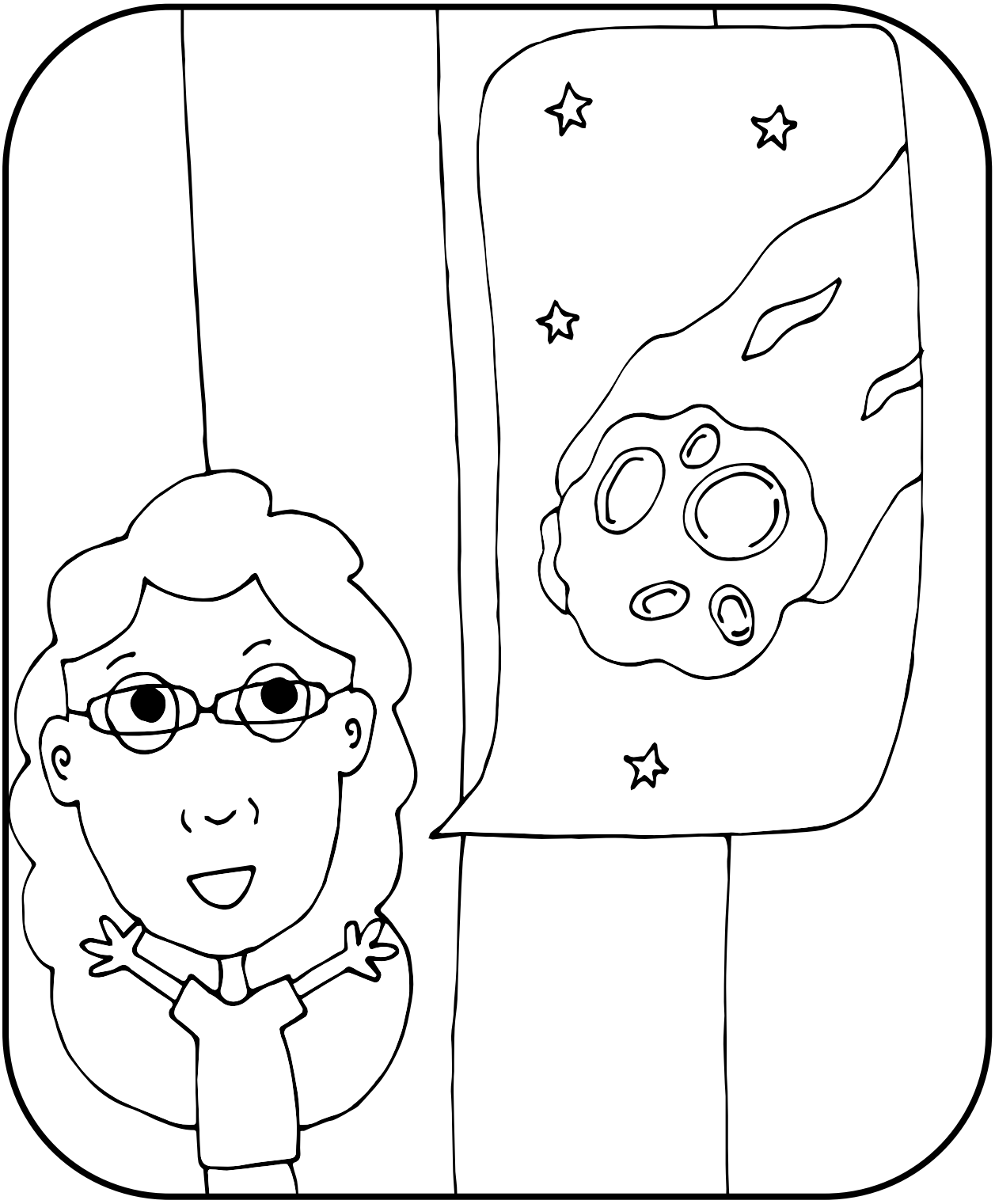
START

FINISH

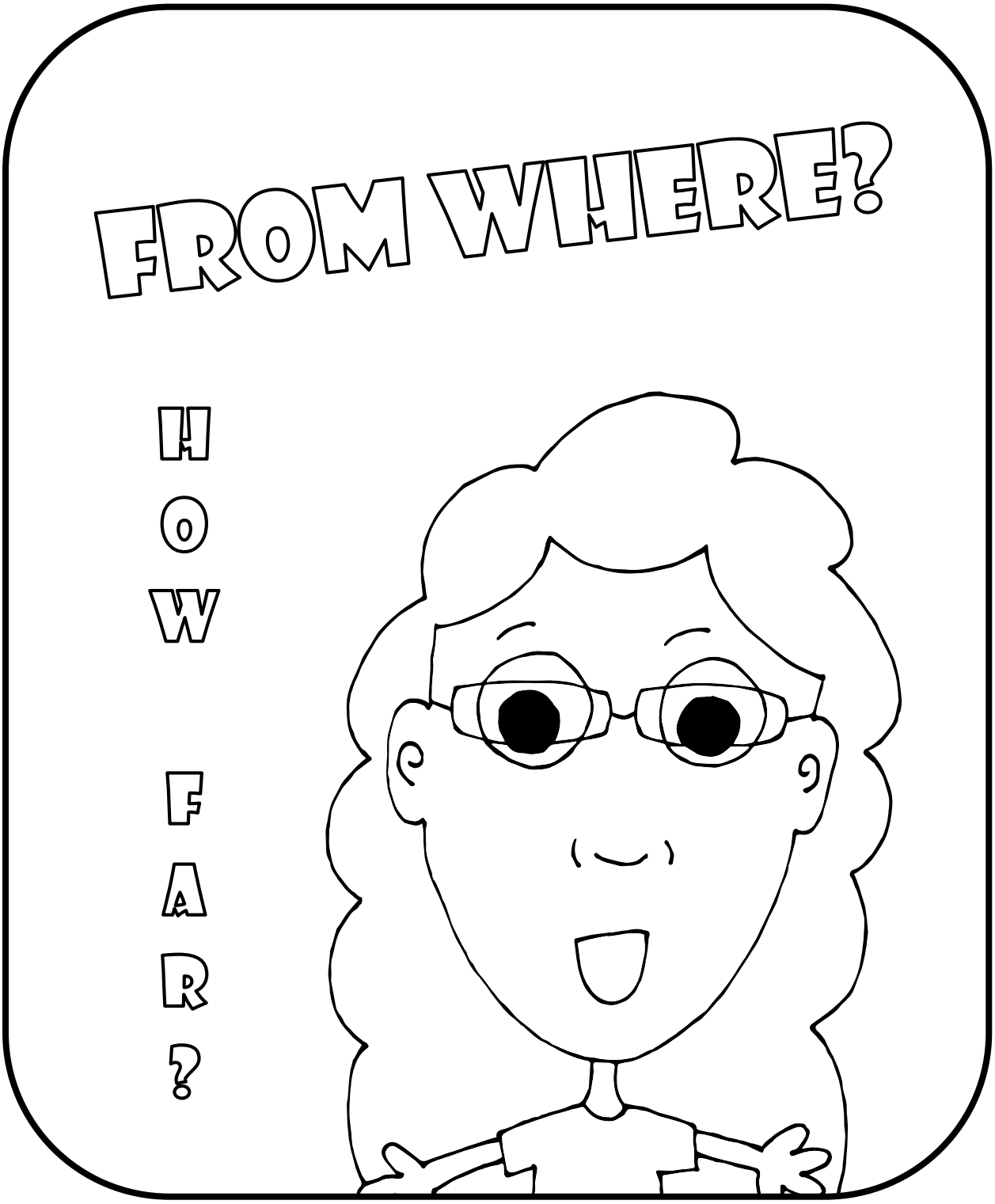


500 Football Fields	500 Football Fields	500 Football Fields	500 Football Fields

“They call this crater the Chicxulub crater. It had a diameter of about 115 miles long!” (Schulte et al., 2010). “That is roughly the length of 2000 American football fields!”

