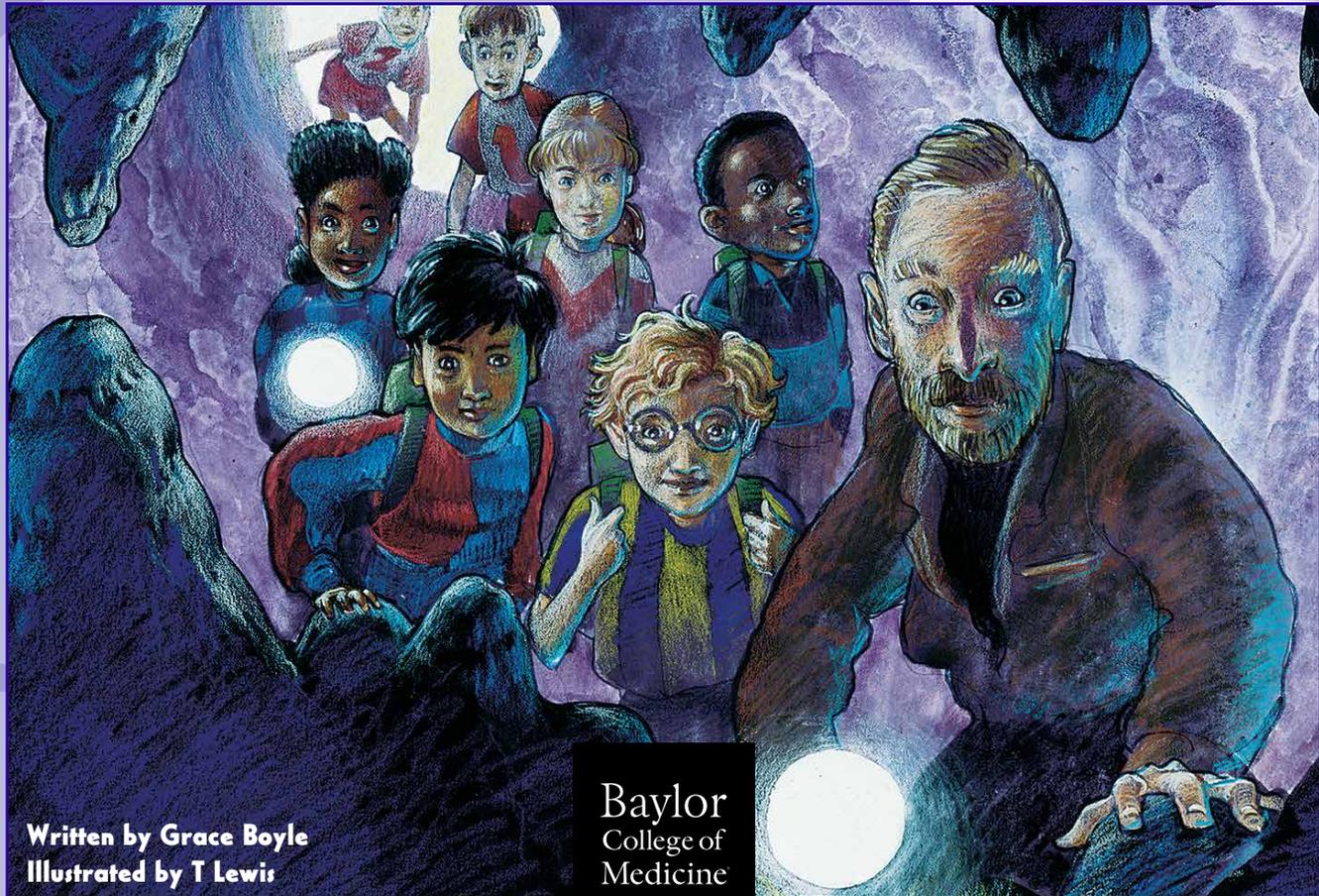




BRAIN COMPARISONS

# SKULLDUGGERY

A Case of Cranium Confusion



Written by Grace Boyle  
Illustrated by T Lewis

Baylor  
College of  
Medicine





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Written by Grace Boyle

Illustrated by T Lewis

Revised by Barbara Tharp and Judith Dresden

Science notations by Nancy Moreno



BioEd Teacher Resources from the  
Center for Educational Outreach  
Baylor College of Medicine

ISBN: 978-1-944035-96-5

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Fourth edition. First edition published 1992.  
Printed in the United States of America.

ISBN: 978-1-888997-96-5

# BioEd<sup>SM</sup>

Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.

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Development of BrainLink® educational materials was supported, in part, by funds from the National Institutes of Health, Science Education Partnership Award grant number R25 RR09833. The opinions, findings and conclusions expressed in this publication are solely those of the author and project staff and do not necessarily reflect the views of Baylor College of Medicine, the sponsoring agency or the publisher.

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## Acknowledgments

Many dedicated professionals worked to assure the educational and scientific integrity of this publication. In particular, we are grateful to Leslie Miller, Ph.D., who initially led the project, and to Katherine Taber, Ph.D., and Karen Kabnick, Ph.D., for their contributions. Other specialists who provided guidance include: Vicki Appel, B.S.N.; Cassius Bordelon, Ph.D.; Dane Chetkovich, M.D., Ph.D.; Celia Clay, M.P.H.; Sara Copeland; Greg Duncan, M.S.; Michael Levy; and Ilene Schwarz, M.Ed. In addition, many classroom teachers and their students provided invaluable feedback.

We also are very grateful for the continuing support of James Patrick, Ph.D., Professor and Head of the Division of Neuroscience; Stanley Appel, M.D., Professor and Chairman of Neurology; Carlos Vallbona, M.D., Distinguished Service Professor of Family and Community Medicine; and William A. Thomson, Ph.D., Professor of Family and Community Medicine at Baylor College of Medicine.

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## How the NeuroExplorers Club Began

All Josh Kavil saw was the stop sign. The next thing he remembered was waking up in the hospital. He had been riding his bicycle without a helmet and was struck by a car. His skull was fractured, and his brain was badly damaged.

Some good came of Josh's unfortunate accident. Once he recovered, he remembered never to ride without a helmet. His misfortune also was the beginning of the NeuroExplorers.

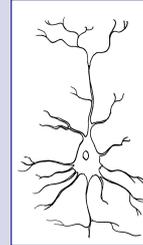
When Josh's friends came to visit him at Worthington Regional Hospital, some of them became fascinated with the field of neuroscience. On their visits, they met a neurosurgeon, a neurosurgical nurse, a neurologist and a neuroradiologist.

These medical specialists help patients who have problems involving the brain or other parts of the nervous system.

It was Kyle Camacho's idea to form the club. The members wanted to know more about the nervous system. They also liked to solve puzzles and riddles and had an interest in investigating some of the mysteries of science.

Since they formed the club, the NeuroExplorers have volunteered at a rehabilitation center for brain injury patients, held a Neuroscience Fair at their school and spent a day in the hospital on rounds with a neurologist. They have learned a lot about how the brain and nervous system work, and they always are looking for exciting things to do with neuroscience.

Neuroscientists study the brain and the rest of the nervous system. The basic building block of the nervous system is the nerve cell, or neuron. The word "neuron" comes from the Greek word for "nerve." How many words can you find that start with "neuro-"?



## The NeuroExplorers



### **B.J.**

B.J. Armstrong spends a lot of time with her drums. In fact, she carries her drumsticks with her and uses them on any hard surface she can find! She wants to play in a band, but she also wants to be a physician. B.J. has two brothers who sometimes act as advisors to the NeuroExplorers. One brother is a neurologist at a medical school. Her brothers never liked to use her formal name, Beverly Jane, so they always call her B.J., and so do her friends.



### **Kyle**

Kyle Camacho's father is an archaeologist at Dargate University and often is away on digs. Last year, he took Kyle with him on a short dig in Belize. Kelly, Kyle's sister, sometimes does things with the NeuroExplorers, although some of the members feel that she is a little young for the club. Kyle likes to read science fiction books, solve puzzles and play computer games. His hobby is memorizing fascinating trivia.



### **Lakeisha**

Lakeisha Crawford wants to be a chess grandmaster, so she carries a pocket chess game around with her. She often thinks about things in terms of chess problems, and she has developed a good memory, and has easy recall of facts and figures. She also likes to play other games and sports. She loves hiking and snowboarding, but karate lessons are her latest passion. Lakeisha's little sister has epilepsy.



