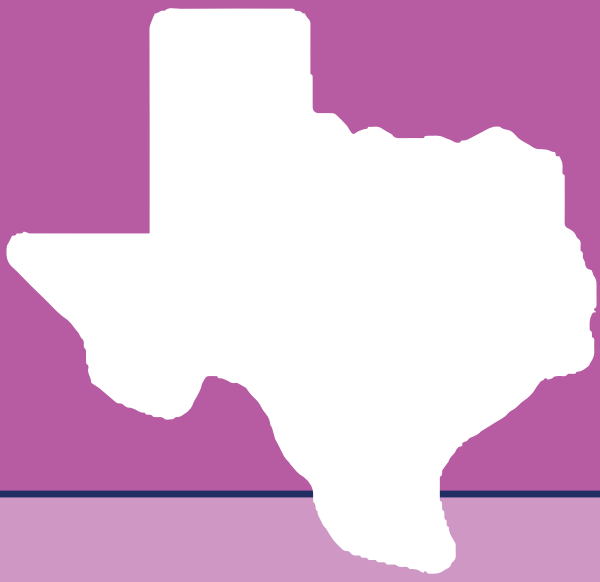
Bluebonnet Learning
K–5 Reading Language Arts

ENGLISH

THE BADLANDS SLEUTH: THE CASE OF THE MISSING FOSSILS



GRADE 5 UNIT 8 | READER

EDITION 1

Grade 5 | Unit 8

The Badlands Sleuth:
The Case of the Missing Fossils

Reader

Acknowledgement:

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Chapter 1

Welcome to Fossil Camp!

THE BIG QUESTION
What is the "stuff" that makes up the universe?

"It's got to be over a hundred degrees out there," Amy **muttered**, staring through the windshield of the pickup. The badlands of eastern Montana **shimmered** in the heat under a pale, cloudless sky. **Barren** ridges of weathered rock towered above dry gullies and patches of stiff prairie grass. Amy aimed the air conditioner vent so it blew directly on her face. "I really don't like being hot."

"I'm afraid it's even hotter out at the fossil site," said Tess, swerving to avoid a pothole in the narrow dirt track. "Lately it's been over ninety degrees in the shade."

'*Great!*' thought Amy. She fanned herself with a paperback book. It was her favorite kind of book: a mystery featuring a clever detective. She had read most of it on the flight from Chicago and then finished it while she and Matt waited for Tess to pick them up at the small airport in Billings, Montana.

Amy glanced back at her twin brother. He was **sandwiched** between their two backpacks in the back seat, with a big grin on his freckled face. Last month, when Matt had learned about Fossil Camp, he'd burst into her room, waving the camp brochure. "We can actually dig for dinosaur fossils," he'd whooped. Amy had planned to spend her summer vacation at home, reading mysteries out on the breezy screened porch and drinking tall glasses of icy lemonade. But Matt had talked their parents into Fossil Camp—and Amy into coming with him. Now, sweltering in the heat, she was having second thoughts.

"What's Dr. Forester like?" Amy asked. She'd read in the brochure that Dr. Pam Forester was the paleontologist in charge of Fossil Camp.

"She's amazing," Tess replied, "and a world **expert** on Cretaceous dinosaurs."

"Like *Tyrannosaurus*?" Matt asked.

"Like *Tyrannosaurus*," Tess said, smiling at him in the rearview mirror.

"I hope we make an important **discovery**," Matt said, digging his water bottle out of his pack.

"Anything's possible," Tess said. "These dry badlands are among the best places in North America to look for fossils, especially dinosaur bones." She swerved again but failed to avoid a deep rut, and the pickup **lurched** hard to one side. "Sorry about the bumps," she said, "but the road washes out a little bit more every time it rains."

"Who are the other campers?" Amy asked.

"There are two other girls and two other boys," Tess replied. "Daria and Julian are your age. Felix and Kristal just finished sixth grade, so they're a year ahead of you in school."

Amy hoped the other kids would be nice, because together with Dr. Forester and Tess, they were all going to be camped out in this desolate landscape for ten days. She glanced back at her brother again. Matt made new friends easily and he also didn't mind heat. Or dirt. Or bugs. Or... Amy sat up suddenly as a new thought occurred to her. "Are there snakes out here?"

Tess nodded but kept her eyes on the track. "Plenty. But we rarely see them during the day because it's so hot and they stay curled up in holes or under rock ledges."

'*Double great!*' Amy thought, swallowing hard. Snakes made her sweat as much as hot weather. And what did Tess mean about not seeing snakes "during the day"? Did they come out at night? She was about to ask when they crested a low rise and Tess suddenly pointed.

"There's our camp!"

A cluster of tents stood in the shadow of a high, barren ridge. A slender woman with a deep tan waved as they pulled in. When they stopped, she strode over to the pickup, followed by four kids.

"Welcome to Fossil Camp, Amy and Matt! I'm Dr. Forester, and these are your fellow campers." She quickly made the introductions. Felix was tall and very thin, with bony knees and elbows. Julian was about Matt's height, with close-cropped hair and a friendly grin. Daria was average height with short, dark hair and watchful eyes that seemed to take in everything at a glance. Kristal was taller than Daria. Her blonde hair was swept to one side in a ponytail, and she wore big dark glasses.

"Why don't you all help Amy and Matt get settled?" Dr. Forester suggested. "Then we'll have orientation in our field laboratory. That's the big canvas tent with the awning out front."

A wave of hot, dry air hit Amy as she stepped into the tent she was going to share with Kristal and Daria. "It's unbearable in here," she choked. "How are we supposed to sleep?"

"Dr. Forester says it gets a lot cooler at night," Daria said.

There were three cots inside, each with a sleeping bag and pillow. Kristal took off her sunglasses and used them to point at the cots, one by one. "I'm here and Daria's there, which leaves you in the bed by the door. Sorry."

Amy thought sleeping close to the tent flap might be the coolest spot at night, so she didn't mind not having a choice. She dropped her backpack onto her cot.

"Did you bring your phone?" Daria asked.

Amy nodded. "But I haven't gotten a signal since we left Billings."

Daria sighed and looked disappointed. "I thought maybe it was just my phone. I've never been anywhere I couldn't make a call. It's like being in the middle of nowhere."

"We *are* in the middle of nowhere," Kristal said. She reached under her pillow, grabbed what looked like a large sketchbook, and stuffed it under her arm. "Come on, I don't want to miss anything."

"Cool camp, huh?" Matt whispered to Amy as they joined the others in the lab. "This is going to be so much fun!"

Hoping her brother was right, Amy tried to put the heat and the possibility of snakes out of her mind as everyone gathered around Dr. Forester. She was standing next to a long table on which there were boxes, some instruments that Amy recognized from science class, and six, small, cloth bags.

"Over the next ten days you're going to get firsthand experience excavating fossils," Dr. Forester began. "You'll also learn about other things that paleontologists do."

Felix raised a lanky hand. "Um, when do we eat?"

"Breakfast is at six o'clock and we'll leave for the fossil dig site at seven o'clock, along with a packed lunch and a cooler full of cold drinks. We'll return to camp around five, have dinner at six, and then you'll have some time to relax around the campfire before bed."

Felix raised his hand again. "And what about snacks?"

Dr. Forester suppressed a smile. "Don't worry, Felix, there will be plenty of food." Then she **gestured** toward Tess. "And now Tess has something to show you I think you'll find pretty interesting. She's one of my students, by the way, and is getting her degree in **paleontology**, with a minor in **chemistry**."

"Chemistry?" Julian raised an eyebrow. "What's chemistry got to do with fossils?"

"Actually, quite a lot," Tess replied. "Chemistry is the reason we have fossils out there to hunt for and collect." She reached into the pocket of her jeans and drew out something dark and curved that she held up for them all to see. "Fossils like this."

"Wow, a raptor claw!" Matt gasped.

"This claw belongs to *Velociraptor,* the type of dinosaur that certain movies made so famous," Tess explained. "The dinosaur whose fossil bones you will be excavating was closely related to *Velociraptor*, so there's a chance we might unearth a claw similar to this one." Tess handed the fossil claw to Daria and asked her to pass it around.

When Amy took the claw from Daria, she was surprised at how heavy it was. "What is a fossil, exactly?"

"You'll learn a lot about fossils and how they form while you're here at camp," Tess replied. "But for now, think of a fossil as **matter** that's undergone a change."

"Matter?" Julian asked, frowning.

"Matter is everything in and around you," Tess explained, "all the 'stuff' on the earth, in our solar system, our galaxy, and the rest of the universe."

"You mean the solid stuff, right?" Julian's frown had deepened.

"Not just the solids. Matter exists in different forms, or states. Most matter on the earth exists as a solid, a liquid, or a gas. For instance, that fossil claw is matter in a solid state, water is matter in a liquid state, and the air we're breathing is matter in a gaseous state."

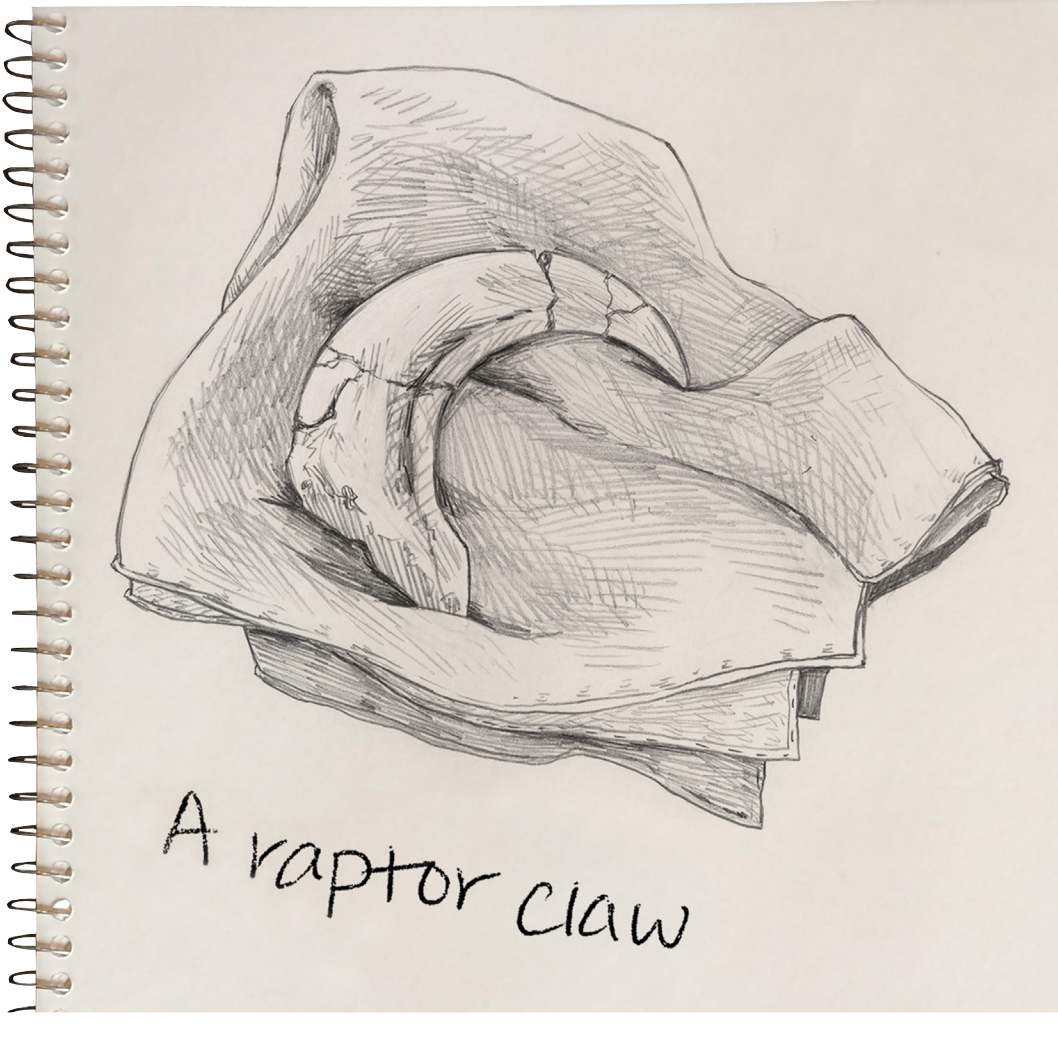
Tess took back the claw from Felix. "Most of the fossil bones we'll be excavating, Dr. Forester and I will study back in our lab at the university. Some of the smaller ones, though, we'll analyze right here. Part of analyzing fossils involves recording information about each one."

"What kind of information?" Kristal asked, quietly flipping open the book she'd brought along. Amy saw that its pages were filled with drawings and realized it was indeed a sketchbook.

"We typically start by recording a fossil's physical properties. We can use our senses to describe the physical properties of a given type of matter. For instance, how would you describe this fossil claw?"

Kristal began sketching the fossil in Tess's hand. "It has a smooth, curved surface," she said softly.

"Very good!" Tess said smiling. "Shape and texture—the roughness or smoothness of something—are physical properties of matter. Some fossils we find might be smooth like this claw, while others may be rough or pitted or have interesting marks on them."



"Marks?" Daria looked puzzled.

"Grooves, dents, or possibly bite marks made by predators."

"Awesome," Matt murmured.

"If color is a physical property, then we could record that the claw is really dark brown," Julian suggested.

Tess nodded. "Basically anything you can see, touch, taste, or smell is a physical property of matter."

"You really want us to taste and smell the fossils?" Felix asked, wide-eyed.

Tess burst out laughing. "That won't be necessary, Felix. But keep in mind that people see colors and describe textures differently. A fossil that looks dark brown to Julian might look different to someone else. **Mass** on the other hand," she continued, "is a physical property of matter that can be measured. Mass is the amount of matter something has. In fact, a formal definition of matter is anything that has mass and takes up space."

Tess stepped over to the table. "Mass is typically measured in metric units such as grams. We use a balance to measure the mass of small fossils such as this fossil claw." She placed the claw on the flat pan of the balance and slid the weight along its arm. "As you can see, the claw has a mass of 113.4 grams. If you don't know how to use a balance, I can show you later tonight."

"That's because right now," Dr. Forester said, gathering up the cloth bags and handing them out, "we are going to head out to the dig site. These bags contain tools that paleontologists use to excavate fossils. So grab your hats and let's go meet our dinosaur!"

Matt **nudged** Amy, and she saw the glow of excitement in his eyes. Amy wanted to feel excited too, but she wished she hadn't let Matt talk her into coming to Fossil Camp. She wished she was back home in Chicago instead of being stuck out here in such a hot place—a hot place with snakes.

Chapter 2

A Bed of Bones

THE BIG QUESTION
How can water, ice, and vapor be the same thing?