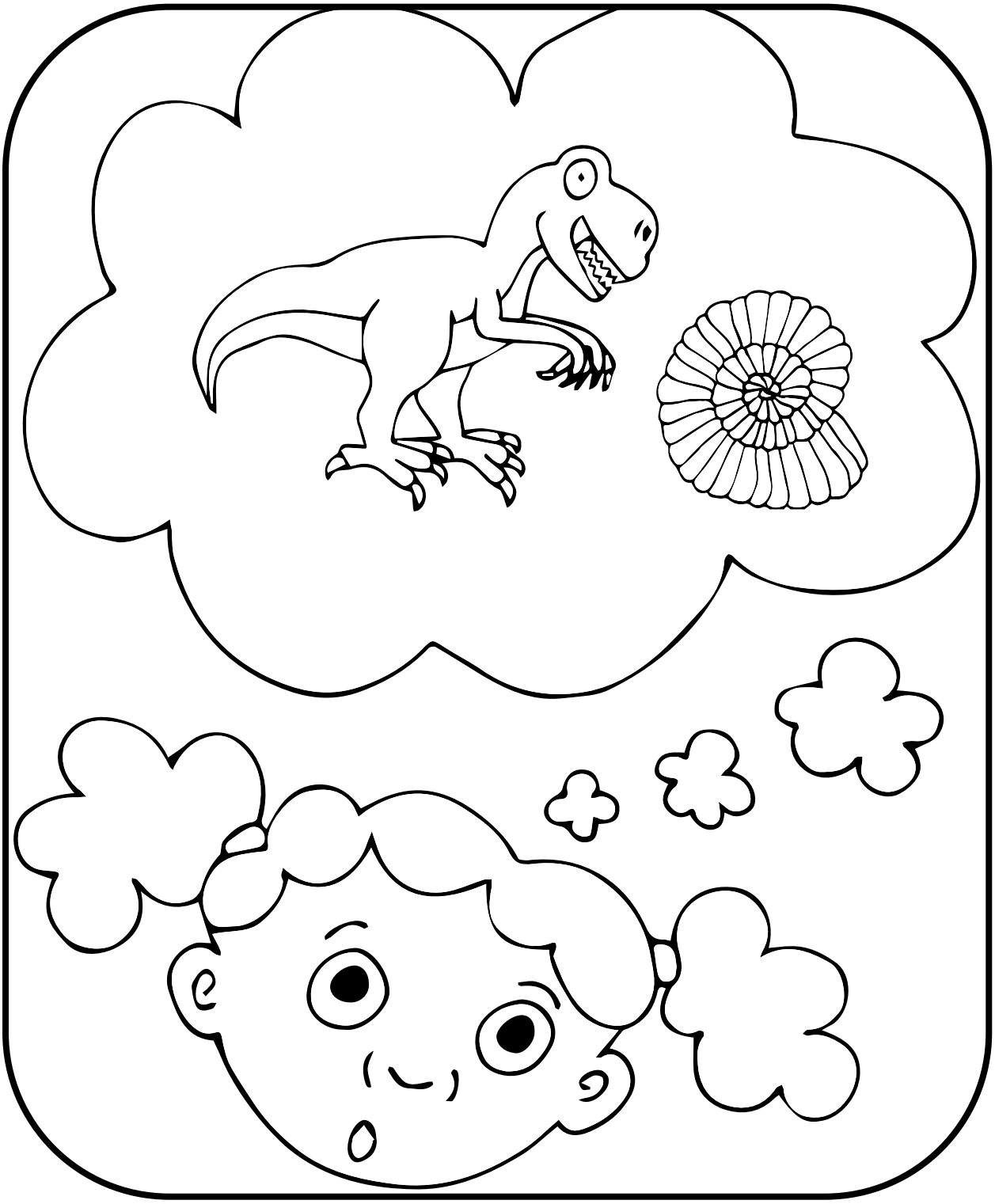


“When the asteroid hit the planet, it caused a huge explosion. This explosion caused a lot of debris to fly into the air. Some of the debris stayed in the air for a long time, blocking out the sun. This event caused extended darkness and a global cooling period,” (Schulte et al., 2010).

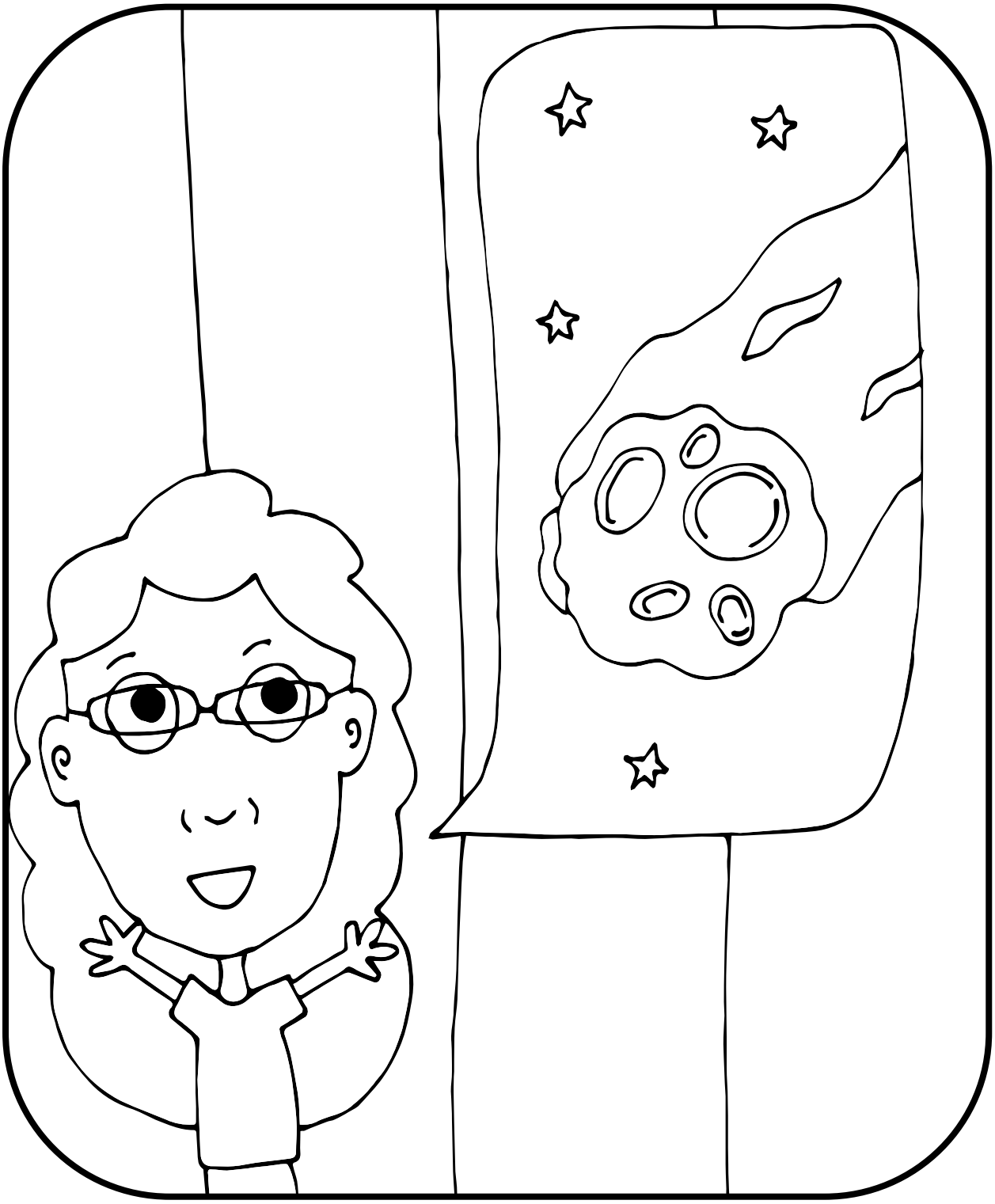


"The debris flew at a VERY fast rate. This high speed caused the small particles of the debris to rearrange themselves before falling back to the ground. Scientists can look at this rearrangement and determine how far the debris flew and from where it came."

"Well, scientists found that the debris came from the crater's location," (Schulte et al., 2010).

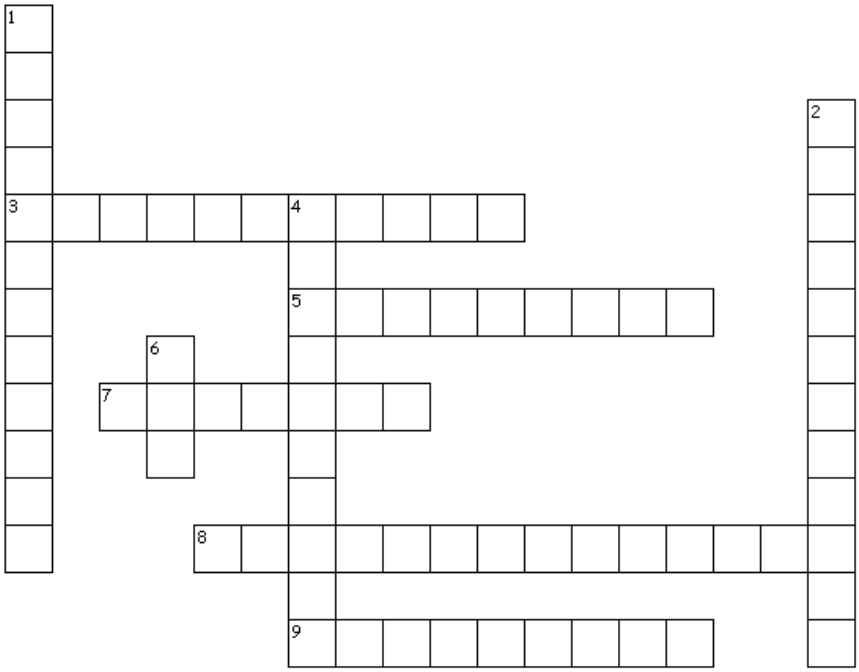


“I still don’t understand how the asteroid impact contributed to the mass extinction of species all over the planet.”



“Remember when we discussed how the asteroid impact would cause extended darkness and global cooling?”