### **Josh**

When Josh Kavil recovered from the head injuries he received in a bicycle accident, he couldn't wait to join the club with his friends. Josh has always liked science, because he loves to figure out how things work. He also loves animals. He has a pet lizard named Scooter, a snake named Slim, two dogs and two cats. After his experience as a patient in a rehabilitation center, he decided he would like to be a physical therapist when he grows up.

**Max**

Max Miller has been friends with Antonio, “The Brain” since they were babies, and that’s why he understands him so well. They spend most of their time together. While The Brain reads, Max often works on models of boats and planes or builds things with wood. Max became interested in neurology when his grandfather had trouble with his memory and was diagnosed with Alzheimer’s disease.

**Shiloh**

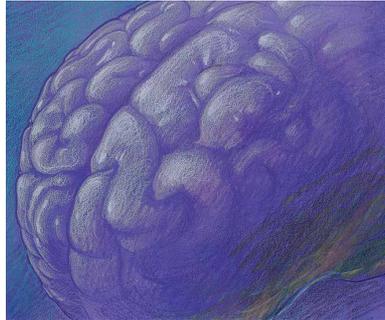
Shiloh Nimbus lived on a game reserve in Africa for many years. While there, her back was injured, and now she must use a wheelchair. Before her injury, Shiloh was very athletic. Now she has become an excellent wheelchair tennis player. She also likes to put together jigsaw puzzles with thousands of pieces. Shiloh was happy to make friends with the NeuroExplorers when she came to her new school in America.

**Antonio “The Brain”**

When Antonio Velasquez-Ruiz was a toddler, he was very quiet and never tried to talk. One day he suddenly began speaking in complete sentences. Since then, he has been known as the smartest boy in town. The trouble is, only his best friend can understand The Brain’s big words and long sentences. The Brain reads a lot, but his most-used books are a very fat dictionary, a set of encyclopedias, and *Gray’s Anatomy* (of the human body).

**The Twins: Isley I and Isley II**

Identical twins, Isley I and II (even their parents don’t call them by their actual first names) are always kidding each other. They both love sports and play soccer, baseball and basketball. Isley I collects baseball cards and has a 1954 Mickey Mantle in good condition. Isley II holds the record for consecutive basketball free throws in his school. Their father, a bird-watcher, got them interested in science by reading to them about Charles Darwin.



## Calling All NeuroExplorers

Grinning a cracked-tooth smile, a model human skull peered down from the shelf above Kyle Camacho's head. The skull's neighbor was a gray plastic brain, and both lay below a giant wall poster that said, THINK! YOUR MIND DEPENDS ON IT!

Kyle didn't notice the skull's grin or the model brain's icy silence. He was deep in thought, his fingers flying across the computer keyboard, typing out this urgent message:

**Attention NeuroExplorers  
Emergency Meeting STAT!  
KC's Basement, ASAP  
No Reply  
Just Come Now!**

Click! He sent his message scurrying across the Internet to the homes of the NeuroExplorers. He needed the club here. On the double!



In minutes, the NeuroExplorers arrived. Kyle looked around his basement. Lakeisha, B.J., Isley I and II, Max and The Brain all were there. The Brain, of course, was the first to speak.

“Kyle, I’m sure I speak for all of the NeuroExplorers. We admire your leadership qualities, forthrightness and general acumen. But was it really necessary to expedite this meeting with such alacrity?”

Kyle looked at Max, The Brain’s translator, who explained. “He wants to know why you made us run over here like there was a major catastrophe or something.”

Kyle smiled. “Thanks Max. There *is* an emergency, Brain. I think we need to take action, fast. It’s time for a skull session.”

Everyone started talking at once. The Isley twins, I and II, seemed annoyed. “Does this mean we’ll miss the basketball game tonight?” Isley I asked. “I hate to miss championship games,” Isley II finished.

“This isn’t just another case, like helping Laura Bolter look for her missing science project, is it?” asked Lakeisha.

“Hold on, hold on everyone,” Kyle said, waving his hands. “We have

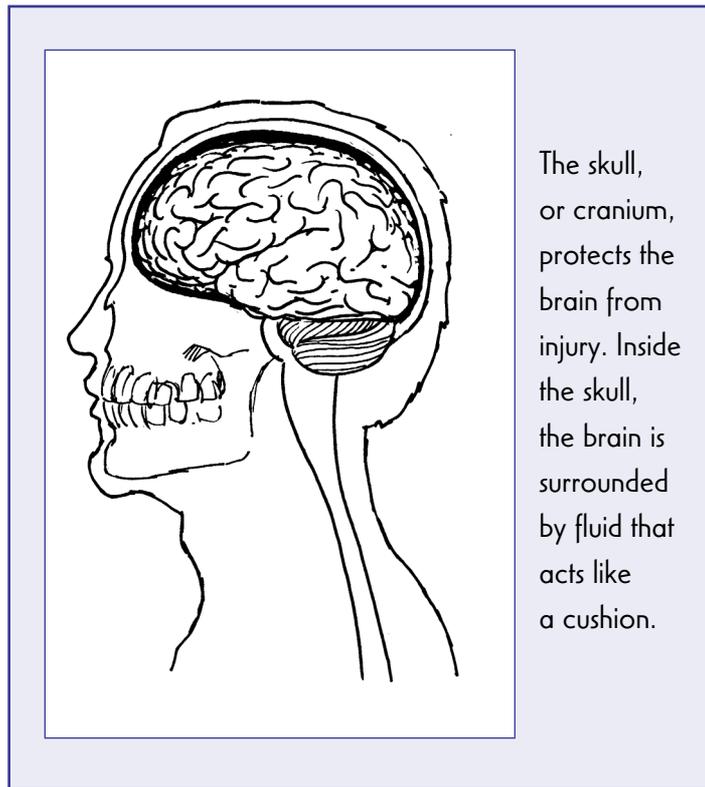
a real puzzle to solve. Someone truly needs our help. This is an official NeuroExplorers double barrel, full scale alert!” The room fell silent.

“Who?” asked Isley I. “And where?” asked Isley II.

“Professor Paul Ottzinger. The Skull Caves at Calicoon,” Kyle replied.

The room was quiet. The NeuroExplorers sat in stunned silence. The grinning skull seemed to be laughing to itself.

“Extraordinary!” whispered The Brain.



## Who Took the Mishigara Man?



Kyle scanned the blank faces of the NeuroExplorers. They all knew about Ottzinger. He was a professor at nearby Dargate University, and his specialty was skulls. He was a well-known expert, and once he had brought his skull exhibit to their school. Recently, the most famous and valuable skull of all, the pre-historic Mishigara Man's, had disappeared from Professor Ottzinger's laboratory. The papers were full of stories about who might have taken the skull, and why. People even suspected Ottzinger, himself.

But Kyle knew that it wasn't so much the thought of Ottzinger that had frightened the group into silence. It was the mention of The Skull Caves at Calicoon — dark, frightening caves that were shaped like a human skull.

Kyle broke the bone-cold silence. "This is just the opportunity we've been waiting for, believe me," he said.

"Some explanation is mandatory," The Brain said, stonefaced.

"Explain, please," Max interpreted without prompting.

"Well," Kyle started slowly, "I was going through my e-mail on the computer, and I found a letter in my mailbox."

Isley I looked up. "Don't tell me. The letter was written by..."

"Professor Ottzinger," Isley II finished.

Leaning off the edge of her seat, nervously tapping her drumsticks, B.J. looked at Kyle. "Professor Ottzinger?" she said. "What could he possibly want with us?"

"Why don't I let him tell you?" Kyle said.

## Ottzinger's Plan

Suddenly, hovering far above the heads of the NeuroExplorers, a tall figure appeared in the doorway. It was Professor Ottzinger. "You can give me my last chance," he said.