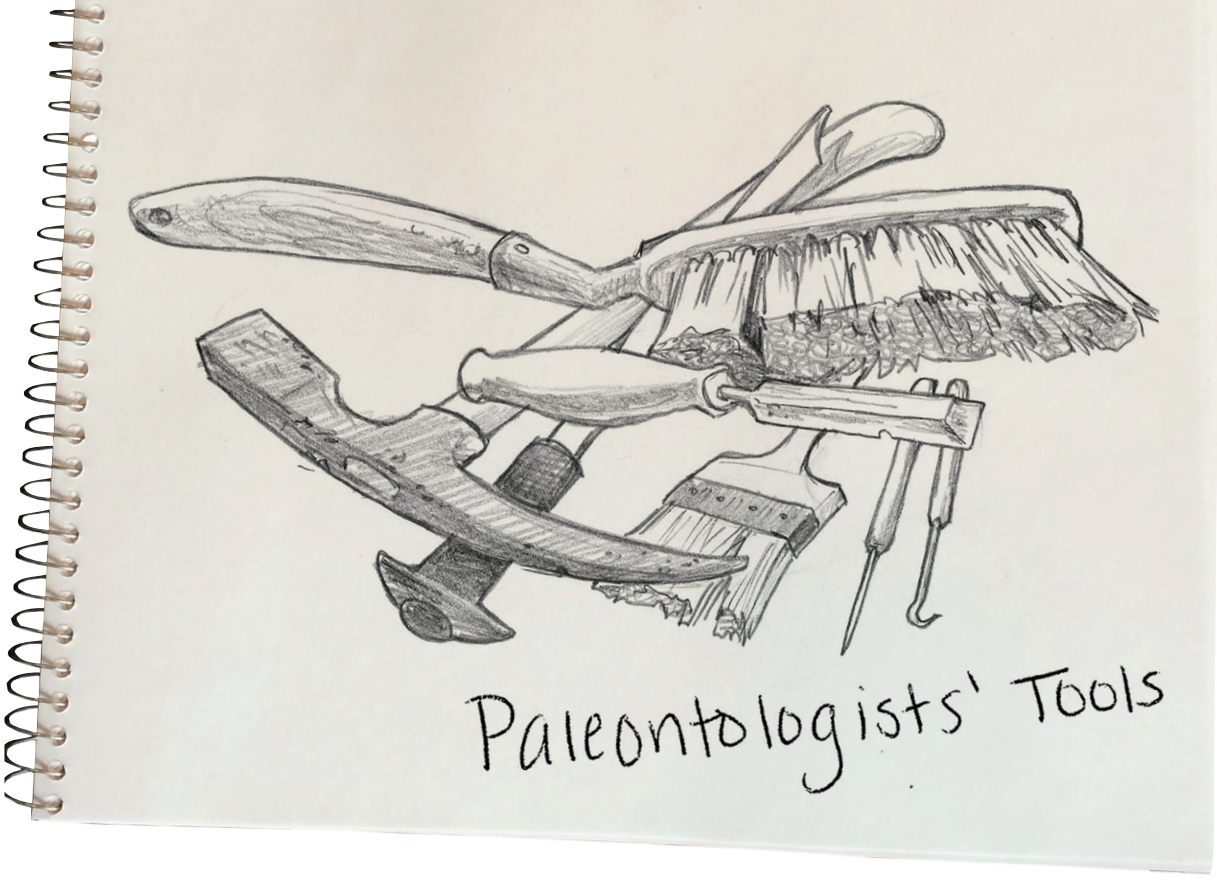
"Meet *Acheroraptor temertyorum*," Dr. Forester said, gesturing down at the dark fossils **embedded** in the pale rock at their feet. "He lived in this part of North America about 66 million years ago, along with other dinosaurs such as *Tyrannosaurus* and *Triceratops*. Tess and I call him Achy-Breaky for short: Achy for the first part of his scientific name, *Acheroraptor*, and Breaky because some of his fossil bones are broken up into pieces."

'No kidding!' thought Amy. She had expected the dinosaur skeleton to be nicely laid out like those she'd seen in museums. Instead, different fossil bones were angled this way and that, like a jumble of large and small puzzle pieces. She edged further into the square of shade cast by the blue plastic tarp that had been strung over the dig site. It was situated on a narrow **plateau** about halfway up a rocky ridge, completely **exposed** to the blazing afternoon sun.

Julian pulled out a rock hammer and a small chisel from his cloth bag. "So, do we use these to chip the fossils out of the rock?"

Dr. Forester shook her head. "Paleontologists use a hammer and chisel to break apart big chunks of rock or in places where there's no chance of damaging fossil bones. Once fossils are partially exposed, like they are here, we switch to smaller tools designed for more delicate work." She held up a slim metal pick and a small paintbrush. "In your tool bags, you'll find a pick like this for scraping away rock and a brush to whisk the rock dust away."

"Dr. Forester and I will demonstrate how to use these tools correctly on this leg bone we're working on," Tess explained, kneeling beside a long, narrow fossil. "Please listen and watch closely." She and Dr. Forester used their picks to scrape and scratch at the rock where it met the fossil.



"This rock is a type of sandstone and is quite soft and crumbly. Excavating fossils like this is time-consuming, but not particularly difficult. It just takes patience," Dr. Forester said. She used her brush to gently clean the area where she'd been working. "Every few minutes, use your brush like this to clear away the rock dust so you can see what you're doing," she added.

Amy and the other campers watched intently for a few minutes. Then it was their turn.

"Working with a partner," Dr. Forester instructed, "Tess and I want you to choose a bone that you'd like to excavate together. Tess and I will work with you to make sure you're getting the hang of it."

Amy followed Matt, who made a beeline for the dinosaur's jawbone at the far edge of the dig site. Julian and Kristal chose bones that Dr. Forester said were part of a foot, while Felix and Daria settled on a short chain of bones that were unmistakably part of the dinosaur's backbone.

Matt began using his pick to very carefully scrape away the rock around one of the teeth that were embedded in the jawbone. “These teeth still look sharp!” he exclaimed.

Amy ran a finger around the bony edge at the back of the jawbone. It seemed as good a place to start as any, so she got out her tools and set to work.

Dr. Forester and Tess came around every so often and checked how everyone was doing. When they were confident that all the campers had the **technique** down, they worked together on the leg bone. For more than two hours, the only sounds were the scratch of picks and the swish of brushes, the buzz of flies, and the wind sighing through the dry grasses that grew along the edge of the plateau.

Julian broke the silence by asking what Amy thought was a strange question. “Dr. Forester, if I wanted to be a famous paleontologist, what would I need to do?”

She considered the question for a minute. “Well, finding a new type, or species, of dinosaur might make you famous—at least among other paleontologists. But there’s a lot of luck involved in fossil discoveries, Julian, and really important discoveries are few and far between. I’m afraid you can’t just set out to become famous and expect it to happen.”

Julian frowned. “My dad’s famous. He owns four restaurants in Dallas. And my brother is famous, too, because he plays football for a big university team. If we discover something new, I sure hope I’m the one to find it.”

Dr. Forester didn’t seem to know what to say. But Felix had perked up at the mention of restaurants. “Speaking of food,” he said, “is there anything to eat? Excavating fossils is hungry work.”

“Let’s take a break,” Tess offered, and led them to the far end of the plateau where the ridge formed a wall high enough to create a patch of shade. Everyone sat with their backs against the rock wall and stretched their legs out in front of them as Tess passed out bottles of water and energy bars from the cooler. Felix **devoured** one bar and started on another before anyone else had taken a bite. Amy wondered if he was always so hungry.

Munching slowly, Daria pulled out her phone and then frowned down at the screen. "No signal here, either."

"The cell coverage is pretty spotty," Dr. Forester explained, "so I'm afraid cell phones are fairly useless out here."

"It's no big deal," Daria said quickly. "I just miss my mom—I mean, I was just wondering what my friends are doing right now, that's all." She slipped her phone back into her pocket.

Julian helped himself to another bottle of water from the cooler. "The ice is melting fast in this heat."

"A good example of chemistry in action," Tess said.

"Chemistry?" Felix mumbled, swallowing the last bite of his third energy bar. "What does melting ice have to do with chemistry?"

"Remember that chemistry is the study of matter and how it changes," Tess said. "Solid ice melting to liquid water is an example of a physical change in matter in which matter changes from one state to another. Ice is water in its solid state. When ice melts, water undergoes a physical change, going from a solid state to a liquid state." Tess gestured toward the ice chest. "Suppose we poured that water out on the ground here. What do you think would happen to it?"

Kristal raised her hand hesitantly. "The water would gradually dry up and disappear, like rain on the pavement does when the sun comes out."

"Well, it might seem like it is disappearing," Tess replied. "But matter can't be created or destroyed. The water would slowly change states again, this time changing from a liquid to an invisible gas called water vapor that floats up into the air."

"You mean it **evaporates,**" Amy offered.

"Yes, that's the term," Tess replied. "A similar change in state from liquid to gas takes place when water boils."

"So if ice, water, and water vapor are all the same kind of matter, what explains the different states?" Matt asked.

"Excellent question, Matt," Tess replied. "All matter is made up of small particles, so small that they can't be seen with the naked eye. Whether a type of matter is in a solid, liquid, or gaseous state depends on how tightly packed these particles are, and how much energy they have. In a solid, such as an ice cube, the particles are crammed together. They can wiggle, but they don't have enough energy to do much more than that. A solid keeps its shape because its particles are in such fixed positions."

Tess took a sip of water from her bottle. "Matter in liquid form has particles that are farther apart than those in a solid. But the particles in water and a few other substances are a little different. The particles of solid water (ice) are further apart than they are in a liquid. Solid water is less dense than liquid water—ice floats. They have more energy, too, enough so they move freely, and slip and slide past each other. That's why liquids flow. Matter in a liquid state doesn't have a fixed shape. It takes the shape of whatever space it occupies." She held up her bottle and tipped it from side to side.

"Matter in gaseous form," Tess continued, "is made up of particles that are farther apart than those in a liquid or a solid. And they have more energy, too. There is so much space between gas particles that they move very freely and rapidly in different directions. A gas spreads out to fill whatever space is available." Tess spread her arms wide. "And here in Montana, we have lots of space!"

Julian scooped up a handful of the cold water in the bottom of the cooler and splashed it onto his face. "So my question is, how do we get more ice? I'm not too keen on drinking warm water."

"Fortunately, some physical changes in matter, like changes of state, are reversible," Dr. Forester chimed in. "Matter changes state when energy is added or taken away. For example, ice melts as it gets warm. Chill that water down by removing heat energy, and it turns back into ice. That's what our **portable**, battery-powered refrigerator back at camp can do. It keeps our food cold and even makes ice." She glanced at her watch. "How about we work for another half hour or so, and then head back to camp for dinner?"

“Dinner! Yes!” Felix cried, pumping his fist in the air.

“But you just ate three energy bars,” Daria said, looking amazed.

“That was nothing,” Felix replied, “because in a half hour I’ll most certainly be starving again. My mom says I burn calories really fast because I never sit still.” He leaped up and started doing a little dance along the edge of the plateau.

It seemed to Amy that what happened next unfolded in slow motion. Just as Dr. Forester called out for Felix to be careful, part of the rock ledge where he was dancing gave way. Felix swayed, trying to keep his balance. His eyes grew wide and, in the next instant, he was gone.

Everyone scrambled to the edge and looked down. Felix was sitting at the bottom of the gully about ten feet below, with a surprised expression on his face.

Dr. Forester’s face was dark with worry. “Felix, are you all right?”

Felix jumped to his feet and started dusting himself off. “I’m fine,” he called up, grinning. “I didn’t really fall; I just scooted down on my backside.” He started to climb the slope, but paused to pick something up from the gravelly bottom of the gully.

“What do you make of this, Dr. Forester?” he asked when he was back on the plateau. He held up what looked to Amy like a dark, oblong rock.

Dr. Forester gripped him by the shoulders. “Never do anything like that again,” she said sternly. “You could have been hurt.” Then she looked carefully at Felix’s find. “It’s definitely a piece of fossil bone,” she said slowly, turning it over and over in her hands. She nodded toward the gully. “I think I’ll hike down there and have a quick look around.”

Fifteen minutes later she was back with several more small fossil fragments. Everyone gathered around as she laid them out on the ground.

"What kind of animal are they from?" Kristal asked, pulling out her sketchbook and beginning to make drawings of the bones.

Dr. Forester shook her head. "I won't really know until I've looked at them more closely. Let's pack up our gear and head back."

***

Back at camp, Amy and Julian helped Tess make spaghetti in the tent that served as a kitchen. When dinner was ready, everyone gathered around a table set up outside. Tess went to the lab to get Dr. Forester, but she came back alone. "Dr. Forester says she'll eat later after she's done studying those little bones."

The sun set while they were eating and a cool breeze sprang up. When they had finished dinner, Kristal and Matt did the dishes, and Tess built a huge campfire with thick chunks of wood. Everyone gathered around the fire, and Amy was surprised how good the heat from the flames felt as the temperature kept dropping.

Suddenly the fire popped and sparks shot up into the air.

"Whoa!" Daria said, scooting back a few feet. "I think a log just exploded!"

"It did, because water changed states," Tess said quietly.

"What? Chemistry again?" Felix teased.

Tess just smiled. "Logs often have small pockets of water and sap in them. As the logs start to burn, the liquid gets hot enough to boil and changes states to become a gas. But the gas is trapped inside the log. Pressure builds as the gas gets hotter until at some point the wood gives way with a *pop* and the hot gas escapes."

Just then they heard footsteps, and Dr. Forester appeared in the firelight. "Those little fossil bones are very interesting," she said. "I'm thinking they might belong to a small dinosaur, rather than an ancient **mammal** or bird, but unfortunately I don't have enough pieces yet to be sure."

"I want to look at them!" Julian said, jumping up from his chair and heading for the lab.

Dr. Forester caught him by the shoulder. "If you don't mind, Julian, let's wait until morning. It's really time for everyone to head for bed."

Julian shrugged and **reluctantly** said, "Okay."

As Amy walked with Kristal and Daria to their tent, she suddenly remembered the snakes. Were snakes coming out of their daylight hiding places now that it was cooler? With one eye peeled for anything slithery, Amy brushed her teeth with water in a cup and spat the minty foam onto a rock beside the tent. Then she checked to make sure there was nothing in her sleeping bag before crawling inside.

Daria and Kristal were quickly asleep, but Amy lay stiffly on her cot, listening for rustling sounds. Finally, she got up and shone her flashlight into every corner of the tent, under all the cots, and then zipped up the tent flap. She was pretty sure there was no other way for snakes to get in.

Even then, though, sleep refused to come. Amy flicked on her flashlight and pulled out one of the books she had brought along: *The Mystery of the Old Masters*. She had read the book many times, but she never tired of reading how Inspector Ellis figured out who'd stolen the priceless paintings. She thought it was clever the way the Inspector kept track of clues on a small notepad and consulted this list often. After finishing the first chapter, Amy felt better. She just wished that instead of Fossil Camp she could have gone to Detective Camp, if there was such a thing.

Chapter 3

A Fossil Goes Missing

THE BIG QUESTION
How do we keep track of all the elements?

"Dr. Forester doesn't look very happy this morning," said Felix as he poured milk on his instant oatmeal and passed the carton to Amy. She followed Felix's gaze. Dr. Forester was standing outside the lab with Tess, gesturing and shaking her head.

