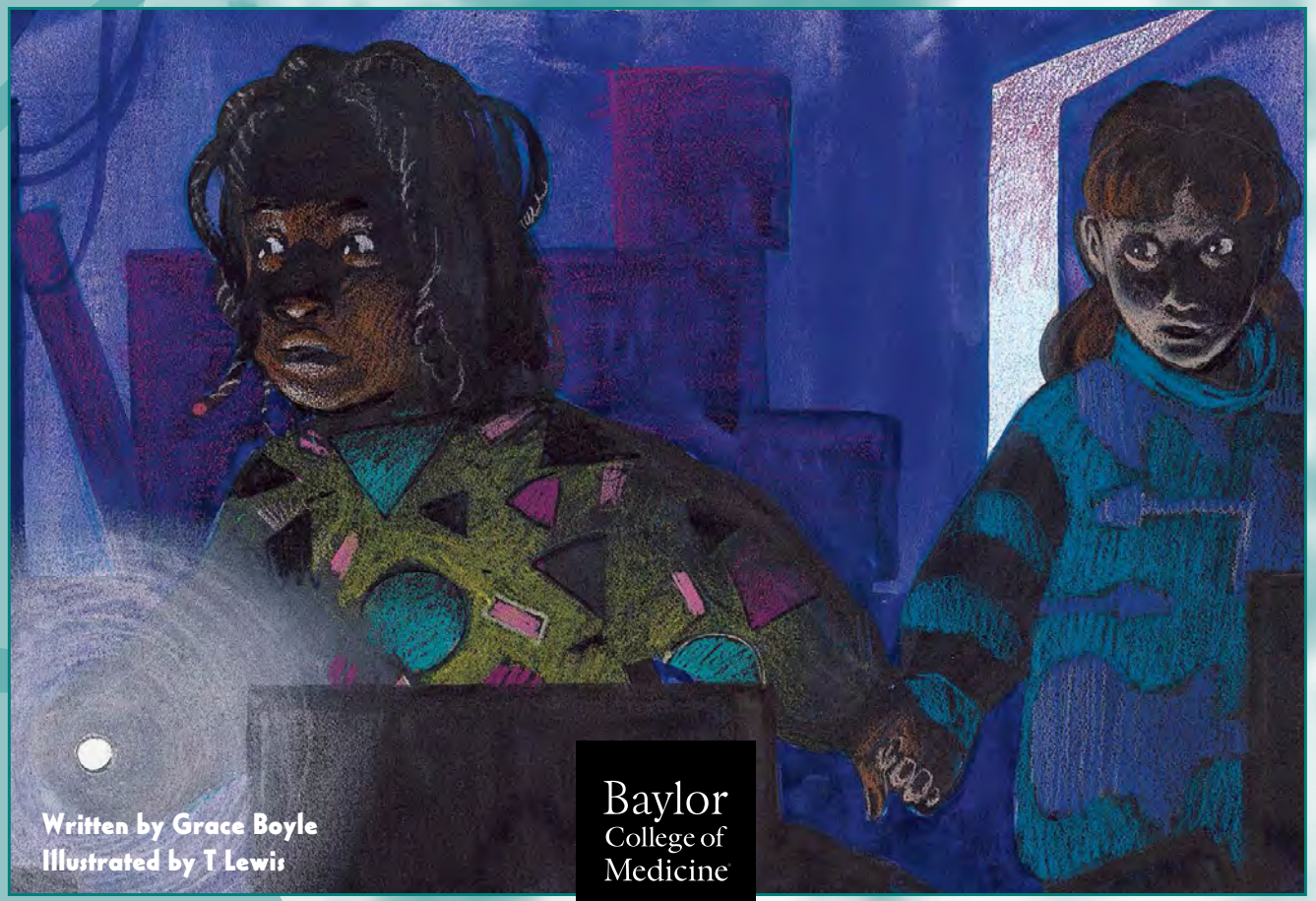
BrainLink®

THE SENSORY SYSTEM

THE COOKIE CRUMBLES

A Case of Sensory Sleuthing



Written by Grace Boyle
Illustrated by T Lewis

Baylor College of Medicine

The Sensory System

THE COOKIE CRUMBLES

A Case of Sensory Sleuthing

Written by Grace Boyle
Illustrated by T Lewis

Revised by Judith Dresden and Barbara Tharp
Science notations by Nancy Moreno

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

ISBN: 978-1-944035-11-2

Fourth edition. First edition published 1993.
Printed in the United States of America.

ISBN: 978-1-944035-11-2

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

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.

Authors: Grace Boyle. Revisions by Judith Dresden and Barbara Tharp. Science notations by Nancy Moreno.
Illustrator: T Lewis, B.F.A.
Editor: James Denk, M.A.
Designer: Martha S. Young, B.F.A.

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: Scott Basinger, Ph.D.; Cassius Bordelon, Ph.D.; Dane Chetkovich, M.D., Ph.D.; Celia Clay, M.P.H.; Sara Copeland; Michael Levy; Ilene Schwarz, M.Ed.; and Quentin Smith, M.S. 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.

Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, Texas 77030
713-798-8200 | 800-798-8244
edoutreach@bcm.edu | www.bioedonline.org

Baylor College of Medicine®

Contents

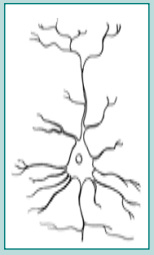
How the NeuroExplorers Club Began

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.

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-"?



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.

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-Ruíz 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.

A Friend Returns

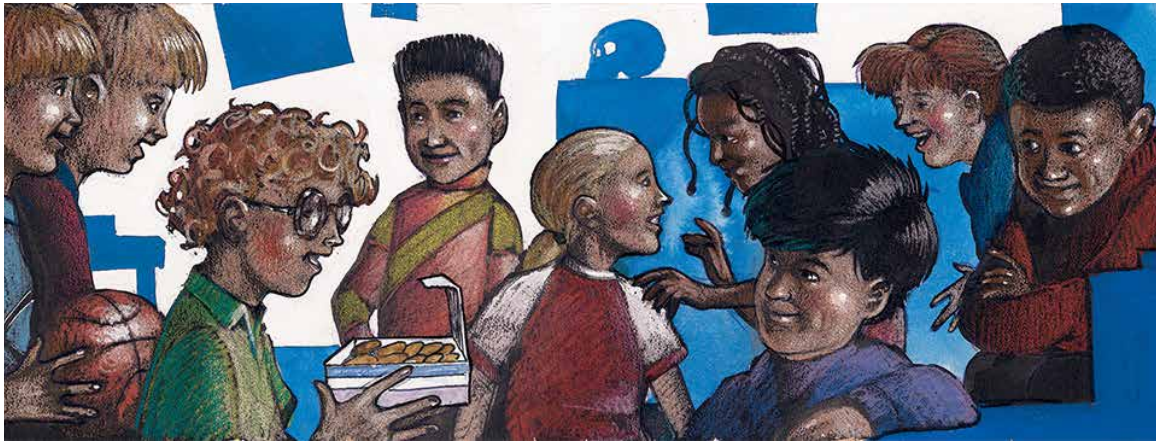
Josh Kavil couldn't believe it. He looked around Kyle Camacho's basement. Here he was with his friends, at last. He was glad to be back!