Photosynthesis



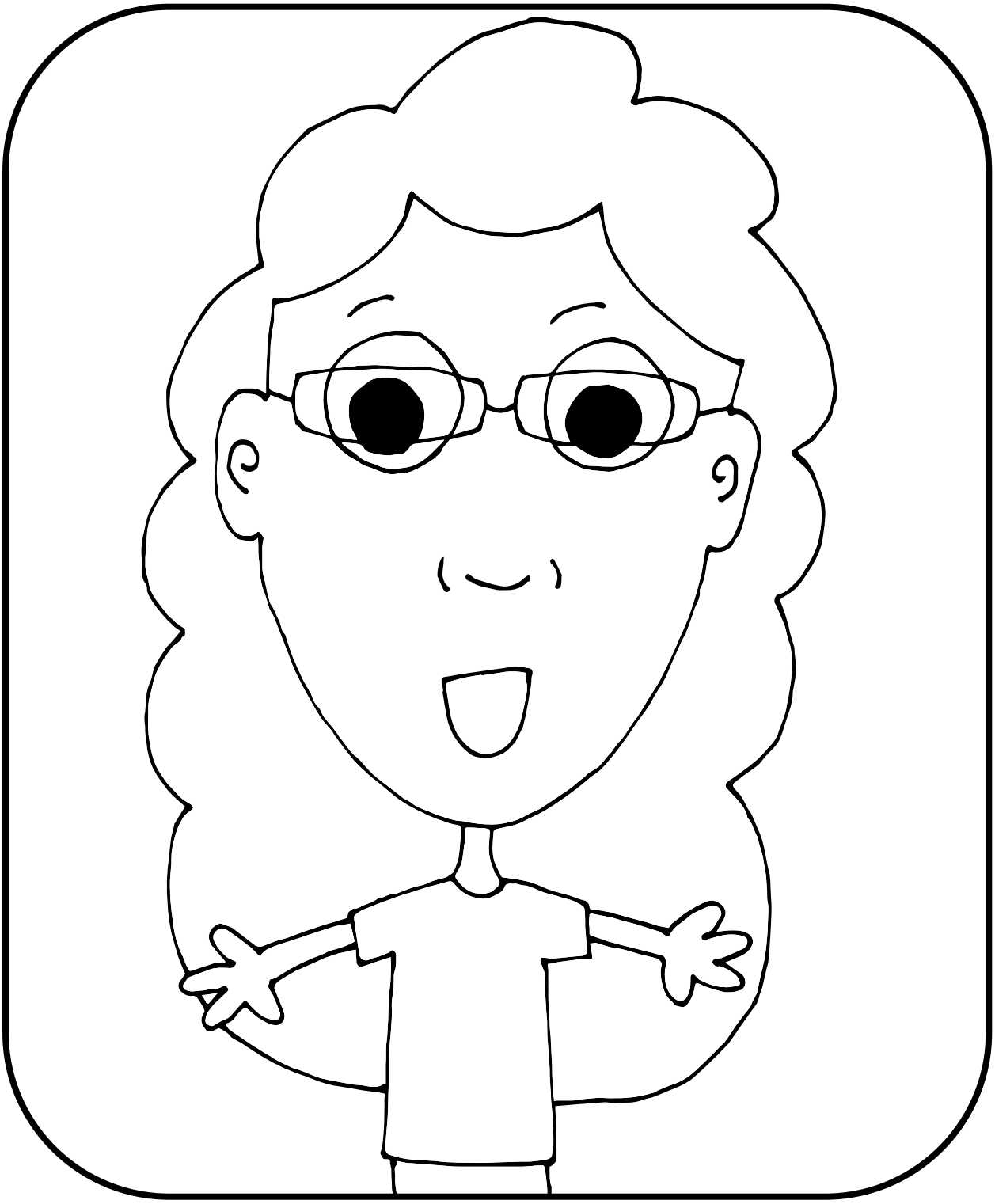
Across

3. Green pigments found in the chloroplasts of plants
5. A specialized subunit within a cell
7. Pores in the epidermis of plants that allow the exchange of gases
8. The process by which plants make food
9. An organism whose cells contain a membrane-bound nucleus

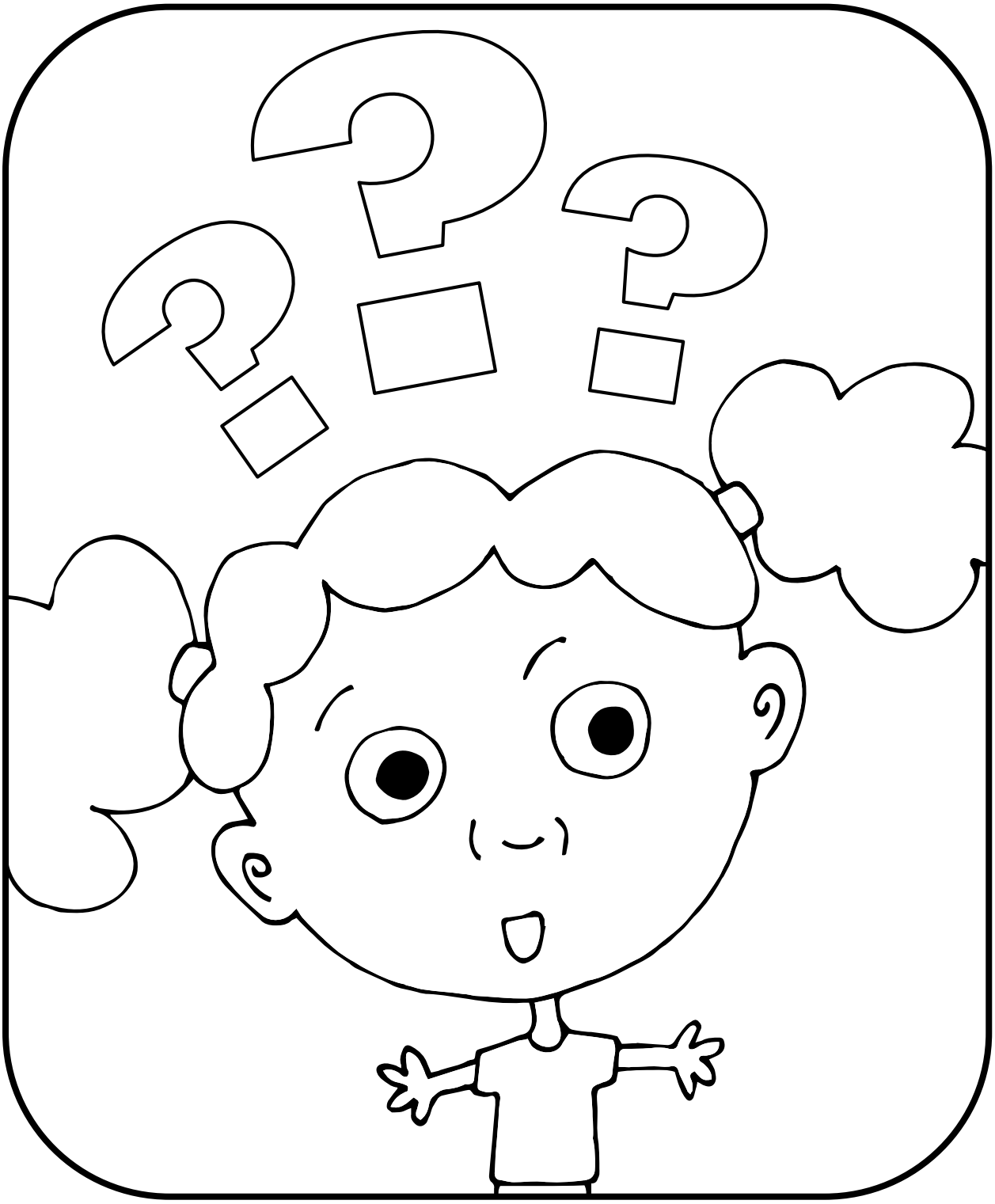
Down

1. The "powerhouse of the cell"
2. The part of a plant cell that turns CO_2, water, and light into sugar and oxygen
4. A single-celled organism that lacks a membrane-bound nucleus
6. A common form in which energy is stored in living systems

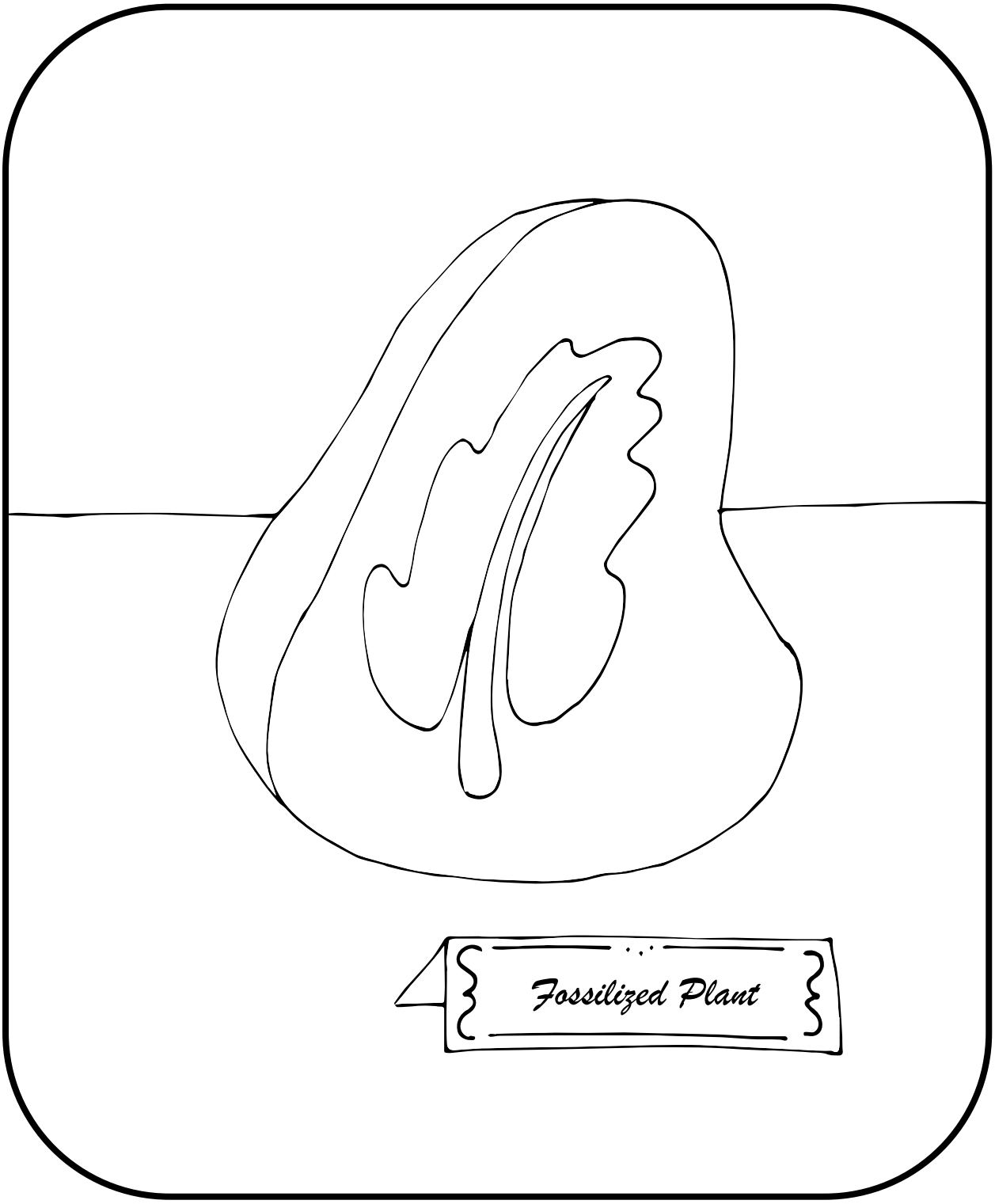
"Well, plants use sunlight as food! The extended darkness would severely impact the ability of plants to survive."