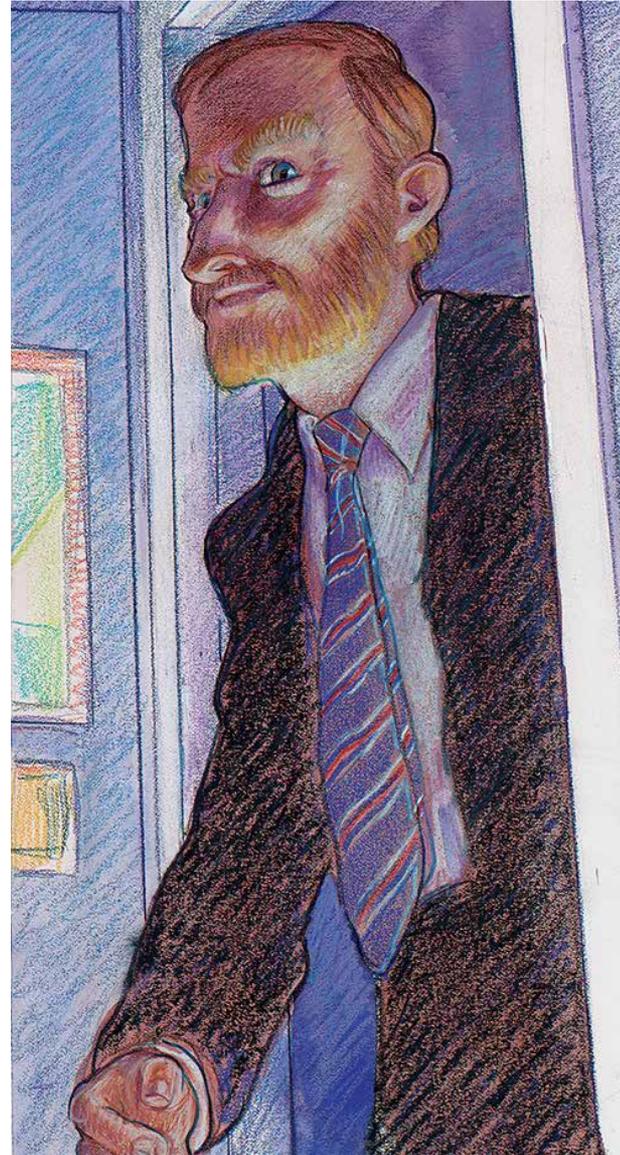
A look of concern came over Max's face. The Professor's voice seemed desperate.

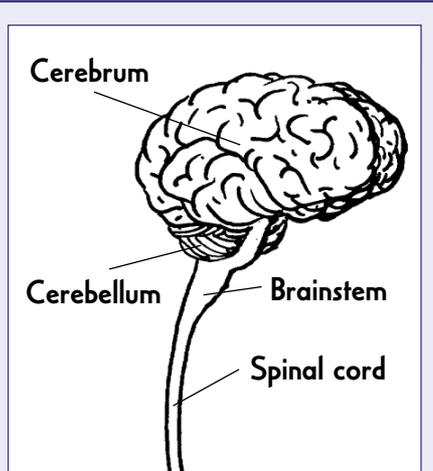
"I need the NeuroExplorers to help me find the Mishigara Man and to clear my name," Professor Ottzinger continued. "I think I know who stole the skull, and I believe I know where it is now."

"Don't tell me...." said Isley I.

"The Skull Caves at Calicoon," finished Isley II.

The Caves! Little children were lost there forever! Mountain lions and snakes guarded the entrance. These were the stories the NeuroExplorers had heard about the Caves at Calicoon.





The cerebrum is the largest part of the brain. It controls learning, memory and thinking. It also is the center of our emotions and senses. The cerebrum even is in charge of directing muscle movements.

The cerebellum stores the programs that help muscles work together smoothly.

The brainstem controls automatic body functions like the heartbeat, digestion, breathing, swallowing, coughing and sneezing.

With a trembling voice, Lakeisha spoke up first. “I thought *you* took the Mishigara Man,” she said to the Professor.

Lakeisha’s bravery inspired Max to say, “And even if you didn’t, why would anyone take it to the Caves?”

Ottzinger looked around the room at each NeuroExplorer. “I assure you, I did not steal the Mishigara Man. As for Calicoon, what better place to hide the stolen skull than a cave where everyone is afraid to go? After the whole affair dies down, the thief simply takes the skull from the cave and is off with it.”

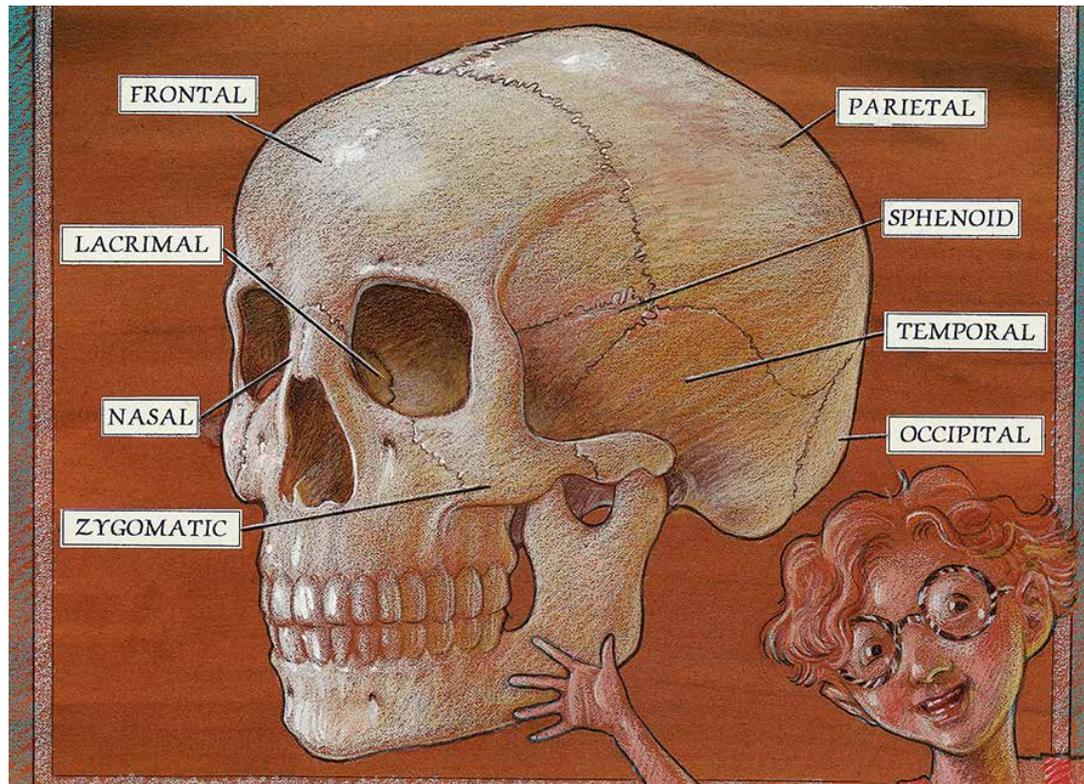
“Exceptional plan!” The Brain said approvingly. “But of what service are we?”

“How can we help?” Max echoed.

“I need the NeuroExplorers to come with me to the Caves to look for the skull. The Caves are very old. There may be many confusing bones. I need a group that is brave, adventurous and intelligent, with special knowledge of skulls and the brain. And you can fit into small spaces better than I. What do you think?”

“Sounds like us,” said Isley I.

“Speak for yourself,” said Isley II.



## Preparing for the Worst

Ottzinger disappeared as mysteriously as he had come, leaving the NeuroExplorers in a haze of wonder.

Kyle acted quickly to snap them out of it. Marching to the front of the room, he pulled down a chart. “We need to go over a few facts,” he said. “There could be lots of skulls at the Caves. We have to be able to tell them apart. Let’s start with some basics. Why is the cranium hard?”

“Isley I should be able to answer that. He’s a hard-head!” Isley II said. Isley I picked up a beach ball and threw it at Isley II. “The cranium has to be hard to protect the brain, which is soft,” he said.

“Good,” Kyle said. “Let’s keep rolling.” Kyle looked over at B.J. who was pretending to play the drums on the sofa. “B.J.?” Kyle said.

“Yes?” B.J. answered.

“Can you stop playing drums for a second and describe the cranial bones to me?” Kyle asked, pointing to the illustration on the chart.

“Playing drums helps me remember,” B.J. said, smiling. “Two layers of hard bone,” B.J. said, striking her sticks on two invisible drums. “There’s a softer layer of bone marrow between them,” she said, finishing with a smash on her imaginary cymbals.

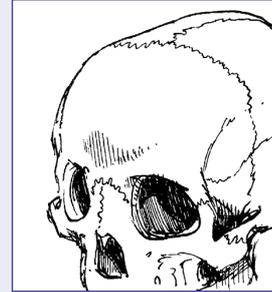
“Laudatory response!” said The Brain.

“Good answer!” Max interpreted.