Kyle was tapping on the blackboard at the front of the room. "NeuroExplorers," he announced, "how about sitting down so we can start the meeting?"

"Any new mysteries?" Lakeisha asked as she made a crushing chess move against her hand-held computer.

"Guess not," Kyle said, "but it still is a very important meeting. As you see, Josh is back, and he finally is going to be an official member of our club!" Everyone yelled and clapped so much that Kyle couldn't say another word.

All the NeuroExplorers knew what had happened to their friend, Josh. He was hit by a car while riding his bicycle eight months ago. He wasn't



wearing a helmet, and he hit his head when he fell. After an operation to repair damage to his brain, he was in the hospital for a month. He spent two more months in a rehabilitation center. and then continued to go back there every day for therapy. Some of the kids had kept in touch with Josh, so he knew how they'd started the NeuroExplorers Club after his injury.

Josh held up his hands to quiet his friends. "Thanks for the greeting," he said, grinning. "Believe me, I'm happier to be here than you are to see me! And I brought some cookies for everyone, to thank you for sticking by me all this time."

"All right! Give me cookies and I'll follow you anywhere!" Isley I cried as he leaped to get the first cookie.

"Good. Maybe you'll quit following *me* around for a change," Isley II teased his brother. He grabbed a cookie for himself.

While Kyle passed the box of cookies around, Josh answered everyone's questions about his progress. The NeuroExplorers were so glad to see him, they forgot about their wish for a new mystery or adventure.

Cross-Wired

"Hold it a minute," shouted Kyle when everyone was talking to Josh at once. "Let him answer a question without interruption." The room became quiet after B.J. played a drum roll on the table top.

"Well, you know that for a while, I couldn't move my leg and arm at all. Boy, was that scary! But at the rehab center I learned to walk again. Look," he said, walking across the room, "I don't even need to use a cane anymore. And my right arm is working again, too!"

"Your right arm?" asked B.J. "I thought you cracked the left side of your skull and hurt the *left* side of your brain. Why wasn't it your left arm and leg that wouldn't work?"

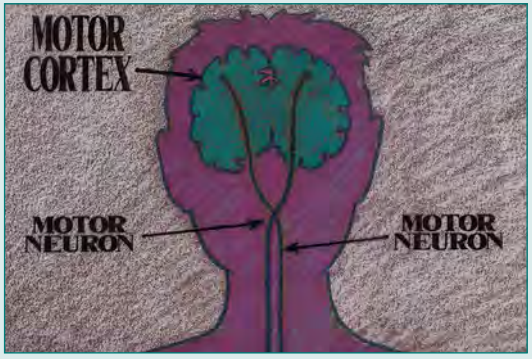
"You remember—the brain and nervous system are cross-wired," said Kyle. "Look, here's a picture," he added, opening a book in the pile on his shelf.

Just then, Shiloh Nimbus eased her wheelchair over to Josh and introduced herself. "Hi! I'm Shiloh," she said. "I'm a new member of the club, and I know how it feels when your body doesn't work right. I was in an accident too, but my spinal cord was injured. You're lucky your injury didn't do permanent damage."

"Yeah, I really *am* lucky to have most of the movement back," Josh said,

REAL-LIFE NEUROEXPLORERS

Today, doctors are able to help accident victims with head or spinal cord injuries in more ways than ever before. Better emergency care, improved techniques for rehabilitation and new drugs are helping to improve the recovery of people with these types of injuries.



Most nervous system pathways from the brain to the rest of the body cross over from one side of the body to the other. This happens in the brain itself or in the spinal cord. You might say that we are cross-wired! This is why damage to one side of the brain can affect movement or sensations on the other side of the body.

"but I still can't hear in one ear."

Suddenly Josh stopped talking. "What's this," he said to himself, looking down into the cookie box, "a baseball card?" He blinked. Why was a baseball card lying in the bottom of the box of cookies?

Picking out the card, Josh held it up and said, "Look at this. I've got a baseball card—a Mickey Mantle rookie card from 1952."

Mystery Cookies

"Let me see that!" cried Isley I as he shoved his way to the card in Josh's hand. "Wow! Cool! That's one of the best cards there is! It must be worth a fortune at the sports card store." He held the card up, and everyone looked at it.

"It looks in perfect condition!" said Kyle.

"It looks like *mint* condition," said Isley I, the expert.

"What does that mean?" asked Shiloh.

"It means it's still in perfect condition after all these years. This is a 1952 card, and it's just like new!" Isley I explained. He pulled the card carefully out of its plastic cover and waved it in the air so all could see.

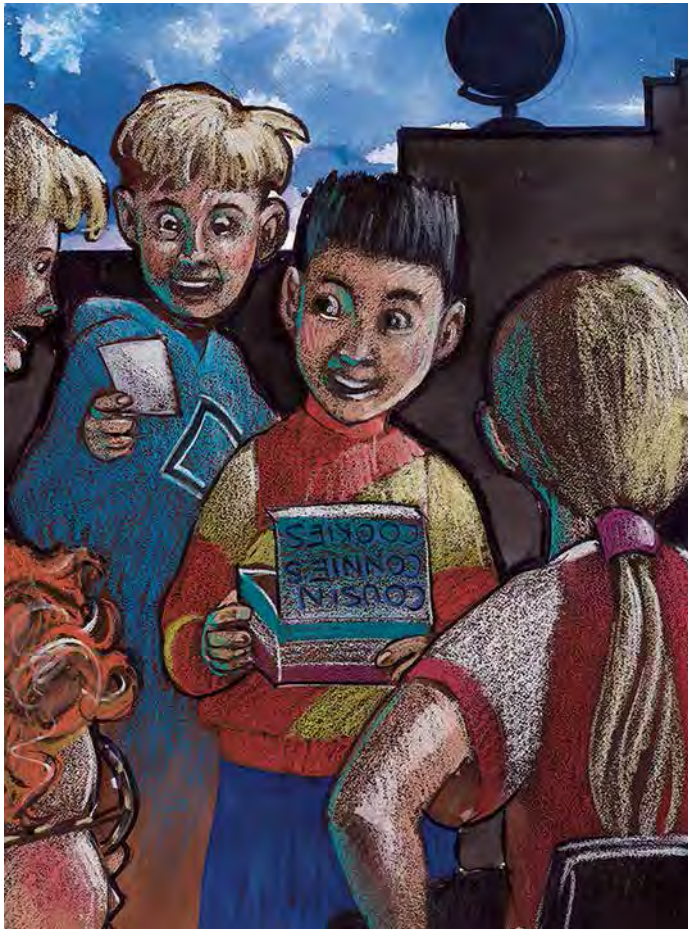
As it waved by his nose, Josh sniffed the card. "Wow, it even smells like new. You know—like a new book."