Matt **slathered** butter on a piece of toast. Julian had made himself a peanut butter sandwich, and Daria was munching an apple. The only one who wasn't eating was Kristal. Wearing her dark glasses, she silently sipped a cup of hot tea. Before breakfast, Kristal had been sitting on her cot, working on a sketch. When Amy had asked to see what she'd drawn, Kristal had pulled her sketchbook tight to her chest. Amy had wondered why Kristal would be so secretive about her drawings.

Dr. Forester finally came over, poured herself a mug of coffee, and joined them at the table. "One of the little fossils from the gully seems to be missing." She lifted the cup but set it down again without taking a swallow. "I could have sworn there were six fossils, but this morning there were just five on the table in the lab."

"Did you search the tent?" Julian asked.

Dr. Forester nodded. "And now Tess is searching again. The thing is, I could be mistaken about the number of fossils. There might have just been five to start with. Still, it's a bit of a mystery."

At the word *mystery,* Amy started to tingle all over. A missing fossil? Now *that* was something she could get interested in! Amy thought about Inspector Ellis and his notepad. She suddenly remembered she'd tucked a

small notebook inside the front pocket of her backpack just before she and Matt had left home. It would be perfect for recording any clues she might uncover regarding the missing fossil.

"Excuse me," she said, pushing her chair away from the table. "I need to get something from the tent, but I'll be right back."

Amy sprinted to the tent and retrieved the notebook from her backpack along with a mechanical pencil. As she turned to leave, she spotted Kristal's sketchbook lying on her cot. Before Amy realized what she was doing, she opened the sketchbook and quickly flipped through the pages until she came to one full of detailed drawings of the little fossils from the gully. There were drawings of six different fossils, not five. So there *was* a fossil missing! Amy put Kristal's sketchbook back where she had found it, and hurried back to join the others.

On the drive out to the dig site, Amy clutched her notebook, lost in thought. How had the fossil gone missing? Had someone taken it? And why hadn't Kristal mentioned her drawings to Dr. Forester?

"You look better today, Sis," Matt said, interrupting the stream of questions running through Amy's head. "Yesterday you seemed pretty unhappy."

Amy smiled at her brother. '*Today is different,*' she thought. '*Today there's a mystery to be solved.*'

***

When they arrived at the dig site, Dr. Forester suggested they spend the morning continuing their excavations. After lunch, when the afternoon sun was turning the narrow plateau into a **furnace**, they'd scour the gully. "Maybe we'll be lucky and find more small fossil bones," she explained.

Amy noticed that this plan seemed to please everyone, especially Julian. He pulled out his pick and brush and set to work before anyone else. After a while, he paused and looked over at Tess. "Yesterday you were talking about how matter can change states. But what makes one kind of matter different from another? What makes this pick different from, say, the rock or the fossil bones?"

Tess rocked back on her heels, wiping the sweat from her brow. "Before I can explain that, we need to fill in a few background details. Remember when I said that matter was made up of small particles? Those particles are called atoms, which are so small they are invisible to the naked eye. There are more than a hundred different kinds of atoms, and each kind is called an element."

"But aren't **atoms** composed of even smaller particles called protons, neutrons, and electrons?" Daria asked.

"Indeed they are," Tess agreed, "but an atom is the smallest amount of any element that still has the properties of that element. Elements, then, are the basic ingredients of matter. All the known elements are arranged on something called the **Periodic Table** of the Elements."

"We have one of those hanging on the wall of our science classroom this year," Kristal said.

"Excellent!" exclaimed Tess. "Then you may have noticed that each element has a name and a symbol made up of one or two letters. For example, oxygen is an element and its symbol is O. The element nitrogen's symbol is N, and the element aluminum's symbol is Al. The elements are arranged on the periodic table based on their properties and certain patterns in their atoms." Tess grabbed her rock hammer and held it up. "And that brings me back to your question, Julian. The elements are often divided into two basic groups: metals and nonmetals. The head of this hammer is mostly made up of the element iron." She flipped the hammer upside down. "The wooden handle is made up mostly of nonmetal elements, such as carbon, nitrogen, sulfur, and phosphorus."

Felix suddenly pulled out all his digging tools and arranged them in a line on the ground. "Ever notice how metal objects make a nice sound?" he asked with a mischievous look on his face. He began tapping his chisel against all the other metal objects, like he was playing the drums. Each one gave out a *clang* when he struck it.

"If paleontology doesn't work out for you, Felix, you might have a future as a musician," Matt joked. "Then again, maybe not."

Felix made a face at him.

"Felix is right, though," Tess broke in. "That ringing sound—scientists call it resonant frequency—is a property of metals. Being shiny is another. So is being malleable and ductile, which means that you can hammer metals into shapes and stretch them out into long, thin wires. And, if you've ever seen the inside of electrical cord, you've probably noticed the metal wires inside. Another property of metals is that they are good **conductors** of electricity and heat."

Tess picked up a piece of sandstone and set it out on a flat space beside her. "Nonmetals, on the other hand, have very different properties. They tend to break or crumble, not bend." She hit the rock with her hammer and it shattered into pieces. "They also don't conduct electricity, they are usually dull rather than shiny, and they lack that lovely **resonance**." She tapped her hammer on her water bottle and it made a dull *thunk*.

Amy noticed that Dr. Forester had been listening to Tess, but she'd suddenly walked over to the far end of the plateau. Now she was returning—in a hurry.

"Change in plans, everybody," she said, breathlessly. "There's a storm coming." She turned and pointed toward the northwest, where a line of dark clouds hugged the **horizon**. Even as Amy watched, the clouds seemed to expand and move closer.

"I'm afraid it's moving directly toward us," Dr. Forester said, untying the lines that held the tarp over the dig site. "And when it hits, we don't want to be standing up here, exposed on this plateau."

"Why is that a problem?" Kristal asked.

Tess summed it up in one word. "Lightning."

Kristal's eyes grew wide. "So we're going to back camp, where we'll be safe in the tents?"

"Weren't you listening to the chemistry lesson?" Felix called out as he ran over to help Dr. Forester with the tarp. "The tents have metal poles, and metals conduct electricity."

"At home we go into the basement when a bad storm is coming," Daria said in a **tense** voice.

"And in a way," said Dr. Forester, stuffing the folded tarp into her backpack, "that's exactly what we are going to do. Everyone, grab your gear and follow me." She led them to the spot where Felix had slid down into the gully. The wind was blowing much harder, and the storm now covered half the sky like a huge, black curtain sweeping toward them.

"Yesterday when I was walking along the gully, I spotted a shallow cave near the end of this ridge." Dr. Forester had to shout to be heard above the rising wind. "Climb down carefully; it's slippery."

"You can say that again!" yelled Felix.

Amy kept her eye on the storm as they hurried along the dry gully. Bright chains of lightning zigzagged through the steely gray clouds that were quickly approaching, and she could hear the deep rumble of thunder.

By the time they reached the cave, the storm had blotted out the sun. They scrambled up the rocky hillside and stepped beneath the cave's sheltering overhang just as the first raindrops began to fall.

"Move to the back," Dr. Forester shouted above the booming thunder. They huddled together in the deepest corner as the storm struck. Rain fell in great, swirling sheets. Bolts of lightning flashed and thunder crashed so loudly that Amy had to cover her ears.

Gradually, the rain began to let up. The rumble of thunder grew more and more distant as the storm slowly moved off. Dr. Forester stepped to the front of the cave and the others followed.

"Everything looks so much more colorful," Kristal said, as the sun came out,"like the rain washed it clean."

"It might have done a lot more than that," Dr. Forester mused. "Rain erodes these rocky ridges and loosens fossils hidden inside them. Sometimes," she paused and looked thoughtfully at the gully below, "it washes fossils down off the ridges into low spots."

Felix was the first to understand. "You mean—we might find more of those strange little fossil bones in the gully below the dig site?"

Dr. Forester gave a quick nod. "Exactly! So, if you all don't mind getting your boots a little muddy, let's go on a fossil hunt!"

Chapter 4

Who's Hiding What?

THE BIG QUESTION
What is the difference between gold and fool's gold?

"Let's all spread out," Dr. Forester suggested as they reached the stretch of the gully below the dig site. "Keep your eyes peeled for anything that looks like the small fossil bones we found yesterday."

Everyone fanned out across the width of the gully, and with heads bowed, began scanning the rocky ground. Daria picked up something, frowned, and dropped it again. Then she **prodded** the rocky soil with the tip of her finger. "Wow, everything is sure drying out quickly," she said. "What happened to all that rainwater?"

"Some of it soaked into the ground," Tess replied. "But some of it evaporated and changed to water vapor that has mixed with the air. Remember, though, that changes of state are reversible. High above the earth's surface, the air is much colder. When water vapor encounters cold air, it loses heat energy and **condenses**. It changes states from a gas back to a liquid, forming tiny droplets of liquid water. Those tiny droplets in the air form clouds. If the droplets are big enough, they'll fall back to earth as rain."

"You mean we might get another thunderstorm?" Kristal eyed the sky warily.

"It's possible, but I'm guessing it won't rain again for quite a while," Tess replied. "I think the excitement is over for today."

Just then, Julian let out a shout. "Don't be so sure, because I just found gold! **Eureka**!"

Everyone rushed over to see the gleaming, dark, yellow rock that Julian held in the palm of his hand.

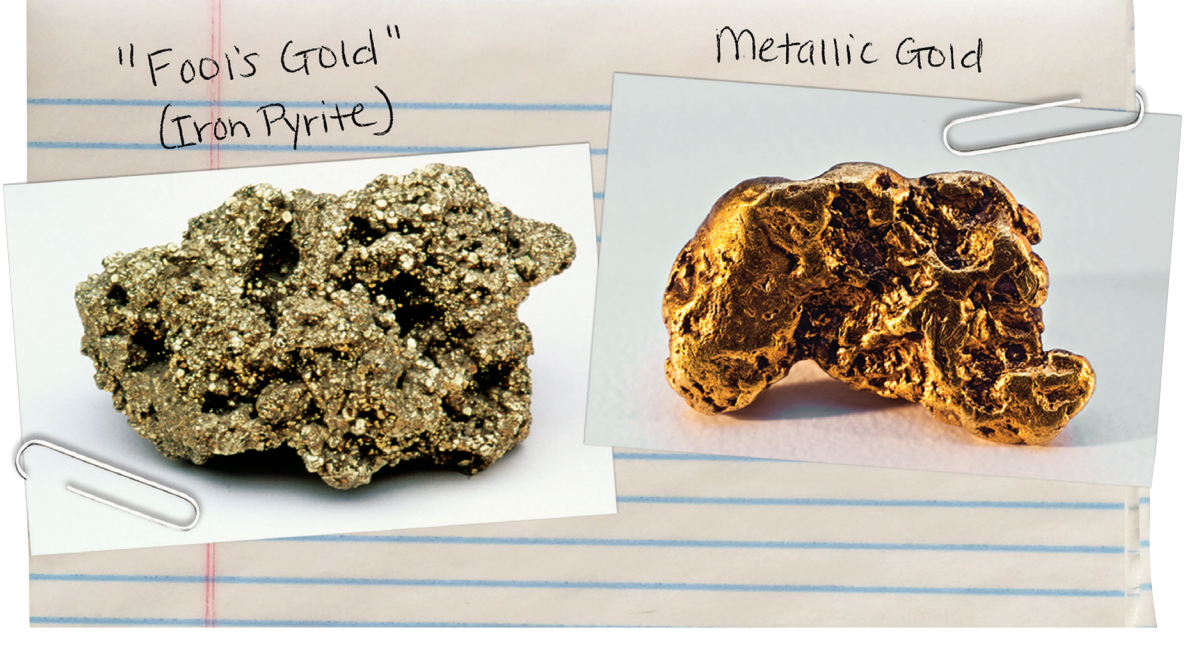
"I'm not only going to be famous," Julian said, triumphantly, "I'm going to be rich. Just look at the size of that nugget. My dad is going to be so proud of me!"

Dr. Forester examined Julian's find carefully. "Sorry to disappoint you, Julian. I'm afraid what you have there isn't gold but a very common type of rock called iron pyrite."

Julian's face fell. "You're absolutely sure?"

Tess laid a comforting hand on his shoulder. "You're not the first person to make that mistake, Julian. In fact, iron pyrite is often called fool's gold for that very reason."

Amy could tell Julian was very disappointed that his great discovery turned out to be nothing. He didn't say anything as he took the rock back from Tess and shoved it deep into his pocket.



A few minutes later, Matt stopped and nudged something with the toe of his shoe. “Hey, what about these?” Everyone rushed over and watched as Dr. Forester knelt down and then picked three more fossils out of the gravel.

“Maybe these will help me figure out just what kind of animal we have,” she said excitedly.

“Can we get back to the dig site now?” Julian blurted out in a loud, impatient voice. It was clear he didn’t want to look for small fossils anymore.

“It *is* almost noon,” Tess acknowledged, “so let’s break for lunch.”

They climbed up the slope to the dig site and retreated to the far end of the plateau again to eat sandwiches and fruit. Amy made a point of sitting next to Kristal. She unwrapped her sandwich but then laid it aside as she leaned in to ask the question she’d wanted to ask all morning. “Why haven’t you shown Dr. Forester your drawings of the little fossils yet?” Amy whispered. “If you did, she’d know there really is one missing.”

Kristal’s eyes went wide with surprise. “How did you know about my drawings?”

“I admit I peeked at your sketchbook,” Amy confessed, “but you can’t keep this information quiet. You need to let Dr. Forester know.”

Kristal was silent for a while. “Okay, I promise I will, but only—only if there is no one else around. Otherwise, people will make fun of my drawings.”

“No, they won’t!” Amy gasped. “You draw really well.”

Kristal suddenly looked past Amy with a surprised look on her face. “Hey, your sandwich!”

Amy turned just in time to see a small animal with narrow stripes making off with part of her sandwich. “You little stinker,” she said, laughing as the animal disappeared into a crack in the rocks far above them.

"Those little ground squirrels are all over these badlands," said Tess, chuckling. "They are very good at stealing food. I've known them to make off with other small objects they think might be food, too."

After lunch, they returned to excavating Achy-Breaky's bones. Matt had already exposed three of the dinosaur's fossil teeth. Amy was making much slower progress because her mind kept wandering back to the missing fossil bone.

"We're never going to get this jawbone excavated if you keep staring off into space," Matt said quietly, glancing up at his sister.

"I know, I know," Amy said, hurriedly picking up her brush to sweep away the bits of rock dust she'd created. "But I can't stop thinking about that missing bone." She told him about Kristal's drawings.

"Maybe Dr. Forester simply mislaid it," Matt suggested, "like Dad does with his car keys all the time. There's no evidence someone took it, and why would they?"

Amy had to admit that Matt's question was a good one. She glanced around at the group. Everyone was hard at work—except Felix, who just at that moment took something out of his pocket and popped it into his mouth! Felix noticed Amy staring and swallowed hard, gulping down whatever it was. He cleared his throat and suddenly turned to Tess. "I was wondering, Tess, just what is the difference between gold and fool's gold?"