“O.K.,” Kyle called out. “Let’s try this one. Who can name the major bones of the cranium?”

Lakeisha was quick to answer. “Temporal, frontal, parietal, occipital and sphenoid,” she said rapidly.

The human skull is made up of 22 different bones. The cranium, the top part of the skull that surrounds most of the brain, is made up of eight thin bones joined to form a hard protective “helmet.” The bones of the skull meet at irregular joints called sutures. The jagged-looking edges of the sutures actually provide extra strength to the skull, because the different pieces are locked or “zipped” securely together.



“You forgot nasal, zygomatic and lacrimal,” added B.J., with a drumroll.

Lakeisha shot B.J. a quick look. “He said *major* bones,” she replied.

“Let’s not quibble,” said The Brain.

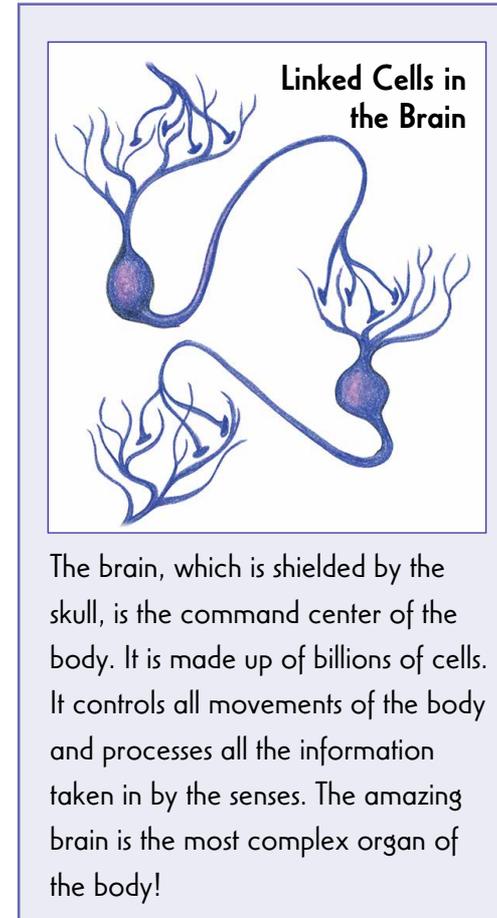
“Cool it,” added Max.

The NeuroExplorers began to get excited. They knew a lot about skulls and the brain. They *would* help find the Mishigara Man. Somehow they believed in Professor Ottzinger, and they could help clear his name. Besides, it sounded like a great adventure. They would go to the Skull Caves at Calicoon!

## The Caves at Calicoon

Agreeing to meet at nine on Saturday morning, the NeuroExplorers went home to explain the plan to their families, collect their gear and get a good rest before starting out on their adventure.

On Saturday, the seven fearless explorers hopped on their bikes, helmets secured and gear stowed in backpacks. They rode the five miles to a place just north of Calicoon and then onto a dirt road to the Skull Caves. Professor Ottzinger was there to meet them. Leaving their bikes outside, they stepped cautiously into a large, dark hole.





The coolness of the rock walls wrapped around the NeuroExplorers like a wet blanket. Their flashlights poked holes through the inky blackness. Kyle knew they were deep into an adventure as he led the club members, behind Professor Ottzinger, into the Skull Caves at Calicoon.

Suddenly Ottzinger stopped, turned and said to the NeuroExplorers, “There’s one thing Kyle and I haven’t told you.”

A shiver passed electrically through the whole group.

“Show them the map, Kyle,” said Professor Ottzinger.

“I have a map of the Caves,” Kyle explained, unfurling a rolled paper. He shined his flashlight on the opened map as Lakeisha and B.J. held it down at the edges. “One of the reasons the Professor needed us for this job,” Kyle said, “is because the Caves are laid out like...”

“The sinuses in a cranium,” Ottzinger finished.

“The sinuses?” asked Isley II.

“Don’t be slow, Isley II,” said Isley I. “You know what the sinuses are. Everyone has them. They’re the large air spaces inside the bones of the face.”

“Yes, of course,” Lakeisha said quickly, “frontal sinuses behind the eyebrows, sphenoid sinuses behind the nose, maxillary sinuses behind the cheeks, and...”

“Ethmoid sinuses, inside the nose,” finished Max, “the four main sinuses.”

The Brain spoke up. “Not quite,” he said. “The sinuses are paired, bilateral and roughly symmetrical, so technically there are eight sinuses, although the sphenoids are midline and appear as a single entity.”

Professor Ottzinger squinted hard as he stared through the darkness at The Brain. “What did you say?” he asked.

“The Brain says that there are two of each sinus, one on either side of the cranium. The sphenoid sinuses are right in the middle of the cranium and look like just one sinus,” Max explained.

“Right you are,” Ottzinger said slowly. “Good point.”

“It’s much easier if you just look at this drawing,” Kyle said, pointing to his papers. “Here is a picture of the sinuses, just as we described them.



And here is the map of the Caves. Isn't it amazing? They're almost alike! Anyway, we're going to split up," Kyle went on, handing out small versions of the map to each NeuroExplorer. "Isley I and II will start with Professor Ottzinger in the frontal sinus. B.J. and Lakeisha will begin in the sphenoid sinus, and Max, The Brain and I will start in the maxillary sinuses."

"What about the ethmoid?"

B.J. asked.

"We all meet there," Kyle said.

"Yes, and bring anything you find that you think could be the missing skull of the Mishigara Man," Professor Ottzinger added.

"Doesn't sound too difficult," Lakeisha said.

"Unless someone is guarding the Mishigara Man and doesn't want us to take it away," B.J. said. "Then it could be *highly* difficult!"

The Brain calmly folded his map, tucked it into his pocket and smoothed his hair with the palm of his hand. "Even a novice prognosticator would predict a daunting intellectual and physical task."

Everyone looked at Max. He shrugged his shoulders. "I guess he means we have our work cut out for us!" he said.

The sinuses are connected to the cavities of the nose by tiny tunnels about the width of a pencil lead. The sinuses are lined by thin layers of cells that filter and moisten the air we breathe. Sinuses easily can become blocked after a bad cold or bout with allergies. This can cause headaches or stuffiness.





## Problems in the Frontal Sinus

Climbing slowly, Isley I and II led Professor Ottzinger up an old path to the highest cave — the frontal sinus. The twins pulled themselves over the final stone wall and stood facing a deep, dark open chamber. “This must be it,” said Isley I.

“The frontal sinus,” finished Isley II.

Suddenly, Isley I was hit from behind. Sprawling forward, he lurched, grabbing Isley II by the arm and spinning him around. An instant later, the air was filled with wild sounds of something beating and fluttering. Wings seemed to sprout from the air, surrounding the two NeuroExplorers.

“Stay down!” yelled Isley II, throwing up his arms to cover his head.

“What is it?” cried Isley I.

“Bats!” Isley II answered. “Must be a million billion bats!”

Isley I and II covered each other beneath the storm of flying mammals. It seemed like an hour before the cave was quiet again. Isley I lifted his head, scraping sand off his cheek. “I think they’ve gone,” he whispered.

Isley II refused to lift his head. “I hate bats,” he mumbled to the ground.

“Look, Isley II, look at this!” his brother suddenly shouted.

Peeking over his arm, Isley II squinted, adjusting to the dark cavern. Isley I was holding a small skull! “Could this be the Mishigara Man?” he said.

Isley II shook his head. “I don’t know,” he said, “it looks kind of small. Let’s ask Professor Ottzinger. Hey, Professor...”

Isley II looked at Isley I. “Ottzinger’s gone!” they both yelled.

“Don’t yell!” they both said together again.

Too late. In another second the cave was again alive in a blizzard of bats. Scrambling to their feet, the twins took off, hundreds of bats shooping them from the frontal sinus.

Clutching the tiny cranium, running as hard as he could, Isley I couldn’t help thinking, *What happened to Ottzinger?*

## Snakes in the Sphenoid

Lakeisha loved chess, karate and being a NeuroExplorer. But she wasn't crazy about heights, and she hated snakes. Yet there she was, sitting high atop a boulder in the middle of a dark cave, surrounded by swampy water filled with snakes. She looked at B.J. "Walking across that rotten old plank was not a very good idea, B.J.," she said.

"How could we know it would collapse? At least we landed on this huge rock," B.J. replied.

Lakeisha listened to the hissing from the murky water below. She thought she could see long, thin forms slithering through the slime. "Snakes!" she moaned.