"How extremely extraordinary that an object should emit such an aroma after 40-odd years," The Brain commented.

Max turned to Josh as he explained The Brain's words for the group. "He says it's funny that a card over 40 years old smells like new."

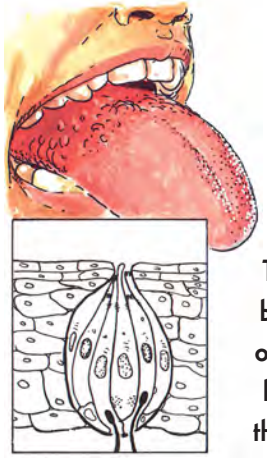
"It's funny that an old card is in a box of cookies!" Lakeisha added. "Why do you suppose it's there?"

Josh looked puzzled. "I don't know," he said. "The box doesn't say there's a baseball card in it. It doesn't say there's any surprise. In fact, I was surprised when the cookies came to my house! A delivery truck



brought the package, and it had my name on it. I don't know who sent them."

The sense of taste depends on tiny structures called taste buds, located on the tongue and inside the mouth. Estimates on the number of taste buds in the mouth range from 4,000 to 10,000 or more! When you taste something, tiny receptors inside the taste buds send messages along nerves to special areas inside your brain.



Tiny taste bud inside one of the bumps on the tongue

"It was nice of you to share them with us, anyway," B.J. said.

"I thought they'd be good for a celebration, so I saved them for today," Josh answered. "It says they're from Cousin Connie's Cookie Company, but I don't know anything else about them."

"In that case, I have to tell you that this cookie isn't very good," said Lakeisha. "It's not sweet enough. I never had a cookie before that wasn't sweet."

"Mine tastes sort of like sawdust," added Max.

"I never met a cookie I didn't like, but I don't even want to finish this one," chimed in Isley II.

Tapping out a jazz beat with her feet and smashing an imaginary cymbal, B.J. spoke for the rest of them. "There def-in-ite-ly is . . . some-thing wrong . . . with these cook-ies." Smash!

The group of friends looked at each other. They almost shivered, as though an electric current had run through all of them. Kyle whispered excitedly in the

sudden silence, "Why is a valuable baseball card stuck in a box of tasteless cookies? We seem to have a mystery after all!"

NeuroExplorers in Action

The club members couldn't stop thinking about the cookie mystery. Josh looked at the cookie box and found the company's address. It wasn't far away. They decided to take a field trip to Cousin Connie's Cookie Company!

The next day, they all met on a corner to take a city bus. Shiloh got on the wheelchair lift and the others climbed up the steps of the bus, excited to be on their way. At least *most* of them were. "Are you certain this bogus excursion is prudent?" said a voice behind Kyle. It was The Brain.

"He wonders if it's smart for us to be going to this cookie company, pretending we like their cookies," Max translated.

"This is a fine time to be wondering," B.J. called out from across the aisle. "It's too late now! We're on our way."

"It's a mystery that needs solving," Kyle stated, "even if it isn't a neuroscience adventure."

"On the contrary," The Brain added thoughtfully, "it is evident that almost all human endeavor involves neuroscience. Think about it."

"He disagrees," Max said simply. "He thinks neuroscience is everywhere."

Everybody smiled. They knew that The Brain had fun being difficult. They knew he thought this trip would be a lot of fun, too—and he couldn't resist a mystery, neuroscience or not.

Loud noises can damage hearing by harming tiny hair-like cells in the innermost part of the ear. These cells convert sound waves in the air into signals that can travel along nerves to the brain.

Examples of loud sounds that can be dangerous include noises from motorcycles or trains, very loud music heard through head phones or at a rock concert, or noise from firecrackers or gun shots.

Cousin Connie's Cookie Company

"This is the stop you wanted, son," the bus driver announced to Kyle, "East Adams Street."

"This is it, everybody," Kyle said, leading the NeuroExplorers off the bus and waiting while the driver operated the wheelchair lift for Shiloh.

The bus's engine roared as it started off again on its journey down the winding road. "The decibel level emitted by this vehicle is sufficient to damage our auditory capacity!" shouted The Brain, covering his ears with his hands.

"He says the bus is so loud, it could really hurt your ears," Max yelled to his friends. They tried to close off their eyes, ears and noses as the bus sputtered off noisily in a cloud of smoke and oil.

Looking around to find their way, they noticed the sky beginning to darken. Rain clouds rolled in overhead. They walked down the street and stopped in front of a large gate.

"This is the address on the cookie box—410 East Adams Street," Josh announced.

"There's a sign," Kyle said, pointing to the other gatepost. "It says Cousin Connie's Cookie Company."

"*That's* the cookie company?" B.J. said softly.

There, just over a mound of weedy lawn, surrounded by a black iron fence and perched on a small hill was a tall, old building. It looked more like a haunted house than a bakery.

"I say we go home," Isley II said as he turned to run. His brother held him by the belt.

In an instant, dark clouds piled upon darker clouds until the entire sky was blotted out by threatening shadows. Rain began coming down hard.

"We have no choice now," Kyle announced. "The next bus doesn't come

In a pack, the club shoved through the gate and moved up the path and onto the porch of Cousin Connie's Cookie Company. Kyle and Lakeisha helped Shiloh up the worn steps. Josh boldly knocked on the door.

The door cracked open, and two eyes peered at the NeuroExplorers. Thunder boomed in the distance. The eyes squinted and pulled away, as if they were being sucked in by the darkness. Then the door swung open. A large woman loomed over them. "What is it?" she asked impatiently.

"We're the NeuroExplorers Club," Kyle told her, "and we'd like to visit your bakery. We thought you might be able to make us some brain-shaped cookies for our meetings."

"No! We don't do special orders," replied the woman, "and we don't take visitors." She quickly stepped back and slammed the door.

Decision Made

The NeuroExplorers flattened themselves against the wall of the porch, trying to stay out of the blowing rain as the storm got worse.

"Curiouser and Curiouser," The Brain said, rubbing his hands together as he looked around the mysterious building.