Amy thought Felix just asked the question to turn her attention away from him.

Tess didn't notice, though, and was happy to answer it. "Remember that atoms are the smallest unit of an element. The thing is, you don't find many atoms all by themselves in nature. Atoms typically join together, or **bond** into groups of two or more as elements or to form **compounds**. Some elements and compounds are also **molecules**, depending on the way in which they bond. The element oxygen, for example, is two oxygen atoms bonded together into a molecule.

"Most substances, though, are compounds—combinations of two or more different atoms. The chemical formula of iron pyrite, for example, has two atoms of the element sulfur bonded to an atom of the element iron. Water is another example of a compound, but one that exists as molecules. Water molecules are made up of two atoms of the element hydrogen and one atom of the element oxygen."

"Is that why people sometimes call water *H-two-O*?" Daria asked.

"**Precisely**," Tess replied. "Different atoms bond together in different ways to create compounds, and you can find them everywhere and in everything. This sandstone rock we're scratching away at is a compound. So are these dinosaur fossils, and the tools we're using. Each one of you is a walking, talking collection of different compounds that make up your bones, muscles, nerves, and everything else in your bodies."

Tess was about to continue her chemistry lesson, when Daria pointed at something off in the distance, "Sorry to interrupt, but I think someone's coming."

Far off in the distance a black SUV was slowly approaching, bumping along on a barely **visible** track that wound among the ridges.

"I thought no one lived out here," Amy said.

"No one does," Dr. Forester replied, "but maybe these people are lost." She dug a pair of binoculars out of her backpack and trained them on the distant vehicle.

As they all watched, the vehicle stopped, then quickly turned around and headed back in the direction from which it had come.

"That was strange," Julian said. "It's like they suddenly saw us and turned around."

Amy thought it was strange, too. What was even stranger, though, was the look Dr. Forester and Tess exchanged as the black SUV drove away.

Nothing else disturbed their work for the rest of the day, and Dr. Forester was very pleased with their progress. As the sun started to sink in the western sky, they packed up their gear and said good-bye to Achy-Breaky for another day. Back at camp, Tess grilled hamburgers over the open campfire and heated baked beans in a cast iron pot.

After dinner, Dr. Forester put them all to work in the lab, helping her measure the little fossils from the gully and use the balance to determine their mass. Amy kept giving Kristal encouraging looks, hoping she would show Dr. Forester her sketches, but Kristal just kept shaking her head.

"Can you tell what kind of animal it was yet?" Julian asked, as they were putting all the instruments away.

"Well, this is a part of a leg bone," Dr. Forester said, pointing at one of the fossils. "And this one looks to be part of a vertebra, or a piece of the backbone. But I'm still not sure what we have. It's never a good idea to jump to conclusions."

And then it was time for bed. Amy caught up to Kristal as she was heading to the tent.

"I know, I know," Kristal whispered. "I promise I'll show my sketches to Dr. Forester tomorrow. I need to get my courage up."

Kristal fell asleep within minutes, but Amy decided to read until Daria came in. She finished one chapter and then another, but Daria still hadn't come. Amy peered out through the tent flap and looked around at the silent camp. Everyone else was asleep as nearly as she could tell. Amy sat on her cot and began to worry. What if something had happened to Daria? What if she'd been bitten by a snake? Just as Amy was about to tug on her sweatshirt and shoes and go in search of her, Daria came bouncing into the tent with a huge smile on her face.

"Where have you been?" Amy hissed. "I was starting to worry."

"Um! Ah—I went for a long walk!" Daria whispered back, sounding strangely excited.

"In the dark?" Amy asked.

"Oh—um—I used the flashlight on my phone," Daria said quickly. "Good night!" She spun on her heel and headed for her cot.

Amy lay awake, thinking about Daria's strange behavior, Felix's secretive snacking, and the odd look Tess and Dr. Forester exchanged when the black SUV appeared. Perhaps they were clues to the missing fossil. She pulled out her notebook and by the light of her flashlight, listed them one by one. No matter how many times she read through the list, however, she couldn't make sense of any of them, and finally decided, like Dr. Forester had with the small fossils, that there wasn't enough evidence to draw any conclusions. But from now on she was going to keep a closer eye on Daria—and Felix.

Chapter 5

Sketches and Secrets

THE BIG QUESTION
What do the sea and sweet tea have in common?

The sun looked like an angry red ball on the horizon when Amy got up. It was going to be another scorching hot day.

Tess had put out boxes of different kinds of cereal on the table, along with fresh and dried fruits and nuts. Amy sprinkled a few blueberries on her wheat flakes.

"Could you pass those, please?" Felix asked. Amy did and then stared as Felix dumped a handful of blueberries on top of all the things he had already heaped onto his cereal: raisins, sliced bananas, almonds, dried cranberries, peanuts, grapes, and flakes of dried coconut.

Felix noticed Amy staring. "What?" he asked, looking down at his bowl. "I always do this with cereal. It makes it more interesting and better tasting, too." He began stirring all the ingredients together with his spoon.

Tess tried to hide her smile. "Well, all I can say is that is quite a **mixture** you've got going there, Felix, at least in the chemical sense of the word."

"What do you mean?" Matt asked.

"In chemistry," Tess replied, "a mixture is made from two or more substances that are physically mixed together but can still be separated."

"You mean that I could pick out all the raisins," Felix said, plucking a raisin from the bowl and popping it in his mouth, "and all the nuts and all the banana slices and cereal pieces and so forth."

Tess nodded. "And no matter how much you stirred the—er—mixture in your cereal bowl, all the different types of matter wouldn't change. They would still have the same properties that they had before you mixed them together."

Kristal had added a spoonful of sugar to her tea and was stirring it in. "But mixing sugar into tea is different, right?"

"Not really," Tess said, "because what you are making there is a solution, which is similar to a mixture, but with one critical difference. Solutions are formed when one substance is mixed into another and **dissolves**. It might look like the sugar disappears, but it breaks down into particles so small you can't see them in the liquid."

"But if sweet tea is a solution, can you separate the tea from the sugar, like you can with a mixture?" asked Matt.

"Actually you could," Tess replied. "It wouldn't be as easy as picking raisins out of cereal. But if you let all the liquid evaporate, the sugar would be left behind as tiny crystals."

"That's like what happens when you go swimming in the ocean and don't rinse off afterwards," Daria added. "The water molecules in the seawater evaporate, leaving little crystals of salt on your skin."

"Seawater is a solution that has lots of things dissolved in it," Tess agreed, "but especially a lot of salt! This doesn't work for all solutions, though. Sometimes, a substance is made when two liquids are mixed together, and it's hard to tell if you've made a solution or a compound. When you heat them up, everything might evaporate and leave nothing behind. When that happens, more tests are needed to tell if something is a solution or a compound."

"Here comes Dr. Forester," Julian said. Amy got the impression he had been waiting for her, and when she sat down, he asked again if she'd had any luck figuring out what kind of animal the small gully fossils had belonged to.

Dr. Forester shook her head, but she was smiling. "The more I look at those little bones, though, the more excited I become. One of the three new

pieces we found yesterday was especially interesting. From its shape and texture, I am quite sure it's from a small dinosaur."

Amy shot a hard glance at Kristal, who started to shake her head but then nodded and coughed softly. "Um, Dr. Forester," she said, producing the sketchbook she'd been holding on her lap, "I wanted to show you some drawings I made of the first little bones found in the gully." She flipped open to the drawings Amy had seen, and turned the book around so Dr. Forester and everyone else could see.

"These are very professional!" Dr. Forester exclaimed. "Kristal, you've captured the details well!"

"Thanks," Kristal said, embarrassed but obviously pleased. "But I wanted you to see them for another reason. You and Felix found six fossils that first day, not five, and my drawings prove it."

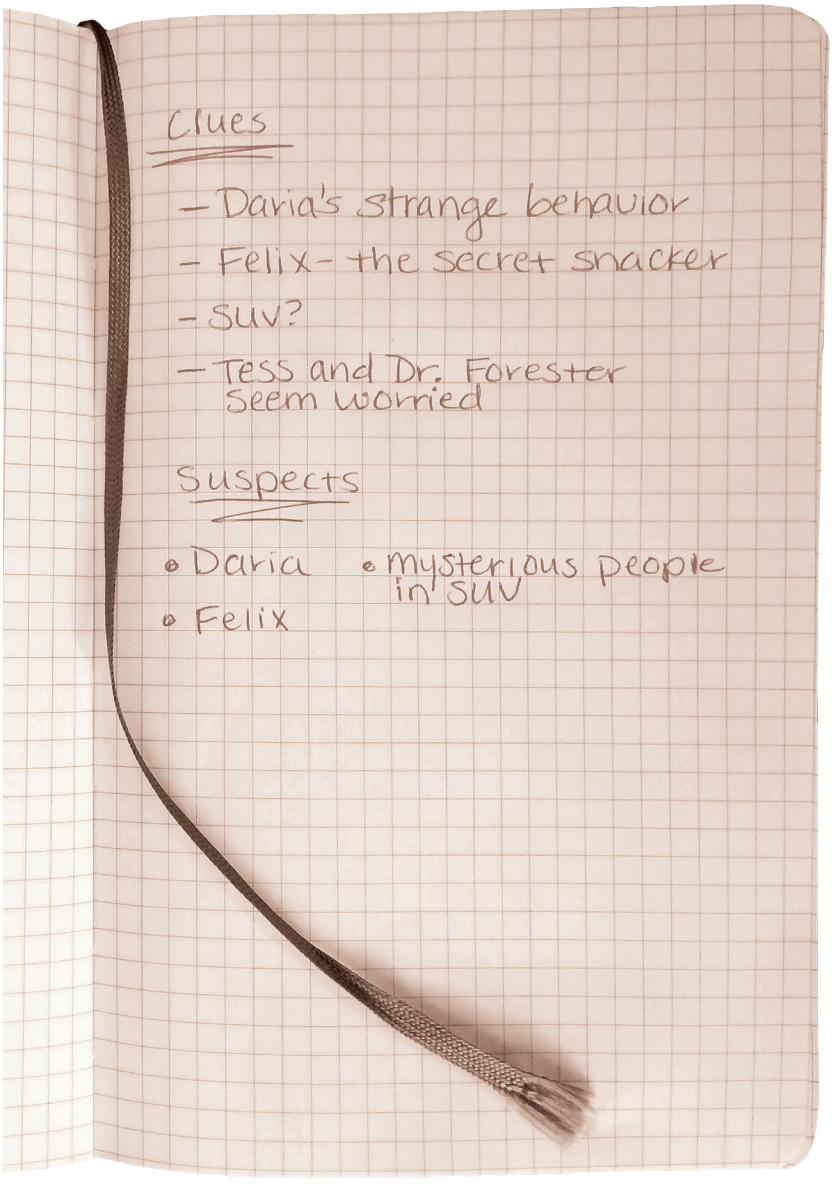
Dr. Forester studied Kristal's sketches for a long moment. "So one of them *is* missing," she said softly. "I'm hoping it will turn up, but until it does, I'd like to use your drawings, Kristal, when I study the fossils tonight."

As they were packing up to head out to the dig site, Matt pulled Amy aside. "So, what do you think happened to the missing fossil? Have you uncovered any clues as to where it might be?"

"I really have no idea, at least not yet. But it's not the only odd thing that's happened around here." She told her brother about Daria being gone for such a long time the previous night.

"Hmmm," Matt mused, "that does sound a little **suspicious**. Something strange happened in our tent last night, too. Felix has a huge backpack that's absolutely stuffed. Last night I was scooting it under his cot to make more room in the tent and he said he didn't like anyone touching his things. And now this morning," Matt's voice fell to a whisper, "there's a lock on it. Who puts a lock on a backpack?"

"Someone with something to hide?" Amy arched one eyebrow. "But why would Felix steal a fossil?"



Matt smiled and mussed Amy's hair. "When you figure that one out, let me know."

It was day three of their paleontology adventure. Felix and Daria had removed nearly all the rock from around the cluster of backbones. Kristal and Julian were making good progress on excavating the bones of the dinosaur's foot. Amy could see that Matt would have the rock cleared away from his half of the jawbone by the end of the day. If she didn't work faster on her

half, she'd be holding things up. Amy tried to put the mystery of the missing fossil out of her mind and concentrate on scraping and sweeping the crumbly rock away.

As more and more of the dark, gleaming fossil was revealed, Amy remembered something Tess had said when they first arrived at Fossil Camp.

"Tess, remember when I asked you what a fossil was?"

"Ah, yes, so you did." Tess said, straightening up. "Now that you all understand a little chemistry, I'll give you a more complete answer."

Everyone put down their tools and stretched, happy for a break.

"Different kinds of fossils form in different ways," Tess began, "but these dinosaur fossils formed as the original compounds in Achy-Breaky's bones were replaced by other compounds, thanks to the powerful effects of a solution at work."

"Like sugar in tea?" Kristal asked.

"In a way," Tess replied. "When Achy-Breaky died millions of years ago, his body was quickly covered beneath a thick layer of muddy sand. As a result, it didn't break down, or **decompose**, in the way most dead things usually do. It was preserved for a long time, sealed beneath tons of sand that gradually turned to rock."

"As time passed, water oozed down through the rock and picked up different mineral compounds along the way. These compounds dissolved in the water, creating a solution. As more and more minerals dissolved in the water, they began to come out of the solution as solids again. Little by little, those mineral compounds settled in tiny spaces in Achy's bones and teeth. They replaced his original compounds so that what was left at the end of this process were fossilized bones and teeth. And that's what you are excavating right now."

"You sure were right, Tess," said Felix, "when you said that chemistry has a lot to do with paleontology."

Amy went back to work thinking about the fossils in the rock beneath her hands in a very different way. They weren't just old bones, but the result of amazing changes in matter that had taken place over an incredibly long period of time. They were pieces of ancient history, very real clues to the past. Thinking about fossils in this new way made Amy glad she'd let Matt talk her into coming to Fossil Camp. Even if she didn't solve the mystery of the missing fossil, she was glad they were here.

Hours later, they returned to camp, hot, sweaty, and tired. Tess warmed a big pot of water and set out a basin and towels. "Does anyone want to clean up before dinner?" she called out.

Amy was first in line. Tess poured some warm water into the basin and handed her a bar of soap. As she washed her face and arms, the water in the basin turned cloudy and light brown—the same color as the sandstone ridges. There was a layer of sandy grit at the bottom of the basin. "Wow, was I ever dirty," she said, patting her skin dry with the towel. Amy picked up the basin to toss away the dirty water and exclaimed, "I created a mixture, didn't I?" Tess nodded and laughed as she rinsed and refilled the basin for the next person in line.

After dinner, everyone gathered in the lab. Dr. Forester had laid out all eight of the fossil bones from the gully on a piece of cloth on the big table. "Tonight I want to show you how paleontologists help preserve fossils that are rather fragile, as these tiny bone fragments are." She held up a small brown glass bottle. "This is a special solution, a sort of glue called a consolidant, that we paint onto delicate fossils. Let me show you how it's done." A brush was built into the bottle's lid, and Dr. Forester used it to carefully apply a thin coat of consolidant onto each of the fossils. She explained that the consolidant soaked deep into the fossils, and as it dried and hardened, it would make them stronger and less likely to break.