"Don't think about the snakes," B.J. said bravely, tapping her fingers on her flashlight.

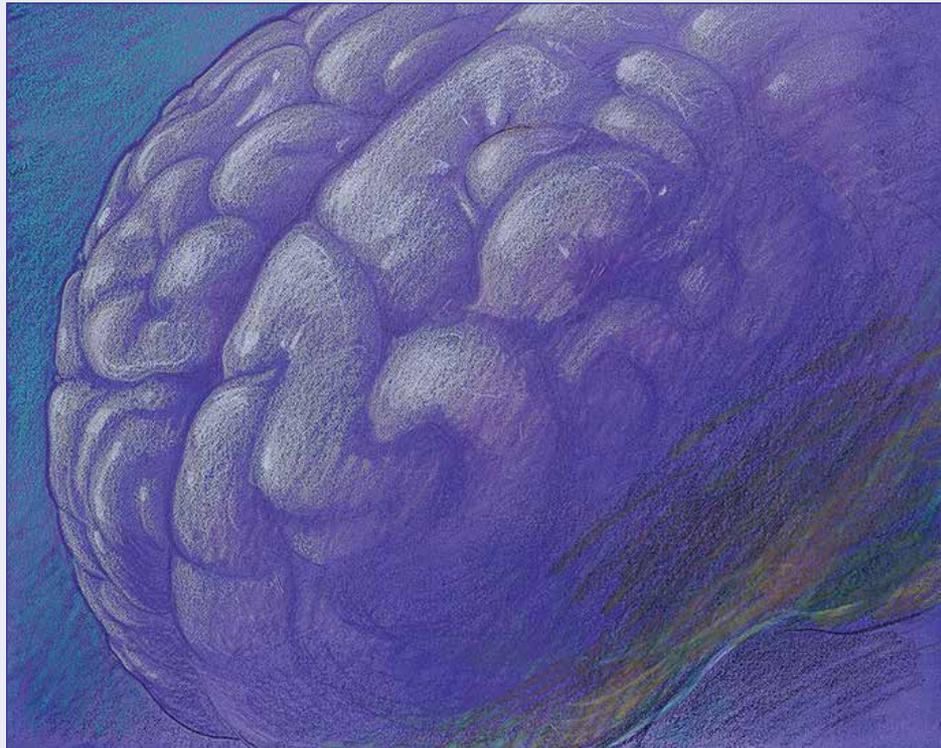
"Hey! Think about that skull!" Lakeisha blurted out. She had spotted a cranium stuck in the side of the wall across the cavern.

"You're right!" B.J. said, inching forward to get a better look. "That could be the Mishigara Man." B.J. leaned too far. In a second she was sliding across the rock face, down the edge of the boulder. Lakeisha reached out. Their hands clasped for a second, but B.J. slipped over the edge and down, down into the darkness.

Lakeisha heard a splash. "B.J.!" she yelled. "The snakes! Swim! Get out! B.J.!" In her panic, Lakeisha lost her balance, and in another instant she, too, was sliding down the boulder. The cold, murky water greeted her. Lakeisha struggled for a second until she realized that she was fighting B.J. Their arms were wrapped around each other.



The cerebrum is the thinking part of the brain. The cerebrum in most mammals looks wrinkled. The grooves or wrinkles are called sulci. The rounded folds on the surface of the cerebrum are called gyri. This folding allows more tissue that is important for thinking to fit into the cranium.



“It’s okay, Lakeisha,” said B.J., slowly relaxing her grip.

“But the snakes!” Lakeisha said, still horrified.

“They’re vines,” B.J. said, almost laughing. “Not snakes. Just big vines.”

“But that hissing?” Lakeisha insisted.

“Water coming out of the rocks over there,” B.J. answered. “Come on, let’s swim over to that skull. It could be the one we want.”

In a few minutes, B.J. and Lakeisha had the skull and pulled themselves out of the water. “That doesn’t look like a human cranium,” Lakeisha said. “Too small. Not enough impressions inside.”

“Impressions?” B.J. asked.

“From folds in the cerebrum. Advanced brains, like humans’, have more of the wrinkled thinking part. You know that,” Lakeisha said.

B.J. tapped her right foot as if she were trying to pump up her memory. “That’s right,” she said, finally. “And to fit all that cerebral tissue inside the cranium, the brain surface is folded over many times. Those rounded folds are called gyri, and they make marks on the inside of the cranium. So the more marks, the more advanced the brain.”

“Right,” Lakeisha said quickly, turning the skull over in her hands. “This one can’t be human.”

“Should we look around some more?” B.J. asked. “Uh-oh!” she said, pointing to something moving on the cave floor.

Lakeisha looked down. A snake was slicing through the gravel toward them. Its tongue flickered quietly.

Without a word, the two girls turned at the same time and carefully walked away. “I think we’d better just head for the ethmoid and see what the others have found, don’t you?” said Lakeisha when they had put some distance between themselves and the snake.

## The Brain Runs into a Wall

“What did The Brain say?” Kyle asked Max.

“He thinks we’re lost,” Max said with concern.

Kyle studied the map for the tenth time. “I don’t know how we could be lost. I followed the map exactly. We should be standing in the maxillary sinus cave right now.”

Max paced back and forth. Kyle studied the map. The Brain was staring at a wall.

“Brain,” Kyle said impatiently, “you *could* help us over here, instead of staring at the wall.”

“Prefabricated, I would guess,” The Brain said without turning. “Hardly a Pliocene artifact.”

Even Max was confused. “Brain, what are you talking about? We need your help to find the maxillary sinus!”

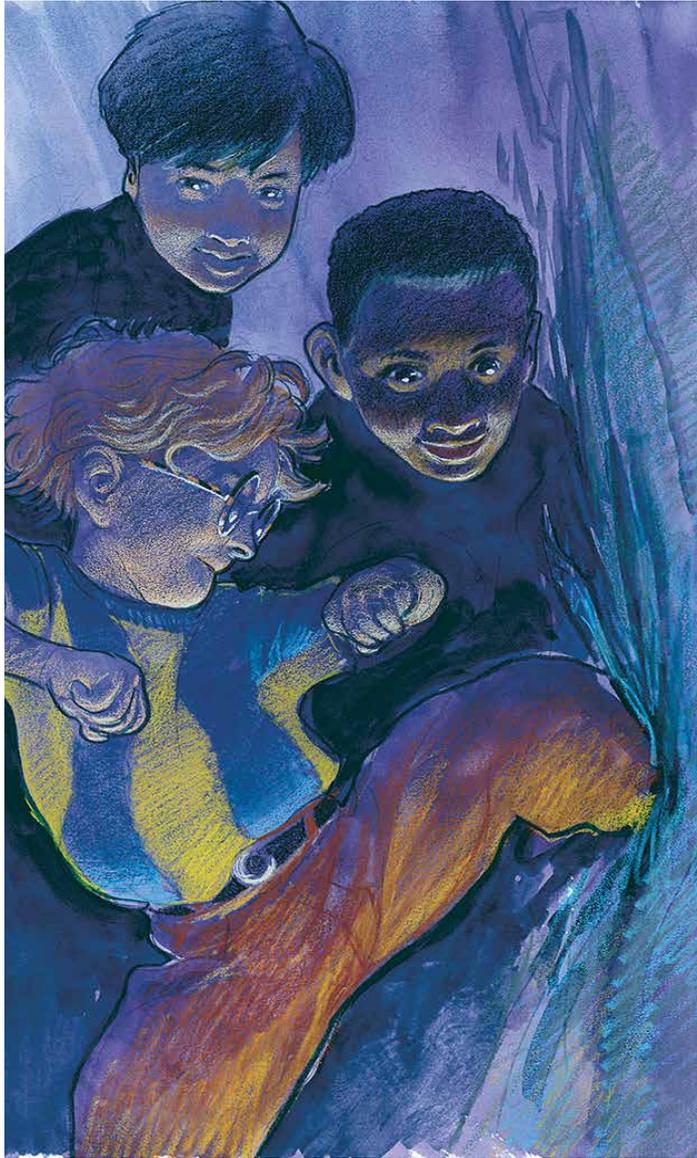
“I’m trying to do just that,” the Brain answered, scratching the wall. “This cave wall is ersatz, spurious, unauthentic.”

Max grabbed his friend by the shoulders and shook him. “What do you mean?” he said. “Can’t you speak plain English for a change?”