"I think that's a quote from 'Alice in Wonderland'," Max explained.

"This is no wonderland!" Lakeisha said, as the NeuroExplorers pushed together more tightly. "We'd better get out of here."

"What are we going to do now?" Isley I asked.

"Walk back to the bus stop and go home?" Isley II replied hopefully.

Kyle looked at the other NeuroExplorers, searching their eyes. Finally, he spoke. "Something's *weird* here. I say we snoop around a little. Maybe we can peek through a window or something—see what's going on."

"I believe there is consensus for that endeavor," The Brain replied.

"We all agree," said Max. "Let's take a look."

The NeuroExplorers tiptoed across the creaky porch, following its winding path around the side of the house.

"Shade's down," B.J. said, pressing her nose against the first window. "Can't see a thing." It looked as though every shade was down, every crack was sealed and every door locked.

At the very end of the porch was one last door. Lakeisha jiggled the handle. "I guess this one is locked too," she said.

Disappointment settled over the young explorers. Lakeisha sighed and leaned heavily against the door. "Well, I guess that's it," she said.

And it was! Because as Lakeisha leaned against the door, it opened, and

she disappeared from sight, as if she had been swallowed up by the dark, old house.

Dark Voices

"Lakeisha, where are you?" the NeuroExplorers voiced in loud whispers, as each of them followed through the door from the gloom of a stormy day into the blackness of the closed-up old house.

As far as the Isleys were concerned, this was the darkest place they had ever been—even darker than the Caves at Calicoon! There were no lights, and every window was shaded. Only a dim light came through the still-open door. Staring into the darkness in the corner of the room, the Isleys were startled as something moved toward them through the gloom.

"What's that?" Isley I exclaimed.

"It's just me," Shiloh said, emerging from the darkness and rolling closer to the twins.

The Isleys relaxed. Now they could see the other NeuroExplorers. Nobody was speaking. But there *was* someone speaking—a voice, getting closer. It was a woman's voice. Kyle waved his hand, then held his finger to his lips.

"What do you *think* I did?" the voice said. "I sent them away."

"Are you sure they're gone?" a gruff man's voice answered.

"Yes. I checked. There's no one out front. They were just a bunch of kids anyway. It's nothing to worry about, Charlie," the woman said.

"I guess not," said Charlie. "I'm just a little nervous, Connie. After all, we still have more to do today. We haven't gotten all our phone calls yet, you know."

"We still haven't heard from the guy in Chicago?" Connie asked anxiously.

"No, and he said he'd order more if he liked the first one," Charlie replied.

"Okay, I'll stay near the phone," she said. "You go check the press."

The voices stopped and footsteps disappeared into other rooms.

"A most peculiar conversation," The Brain said, scratching his chin. No one looked at Max, because they understood. They all were thinking the exact same thing. This was very strange.

A Sensory Plan

The NeuroExplorers didn't know what was going on or where they were in this dark house, but they all knew what they were going to do. There was a mystery here, and they would not turn away from it!

"We need a plan," B.J. said, twirling imaginary drumsticks.

"Teams," Isley I said.

"Right," continued Isley II. "We need to split into teams. Solving mysteries is just like sports. We need teamwork."

"The teams need to gather clues," Josh added, "to try and make some sense out of all this."

"That's it!" Kyle exclaimed. "You said it!"

"*What* did he say?" Isley I asked, peering through the darkness for Josh's face.

Kyle answered, "Let's make some sense out of this in the way we know best, using neuroscience. Let's use our *senses*!"

Lakeisha understood immediately. "Sense teams," she said. "We'll divide up into teams and gather clues by using our senses."

Excitedly, the NeuroExplorers started whispering back and forth. Who would be on the teams? Where would they go? What would they find?

Isley I and II were ready to go. They turned toward each other in the dark. "High five!" Isley I said, raising his hand and—hitting Kyle in the side of the face! Kyle's glasses flew off and his head snapped to the side.

"Ow!" Kyle cried out. "Isley! Be careful! Where did my glasses go?"

Scooping up Kyle's glasses, Lakeisha examined them. "One of the lenses is gone, Kyle, and they're bent," she said.

"Sorry," Isley I said. "I hope you don't need those to see!"

Isley II gave his brother a small shove. "This is no time for jokes, klutz," he said.

"Well, I guess you couldn't help it," said Kyle, fingering his useless eyeglasses. "It's too dark to see much around here anyway."

A calm voice spoke out—calm, but also confident. It was a voice with a plan. “I know what we can do,” Shiloh announced, “and I know how we can do it.”

Everyone Needs a Brain

Shiloh gently rocked her wheelchair back and forth while she talked. “We’ll split up into four sense teams. Since tasting and smelling work together anyway, we can combine them in one team. The other teams will be seeing, touching and hearing.”

Isley I spoke first. “Isley II and Kyle can be on the seeing team with me. We’ll look for clues using our vision.”

“If we had a thinking team, you couldn’t be on it, Isley I!” his brother said. “Kyle won’t be much of a vision partner without his glasses!”

“That’s right,” Shiloh added, “and Josh shouldn’t be on the hearing team.”

“But you can hear, can’t you Josh?” asked Isley II.

“Yes, but only out of one ear,” Josh answered. “When you hear with *both* ears, it’s easier to figure out where sounds are coming from. Sometimes that helps!”

“I have a cold,” Lakeisha said with a sniffle. “I won’t be much good for the tasting and smelling team.”

Shiloh nodded. In her head she was assembling teams, making plans and estimating outcomes. “Okay,” she said finally, “here’s how it will be. Lakeisha and B.J. will form the seeing team. Isley I and II will be the taste and smelling team.” Shiloh spun her wheelchair to face the others. “Josh and Kyle will take the sense of touch, and The Brain and Max, hearing.”

“What about you, Shiloh?” Kyle asked.

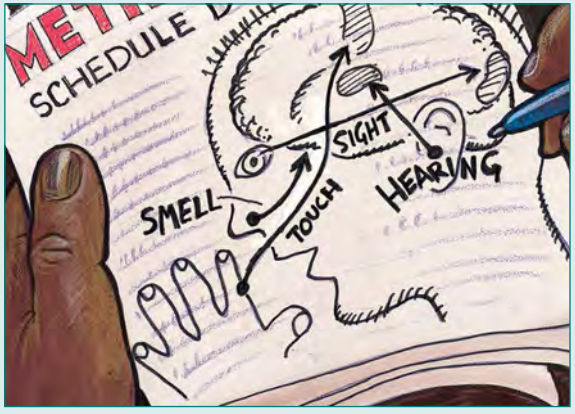
Josh stepped forward. He was looking at Shiloh with admiration. "That's easy," he said. "Shiloh obviously is the center of this nervous system. She's going to be the brain of our sensory network."