"These will be dry by morning. Then I'll go back to work analyzing them. If I could just find a matching edge for even just two of them, I might have a large enough piece to say for sure what type of dinosaur this is." She sighed and screwed the lid back on the bottle. "We'll just have to wait and see."

Chapter 6

The Quest for Clues

THE BIG QUESTION
What are chemical reactions?

When Amy arrived at the breakfast table the next morning, it was obvious that something was wrong. Tess and Dr. Forester both looked tense, and no one at the breakfast table was talking. For once, even Felix was quiet.

Amy slipped into the chair beside Matt and asked softly, "What's going on?"

"Not sure," Matt whispered back. "They said they have something important to tell us but wanted to wait until everyone was here."

Julian was still missing. They all waited in silence until he finally came running up, **flushed** and breathless. "Sorry," he said, taking the last chair, "I overslept."

Dr. Forester clasped her hands on the table in front of her. "I'm afraid that Tess and I have some disturbing news. This morning when I went into the lab to see if the consolidant I applied to the gully fossils last night was dry, I discovered that they were gone."

"Gone?" Amy exclaimed, her heart suddenly pounding.

"All of them?" Felix asked, wide-eyed.

"Yes, every single one. We've looked everywhere, of course, but haven't found any **trace** of them. I can only conclude that someone took them during the night." She paused, and looked hard at each person at the table, one by one. "Did any of you see or hear anything strange last night?"

Amy shook her head and shot a glance at her fellow campers. They all seemed **genuinely** upset and denied seeing or hearing anything other than the rhythmic creaking sounds of crickets and the soft sigh of the wind.

"Then I can only conclude," Dr. Forester said with a heavy sigh, "we were the victims of very clever fossil thieves."

"People steal fossils?" Matt was **incredulous**. "Who'd want to make off with dinosaur bones?"

"Oh, you'd be surprised," Dr. Forester said grimly. "Fossil hunters supply museums and private collectors all over the world. Most are honest people who obey the laws about where and how they can collect fossils. But unfortunately there are also some **unscrupulous** characters who dig up fossils on protected land without permission, or"— she paused—"steal them from paleontologists' dig sites."

"Since none of us heard anything," Dr. Forester continued, "I'm guessing the thieves parked their vehicle some distance from camp and then slipped in and out of camp on foot."

"That SUV we saw yesterday," Felix mused. "That was pretty suspicious. Do you suppose the thieves were in the SUV? Maybe they were spying on us?"

Dr. Forester shrugged. "It's possible, Felix, but it's just as likely that what we saw was nothing more than a car turning around."

"What if the thieves come back?" Daria asked, nervously.

For the first time that morning, Dr. Forester smiled. "That is the good news. I doubt very much that they will because they took the only fossils we have here at camp right now. I can't imagine they'll return."

"Shouldn't we call the police or something?" Matt asked.

"Well, there aren't really police out here," Tess said, "at least not like there are in a city. But Dr. Forester and I are discussing what to do."

Tess served eggs and bacon, which put everyone in a better mood. But while the other campers chatted excitedly about fossil thieves and stolen bones, Amy was trying to think like Inspector Ellis. She guessed that the big thunderstorm that had washed the little fossils into the gully had also smoothed away any old tracks and footprints on the ground around camp. If fossil thieves had parked a vehicle nearby and walked into camp during the night, there should be clear sets of new tire tracks and boot prints to be found. She added this possibility, followed by a question mark, to the list in her notebook.

Amy slipped out of camp while the others were busy making lunches and packing up the excavation gear. She circled the cluster of tents at a distance, scanning the ground in open areas and dry gullies wide enough for a vehicle to drive along. Wherever she looked, the sandy soil was rain-flattened and smooth. Except for tiny footprints she'd guessed were made by ground squirrels and rabbits, there were no signs that anyone had approached their camp from the outside the night before.

Finding no clues is a clue in itself, Amy thought.

Convinced she'd made a thorough search, Amy headed back to camp. She was **weaving** around several clumps of tall grass when someone suddenly shouted, "STOP!"

Amy froze as Julian appeared off to her left, hurrying toward her. "Don't take another step, Amy!" he called out. "Stay absolutely still!"

She was about to ask why when she saw the snake emerge from a big clump of grass not five feet ahead and start **slithering** toward her. Amy's mouth went dry, and cold sweat beaded her skin.

Out of the corner of her eye, Amy saw Julian slowly back up. "I want you to slowly back away from the snake with me," he said worriedly. "Hopefully, the snake will go in the opposite direction and head away from you."

Hopefully? Amy thought, as her heart thumped harder.

"Are you ready?"

Amy wasn't sure she was, but she took a deep breath and said "Ready!" in a tight, squeaky voice.

Julian and Amy slowly backed away from the snake. The snake stopped, tensed, and then turned and wriggled away, leaving a thin, S-shaped track in the sand.

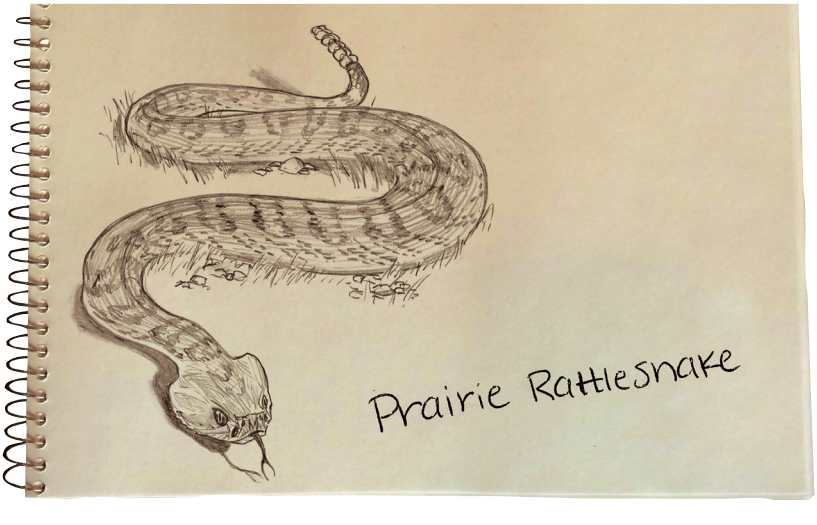
Amy's breath went out of her in a huge rush as Julian came running up. "That was too close," she said in a hoarse voice. "If you hadn't stopped me right then—anyway, thanks."

"You're welcome." He looked around and then back at Amy. "What are you doing way out here?"

"I was looking for tire tracks and footprints," Amy admitted, "to see if I could spot where the fossil thieves had parked their vehicle and where they'd walked into camp."

"Oh," Julian said, looking at her and then quickly glancing away. "Did you find any?"

Amy said she hadn't, and then something occurred to her. "So, Julian, what are you doing out here?"



"It was—it was getting time to leave and—I spotted you out here so I thought I'd come and get you." The words tumbled out of his mouth in a sudden rush.

"Well," Amy said, watching him closely, "it's a good thing you did."

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"Where did you disappear to this morning?" Matt asked later that day, as he twirled his rock pick between his dusty hands.

"I was looking around the camp for evidence of fossil thieves," Amy murmured.

"What did you find?"

"Not a single boot or tire print, and that can only mean one thing."

"Which is—?" Matt looked at Amy questioningly.

She leaned closer and dropped her voice to a whisper. "That the thief is one of us!"

Just then, Tess clapped her hands to get their attention. "You're almost ready for the next stage of the excavation process, which is removing the bones you've exposed from the rocks beneath them. This morning, Dr. Forester and I are going to show you how that's done."

They gathered around Dr. Forester, where she knelt by the leg bone she and Tess had been excavating. "The challenge in removing fossil bones from the underlying rock is to make sure we collect them without breaking them. If we tried to **pry** or chisel them out from underneath, we'd almost certainly break them. Instead, we use a clever technique called trenching. Take a look," she said, gesturing to the leg bone.

"After the entire bone was exposed on top, we started carefully chipping away the rock all around, about six inches out from the fossil. We chiseled down for several inches—well below where we think the underside of the leg

bone is—and then started chiseling inward. As you can see here, what we've ended up with is our leg bone fossil sitting atop a narrow rock pillar."

"It looks like a mushroom," Kristal said.

"That's a very good description," Dr. Forester said. "Once we have this mushroom shape, we put what's called a plaster jacket around the mushroom cap."

Tess continued, pulling on a pair of thin, latex gloves. "I'm going to demonstrate how paleontologists make a plaster jacket. It's a little like a doctor putting a plaster cast on someone's broken arm."

"I broke my arm and had a cast once," Daria said.

"Then you'll know what this leg bone is going to feel like," Tess joked. She had set out a bucket, a jug of water, a roll of paper towels, a wooden spoon, long strips of a rough fabric, and a bag labeled plaster of paris. "First, I'm going cover the fossil with damp paper towels," Tess explained, laying several wet towels on the exposed bone. "That will keep the plaster from sticking directly to our fossil."

"Next, I'll mix a white, powdery compound called plaster of paris with enough water to make a thin paste. Plaster of paris is made from a natural mineral called gypsum." Tess added water to the plaster in the bucket and used the wooden spoon to stir the two ingredients together.

"It looks like runny, white frosting," said Felix, leaning over to peer into the bucket.

Tess held up a strip of the rough fabric. "Now I'll soak strips of this burlap in the wet plaster and then lay them onto the fossil." She fitted and wrapped the mushroom cap with plaster-soaked strips until the fossil was completely **encased**, except for the place on the underside where it was still connected to the little pillar of rock. "Now we wait for the plaster to harden."

"But won't it take a long time for all the water to evaporate so it dries?" Amy asked.

"Actually the water isn't evaporating, Amy. Evaporation is a physical change in matter—a change in states. Here, the powdery plaster and the water I added to it are **undergoing** what's called a chemical change in matter. Remember that a physical change may alter some properties or the appearance of a substance, but it doesn't change what the substance is actually made of—its chemical composition. When matter undergoes a chemical change, however, its chemical composition does change. Typically, bonded atoms in the starting substances break apart, and rearrange themselves to form new substances.

"After a chemical change takes place, you end up with new types of matter, often new compounds, with different properties than those you started with. In this case, the gypsum dust and the water are combining in a chemical change to produce a new type of matter: solid, hardened plaster."

Tess set the bucket of wet plaster in the middle of the group. "Unlike physical changes of state, many chemical changes are not reversible. In other words, they can't be undone. Another clue that a chemical change is taking place is that energy is used up or given off in the process, often in the form of heat or light. With that in mind, I want you all to put your hands on the outside of this bucket and tell me what you feel."

Everyone leaned in and did just that. "It's warm!" Kristal marveled.

"When a mixture of plaster of paris and water undergo a chemical change, heat is given off," Tess explained,"enough heat to make the plaster quite toasty as it hardens!" She stood and peeled off her latex gloves.

Tess suggested they all eat lunch while the plaster jacket finished hardening. When they returned, Dr. Forester knocked on the jacket with her knuckles. "Good and solid. Now, Tess and I will break the cap off the mushroom, so to speak, and plaster over the hole on the bottom, just like we did the top."

While Tess gripped the jacket firmly, Dr. Forester used a hammer and chisel to break it free from the rock pillar. They flipped the jacket over and then applied more strips of plaster-soaked burlap to the bottom. When they

were finished, the fossil was completely enclosed and looked like a huge, white egg.

"When it's dry," Tess explained, "we'll use permanent marker to write a fossil number, the date, and the location of the dig site on the jacket. Then we'll take it back to camp."

"Actually, I'd like us to stop working a little early today," Dr. Forester said. "Tess and I have been talking about our missing fossils, and I've decided to drive over to Dry Creek and tell the sheriff what happened. It's a long drive, so I'll stay overnight. I'll ask the sheriff to come back with me tomorrow morning and take a look around."

"Wow, a sheriff!" Felix exclaimed. "Just like the Old West. Those fossil thieves had better watch out!"

Tess asked Julian and Amy to help her carry the jacketed fossil bone down to where the two pickups were parked. As they set it gently into the back of one, Amy realized that Julian had hardly said a word since the snake incident that morning. When Tess headed back up to the dig site, he just stood by the pickup and kicked at one of the tires.

"Thanks again for saving me from the snake," she said. "I don't know what would have happened if you hadn't shouted at me."

Julian was silent for a long moment and then asked, "What do you think the sheriff will do to the fossil thieves if he catches them?"

Amy shrugged. "I suppose he'll arrest them."

Julian didn't say anything at all.

Chapter 7

The Clues Add Up

THE BIG QUESTION
How do you use chemistry to catch a thief?

"There is nothing like a great dinner after a long, hard day in the field." Felix patted his flat stomach as he lounged in a camp chair beside the fire. "I'm stuffed."

They were all sitting around the campfire again, listening to the wood crackle and pop, and watching sparks rise up toward the night sky. It was perfectly clear, and the moon had not yet risen, so the stars were incredibly bright. Amy had never seen so many stars before, but now she could easily see the pale streak of the Milky Way as it **rambled** across the heavens.

"Too stuffed to eat roasted marshmallows?" Tess asked, walking up with a bag of marshmallows and enough roasting sticks for everyone.

"Wait a minute! I think my appetite just came back," Felix said. He pushed two marshmallows onto the end of a stick and held them out near the flames.

Tess pulled up a chair and glanced around. "I know it feels a little strange without Dr. Forester here tonight. How about we play a little game to liven things up?"

"You mean like Charades or Twenty Questions?" Daria asked.

"Well, you guys should know me pretty well by now," Tess said, grinning at them. "I was thinking more along the lines of a good, rousing game of Spot the Chemical Changes!"

"Rules, please!" Amy said, giggling.

"You must identify a chemical change that's taking place within the **boundaries** of the camp, and explain why it's a chemical change," Tess explained. "For every correct answer you get one point."

"And the person with the most points wins!" said Felix, popping his first toasted marshmallow into his mouth.

Matt's hand shot up. "The wood in the campfire is undergoing a chemical change, isn't it? And it's giving off both heat and light in the process."

"A point for Matt!" Tess cried. "Yes, when wood burns it is undergoing a very dramatic chemical change."

"And it's not reversible, either," Daria chimed in. "You can't turn the ashes into wood again."

"Excellent!" Tess agreed. "Who's next?"

"As my marshmallows are toasting," Felix murmured, "they're turning a delicious golden brown on the outside and they smell heavenly, too. That's got to be because a chemical reaction is taking place as they're heating up."

"A point for Felix!" Tess said. "The sugary substance of the marshmallow is undergoing a chemical change as it gets hot. It changes color and also gives off an odor, both signs that a chemical change is taking place."

"And you can't un-toast marshmallows any more than you can un-burn wood," Kristal said, gently pulling a perfectly roasted marshmallow off her stick and admiring it before taking a bite.

"Digesting marshmallows and other food has got to be a chemical reaction, too," Amy offered. "And we know the changes take place because our bodies grow and we get energy from the food we eat."