The Brain faced his friends and said, “This wall is not rock. It’s not real. A fake plaster copy. Phoney baloney! How’s that?... It may be hiding the maxillary sinus cave.”

Max almost hugged him. “I’m sorry, Brain. How could I have doubted you?”

Running across the floor of the cave, Kyle kicked the fake wall with his foot, opening a large hole in the plaster.



“That’s it!” Kyle said, leaning through the opening. “This *is* the maxillary sinus. Let’s go!” The NeuroExplorers stepped through the opening into a great cavern.

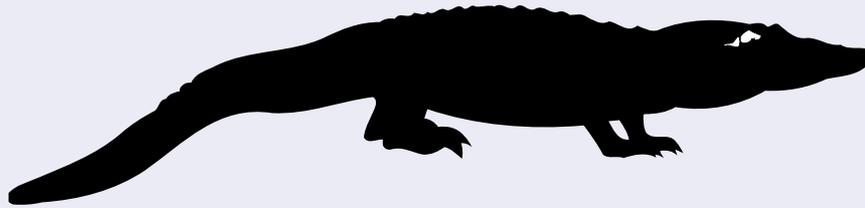
## Sorting Skulls

After dashing out of the frontal sinus cave, Isley I and II had tumbled down a long rocky slope, jumped a small stream and ducked through two long tunnels. Finally, they dragged themselves into the ethmoid area — and there was Ottzinger, crouching over a pile of bones with Lakeisha and B.J.

Isley I looked at Isley II before he spoke. “Professor Ottzinger?” he said.



An animal's intelligence is related to the amount of folds on its cerebrum. Intelligence also is related to how large the animal's brain is, compared to its body. Some large animals, such as alligators, actually have very small brains, compared to the overall size of their bodies. Others, such as chimpanzees or humans, have relatively large brains, compared to their body sizes.



Isley I looked at Isley II before he spoke. “Professor Ottzinger?” he said. The darkly clad man twisted his neck to look at Isley I. “Yes? Oh, I’m glad you finally made it,” he replied.

“What are *you* doing here?” asked Isley I.

“Where did you go? We thought you were with us,” finished Isley II.

Ottzinger shrugged and said, “Oh, uh, I... I found a short cut, and... I thought you were right behind. Where have you been?”

Isley I narrowed his eyes as he looked beyond Ottzinger. He hadn’t seen any other way to get here. Why had Ottzinger left them, and where had he gone? “We were trapped with the bats!” he almost shouted.

“Bats?” said the Professor. “Oh, dear, I didn’t mean to... Say, what’s that you’ve got? Let me see that skull.”

Isley I and II reluctantly added their cranium to the pile.

“Sit down, you guys,” Lakeisha said. “We were just talking about these skulls.”

The Isleys sat down, but they were uneasy.

“None of these is the Mishigara Man, I’m afraid,” Professor Ottzinger said, turning a skull over in his hands.

“How do you know?” B.J. asked. “Can you tell if a skull is from a man by its size? Humans are the most intelligent animal. Are human skulls the biggest?”

“Oh, no,” said Ottzinger, “bigger cranium size doesn’t necessarily mean more intelligence. A horse’s head and cranium are much larger than a human’s, and horses certainly aren’t as intelligent as we are. Size alone doesn’t tell the whole story.”

Lakeisha spoke up quickly, “I could tell a horse’s skull from a human cranium.”

“Of course,” Ottzinger answered. “That’s an important point. The shape and appearance of the cranium is the first factor. It has to *look* like a human skull and be the right size for a human. Then there are other factors....”

“So what kinds of skulls *are* these?” Isley I interrupted.

“The smallest one is a bird,” said Lakeisha, “and then there’s a large reptile, a goat and a human.”

“Human?” said Isley I.

“A human being?” asked Isley II.

“That’s right,” said Professor Ottzinger, “but it isn’t the Mishigara Man, because it’s had some dental work — and there were no dentists in Mishigara’s time!”

“But who... how?” Isley I was stuttering.

“Take it easy,” said B.J. “It’s probably over a hundred years old and belonged to some miner, or...”

“Some explorer,” finished Lakeisha.

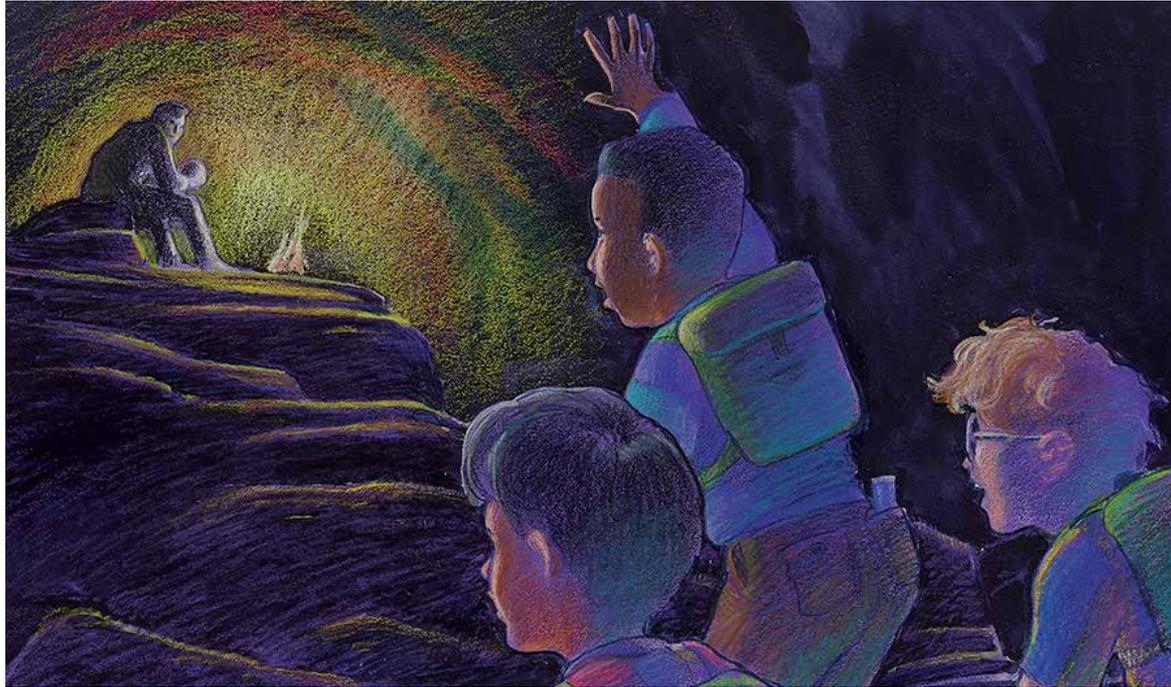
Isley I and II looked at each other. The cave was cold, damp and scary. They had been frightened by hundreds of bats and now they were sitting with a pile of skulls, one of which belonged to an *explorer*.

“What time do we go home?” Isley II asked.

## Light at the End of the Tunnel

In the meantime, Kyle, Max and The Brain were wandering in a huge cavern. They couldn’t even see the ceiling. Echoes sounded far away. They could hear bats flying high above, but they couldn’t see them.





The boys might have been lost forever, except that Kyle had brought his father's infrared binoculars. The super-binoculars allowed him to see in the dark, far beyond their flashlight beams. For the last fifteen minutes he had been leading the others, following a small glimmer of light he'd spied on a cliff, far off to their right.

Finally, they approached the source of the light. Creeping silently to the edge of a ridge, they saw a man sitting before a small campfire. It looked like Professor Ottzinger. And it looked like he had the Mishigara Man in his hands!

Max's "Hello" echoed through the canyon.

The man looked up and saw the boys. Suddenly, like a big black bird of prey raising its wings, he leaped up, threatening the intruders who unexpectedly came upon him.

“Professor!” Kyle cried out. “It’s only us, the NeuroExplorers!”

“Who?” Ottzinger called, towering over the campfire.

“Us — Kyle, Max, The Brain. Professor Ottzinger, it’s *us*,” Max said again.

Ottzinger tilted his head slightly and lowered his chin. Slowly he sat down, rubbing his neck with his free hand. In the other hand he tightly clasped a skull. “Oh, yes,” he stammered. “I’m sorry. You startled me.”

They advanced slowly toward the campfire. The Brain was uneasy.

“How did you get here?” Kyle asked. “I thought you were with the Isleys in the frontal sinus caves.”