"Exactly!" Shiloh answered excitedly. "I'm going to stay right here. As soon as your sense team discovers a clue, come back here and tell me about it. I'll try to put the clues all together and make some sense of them."

"Of course. Shiloh will be the center of integration and analysis—our cerebrum," The Brain added to himself. Pulling a pen from his pocket, he began to draw a brain on his bus schedule, with lines from each sense organ to show how sensory messages go to the brain.

"You can put all the sensory clues together, Shiloh, and try to come up with an answer," Max said, glancing at his friend's drawing. "It's perfect! Just like clues from all the senses are sent to the brains in our bodies!"

Information about the world around us is detected by receptors in the nervous system. Each kind of receptor responds to a certain type of information. For example, receptors in the back of the eye detect light and receptors on the tongue receive information about taste.



The information from each sense is processed in a different part of the brain. After sensory signals are received, they are sent to other areas of the cerebrum to be combined with additional information. The amazing brain is able to organize and process many different kinds of information!

It was almost as if someone had turned on the lights, because now the NeuroExplorers could see clearly. The mystery was defined. They knew what they had to do. And they had a sensible way to do it.

Bittersweet

After creeping along a dark, dusty hallway, the Isley twins found the kitchen. They weren't sure of the path they had followed and didn't know how they would get back to where they had been.

"We should have left a trail of crumbs," Isley I said.

"I feel like I'm playing basketball with a blindfold on," Isley II said.

This surely was the kitchen. It smelled like something had been baking, and a faint heat still lingered around the ovens. A glimmer of light in the gloom showed pots and pans hanging from the ceiling like bats in a cave. There seemed to be boxes of cookies neatly stacked on large tables lining the walls.

"What do you smell?" Isley I asked his brother.

Isley II was unsure. "Baked things, I guess," he said.

"Yes, cookies—but there are other things too," Isley I said, taking a few slow sniffs. He bent close to a table top. "I think there was fresh ink on this table. And I smell oil, too, like machine oil."

"Hey," Isley II said, "that's amazing. How did you smell all those things?"

Isley I laughed quietly. "Maybe there are *some* things I do better than you."

"This tastes salty," Isley II announced suddenly from a far corner of the kitchen.

"Where are you? What are you doing? Don't taste anything unless you know what it is!" his brother said in a loud whisper.

"Over here," Isley II answered. "Don't worry. I just found the cookies. Hey, this one tastes sort of sweet. Here, try one."

Isley I stumbled over to Isley II and took a cookie from him. "Hmm," he said after biting off a small piece, "this cookie is *bitter*."

The twins tasted several cookies from different boxes. "They all taste a little different—and most of them aren't very good," Isley I said finally.

"This baker has no sense of taste," said Isley II. "I think we need to report this back to Shiloh."

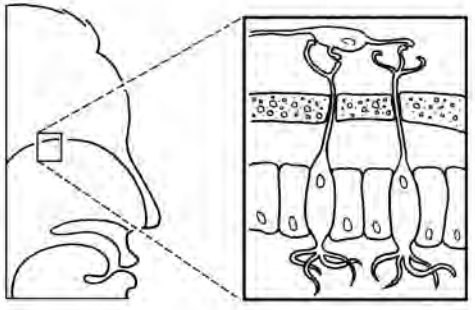
Isley I didn't understand. "What for? Just because we tasted some bad cookies?"

"No, because it seems like Cousin Connie doesn't care how her cookies taste," Isley II answered. "Does that tell us anything?"

Isley I shook his head. "All it tells me is that she's a pretty bad cook."

"We need to report to Shiloh," Isley II insisted. "Let's go."

The sense of smell detects molecules that are carried in air. The molecules drift into the nose and stimulate special nerve cells, or receptors. The receptors send signals to the brain, telling it which odor is being smelled.



Often, the senses of smell and taste work together. To test this, try eating something while you hold your nose.

Visible Clues

In another part of the house, Lakeisha walked into a closed door, with a thump. "Ow! I can't see a thing!" she cried.

"Shhh," B.J. warned. "Of course you can't see. The lights are out!" she whispered. "*Light* has to go into your eyes before you can see, remember?"

"Okay, okay, I get the point," said Lakeisha, "but it doesn't help me right now."

"You're right," B.J. said. "Maybe it will be better on the other side of this door."

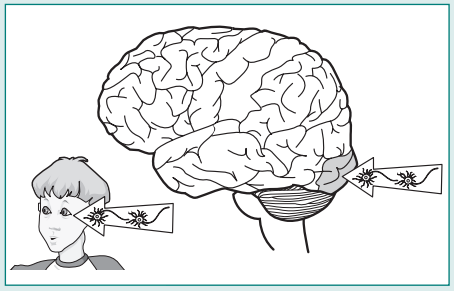
Lakeisha and B.J. entered yet another large, unlit room. This was the third in a row. They stumbled forward unsteadily.

"B.J.? I have a feeling we're not alone," Lakeisha said with a quiver.

B.J. swallowed hard. "What do you mean?" she whispered.

"Well, my eyes are getting used to the dark, and there's something over there," Lakeisha said, "something big and white over by the wall!"

B.J. squinted and stepped closer to the huge, ghostly thing, not daring to breathe. "It's . . . it's just a stack of boxes covered with a sheet!" she said with a sigh of relief.



Light enters the eye through the pupil. The lens behind the pupil focuses light on the retina at the back of the eye. The first layer of the retina is composed of specialized receptor cells called photoreceptors (rods and cones) that connect to a another layer of nerve cells which signal information to the brain.

The primary visual cortex, where information from the eyes is received in the brain, is located at the back of the head. There also are 25 areas of the brain to help process visual information.

"What's in them?" Lakeisha said. "Wait! I just remembered I have a flashlight on my keyring." She pulled it out. "It works!"

B.J. and Lakeisha quickly opened several boxes and held their contents up to the tiny flashlight. They saw paper . . . all kinds of colored inks . . . cardboard . . . sheets of plastic.

"These aren't baking supplies," Lakeisha said. "We'd better go report this."

"But there are a few more rooms we should go through," B.J. protested.

"I don't know," Lakeisha said. "This is kind of spooky."

"Are you scared?" B.J. asked.

"You bet!" said Lakeisha.

"So am I. Let's get out of here," said B.J., and she grabbed Lakeisha's hand.

Making Sense?

Rocking her wheelchair back and forth in the dark room, Shiloh considered the first clues. The Isleys had just left after reporting what they found—the smell of ink and machine oil, and bad-tasting cookies. Shiloh sent them back to sniff out more clues.