"A point for Amy, who is absolutely correct that all sorts of chemical changes take place in our digestive tracts," Tess said. "As we eat these marshmallows, for example, compounds in them are broken down in our stomach and intestines. During this process, atoms are rearranged to form

entirely different molecules that our bodies use as building blocks for making substances, carrying out tasks, repairing **cells** and structures, and much more. Certain chemical changes that take place in cells are responsible for capturing energy released when compounds from food are broken down even further, and then converting that energy into a form that cells can use." Tess pulled a marshmallow off her roasting stick, letting it cool slightly. "Just think—there are trillions of cells in our bodies, and at any given moment, countless chemical changes are taking place in each one."

"I've got one," Kristal said, slipping a ring off her little finger. "My mom gave me this silver ring. She'll shine it up for me now and then with a special cloth, but within a couple of weeks it gets a little dull, like there is dirt on it. **Tarnishing**—that's what she called it. Is tarnishing a chemical change?"

"It certainly is," Tess said, "and it typically happens when silver atoms on the surface of a silver object interact with sulfur-containing compounds in the air. Unlike wood burning or food cooking, chemical changes such as tarnishing take place quite slowly. Definitely a point for Daria!"

As the game continued, Amy noticed that Julian was lost in thought, but he'd been like that all day. Daria, on the other hand, seemed nervous. Every few minutes she turned and looked out into the darkness, in the direction Dr. Forester had driven away before dinner.

Amy thought of Inspector Ellis. In every book, he listed all the clues in his notebook to help him see the case more clearly, just as she had been doing. Amy didn't have her notebook handy, so she picked up a stick and made a sort of list in the sandy soil. She drew symbols that stood for backpacks and disappearances, cell phones and snakes, discoveries and appearances and things people had said.

Inside her head, several clues fell together—click, click, click.

There was a pause in the game, and Amy took advantage of it. She leaned back in her camp chair and let out a huge yawn. "Sorry, everybody," she said. "I'm tired and I'm going to bed. I want to be wide awake and alert tomorrow morning when Dr. Forester comes back—*with the sheriff*," she

added, emphasizing the three words. As she stepped past Matt's chair she tugged on his shirt, a signal that he should follow her.

"What's up?" Matt asked, as he joined her where she stood beyond the reach of the firelight.

"I'm doing what any good detective would do. I've put the clues together and come up with a plan."

"A plan for what?"

"A plan to solve the Case of the Missing Fossils," she said softly. "Meet me outside the kitchen tent after Julian and Felix have fallen asleep."

***

Amy picked her way slowly across the clearing toward the kitchen tent, trying not to make a sound. The moon had risen in the star-**spangled** sky as a silver **sliver** that gave off just enough light so she could see the shapes of all the tents. She paused and listened outside Tess's tent, but she heard nothing and hoped Tess was sound asleep. As Amy neared the kitchen, a familiar shape detached from the larger shape of the canvas structure.

"What took you so long?" Matt said in a loud whisper. "I've been waiting here for half an hour."

Amy placed a finger gently on her brother's lips. "Not so much noise. I'm late because Daria was tossing and turning and it took forever for her to fall asleep."

"Julian was asleep in record time, but Felix kept fiddling with his backpack for quite a while." Matt swatted at an insect. "So what are we doing here?"

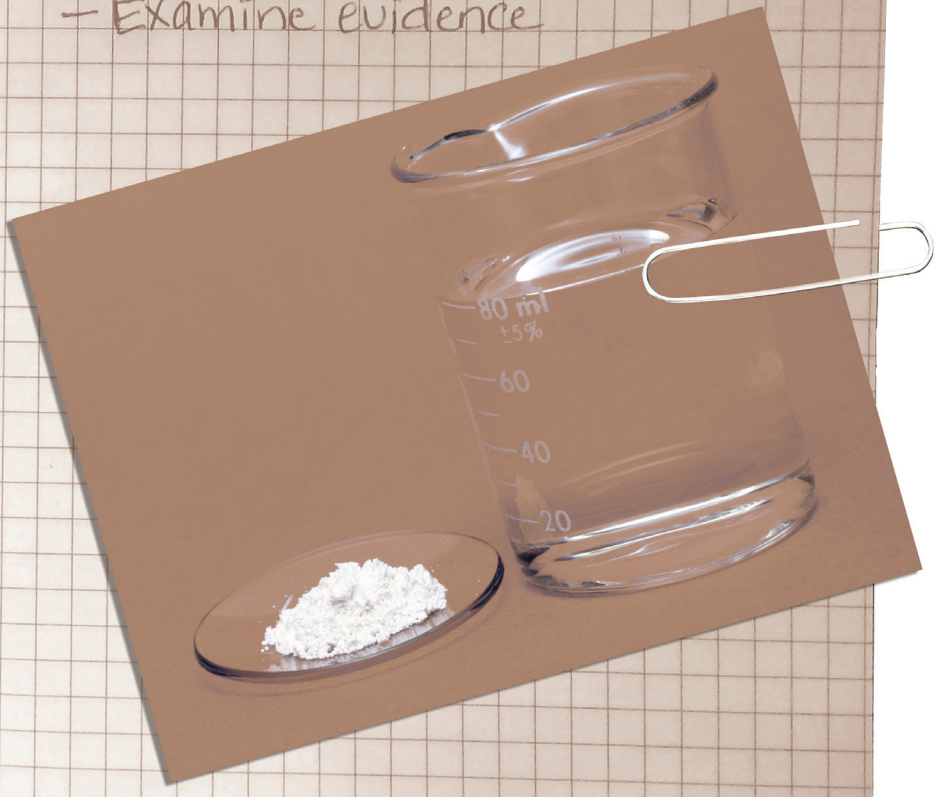
"We're setting a trap for our fossil thief," Amy replied.

"Do you know who it is?"

Amy answered thoughtfully. "A good detective suspects everyone until she has the evidence to prove who did what—and why."

The Plan

- Set a trap
- Use science:
  ice cubes / water
  plaster of paris
- Suspect(s) may leave
  footprints behind
- Examine evidence



"Okay, Miss Good Detective—how exactly are we going to do that?"

"Well, I'm guessing that whoever took the fossils is feeling pretty scared right now, because of the sheriff coming tomorrow. It's just a **hunch**, but I think he or she might try to return the fossils to the lab tent tonight."

"You mean we have to stand guard here all night and keep watch?" Matt hissed. "Sis, I'm so tired I can hardly keep my eyes open."

Amy shushed her brother again. "We're not going to stand guard. We're going to use chemistry to identify the culprit instead."

"Chemistry?" Matt asked, in a tone that made it sound like he thought his sister was crazy. "What do we know about chemistry that could help solve a crime?"

"Quite a bit, actually, if you've been paying attention over the past few days." Amy lifted the flap of the kitchen tent. "Follow me."

She slipped inside and flicked on her flashlight. After grabbing a big bowl and a dishtowel from a shelf, she headed over to the little refrigerator. "First, we need ice," she said, handing Matt the bowl and laying the towel in the bottom of it. As she emptied the ice cubes from two trays into the bowl, the towel muffled their clatter. She listened for a minute, straining to hear any sounds that might indicate someone else was awake. Except for the crickets, there was silence. "Now, let's head for the lab," she instructed.

Amy stopped outside the lab tent and took the bowl of ice cubes from Matt. One by one she placed the ice cubes on the ground directly in front of the tent's entrance.

"Amy, what on earth are you doing?" Matt asked impatiently.

"I'm exploiting a physical change in matter as the first step in solving the case," Amy replied. "The ice cubes will slowly melt over the next few hours. They'll change states from a solid to a liquid, making the ground wet here right in front of the tent. Anyone who enters the lab will get the soles of their shoes nice and damp."

"So what good do wet shoes do us?" The irritation in Matt's voice was growing.

"Trust me." Amy stepped inside the lab, flicked on her flashlight, and shone it where boxes and supplies were stacked in one corner. "Help me find the plaster of paris."

Matt quickly found the bag of white powder and dragged it into the center of the tent. "Okay, now what?"

Amy handed her brother a pair of latex gloves and a dust mask from a box on a shelf, and put both on herself for safety. "Help me scatter plaster dust on the floor of the tent. Let's start in the far corner and work back toward the entrance."

"Amy, this is not just crazy," Matt said, starting to scatter the plaster dust, "but Dr. Forester is going to be very annoyed when she sees this mess."

"The plaster is the second part of my plan and makes use of a chemical change," Amy said. "Remember what happened when Tess mixed water and plaster of paris at the dig site today?"

"It underwent a chemical change and the wet plaster hardened."

"Exactly. So if someone comes into the lab tent tonight, he or she will step in the water from the melting ice cubes just before entering. The soles of this person's shoes will be wet as he or she starts to walk around—"

"—and the plaster dust will stick to them." A grin started to spread across Matt's face. "The plaster dust and water will undergo a chemical change—"

"—and harden into plaster," Amy finished. "We saw today how well plaster sticks to things. It should stick to shoe bottoms at least as well. Then, tomorrow morning at breakfast, we'll check everyone's shoes, and whoever is sporting plaster in the treads will have a lot of explaining to do."

Matt was quiet for a long moment. "Amy, you are a good detective. That's brilliant."

Amy beamed.

Chapter 8

Cracking the Case

THE BIG QUESTION
Why are pancakes light and fluffy?

"Breakfast!" Tess called out from the kitchen tent. "Come and get it!"

Amy fell into step beside her brother. "Okay, once we've started to eat, I'll pretend to drop something under the table, slip down there, and quickly check out the bottoms of everyone's shoes."

They sat down at the table with the others just as Tess came walking up with a huge platter of hot, **fluffy** pancakes and a bottle of maple syrup. "Good morning! This morning's breakfast is brought to you by another amazing chemical change!"

Felix eyed the pancakes hungrily. "Um, do you think you could explain that statement *while* we eat, rather than before?"

"Absolutely," Tess said, handing him the platter. "Last night after the campfire I was thinking about chemical changes that we encounter every day. Some of the most familiar ones have to do with food. When people cook or bake things, all sorts of chemical changes take place. For example, pancakes are light and fluffy thanks to a chemical change between two ingredients: baking soda and buttermilk. When these two ingredients are mixed together, atoms are rearranged and new types of compounds are produced. One of those new compounds is the gas carbon dioxide. Tiny bubbles of carbon dioxide gas form throughout the pancake batter and are trapped as the batter cooks and solidifies. The result is light and fluffy pancakes that are honeycombed with tiny air pockets."

Kristal peered at the pancake on her plate. "So that's why they look like they're full of little holes. I always wondered about that."

Amy took a bite of her pancake. It was wonderful and she wished she could concentrate on simply enjoying it. But she was focused on the results of another chemical change this morning, one that had hopefully left traces on someone's shoes. She waited until everyone was busy eating pancakes, and then casually let her fork slip through her fingers.

"Whoops, dropped my fork," she said easily, and ducking under the table she quickly scanned the bottoms of everyone's shoes. Her plan had worked! Amy sat up and stared at Matt as he raised his eyebrows questioningly. She thought for a moment how to communicate her discovery, and then picked up the bottle of maple syrup. "Matt, would you pass the syrup to Julian?" she said, trying to sound casual. "It looks like he needs more."

Matt's eyes widened in surprise.

Felix was already helping himself to seconds. "These pancakes are great, Tess. Too bad Dr. Forester missed them."

"She planned to be back before we headed up to the dig site," Tess replied, "so I'm guessing she and the sheriff will be here soon. I'll make more batter when they arrive."

Amy noticed that when Tess said this, Julian swallowed hard and put down his fork. He looked scared. Amy's mind raced as she tried to think of what to do next. "Since we're going to put plaster jackets on more fossils at the dig site today," she said, turning to Tess, "how about Matt and I load up the plaster of paris and the other things we'll need?"

"That would be great," Tess said, pouring herself some coffee. "I can sit here and relax."

"Actually, why don't you help us, Julian?" Amy added, as she got up from the table. "It'll go faster with three."

When Amy stepped inside the lab, she saw the shoe prints in the plaster dust on the floor. They led from the entrance to the table, where all the missing fossil fragments now lay in a neat row.

Julian stopped outside the tent entrance and then stepped inside reluctantly.

"I suspected that whoever took these fossils would bring them back," Amy said quietly, "what with the sheriff coming and all."

Julian looked about to deny it, but then stopped and let out a huge, unhappy sigh. "How did you know it was me?"

Amy explained about the ice, the plaster dust, and the shoes. Julian groaned and sat down heavily on a wooden crate full of tools. "I suppose you're going to tell Dr. Forester when she gets here—and the sheriff."

"How about you tell us why you took the fossils in the first place?" Amy said.

Julian hung his head and said, "I didn't mean to take them, really. Everything just went wrong." He paused and then plunged ahead. "Remember when Dr. Forester was so excited about the first set of fossils, but wanted us to wait until morning to see them? Well, I didn't want to wait. So I snuck in here later that night to see them for myself. I'd picked one up to look at it more closely. Then I thought I heard someone coming, and without thinking, I shoved the fossil into my pocket and slipped out the back of the tent."

"Why didn't you just admit it the next morning when Dr. Forester found it missing, and give it back?" Matt asked. "It's not like you meant to steal it. She would have believed you."

"I didn't think she would. I figured she'd be really angry, and send me home, and I didn't want that to happen. I thought I'd just put the fossil back when no one was looking, and she'd just assume she had misplaced it. But every time I tried to do that, either Tess or Dr. Forester was here in the lab." Julian poked at the tent floor with the tip of his shoe. "Then we found more fossils, and Dr. Forester started talking about how great it would be if she could get some of them to fit together. I thought since I had the missing piece, maybe I could use it to figure that out, and maybe it would turn out be an important new discovery, and I might be famous, and then my dad—," Julian's voice trailed off.

"What about your dad?" Matt asked quietly.

"Then my dad might be proud of me, like he is of my brother Jack."

Amy and Matt exchanged a long look.

Julian hung his head again and picked at a seam on his jeans. "It was a silly idea, of course. Once I had the fossils, I couldn't make any sense of them. I couldn't even figure out a way to put them back in the lab without getting caught. So I put them in a sack and hid them under a bush."

"And then Dr. Forester went off to get the sheriff, thinking we'd been robbed by fossil thieves," Amy said.

Julian nodded. "So last night I brought the fossils back and put them there on the table. It seemed better than being caught with them red-handed or having to admit in front of everyone what I did. I didn't think much further than that."

No one spoke for a long moment. Julian looked from Amy to Matt and back to Amy again. "So, what are you going to do? Are you going to tell Dr. Forester I stole the fossils?"

"No, but you are," Amy said quietly. "I think Dr. Forester will understand that it wasn't stealing in the normal sense of the word, because your **intentions** were good."

Julian looked doubtful, but he nodded, sighing. "You're right. I'd feel better if I came clean, even if Dr. Forester decides to send me home."

"I think your chances are pretty good, actually," Matt said.

"We'll be there to support you, too," Amy added. "And I'll be sure to mention that you saved me from that snake!"

Sudden shouts and the sound of a car horn interrupted her. "Dr. Forester must be back," Amy said. "Let's meet her together, okay?" Julian nodded and quietly followed Amy and Matt out of the tent.