Ottzinger glared hard at Kyle. “Yes, well, we got separated, and I wound up here.” Ottzinger looked around. The Brain was studying the maps.

“You found the skull?” Max asked, pointing to Ottzinger’s possession. “Is it the Mishigara Man?”

Ottzinger stared straight ahead, giving no response.

“Could be,” said The Brain, whirling around to face the suspicious man. “In fact, it is more likely that the skull is the Mishigara Man than that *you* are Professor Ottzinger!”

“Brain?” Max said. “What are you saying?”

“It is completely improbable that Ottzinger could arrive here from the frontal sinus caves so quickly. Not according to this map. Not unless he has developed a way to walk on water and over a bottomless chasm!”

Kyle looked at Max. “Is The Brain saying what I think he’s saying?” Max swallowed hard and nodded.

The mysterious Ottzinger jumped and ran. No one dared to follow him.

Framed against ancient cave walls by scant firelight, the three Neuro-Explorers stood silently, trying to make some sense of what was going on.

## Two Many Professors

The two girls and the Isleys were in the ethmoid cave waiting for Kyle, The Brain and Max. Professor Ottzinger was standing to the side, talking with them about differences among the skulls they had found. “You NeuroExplorers are quite good. Quite smart. Maybe too smart,” he said.

The girls and the twins fell silent. What did Ottzinger mean? “*Too smart?*” What was he talking about now?

Their wondering was suddenly interrupted by a noise — someone running toward them. A man burst in upon the group. It was Professor Ottzinger... But the Professor was already here! Now there were two Ottzingers!

*Two Ottzingers?* There they were, like two reflections. Only, which one was real, and which one was the reflection?

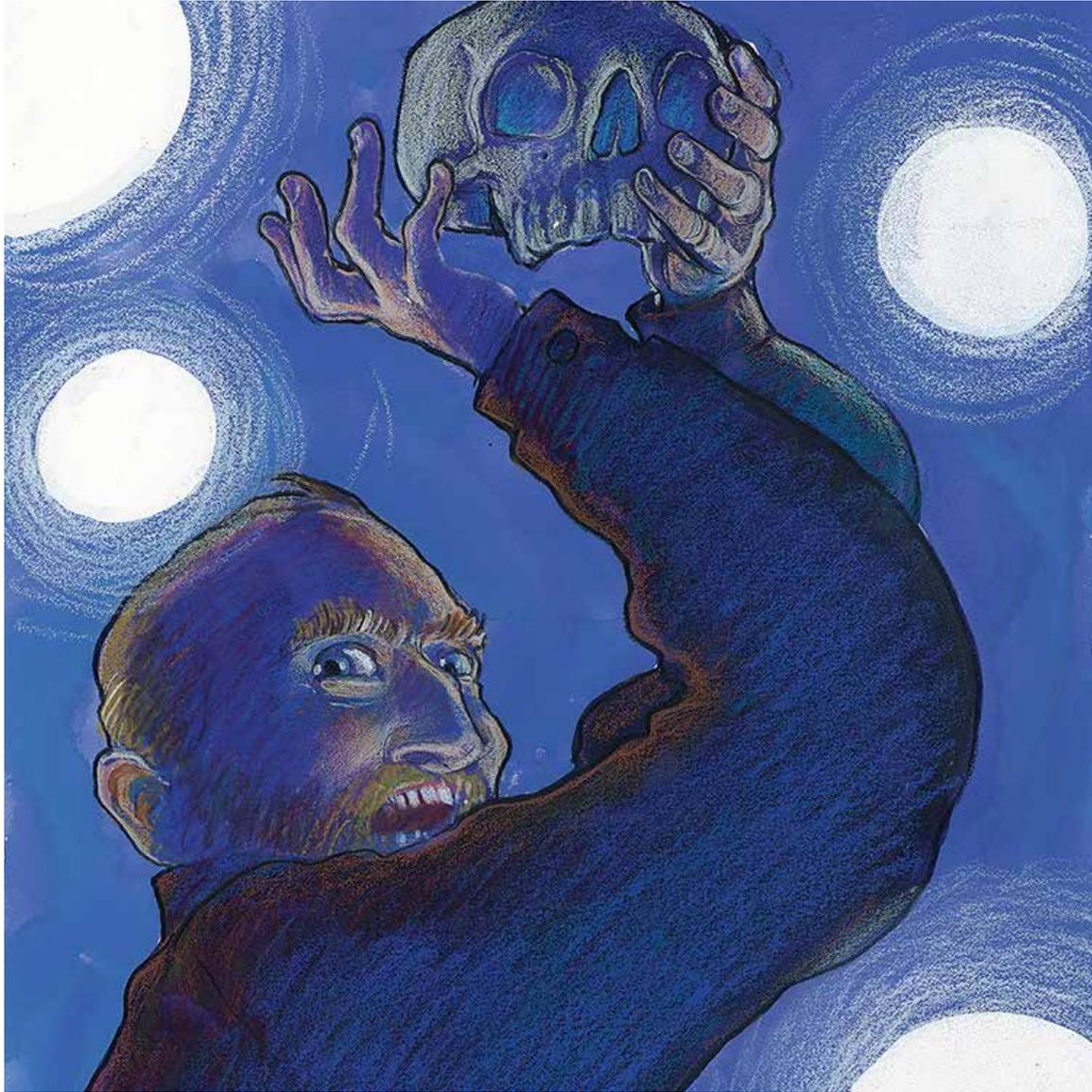
Kyle, Max and The Brain arrived on the scene just in time to witness the amazing picture. They stopped and stood stone still. What was this double vision?

The Brain looked at the two Ottzingers and spoke. “Monozygotes,” he said.

“Max,” Kyle ordered, “translate!”

“Twins!” Max snapped back. “They’re identical twins, just like the Isleys!”





## The End of Darkness

Kyle looked quickly from one Ottzinger to the other. They looked exactly alike, right down to the clothing — except for one item. The Ottzinger who just ran in was clutching a human-looking skull.

“The Mishigara Man!” B.J. yelled. The echo of B.J.’s words resounded a thousand times above their heads and beyond, shrinking to a small, distant whisper.

The Ottzinger without the skull spoke first. “Peter,” he said, “I want the skull. Give it back now, and I’ll let you go, no questions asked.”

The other Ottzinger growled, “And who’s going to make me? You and these ‘Noorow’ explorers?”

Isley I and II jumped up, but Kyle held them back.

Professor Ottzinger held up his hand. “Easy, boys,” he said. Then he turned back to his brother. “Peter, this is your last chance,” he said.

“No!” his brother called out. “I discovered the skull and I’m going to keep it!”

“I thought we settled all that,” the Professor responded. “Credit was given to everyone who worked on the dig. But the skull belongs at the University.”

“Not if I can help it,” said his brother, holding the skull high above his head and backing away from the group.

Kyle had had about all he could take. Stepping forward, he spoke accusingly to Professor Ottzinger, “You haven’t told us everything, Professor!”

Professor Ottzinger turned toward Kyle and smiled. “You’re right, Kyle,” he said, “and I’m sorry, but it was necessary.”

Peter Ottzinger turned to run. Then, suddenly, the cave turned brilliant with light, practically knocking the NeuroExplorers off their feet. Peter Ottzinger stopped and slumped to his knees. The NeuroExplorers shielded their eyes.

Groping for an answer, they squinted through the glare. The sun hadn't broken into the Caves at Calicoon. Those were searchlights — police searchlights.

## **A Plan for Mishigara Man**

“My brother just couldn't accept that it wasn't a single person's discovery, and that the skull belonged to science,” Professor Ottzinger said to the NeuroExplorers when they visited his office at Dargate a few days later. “He wanted to sell the skull to the highest bidder.”

“I still don't understand why you needed *us*.” Lakeisha said. “Why not just bring the police?”

The Professor shook his head. “Peter's been very successful in keeping away from the police. I had to get him trapped somewhere. I guess I'd better tell you the whole story. I knew my brother would have hidden the skull somewhere in the Caves at Calicoon. I let him know that I was taking a group of students on a field trip to the Caves. If my hunch was right, he would be there to protect his precious skull.”

“A school field trip? I'm insulted, I think,” Lakeisha said.

“Oh no, quite the contrary!” Ottzinger said. “I didn't bring just any school kids. I brought the NeuroExplorers. Without your intelligence, courage and skills, I don't think we would have flushed Peter out.”

“Right,” said Isley I.