“Herbivores rely on plants as a food source, and other animals rely on herbivores as a food source. The effect of the extended darkness would continue through the food web, harming many species.”

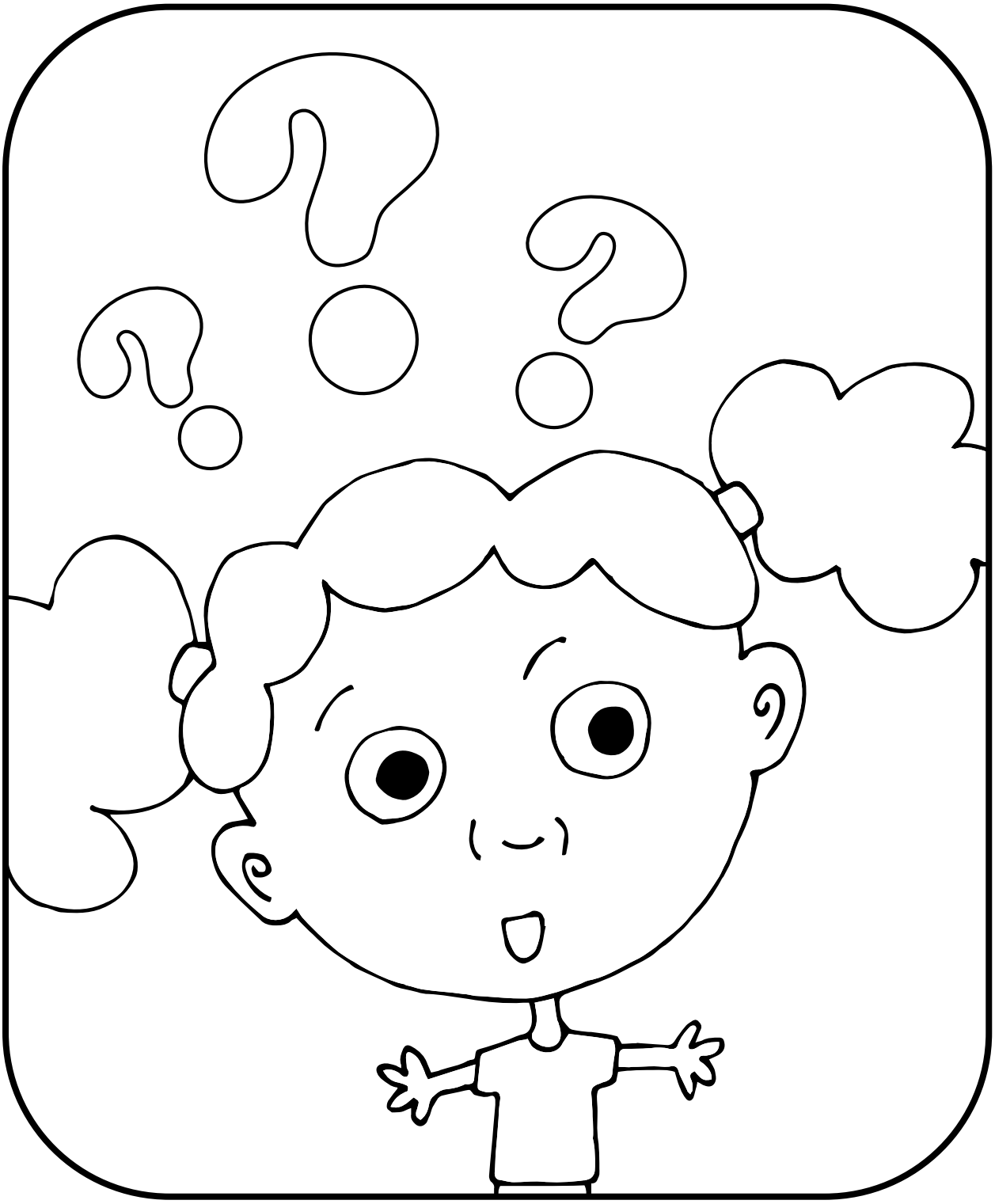


“How was the food web able to recover after the asteroid hit?”



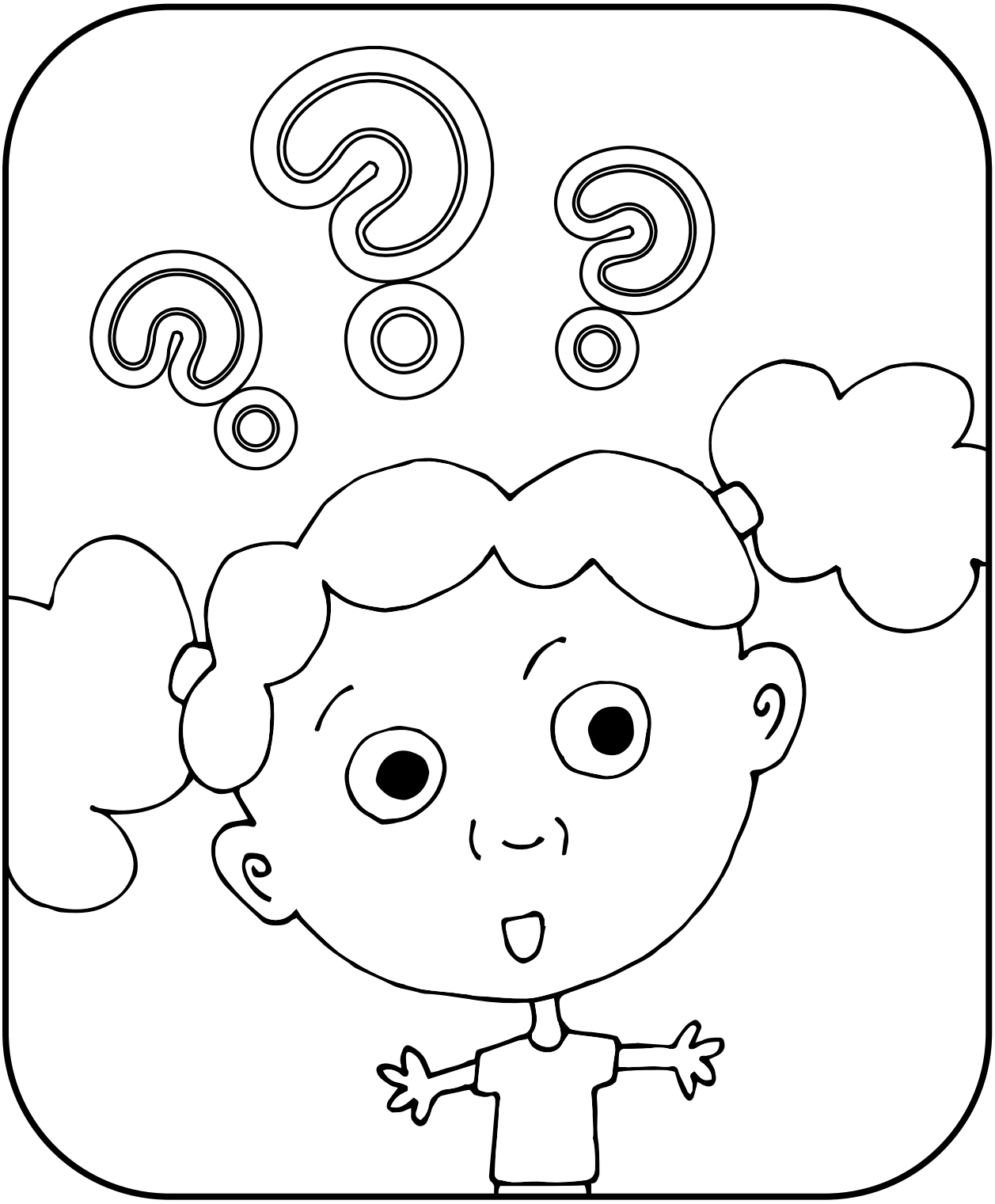
“In order to find out more about the recovery, scientists looked at the fossils of plants to see what they could find.”