Everyone gathered around the pickup. "Where's the sheriff?" Felix asked, as Dr. Forester got out.

"He had something else he needed to do, but he'll be here by mid-morning," she replied. "And he did help explain the SUV we saw. It was a rancher the sheriff knows, out looking for lost cattle."

"While we're waiting, let's pack up our gear," Tess said. "We have a long day of excavating ahead."

Amy, Matt, and Julian hung back, and the other campers followed Tess. "Dr. Forester?" Amy said, glancing quickly at Julian. "Would you mind coming into the lab with us? There's something we need to show you."

Dr. Forester looked quizzically from Amy to Matt and Julian and back to Amy again. "No problem," she said. "Lead the way."

It took Dr. Forester only a few seconds to spot the fossils all lined up on the table in the lab. "Now this is a surprise!" She picked up each fossil, examining it closely. "And they are all here, even the one that first went missing." She crossed her arms and looked at them expectantly. "So, I assume someone is going to explain?"

Julian cleared his throat. “Yes, ma’am, I am.” In a shaky voice, he proceeded to tell Dr. Forester the whole story. Amy chimed in about the snake, and Matt added that Julian felt really bad.

When they were finished, Dr. Forester was quiet for a long time. Then she nodded, as if deciding something. “I **appreciate** your honesty, Julian. And I hope you’ve learned that you should always tell the truth right away. Things just tend to get worse if you don’t.”

Julian nodded and stared at the ground. “When do I have to leave?”

Dr. Forester put her hand on his shoulder. “It took a lot of courage to confess what you did. And I think your worrying about all this has probably been punishment enough. You’re welcome to stay.”

Julian beamed a huge smile. “That’s fantastic. This camp is the most fun I’ve ever had!” Then his smile faded. “But how are we going to explain to the others that the fossils are back?”

Dr. Forester thought for a moment and then said, “Leave that to me.”

When they all joined Tess and the others, Dr. Forester held up her hand. “There has been an unexpected turn of events,” she said, gesturing toward the lab tent. “The missing fossils have been found. Let’s just say—” she paused as a hush fell over the group—“our prime suspect is a curious ground squirrel who decided to make off with the bones rather than food.”

For a moment, everyone was silent. The silence was followed by laughter and loud conversations. Suddenly Tess’s voice rose above all the others. “What about the sheriff?”

Dr. Forester frowned. “That’s a problem. He’s going to make the long drive out here for nothing, and I’ve got no way to reach him.”

“You could call him!” Daria offered. “I know a place where you can get a cell phone signal.”

Dr. Forester looked surprised. “You do?”

"I was pretty homesick the first couple days, so I tried my phone in lots of different places. The other night I found a spot not far from camp where I got two bars!"

Dr. Forester dug her cell phone out of her pocket. "Please show me that spot, Daria, so I can call the sheriff and save him the trip."

As they left, Amy nudged Matt and whispered, "That explains Daria's late-night walk."

When Dr. Forester and Daria returned, Felix arrived with his huge backpack and set it down on the table outside the kitchen tent.

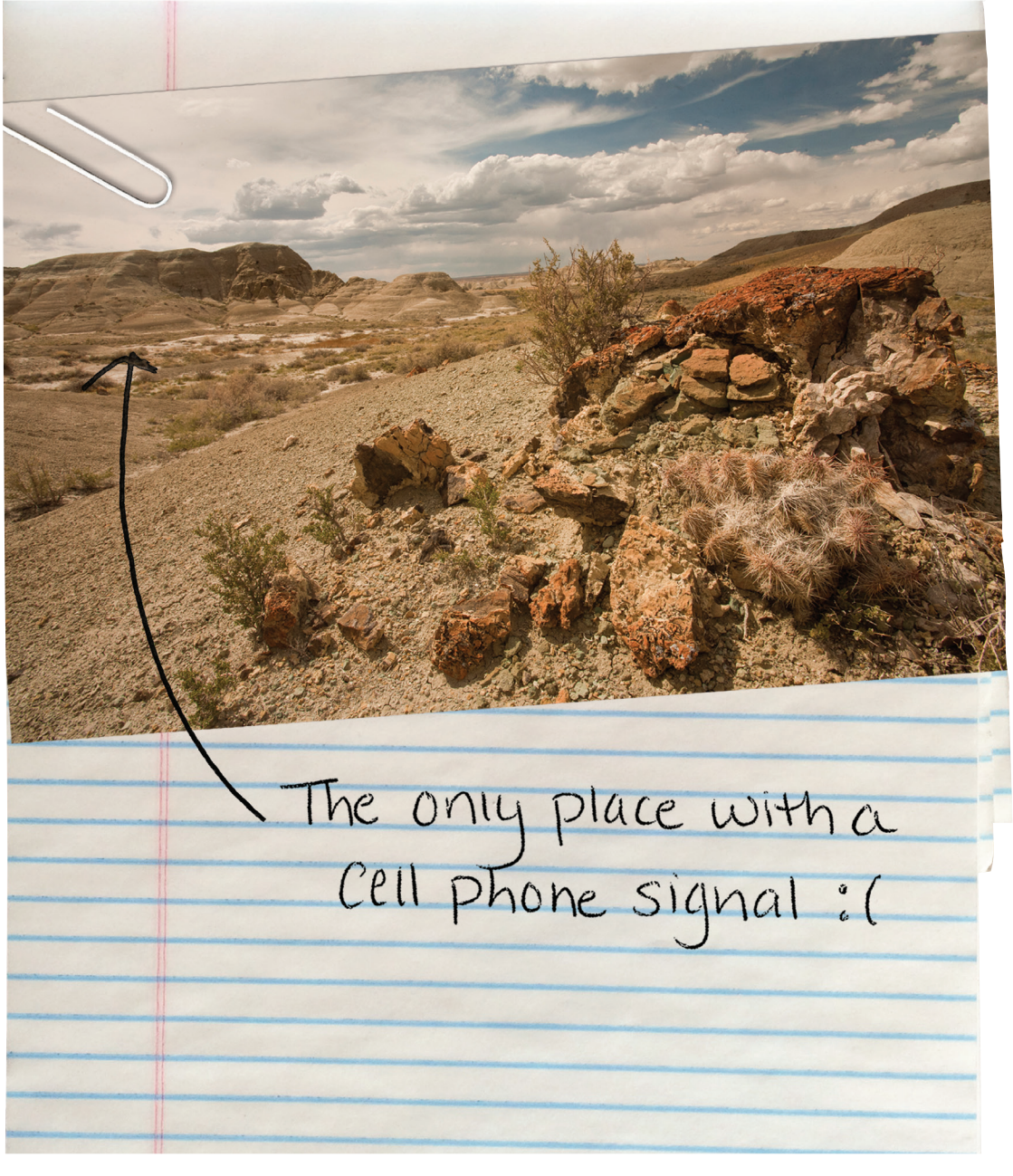
"Gather around, everyone," Felix said. "I'm disappointed we won't get to meet a real western sheriff. But the return of the fossils calls for a celebration, and I've got just the thing." He unzipped the backpack's main compartment and started taking out candy bars and packets of beef jerky, peanuts, jelly beans, licorice, and all sorts of other yummy treats.

"Felix, what is all this?" Tess asked, staring at the growing pile of food.

"Survival rations!" he said gleefully. "I always carry this much food with me, just in case hunger strikes and the next meal is still hours away. And aren't you all just dying for a treat?" He smiled his mischievous grin.

Matt nudged Amy. "That explains a lot."

Amy nodded, pleased with how well things had turned out. The Case of the Missing Fossils was solved, and Julian was able to stay. Fossil Camp felt suddenly right and happy—and she had cracked the case!


The only place with a
Cell phone signal :(

Enrichment 1

A Pioneering Chemist

Do you love science? Percy Lavon Julian certainly did, from the time he was a young boy growing up in Montgomery, Alabama. But while you were probably able to go to any school you wanted to and study any subject you were interested in, that was not true for Julian. He lived at a time in American history when those sorts of freedoms were reserved for people with white skin, and Julian's skin was not white. Despite facing enormous obstacles while growing up, during his education, and in his career, Julian overcame them all to become a pioneering chemist. Julian made important discoveries in chemistry that helped improve the lives of hundreds of thousands of people, and continue to do so.

Julian was born in Montgomery on April 11, 1899, into a society where life was hard for most African Americans. Opportunities for getting a good education or a good job were few and far between. Julian's father was relatively fortunate in that he did have a good job as a mail clerk for a railroad, and earned enough money so that his son could go to a segregated elementary school. After finishing the eighth grade, Julian wanted to continue his education. But there were no high schools in Montgomery that allowed African American students to attend.

That didn't stop Percy Julian. He went to a school for African Americans that trained its students in practical skills, including teaching. While he was training to be a teacher (for African American students only) Julian began reading some of the science books his father kept at home in his personal library. Of all the different science subjects he read about, chemistry was what really fascinated him. Julian decided that

becoming a chemist was what he wanted to do more than anything else, despite the fact that there were few other African Americans working in the field of chemistry at that time in the United States. But once again, Julian didn't let that obstacle stop him. In 1916, with the help of one of his teachers, Julian was accepted into Indiana's DePauw University as a chemistry student.

When he arrived at DePauw, Julian learned two things very quickly. The first was that he was he was woefully underprepared for his college classes and would have to take special classes in order to catch up to his classmates. The second thing he learned was that not all people held the same view about African Americans as those he had known in Alabama. Julian's classmates were friendly, and one of his chemistry professors, William Blanchard, went out of his way to help Julian succeed. After Julian graduated at the top of his class in 1920, he taught for two years at Fisk University in Tennessee before entering graduate school at Harvard University, where he was admitted thanks to the strong support of his former professor and his obvious talent for chemistry.

After receiving his master's degree from Harvard, Julian became a chemistry professor himself at what is now West Virginia State University in 1926. Despite the fact that his university laboratory was not well equipped, Julian began trying to synthesize, or create in the laboratory, certain types of chemical compounds found in plants. He was inspired in his work by an Austrian chemist, Ernst Späth, who had done groundbreaking experiments in synthesizing plant compounds from medicinal plants. In a fortuitous turn of events, driven largely by Julian's talents, he ended up studying under Späth in Austria three years later and receiving his PhD from the University of Vienna in 1931. Späth, a demanding professor, commented that Julian was an extraordinary student, one of the best he had encountered in his teaching career. Julian became the third African American in history to earn such a distinguished degree.

While at the University of Vienna, Julian had worked closely with another chemist, Josef Pikl, and in 1931, the two returned to the United

States together to take up positions first at Howard University and then at DePauw. There, the two chemists began what would become a major discovery in chemistry and in medicine. They successfully synthesized a chemical compound known as physostigmine, a substance found naturally in a plant called the Calabar bean that had been used since the end of the 1800s to treat the eye disease glaucoma. Physostigmine relieves pressure in the eye, a characteristic of glaucoma that, if left untreated, can lead to blindness. By successfully synthesizing physostigmine in the laboratory, Julian and Josef made it possible for this compound to be mass produced and made available at an affordable price to people suffering from this terrible eye disease. Working on glaucoma may have had particular significance for Julian, because glaucoma is a disease that strikes large numbers of African Americans. In fact, African Americans are five times more likely to develop glaucoma than whites. Successfully producing physostigmine in the laboratory made Julian and Josef famous, and for the first time in history, made the successful treatment of glaucoma a possibility for almost everyone.

Despite his success doing chemical research at DePauw, racial discrimination was still a barrier for Julian to advance in his career. The university would not grant him the position of professor because of the color of his skin. In fact, Julian couldn't find any university in the United States that would. When he was offered a position as a research chemist at the Glidden paint company in Chicago in 1936, Julian decided the opportunity to do chemistry research there was too good to pass up. He accepted the job and began focusing on developing new products from soybeans.

Julian's career took off at Glidden, which focused on producing new types of paint products and other novel chemical compounds. He received great support in his work and had the freedom to do very creative work in his laboratory. One of the first products he developed from soybeans was lecithin, a chemical compound that is still used today to keep certain types of food fresh and to improve the smooth consistency of foods such as chocolate. Julian went on to synthesize a

compound from soybeans that was such an effective fire-retardant—meaning it could help put out fires—that it was used by the United States Navy to help fight fires on ships at sea. And that was really just the beginning. Julian's research on soybeans led to the creation of compounds that were useful in paints, as coatings on paper, and as ingredients in glues and plastics. Julian's work helped make soybeans one of the most important crops grown in the country.

Julian's next major chemical discovery came about as the result of an accident at the Glidden plant. Water had unexpectedly leaked into a huge tank of soybean oil, and plant workers reported that a strange white substance had formed at the bottom of the tank as a result. Julian studied this substance in his laboratory and discovered that it was a plant hormone, a substance that helps regulate plant growth and development. Other researchers had proved that this plant hormone could be used as a starting point to synthesize a human hormone very important to human health. The discovery was another huge milestone in Julian's research career.

In the late 1940s, Julian made yet another landmark discovery. He figured out a way to synthesize a hormone called cortisone from the strange substance initially found in the bottom of the soybean oil tank. Cortisone and related chemical compounds are among the most effective drugs that doctors have available for the treatment of a terrible disease known as rheumatoid arthritis, which causes pain and swelling of the joints in people. At the time Julian made his discovery, the only source of cortisone was from animals, and it was only available in small quantities at a very high price. For instance, in order to acquire just one gram (about 0.04 ounce) of natural cortisone, nearly 170 cattle were needed. And that single gram of cortisone would have cost roughly $700, a very large sum of money in the 1940s, one that only the wealthiest people could afford.

Julian's research revealed a method for synthesizing cortisone in the laboratory for a tiny fraction of the cost of the natural hormone—about fifty cents per ounce, or two cents per gram. His discovery meant that

hundreds of thousands of people suffering from arthritis would be able to find relief from their pain as a result of his laboratory research.

Things were going very well for Julian, but he was facing a growing problem. The Glidden Company's primary goal was to make better paint products. Julian's goal was to synthesize chemical compounds in the laboratory that helped people, especially people who were sick. In the early 1950s, he quit his job at Glidden and started his own company. It was a bold step, especially for someone working in a society that was still influenced by people who felt that African Americans didn't have the right to the same opportunities as white people. But Julian went right on making important discoveries with his new company, Julian Laboratories. He developed a new and improved version of cortisone and created new ways to make other chemical products better as well.

Julian Laboratories became a place where young chemists, regardless of color, were welcome to freely explore new ideas and experiment with new chemical compounds. In his early sixties, Julian decided to sell Julian Laboratories and create the Julian Research Institute, a nonprofit organization dedicated to training a new generation of young chemists.

In 1968, the American Institute of Chemists presented Julian with the Chemical Pioneer Award for his outstanding contributions to chemistry research in the United States. A few years later he was elected to the National Academy of Sciences, which is among the highest honors that any scientist can receive in this country.