“Not you, Isley I,” said Isley II. “He was talking about skill and intelligence.” His brother poked him in the ribs.

“I’m sorry about the bats, Isleys,” Professor Ottzinger said. “I didn’t know that would happen. I had to go ahead to be sure of Peter’s location.”

“Well, your brother sure scared us when *we* found him,” Kyle added.

“I had the police all around the caves,” Ottzinger continued, “so I believed we were safe. Besides, Peter may be a bit greedy, but he’s not a violent man.”

“But why the Caves?” Lakeisha interrupted.

“My brother and I played there when we were children,” Professor Ottzinger replied. “We even built some secret walls to hide passages. It was the most logical place for Peter to hide the skull.”

The Brain, with a small, crooked smile, looked around the room and then at Professor Ottzinger. “There remains only one query,” he said slowly, edging his way over to the prized skull. Everyone fell silent and looked at The Brain.

“Where’s the *rest* of Mishigara Man? Shouldn’t we embark upon an expedition to unearth the remainder of the skeleton?”

Not waiting for a translation, the group began to move toward him.

“Let’s make a plan,” continued The Brain, “to extricate...”

Professor Ottzinger had to pull the NeuroExplorers, one by one, off of The Brain as his words faded into the noisy room.



## Glossary

**Alzheimer's disease** (ALLZ-hy-merz diz-eez) - a disease, found especially in older adults, that destroys brain cells so that people can no longer remember or think properly

**archaeologist** (ar-kee-AHL-uh-jist) - a scientist who studies the remains of past human life

**bilateral** (by-LA-ter-ul) - having two sides, as the right and left sides of the body

**brain** (BRAYN) - the control center of the central nervous system, located within the skull and attached to the spinal cord; the command center of the body

**cerebrum** (suh-REE-brum) - the large, domed top area of the brain where thinking, learning, memory, and decision-making occur

**cranial bones** (KRAY-nee-ul) - the bones that make up the skull

**cranium** (KRAY-nee-um) - the skeleton of the head except for the jaw bone

**Darwin, Charles** (DAR-win) - a naturalist in the 1800s who studied plants and animals around the world and is known for his book, "On the Origin of Species"

**epilepsy** (EH-pih-lep-see) - a condition brought about by sudden changes in the brain that affect a person's awareness and actions, often with jerking movements of the body and limbs, for short periods of time

**ethmoid bones** (ETH-moyd) - the bones forming the roof of the nasal cavity, containing air chambers and many small holes

**ethmoid sinuses** (ETH-moyd SY-nus) - small air-filled spaces within the ethmoid bones, on either side of the nose

**fracture** (FRAK-cher) - a break, especially of a bone

**frontal bone** (FRUN-tul) - the front bone of the skull, forming the forehead

**frontal sinuses** (FRUN-tul SY-nus) - air spaces, lined with mucous membrane, within the frontal bone above the eyes

**gyri** (JYE-rye) - the outward folds on the surface of the brain; a single fold is called a gyrus

**impression** (im-PREH-shun) - an indentation, or dent, in a surface

**lacrimal bones** (LA-kri-mul) - small bones at the inside edge of the eye sockets, with small openings to carry tears

**maxillary bone** (MAK-sih-lair-ee) - upper bone of the mouth which holds the upper teeth and forms the roof of the mouth; the upper jaw bone

**maxillary sinuses** (MAK-sih-lair-ee SY-nus) - air spaces in the maxillary bone, in the cheek area of the face

**midline** (MID-lyn) - an imaginary line that divides the body into right and left halves

**monozygotes** (mah-no-ZY-gotes) - identical twins

**nasal** (NAY-zul) - relating to the nose, also the name of the bone at the top part of the nose

**nervous system** (NER-vus sis-tum) - the brain, spinal cord and network of nerves in the body

**neurologist** (nu-RAHL-uh-jist) - a medical doctor specializing in the diagnosis and treatment of disease and injury in the nervous system

**neurology** (nu-RAHL-uh-gee) - a branch of medical science which deals with the nervous system

**neuroradiologist** (nu-ro-ray-dee-AHL-uh-jist) - a medical doctor who uses pictures of the inside of the body (X rays and others) to identify injury and disease in the nervous system

**neuroscience** (nu-ro-SY-ens) - a branch of science related research on the nervous system

**neurosurgeon** (nu-ro-SUR-jun) - a medical doctor who specializes in operating on the brain, spinal cord and nerves

**neurosurgical nurse** (nu-ro-SUR-ji-kul NURS) - a nurse who is part of the team of people who perform surgery on the nervous system with a neurosurgeon

**occipital bones** (ok-SIP-ih-tul) - bones that form the back of the skull

**parietal bones** (puh-RY-uh-tul) - a pair of bones that form the wall and roof of the skull

**physician** (fih-ZIH-shun) - a medical doctor

**sinus** (SY-nus) - a space or chamber containing air or fluid within the bones of the skull

**skeleton** (SKEL-uh-tun) - the framework of bones that support the body

**skull** (SKUL) - all the bones of the head, including the cranium and the facial bones

**skullduggery** (skul-DUG-er-ee) - trickery; underhanded behavior

**sphenoid bone** (SFEE-noyd) - a dragonfly-shaped bone on the inside of the skull behind the eyes

**sphenoid sinuses** (SFEE-noyd SY-nus) - cavities in the sphenoid bone, connecting with the nasal cavities

**sulci** (SUL-kye) - grooves in the surface of the cerebrum; a single groove is called a sulcus

**symmetrical** (si-MEH-tri-kul) - having one side the same as the other side

**temporal bones** (TEM-puh-rul) - bones on both sides of the skull next to the forehead and the eyes, in the area of the temples and partly covered by the ears

**tissue** (TIH-shoo) - many cells of the same kind, joined together to do a specific job

**zygomatic bone** (zy-go-MA-tik) - the cheekbone

## About the Authors and Illustrator

**Grace Boyle, M.S.**, lead author, was a teacher in Hempstead, New York for 20 years and received her degree in Elementary Administration from Hofstra University. She developed, coordinated and implemented a program for gifted and talented students in the Hempstead school system. Ms. Boyle has written curriculum materials for several textbook publishers, specializing in activity books that encourage children’s critical thinking skills and stories that promote scientific curiosity. Currently, Ms. Boyle is a freelance writer. Her son, Dr. Thomas P. Boyle, a Florida radiologist, serves as consultant for her science-based writing.

**Judith Dresden, M.S.**, originally from New York and New England, formerly conducted educational research and evaluation for public and private schools, specializing in language arts. Editorial work with a publishing company also led to her interest in writing and editing stories and science activities for young students. As a BCM faculty member, she served as director of the BrainLink project, which brings the complex concepts of neuroscience within the grasp of children. Other activities involved promoting minority student access to careers in science and the health sciences.

**Barbara Tharp, M.S.**, originally from California and Oklahoma, once worked for the FBI in Washington, D.C., and later was an economic analyst for an oil company. More recently, she has followed her primary interest of working with children, serving as an elementary school teacher and specializing in her favorite subjects, science and math. Currently, she serves as a full-time faculty member at BCM. In addition to creating instructional materials, she directs science and math teacher enhancement programs with classroom teachers from Houston and throughout the U.S.

**Nancy Moreno, Ph.D.**, originally from Wisconsin and Michigan, is a biologist with a specialization in botany. She studied and classified neotropical plants in Mexico before completing her doctoral degree. Her current interests focus on the involvement of scientists in the education of students and teachers. She designs curricula, conducts workshops for teachers on creative methods for teaching science and using technology, and is involved in science education at all levels.

**T Lewis**, the illustrator, was born in Texas but has traveled extensively, living in such exotic locales as Africa, Switzerland and Alaska. Currently living in a small town in the state of Washington, where he and his wife are raising their young son, he “commutes” from time to time to Houston. He holds a bachelor of fine arts degree and has been a teacher in Alaska, 200 miles above the Arctic Circle. During this time, he also created paintings that are included in a Smithsonian Institute collection of Alaskan art.

While his broad range of professional artwork has appeared in many formats, T Lewis is especially fond of creating illustrations for children. Recent books bearing his work are *The Forgotten Helper*, *Bedtime Rhymes from Around the World* and *Cinderella: The Untold Story*. He has drawn the “Mickey Mouse” comic strip for Disney Productions and co-authors the comic, “Over the Hedge,” which appears in newspapers daily through United Feature Syndicate.





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ISBN: 978-1-888997-96-5  
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