“They found plants from different areas with very different levels of damage caused by insects that eat leaves. These findings proved that the food web was still unbalanced 1 million years after the asteroid hit.”



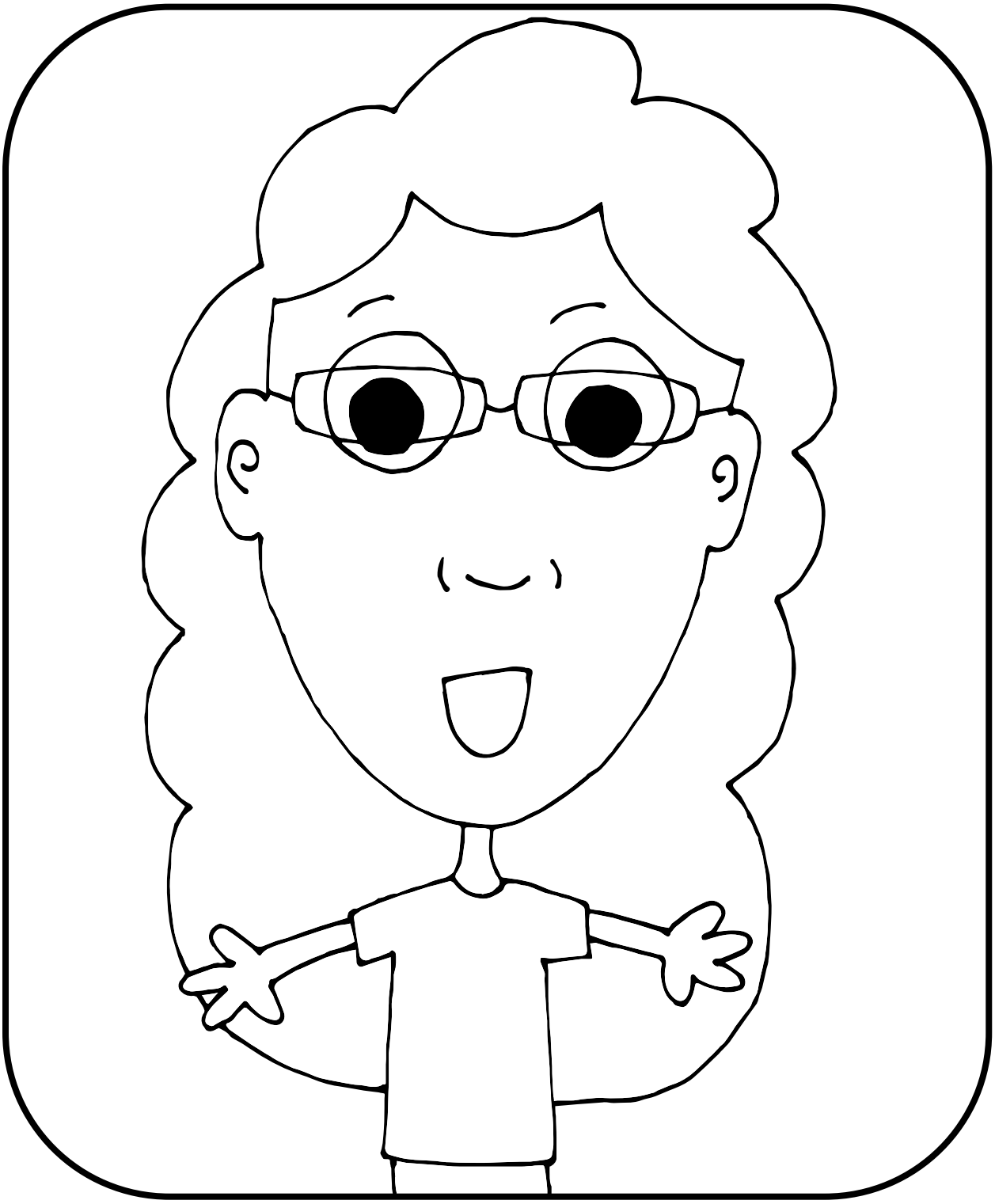
“Did the scientists ever find out how long it took for the food web to get back to normal?”

“By looking at the fossils, they were able to calculate how long it took for the food web to stabilize: 3-4 million years! That’s a long time!”

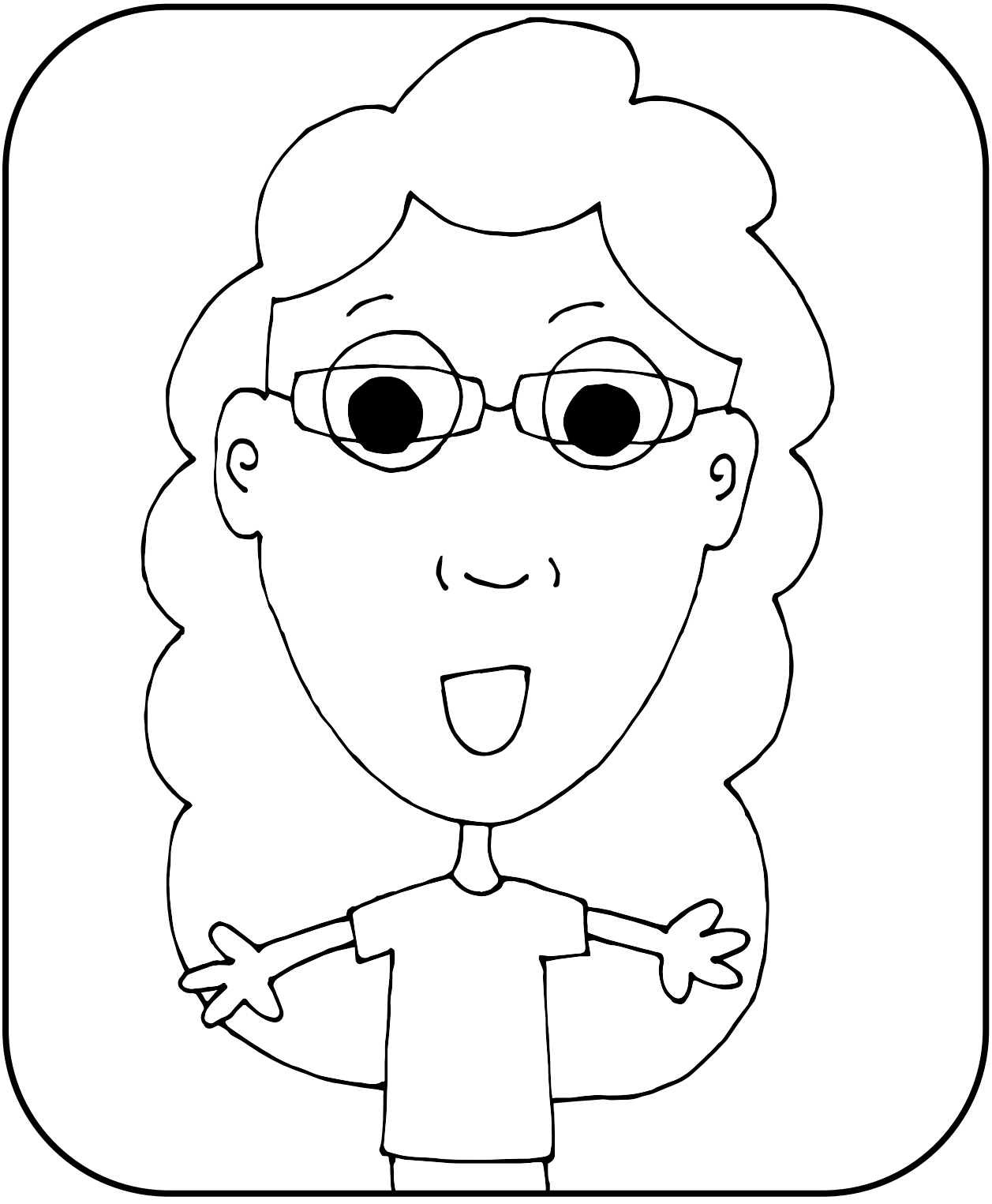


"But how do we know that this asteroid was the cause? What if something else caused the K-Pg extinction?"