Julian died in 1975, leaving behind a legacy of new chemical compounds that by now have helped relieve the pain and suffering of millions of people worldwide. His research institute helped launch the careers of many chemists who have followed in his footsteps. Throughout his life, Julian overcame prejudice and discrimination in order to follow a dream of pursuing chemistry, a dream that was sparked when he was still a young man, and one that he pursued for the rest of his life.

Enrichment 2

Abundant, Amazing Aluminum

The next time you pop the top on a soda can, take a little time to appreciate the packaging. The lightweight can that's become a universal container for all types of fizzy drinks and fruit juices is made of a remarkable element called aluminum.

On the Periodic Table of the Elements, all the elements are arranged from 1 to 118 based on their atomic number, which refers to the number of protons found in the nucleus of an atom. Aluminum is element 13, meaning that an atom of aluminum has 13 protons in its nucleus and 13 electrons spinning around that nucleus. The chemical symbol for aluminum is Al, and on a periodic table you'll see that the elements above and below Al are boron (B), gallium (Ga), indium (In), and thallium (Tl). Except for boron, chemists classify all of these elements as metals. Aluminum is a lightweight, silvery-white metal that is exceptionally malleable. It can be pounded into flat sheets (think aluminum foil) and molded or bent into an endless variety of shapes, from familiar soda cans to the strong, sleek wings of jumbo jets. Aluminum is also very shiny, easily drawn out into thin wires, and an excellent conductor of both electricity and heat.

With all this going for it, it is not surprising that aluminum is used for a wide variety of things that we use in everyday life. Common objects made of aluminum include window and door frames, tent poles, window screens, faucets, patio furniture, mailboxes, ladders, bike frames, golf clubs, baseball bats, and the silvery trim on many cars. In the average kitchen, you are likely to find aluminum pots, pans, and utensils, aluminum foil, and aluminum parts in many appliances. Aluminum

is prized for making strong, lightweight, waterproof containers and packages for food, such as soda cans, trays for frozen dinners, bags for chips and other snacks, and wrappers for candy bars and sticks of gum.

Just as we are surrounded by aluminum products, aluminum surrounds us in nature as well. In fact, aluminum is the most abundant metal in the earth's crust. However, you won't find lumps of pure aluminum lying around like gold nuggets, because the element aluminum is never found free in nature. It exists naturally only in compounds, in which atoms of aluminum are bonded with atoms of other elements, typically oxygen and hydrogen. The most abundant source of aluminum is a type of rock called bauxite. Bauxite is found in many parts of the world, with Australia, China, Brazil, India, and Guinea having some of the largest deposits. Millions of tons of aluminum are produced every year from the processing of bauxite. In fact, essentially all of the aluminum that has ever been produced came from this very abundant type of rock.

It is because aluminum is bound up with other elements in nature that people didn't know with certainty that it existed until the early 1800s. Several chemists in different countries developed chemical processes to try to separate aluminum from other elements that combine with it in these compounds. In 1825, the Danish scientist Hans Christian Ørsted became the first person to successfully carry out such a separation and produce pure aluminum in its metallic form. However, Ørsted's process was slow and expensive, producing only tiny amounts of the element. Over the new few decades, other scientists experimented with more efficient methods for extracting aluminum from natural compounds. French chemist Henri-Étienne Sainte-Claire Deville's process made it easier to produce somewhat larger quantities of aluminum. But the element was still so rare that it was considered a precious metal, more valuable than gold. In 1855, a small bar of pure aluminum was exhibited next to the crown jewels of France at a social event in Paris called the Universal Exhibition. Displayed next to precious jewels and stunning gold jewelry fit for royalty, the little bar of

aluminum caused quite a stir, and aluminum quickly became all the rage among the rich. Emperor Napoleon III had a set of aluminum tableware made, but because it was so costly, it was used only for state banquets attended by his most honored guests. French jewelers and watchmakers crafted aluminum bracelets, watches, and items such as opera glasses for wealthy clients who could afford this rare and unique new metal. As the process for producing aluminum improved over the next few years, the price fell considerably, but it was still considered rare and valuable for quite some time.

Across the Atlantic Ocean, aluminum played an interesting role in the building of the Washington Monument in Washington, D.C. Begun in 1848, the towering Washington Monument was built in the shape of an Egyptian obelisk—a tall and extremely narrow pyramid—as a memorial to honor George Washington, the nation's first president. The monument took over thirty-five years to construct, and there was considerable debate about what type of material should be used to create its pointed tip. The tip was more than ornamental; it also needed to serve as a lightning rod that would help channel electric current safely down into the ground whenever the monument was struck by lightning. Copper, brass, and several other metals were suggested for the cap, but in the end, the construction engineers decided to use aluminum. The monument's pure aluminum tip, shaped like a tiny pyramid and just 8.9 inches (22.6 centimeters) high, was cast in 1884. Its sides were polished until they gleamed like mirrors and were then inscribed with important dates in the monument's construction and the names of people who helped design, build, and fund the project. On December 6, 1884, Lieutenant Colonel Thomas Lincoln Casey of the U.S. Army Corps of Engineers placed the shining aluminum tip on top of the completed monument as crowds of people cheered more than 550 feet below. Up until that time, most Americans had never heard of aluminum, and suddenly it was crowning the country's greatest monument.

Within just two years after the Washington Monument was completed, two scientists working independently—one American

and one French—figured out a way to extract aluminum quickly and relatively inexpensively from a compound called aluminum oxide. The method developed by Charles Martin Hall and Paul Louis Toussaint Héroult in 1886 came to be known as the Hall-Héroult process. In 1888 an Austrian chemist, Karl Josef Bayer, invented a process that made it possible to obtain aluminum oxide from bauxite. By using these two processes together—the Bayer process to produce aluminum oxide and the Hall-Héroult process to extract aluminum from that compound—it was suddenly possible to produce aluminum easily and quite inexpensively. The price of aluminum dropped to just a few cents a pound, and people quickly found new uses for this shiny, lightweight metal in industries and in all kinds of products. Nearly all the aluminum produced in the world today is still done using the Hall-Héroult and Bayer processes.

Mention the word *aluminum* and most people immediately think of aluminum beverage cans. They were first produced in the United States in 1959. Hundreds of billions of aluminum cans are produced worldwide every year, and they can be found in even the most remote corners of the world. Aluminum cans are lightweight, easy to stack, and exceptionally good at preserving whatever they contain without imparting any metallic taste. The cans are remarkably strong, too, able to withstand up to ninety pounds of pressure per square inch exerted by the pressurized gas inside that gives soft drinks their fizz when the cans are opened. It may seem hard to believe, but four six-packs of soda cans are also strong enough to support the weight of a vehicle weighing two tons!

For a while after aluminum cans were first introduced, they were commonly discarded as trash because they were considered disposable. Gradually people began to recognize how terribly wasteful this was, and companies figured out ways to recycle aluminum cans and other aluminum products. According to the aluminum industry in the United States, 113,000 aluminum cans are recycled every minute. Currently, it takes roughly two months for a recycled aluminum can to be turned into a new can, and the average can contains about 68 percent recycled

aluminum. However, there is still plenty of room for improvement. Between 1972 and 2003, it is estimated that Americans threw over one trillion aluminum beverage cans into the trash, enough cans to circle the earth 3048 times. Recycling helps conserve energy as well as *aluminum*. It takes 95 percent less energy to recycle an aluminum can than it does to produce a new one with aluminum extracted from bauxite.

If you have ever had trouble pronouncing or spelling *aluminum*, you are not alone. Part of the problem lies in the fact that *aluminum* has had several different names, or at least different spellings of its name, since it was first identified as an element by the English chemist Sir Humphry Davy, in 1807. When Davy first identified this previously unknown element, he called it *alumium*. Apparently he wasn't satisfied with that name, however, because he changed it to *aluminum* sometime later. In 1812, Davy changed the name of the element yet again, this time to *aluminium*. The reason he did this is unclear, but it might have been because Davy had discovered and named several other elements—potassium, sodium, and magnesium—that all ended in *–ium* rather than *–um*. Perhaps Davy wanted the names of his discoveries to match.

Because Davy was English, his final *–ium* spelling of the element became the accepted one in Britain, and *aluminium* was properly pronounced *al-you-MIN-ee-um* there and in countries under British rule. In the United States, however, people tended to spell the element's name either *aluminum* or *aluminium* for several decades, until *aluminum* won out around the year 1900. Americans pronounced this spelling of the element's name as *ah-LOO-min-um*. In 1925, The American Chemical Society made the *–um* spelling official for chemists in the United States. But in 1990, the International Union of Pure and Applied Chemistry decided that the official international spelling among chemists and other scientists should be *aluminium*. Despite that decision, most people in the United States still spell it *aluminum*.

By either name, though, it is still the same amazing element.

Meet the Author

Rebecca L. Johnson

Rebecca Johnson is the author of many highly acclaimed children's books. In this interview, Rebecca shares her own experiences as a member of a fossil dig team, as well as other fascinating facts about her life as an author.

Rebecca, you once participated in a fossil dig. Can you tell us about your own experience?

I participated in a fossil dig in central South Dakota, in a location along the Missouri River. A long time ago, during the Cretaceous Period, vast areas of this part of the United States were underwater as part of a large inland sea called the Western Interior Seaway. As a result of this area having once been seabed, it is rich in fossils of ancient marine animals. Our dig began along the edge of the riverbank, and then we expanded our search inland. We were digging in exposed sediment, and it wasn't long before we began to uncover some really interesting things.

What did you find?

Well, at one site we found the fossil remains of a prehistoric type of sea turtle deeply imbedded in rock. Its shell was over twelve feet long. At another site we found the fossil skeleton of an ancient, extinct marine reptile called a mosasaur. Mosasaurs are quite fascinating. They were large powerful predators, some as big as a small whale, with very sharp teeth and paddle-like fins.

What was life at camp like?

Well, in many ways it was similar to camp life described in the story. We had daily routines. Some people cooked. Some people washed the dishes. In the evening we did research, and we sat around a campfire and talked about our day. It was a lot of fun. In fact, the menu in our camp was pretty similar to the food the children got to eat at Fossil Camp—and yes, there were lots of snacks, too!

Rebecca, how did you become an author?

When I was in the fifth grade, I loved science and art. As I progressed through middle school, high school and eventually college, I began to think about how I could incorporate my love of science and art into a career. My writing career began when I worked on science materials for textbooks. I illustrated, too. But more and more I wanted to show young people how interesting science and scientific discovery is. That's when my career as a children's author really began. I began to explore ideas and topics that I thought children would find interesting.

(Left) Working beneath the blazing sun, members of our team cover a partially excavated fossil with strips of plaster-coated fabric to create a plaster jacket. (Right) The fossil is chiseled free from the underlying rock.

Rebecca, what are your three favorite children's books?

My first choice would have to be *Alice in Wonderland*, by Lewis Carroll. I have no less than six different copies of *Alice in Wonderland*, so—old or not—it will have to go on my list of the top three books I read over and over again as a child. Second would be Madeline L'Engle's *A Wrinkle in Time*, and third would be Zilpha Keatley Synder's *The Egypt Game*. I was obsessed with everything ancient Egyptian throughout most of my grade school years. I was an odd child reader, I think, because I also read all the Sherlock Holmes stories. I loved mysteries and detective stories, and still do. And I remember very clearly that in fifth grade I read Hugo's *Les Miserables*. Despite the length and the vocabulary, I thought it was one of the best stories I had ever read and couldn't wait to return to it every day after school.

(Large photo) Exposed by wind and rain, the fossil bones of an ancient mosasaur litter the dry ground. Paleontologists use markers and simple grids made of wood and string to help record the exact position of the fossils they find. (Inset) These fossils once formed part of the mosasaur's long backbone.

Glossary

A

appreciate, ***v.*** to recognize the worth of

atom, ***n.*** the basic unit of an element

B

barren, ***adj.*** bleak and lifeless

bond, ***n.*** in chemistry, an attraction between atoms that allow chemical substances to be formed

boundaries, ***n.*** the limits of an area

C

cells, ***n.*** the basic building blocks of living things

chemistry, ***n.*** the science of matter

compound, n. a combination of two or more elements

condense, ***v.*** to change from a gas to a liquid

conductor, ***n.*** a good channel for something (such as electricity, or heat)

D

decompose, ***v.*** to decay

devour, ***v.*** to eat fast and hungrily

discovery, ***n.*** the act of finding something new or unexpected

dissolve, ***v.*** when two or more substances are combined and one of them breaks down

E

embed, ***v.*** fixed deeply into the surrounding mass

encased, ***v.*** completely surrounded

Eureka!***(exclamation)*** an ancient Greek word meaning, "I have found it!"

evaporate, ***v.*** to turn from a liquid into a vapor

expert, ***n.*** someone who has deep knowledge and skill in an area, usually from long experience and study

expose, ***v.*** to make something visible by uncovering it

F

fluffy, ***adj*** light texture; filled with air

flushed, ***adj.*** with a reddish color [usually the face]

furnace, ***n.*** a very hot oven

G

genuinely, ***adv.*** honestly, authentically

gesture, ***n.*** a movement, usually of the hand or head, to express meaning or point to something

H

horizon, ***n.*** where the earth seems to meet the sky

hunch, ***n.*** a guess based on feelings, not facts

I

incredulous, ***adj.*** disbelieving

intention, ***n.*** aim or plan

L

lurch, ***v.*** to make a sudden, unsteady movement

M

mammal, ***n.*** a type of animal that has hair or fur and nurses their young

mass, ***n.*** a measurement of how much matter is in something

matter, ***n.*** anything that occupies space and has mass

mixture, ***n.*** two or more substances which are combined without changing their chemical composition

molecule, ***n.*** a group of atoms bonded together

mutter, ***v.*** to say something in a low or hard-to-hear voice, often with annoyance

N

nudge, ***v.*** to gently touch or push

P

paleontology, ***n.*** the science of fossils

periodic table, ***n.*** a way of organizing chemical elements

plateau, ***n.*** an area of high, level [no slope] ground

portable, ***adj.*** easy to carry

precisely, ***adv.*** exactly; with complete accuracy

prod, ***v.*** to poke someone or something

pry, ***v.*** to use force to open

R

ramble, v. walk without any obvious purpose

reluctant, ***adj.*** unwilling

resonance, ***n.*** a quality of sound: clear, deep, long lasting

S

sandwich, ***v.*** to squash between two things

shimmer, ***v.*** to shine with a light that seems to move a little

slather, ***v.*** to spread on thickly

slithering, ***v.*** sliding along

sliver, ***n.*** thin, narrow piece

spangled, ***v.*** covered with small, shiny objects

suspicious, ***adj.*** giving the impression of dishonest behavior

T

tarnishing, ***v.*** a chemical process by which some metals become dull

technique, ***n.*** a way of doing something, usually with some skill

tense, ***adj.*** nervous, tightly wound

trace, ***n.*** a slight mark

U

undergoing, v. experiencing

unscrupulous, adj. not caring about the right thing to do

V

visible, adj. able to be seen

W

weaving, ***v.*** moving back and forth

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K–5 Reading Language Arts

ENGLISH

THE BADLANDS SLEUTH:
THE CASE OF THE MISSING FOSSILS

GRADE 5 UNIT 8 | READER

EDITION 1

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