Her thoughts kept returning to the strange conversation they had heard between Connie and Charlie. Shiloh stopped rocking, tossed her head back and closed her eyes for a second to try to think harder.

"Shiloh, are you all right?" Lakeisha cried out as she entered the room. Shiloh's eyes popped open. "Wha . . . Oh, yes, of course," she said. "I was just thinking. What did you see? Any clues?"

"We think so," said Lakeisha. "We saw something, but we're not sure what it means."

"Boxes," B.J. continued, drumming on a table with her fingers, "with paper, colored inks, cardboard and sheets of plastic."

"Inks—sounds like *printing* supplies—but why would a bakery need those?" Shiloh muttered, half to herself. "Anyway, why don't you head back out. See what else you can see."

The two girls left Shiloh alone with her thoughts. Shiloh was at the center of the whole investigation, and she was concentrating, trying to put everything together as information came in from each of the sense teams.

Feeling for Clues

Once, when he was a child, Josh hid in a hall closet filled with wool coats and black rain boots. That was pretty dark. He also remembered being caught in an elevator without electrical power. That was darker than night. Then he imagined outer space. Nothing Josh could imagine was as dark as this basement. Every window was shuttered and covered by a black cloth. It was total darkness.

Josh and Kyle inched along the walls. "We'd be lost without our sense of touch," Kyle commented.

"You mean we *aren't* lost?" Josh asked.

"No, I don't think so. We're in the basement, moving along an old wooden wall," Kyle answered calmly.

"A wooden wall? How do you know that?" Josh remarked.

"Use your fingers," Kyle replied. "It's the best way to learn things with your sense of touch."

"Ow!" Josh cried.

Kyle turned and squinted, but he still couldn't see Josh clearly. "What's the matter, Josh?" he said.

"Splinter. In my fingertip," Josh said, shaking his hand. "Thanks a lot!"

"That's another touch sensation—pain," said Kyle. "It lets your brain warn you not to do that again."

"Right," Josh said quickly. "It's telling me I don't want another splinter, so I'm not going to touch that wall again."

"Then you won't feel the vibration," Kyle said.

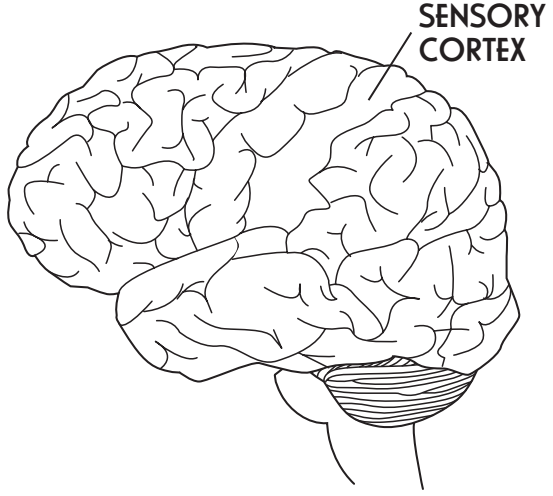
"What vibration?" asked Josh.

"The vibration in this wall," his friend answered.

Josh reached out, placed his palm carefully on the wall and felt it shaking just the tiniest bit. "Wow, you're right. Why is it doing that?" he said.

"I don't know," Kyle responded.

"Let's keep moving," Josh added. "Maybe we can find out what it is." The boys crept slowly around



The sense of touch actually is made up of several different kinds of sensations. Each sensation is detected by a different receptor in the skin. For example, there are receptors for hot and cold, pain and pressure.

The sensory receptors send messages back to a special part of the brain, called the sensory cortex. This part of the brain sits right behind the motor cortex, across the top of the head.

the room, clinging to the wall until they passed through a dark doorway and entered another unlit space.

"Stop," Kyle whispered suddenly. The two boys felt stronger vibrations in the wall. Somewhere in the distance was a faint, mechanical rumble.

"It must be a machine," Josh said. "It sounds just like a . . ."

"—a printing press, like down at the newspaper building," Kyle said.

"Yes," Josh said excitedly, "that's what . . . Wait a minute. I can feel more vibrations under my feet. Not like the steady shaking in the wall. Like clump-clump . . . like footsteps."

"Someone's coming," Kyle said, a little too loudly.

"Who's there?" A strange voice boomed from across the room. It wasn't the voice of a NeuroExplorer; that much they both knew.

"Go! Let's get out of here," Kyle yelled, breaking into a run.

In the pitch black cellar, Josh hesitated. Which way should he go? Footsteps were approaching, but he couldn't tell from which direction. Which way had Kyle gone?

Turning to his left, Josh ran—straight into the legs of Charlie, the man with Cousin Connie.

"What? Who are you?" the terrifyingly huge man growled. He grabbed Josh and lifted him up by the shirt. Josh's legs danced crazily, running on air. "You're one of those kids!" Charlie said, holding Josh up to his face. "How'd you get here? You're coming with me."

Sensing Danger

Kyle found his way back to Shiloh and quickly reported what he and Josh had found—mechanical vibrations that might be from a printing press.

The Cookie Crumbles

Then he told Shiloh about the huge man, and how he and Josh got separated.

Shiloh nodded her head. "Thanks for the info," she said. "That adds a lot to the picture. But you'd better hurry back and try to find Josh!"

As soon as Kyle left, Shiloh started rocking her chair again. She was worried. The Isleys hadn't returned. She still hadn't heard from Max and The Brain, and now Josh was missing. Was this too dangerous for the NeuroExplorers?

Shiloh shook off her doubts. It was too late to turn back. She had better figure out what was going on—and fast!

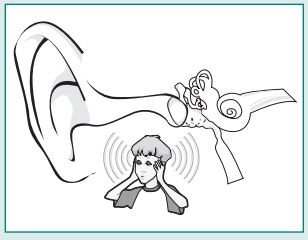
The Better to Hear You With

The Brain and Max walked through three connecting rooms somewhere in the creepy old house. Each room seemed quieter than the last. "Maybe we should head back, Brain," Max said. "I haven't heard anything."