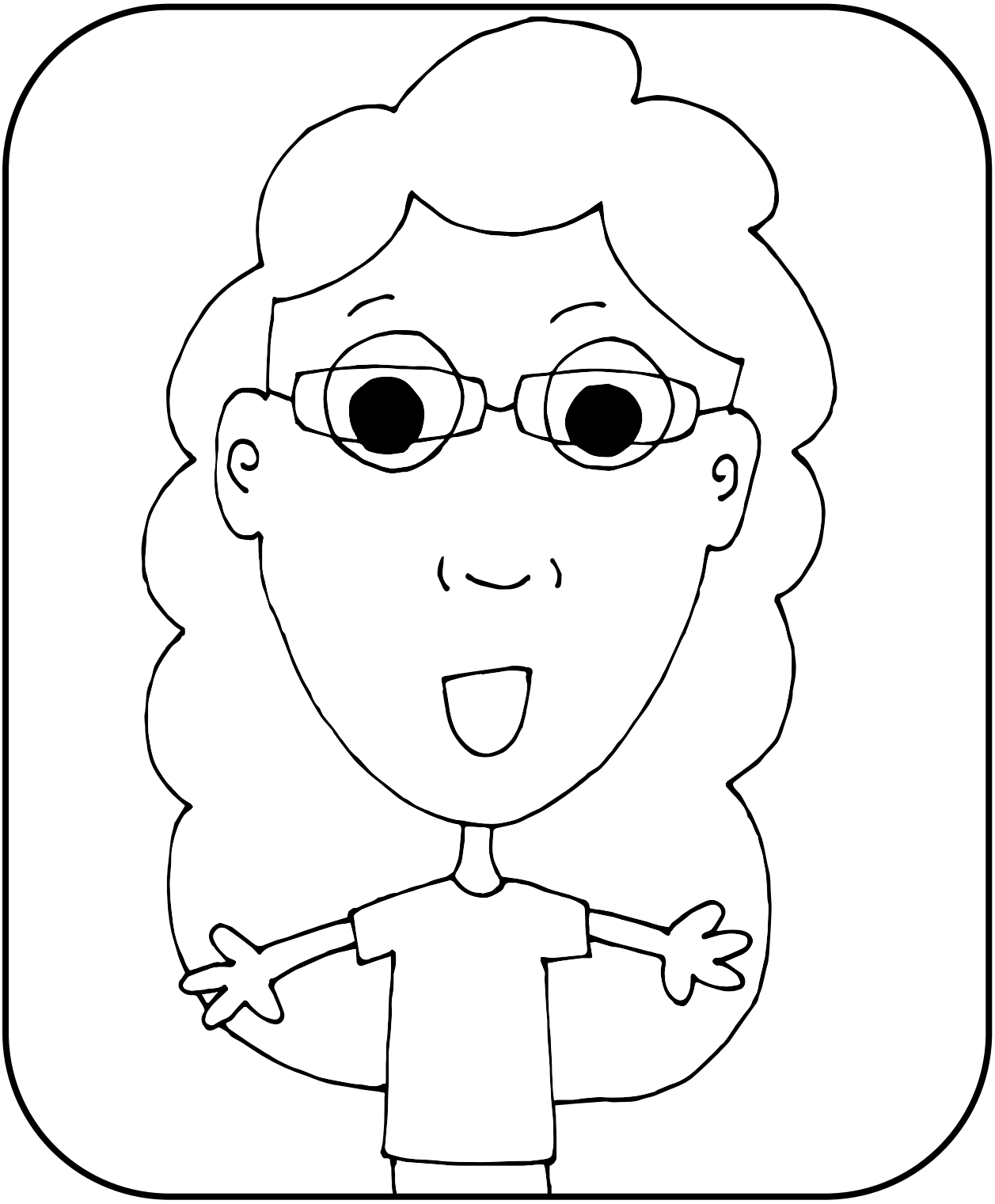
"Well, scientists are still debating over whether the asteroid impact or some other global event was responsible for the extinction."



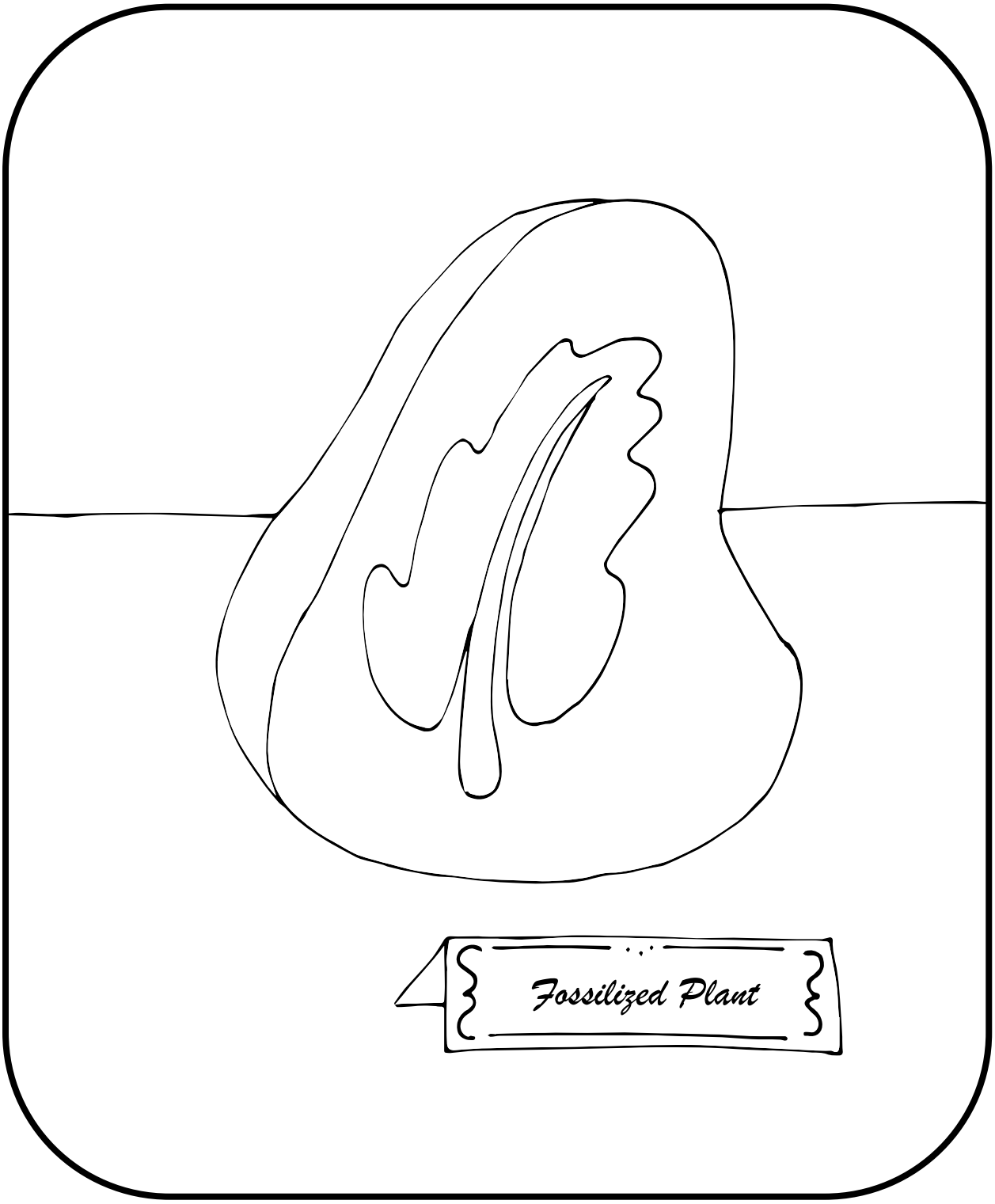
“While the layers of dirt in the Americas support the asteroid extinction theory, the fossils of eggshells from China suggest that the dinosaurs actually went extinct from a series of global events," (ZiKui et al., 2009).



"One of these events was a chain of volcanic eruptions that happened near India and China right around the time of the asteroid impact," (ZiKui et al., 2009).

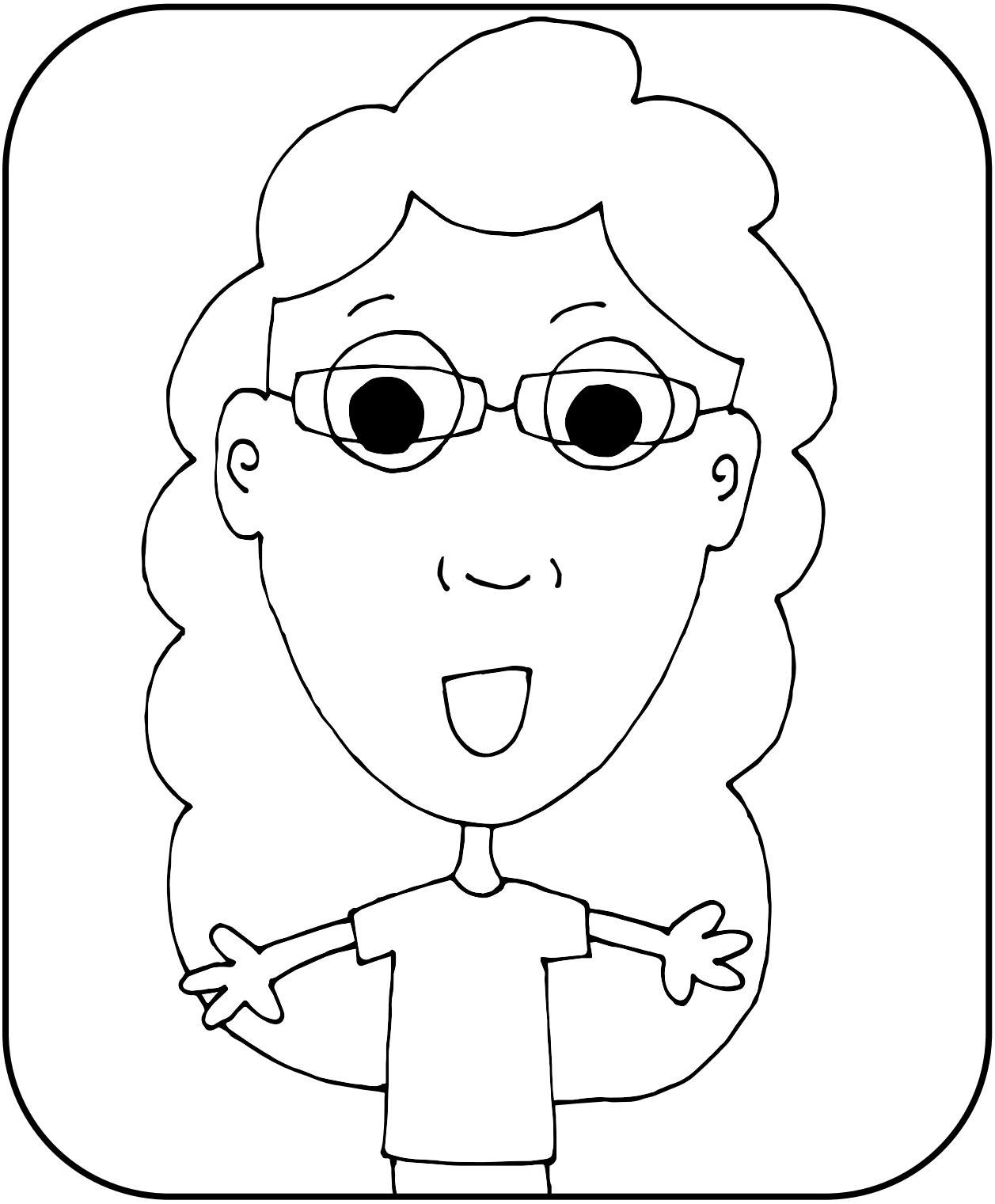


“Some scientists believe that the extinction event at the K-Pg boundary was due to shifts in the climate and not an asteroid hitting the earth.”