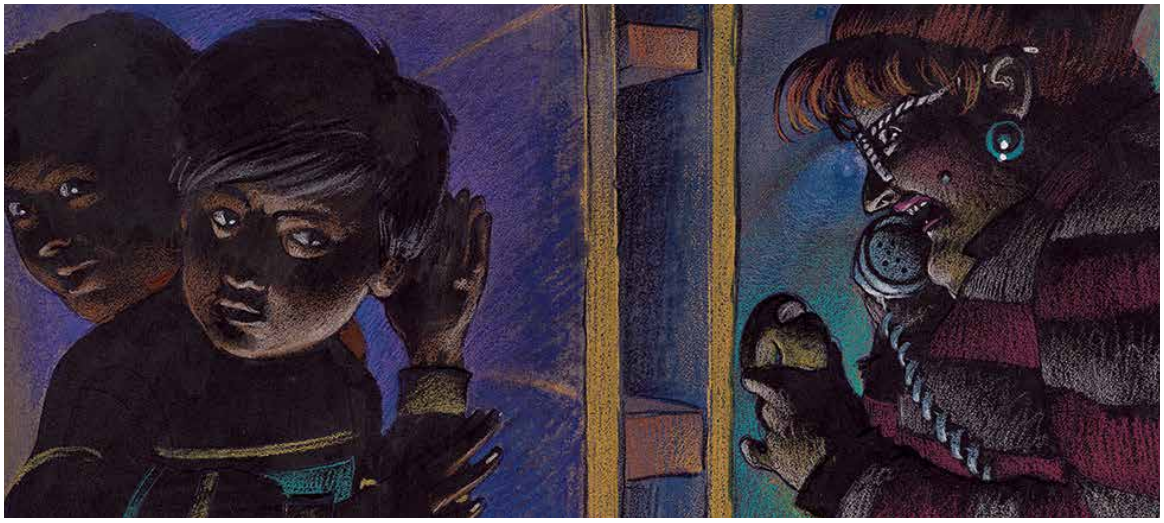
"Perhaps you aren't listening carefully enough," The Brain offered.

"Of course I'm listening," Max said quickly. "There's just no sound coming into my ears except your voice."

Sound travels as waves of compressed air molecules. The ear captures sound waves and translates them into nervous system signals inside the inner ear.



Information about sound is sent to a special part of the cerebrum.



The Brain had his hands cupped around the backs of his ears. “Perhaps if you applied an assistive technique, your auditory sense would function more efficiently,” he said to his friend.

“You mean you’re hearing something by cupping your hands behind your ears?” Max replied. He copied The Brain’s suggestion. “Hey, you’re right!” he whispered. “I can hear a woman talking.”

“I believe she’s talking on the telephone,” The Brain said. He placed his ear close to the wall, putting his cupped hand on its surface. “Listen,” he said very softly.

They heard one side of a conversation. “Yes, of course we sent you the Mantle card . . . . Why would I lie?…It should have gotten there long ago . . . . I don’t know. What should we do? . . . I see, right . . . . Maybe there’s another Joshua Kavil . . . . That’s possible . . . . Yeah, I know. Then someone else gets the card . . . . No, I’m not too worried. Whoever gets it will

probably think it's just a dumb prize and throw it away . . . . Sure, I know how much money it's worth! . . . Okay. No problem . . . . Right. In today's mail . . . . Okay. Bye."

The Brain turned and looked at Max. "We must relay this information to Shiloh with alacrity," he stated.

Max understood. They'd better report to Shiloh right away!

Putting It All Together

After telling Shiloh what they had heard, The Brain and Max turned to leave.

"Don't listen for any more clues," Shiloh told them. "I think we have enough—and we *may* have trouble. Kyle and Josh got separated. Why don't you go and try to find everybody and bring them back here, while I just try to put the pieces together?" The two boys nodded and set off in a hurry.

Shiloh felt that she had the last piece of the mystery. The telephone call put everything together for her. All of the NeuroExplorers had found important clues with their senses, and she was about to have the answer.

She went over the clues in her head. Cousin Connie wasn't interested in making tasty cookies, so she must be more interested in something else. But what? Printing supplies, the smell of ink and machine oil, along with the vibration of a printing press . . . Connie and Charlie were printing something. What were they printing? Not cookie boxes—baseball cards! Why go to all this trouble to print baseball cards? She thought about the telephone call. Suddenly Shiloh smiled. She had the answer.

But Shiloh's joy at solving the mystery suddenly turned into panic.

Her friends were out there, in a dark house, with two *criminals*. Shiloh may have figured out what Cousin Connie was up to, but the NeuroExplorers could be in danger. She had to save them!

Caught in a Web

Charlie had The Brain by the arm and Max by the shirt. "Two more," he said gruffly, tossing the boys into a small room. Max and The Brain tumbled to the floor. "Do you think that's all of them?" Charlie said.

"Almost," Connie answered. "I know I saw one more. A girl. In a wheelchair. I'll go look for her. Keep these brats locked in here until I figure out what to do with them."

Connie and Charlie stormed out of the room, snapping the door shut behind them with a twist of the lock.

"Max?" a voice asked from the corner. Max recognized it as an Isley.

"Isley?" he said. "One," answered Isley I.

"And Two," another Isley voice said. NeuroExplorers' voices came from every shadow.

"I'm here too," said Lakeisha. "So is B.J."

"And me," Josh said, appearing from the side, "and Kyle too."

The NeuroExplorers all stood together near the center of the small room. It smelled dusty and musty. Using Lakeisha's flashlight, they could see a few cobweb-covered pieces of furniture, some boxes of old books, a rocking horse covered with dust—and no way out.

"This is big trouble," Isley II said. "These guys are serious."

"Why would they be this angry just because we looked around their stupid cookie factory?" Isley I asked.

"Things are not what they seemed," The Brain announced. "We obviously have stumbled upon an illicit enterprise operating here."

"This isn't a cookie factory. These guys are crooks," Max interpreted, "and we are trapped like insects in a web!"

Big Trouble

The wheels of Shiloh's chair glided across creaky wooden floors as she maneuvered through dark hallways. If she couldn't find her friends, she must call the police. Where was a phone? Easing around corners, opening closed doors to eerie rooms, Shiloh finally found a desk with a dimly lit lamp on it—and a telephone! She raced across the room and grabbed the phone. Shiloh dialed 9-1-1. Each second seemed like an hour as she waited for her call to be answered.

Then she heard heavy footsteps behind her. A voice screeched, "No, you don't! Get away from there, you trouble-maker."

Cousin Connie grabbed Shiloh's arm, tore the phone out of her hand and jammed it back on its base. Somehow she seemed to wrap herself around

Shiloh's whole upper body. Shiloh felt as though she were being strangled by a huge snake, and she couldn't move.

Connie shoved the chair and Shiloh across the room, out the door and on through the maze of the old house. They stopped by a door, and Shiloh could hear familiar voices. Here they were! At least she would be with the other NeuroExplorers. A hush fell in the room as the door opened and Shiloh was pushed inside.

Then the NeuroExplorers all talked at once. "Shiloh! . . . They got you too . . . . Now they've got us all."

"Not for long," Josh whispered, and he scooted out the open door before Cousin Connie could turn around to grab him.