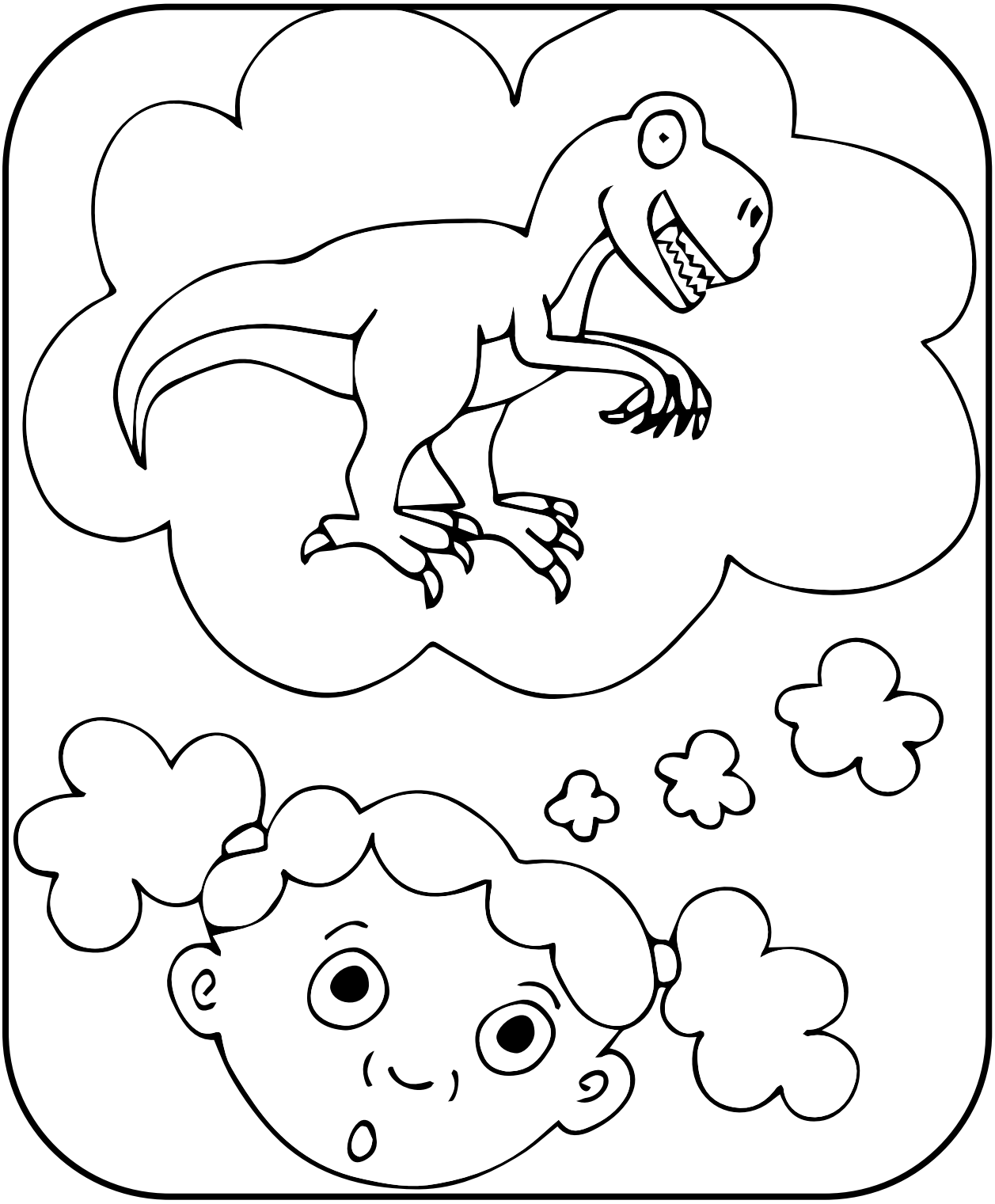


“In order to test this hypothesis, scientists looked at fossilized plants to gather information on the climate at the time of the extinction.”

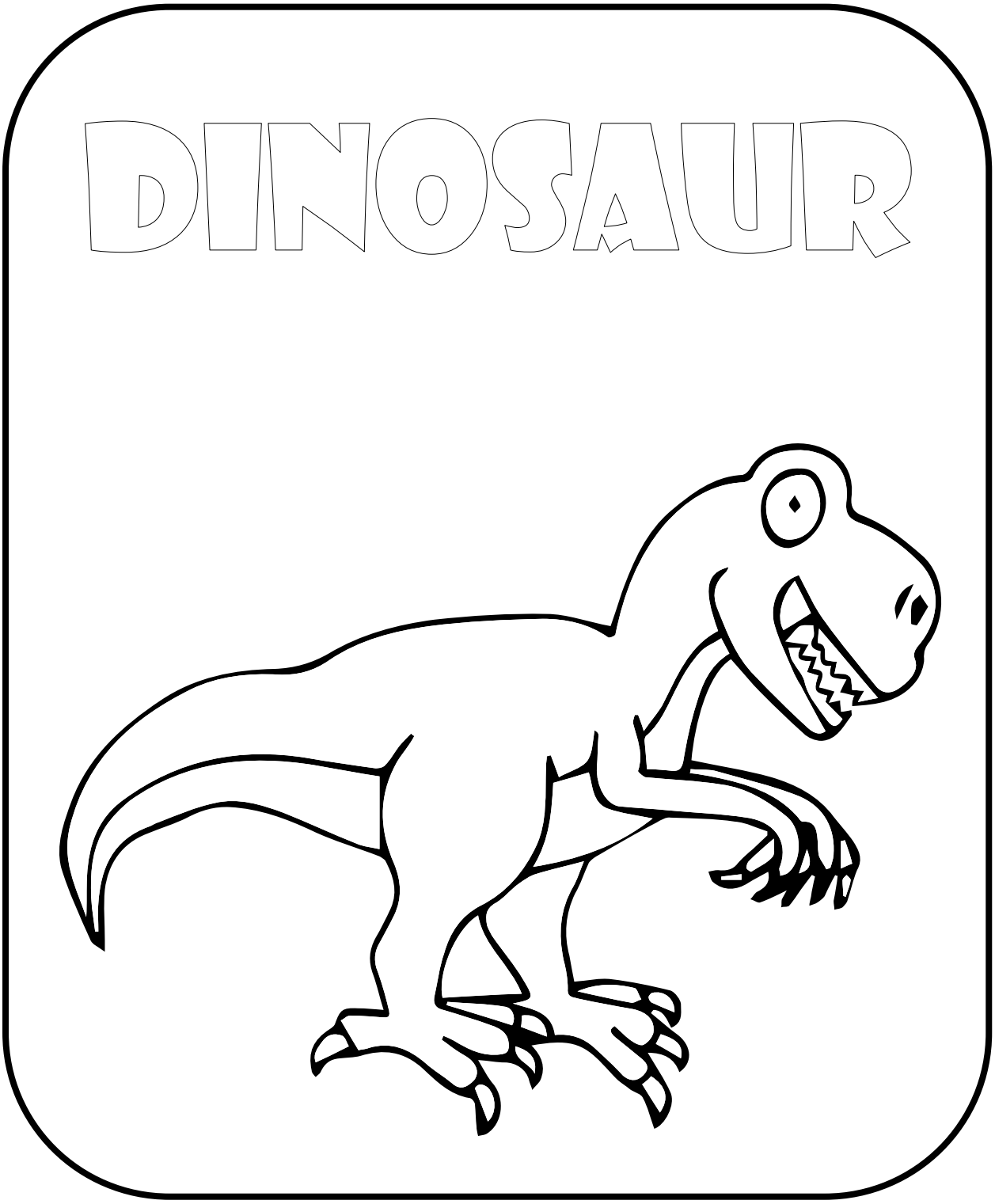
“What they found was surprising. Plants showed a period of warming 66 million years ago and a period of cooling 65.6 million years ago” (Wilf et al., 2003).



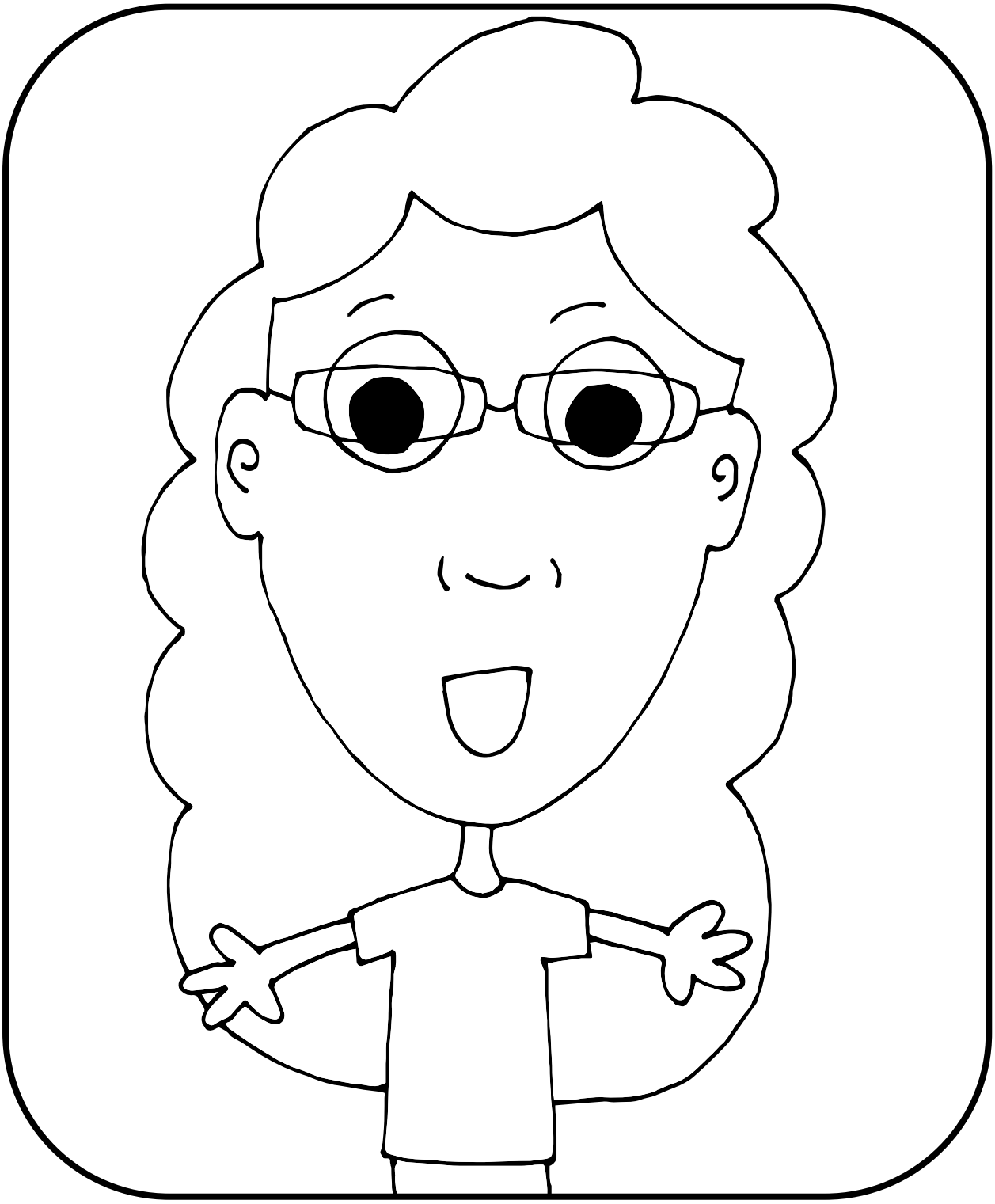
"Scientists are now confident that climate change did *not* cause the extinction of plants at the K-Pg boundary" (Wilf et al., 2003).



“Now that I know more about the extinction of the dinosaurs, can you tell me more about the dinosaurs before the extinction event?”



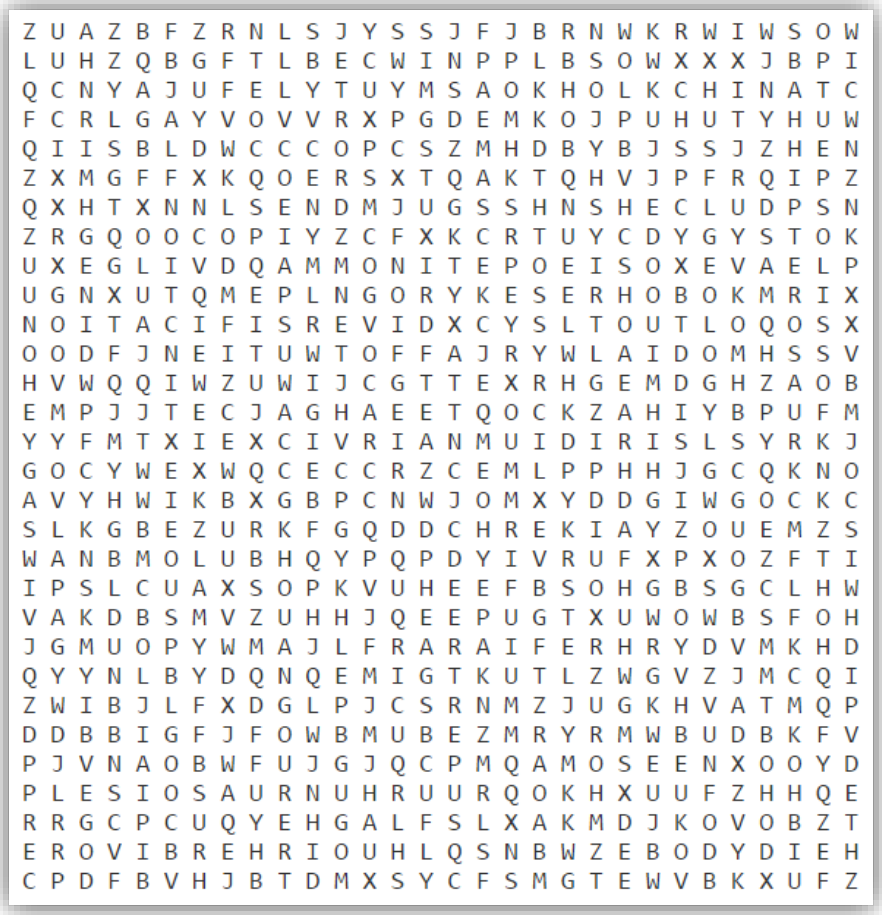
"Of course! Actually, scientists themselves have argued about the diversity of dinosaurs while they were living. Some believe that the dinosaurs reached a peak of diversity 50 million years before the extinction event" (Lloyd et al., 2008).



“In fact, they have been arguing about whether or not the dinosaurs took part in the Cretaceous-Paleogene Revolution—the K-PgR—a time of major diversification for many living things between 125 and 80 million years ago!” (Lloyd et al., 2008).

"Using a supertree of dinosaur species, researchers were able to conclude that dinosaurs did not intensely diversify during the K-PgR" (Lloyd et al., 2008).

The K-Pg Extinction



Z U A Z B F Z R N L S J Y S S J F J B R N W K R W I W S O W
L U H Z Q B G F T L B E C W I N P P L B S O W X X X J B P I
Q C N Y A J U F E L Y T U Y M S A O K H O L K C H I N A T C
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Z X M G F F X K Q O E R S X T Q A K T Q H V J P F R Q I P Z
Q X H T X N N L S E N D M J U G S S H N S H E C L U D P S N
Z R G Q O O C O P I Y Z C F X K C R T U Y C D Y G Y S T O K
U X E G L I V D Q A M M O N I T E P O E I S O X E V A E L P
U G N X U T Q M E P L N G O R Y K E S E R H O B O K M R I X
N O I T A C I F I S R E V I D X C Y S L T O U T L O Q O S X
O O D F J N E I T U W T O F F A J R Y W L A I D O M H S S V
H V W Q Q I W Z U W I J C G T T E X R H G E M D G H Z A O B
E M P J J T E C J A G H A E E T Q O C K Z A H I Y B P U F M
Y Y F M T X I E X C I V R I A N M U I D I R I S L S Y R K J
G O C Y W E X W Q C E C C R Z C E M L P P H H J G C Q K N O
A V Y H W I K B X G B P C N W J O M X Y D D G I W G O C K C
S L K G B E Z U R K F G Q D D C H R E K I A Y Z O U E M Z S
W A N B M O L U B H Q Y P Q P D Y I V R U F X P X O Z F T I
I P S L C U A X S O P K V U H E E F B S O H G B S G C L H W
V A K D B S M V Z U H H J Q E E P U G T X U W O W B S F O H
J G M U O P Y W M A J L F R A R A I F E R H R Y D V M K H D
Q Y Y N L B Y D Q N Q E M I G T K U T L Z W G V Z J M C Q I
Z W I B J L F X D G L P J C S R N M Z J U G K H V A T M Q P
D D B B I G F J F O W B M U B E Z M R Y R M W B U D B K F V
P J V N A O B W F U J G J Q C P M Q A M O S E E N X O O Y D
P L E S I O S A U R N U H R U U R Q O K H X U U F Z H H Q E
R R G C P C U Q Y E H G A L F S L X A K M D J K O V O B Z T
E R O V I B R E H R I O U H L Q S N B W Z E B O D Y D I E H
C P D F B V H J B T D M X S Y C F S M G T E W V B K X U F Z

Ammonite	Dinosaur	Iridium
Asteroid	Diversification	Paleogene
Chicxulub	Eggshells	Photosynthesis
China	Extinction	Plesiosaur
Climate	Fossil	Pterosaur
Crater	Geology	Species
Cretaceous	Herbivore	Supertree

Scientists sure can learn a lot from fossils. Just look at all we have learned today!

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