"Come back here, kid!" the big woman shouted, fumbling for her key to lock the others in their prison. "Charlie!" she yelled. "Help me get that kid!"

All over the house, the small band of prisoners could hear the sounds of a chase—Running. Yelling. A telephone ringing. Then quiet. Still no Josh. Had he been caught? Did he get away? What was going on?

Even as they listened for clues, the NeuroExplorers began to question Shiloh, and she told them quickly what she had figured out from the information each of the sense teams had brought to her.

A Sensational Ending

Finally, there was noise again outside the door of the NeuroExplorers' little prison cell. Now they could make out voices. "Okay, you two. Don't give us any trouble. Just take us to the kids." This was a voice they hadn't heard before.

"Here. This way. They're over here." That was Josh!

Once again, a key went in the lock and the door opened. Piling out of the small room and into a larger one, now lighted, the NeuroExplorers mobbed around their friend. Two police officers held Connie and Charlie by their arms and sat them down on boxes in the middle of the room.

One of the officers took out a note pad and said, "All right, now, let's see what's going on! We come to check out a 9-1-1 and this boy crashes into my partner, here. These two are taking off down the street, and the boy says they're crooks. So what's the story?"

Josh jumped right in, hardly stopping for breath. "We found a baseball card in some horrible cookies that were delivered to my

house. We decided to investigate, and we came here. We got in the house by accident, and we made sense teams, and Shiloh was the brain . . .."

"Wait a minute, son. Slow down," interrupted a police officer. "Let's back up a little. What were you all doing inside this house?"

"We're the NeuroExplorers Club," Kyle explained, "and we came here on a field trip. It's a long story, but something looked fishy about this place, and we tried to find out what was going on. I guess we went a little too far."

"Especially if you sensed something was wrong," added one of the officers.

"That's just it," answered Josh, "we *sensed* something was wrong, but we weren't sure, and it all just happened so fast. We decided to use our senses to try to find out what was going on and, all of a sudden, we were in trouble. We didn't know they were crooks until they locked us up."

"What?" asked a puzzled policeman. "You've lost me again!'

"We split up into teams and found sensory clues," B.J. said.

"And just like neurons reporting information to the brain for processing, we all relayed our sense clues to Shiloh," Max offered, "so Shiloh was the only one who had all the clues, and she came up with the answer."

The Sensible Solution

"Cousin Connie's Cookie Company is just a front for a counterfeit operation," exclaimed Shiloh, somewhat proudly. "They aren't just printing baseball cards, they're *counterfeiting* them. The Mickey Mantle card Josh found is a counterfeit. The cookie business is a fake!"

"I'm still not sure I understand all of this, but I get the general idea," said one officer.

Shiloh continued, "Cousin Connie and Charlie were forging valuable baseball cards, hiding them in cookie boxes and shipping them to dealers to be sold as originals. Josh got a box by mistake because his name was the same as one of their customers. Cousin Connie and Charlie really are criminals!"

"Sounds like you're a pretty smart bunch of kids," said the other police officer, "but you could have been in serious trouble if Josh, here, hadn't been there to help us find you. He helped us catch this pair trying to get away, too."

"Come on," the officer said, "let's get you home safely before your folks get too worried. We'll take Cousin Connie and her pal down to the station for questioning."

The NeuroExplorers filed out of the house, still telling each other excitedly how important *their* sense had been in solving the puzzle, and how great Shiloh's brain had been in putting it all together.

Kyle looked at Josh and said, "I think we all *sense* that it's great to have you back, Josh. Good work!"

"An admirable case of sensory sleuthing, my friends!" The Brain added, his face breaking into a satisfied grin.

Glossary

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

analysis (uh-NAL-uh-sis) - close examination by breaking up an idea or a substance into smaller parts in order to understand it better

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

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, rounded outer layer of the brain where sensory input is received, thinking and learning occur, and voluntary movement is started

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*

decibel (DES-uh-buhl) - a unit for measuring intensity, or loudness, of sound

ear canal (EER kuh-nal) - part of the ear which leads from the outside of the head to the eardrum

eardrum (EER-drum) - a thin membrane, stretched tight inside the ear, which helps transmit sound waves to the inner part of the ear

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

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

inner ear (IN-er EER) - the inside part of the ear that functions in hearing and balance

integration (int-uh-GRAY-shun) - putting or bringing parts together to make a whole

lens (LENZ) - clear front part of eyeglasses that brings things into focus; also, part of the eye that focuses light on the retina

middle ear (MID-uhl EER) - a small cavity between the eardrum and the inner ear where three small bones pass sound waves along to the inner ear

motor neuron (MO-ter NU-rahn) - a type of nervous system cell, originating in the brain or the spinal cord, that sends impulses which cause movement

nerve cell (NURV sel) - neuron; a cell of the nervous system that conducts a signal from one part of the body to another

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 that deals with the nervous system

neuron (NU-rahn) - a cell of the nervous system that conducts a signal from one part of the body to another

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 to the study of 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

operation (ahp-uh-RA-shun) - an act performed on the body with surgical instruments to repair the effects of disease or injury

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

receptor (ree-SEP-tuhr) - a cell or group of cells that receive stimuli from outside the body; a sense organ

rehabilitation (ree-(h)uh-bil-uh-TA-shun) - the process of restoring a person to a condition of health or restoring the ability to function

retina (RET-i-nuh) - sensory membrane at the back of the eyeball that converts light to neuronal activity that travels along the optic nerve to the brain

sensation (sen-SA-shun) - an awareness of stimulation of any of the senses, such as sight, smell, touch, etc.

sense (SENS) - 1) a function of the body by which one is made aware of the world outside, through sight, hearing, touch, smell or taste; 2) a feeling or awareness; 3) to become aware of; 4) clear understanding or good judgment

sensory receptor (SENS-uh-ree ree-SEP-tuhr) - a part of the body by which one receives information from the outside, such as the eyes for seeing, ears for hearing, etc.

sensory network (SENS-uh-ree NET-wurk) - all of the parts of the body involved in receiving and transmitting sensory information (sensory receptors, neurons, and the brain)

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

sound wave (SOWND wayv) - a kind of vibration that travels through a substance, such as air, and can be heard

spinal cord (SPY-nuhl kord) - the thin rope of nervous tissue inside the bones of the spine

therapy (THAIR-uh-pee) - treatment to heal or improve the effects of a bodily disorder, illness or injury

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

vibration (vy-BRAY-shun) - a quivering or trembling motion

visual cortex (VIZH-uh-wuhl KOR-teks) - part of the cerebrum that receives information from the eyes

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.

BrainLink

THE COOKIE CRUMBLES

Baylor College of Medicine

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

ISBN: 978-1-944035-11-2