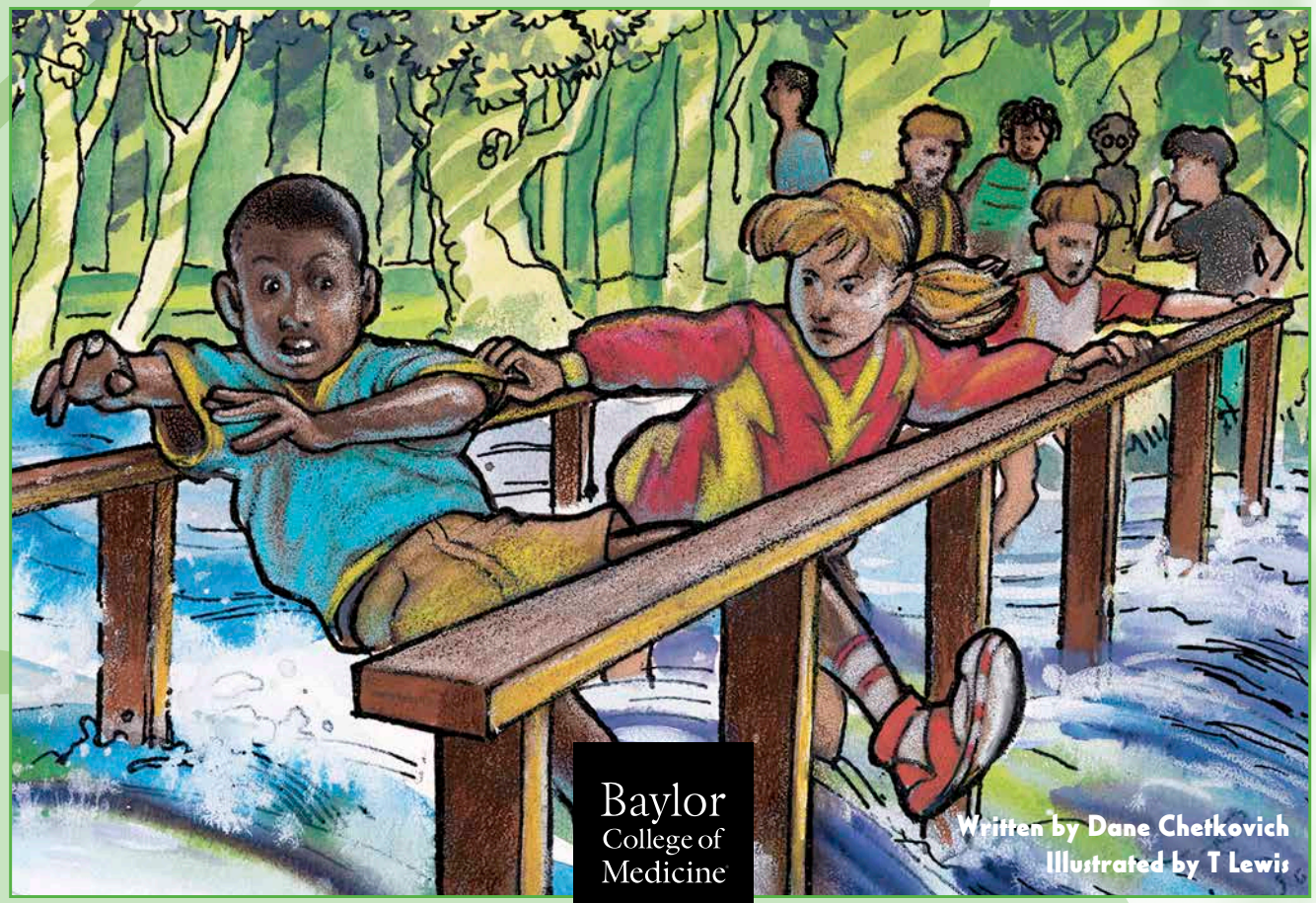
BrainLink

Memory and Learning

DANGER AT ROCKY RIVER

A Memorable Misadventure



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DANGER AT ROCKY RIVER

A Memorable Misadventure

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Baylor College of Medicine

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

ISBN: 978-1-888997-99-6

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

ISBN: 978-1-888997-99-6

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.

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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.

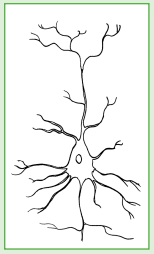
Some good came of Josh's unfortunate accident. Once he recovered, he remembered never to ride without a helmet. His misfortune also was the beginning of the NeuroExplorers.

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-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.

Red Then Yellow

The snake slithered and slinked its way across the floor. Isley I stared down in horror. He was terrified — paralyzed! For some reason, he could not use his voice. He tried to yell, but no shout, no gasp, not even the slightest sound would come out. The snake inched onward. All the while, Isley II slept on in the bunk bed below, his hand dangling over the edge of the bed, inches from the floor. Yet Isley I could not make a sound to alert his sleeping twin brother. Surely the snake would not bite his brother's hand!

The snake hesitated for a moment. Isley I could now see the snake in great detail. It had stripes — red and yellow and black. Only a few days earlier, the twins had learned about different kinds of snakes in science class. Now Isley I recalled a rhyme their teacher taught them about snakes. It was a way to tell a poisonous coral snake from a non-poisonous striped snake by the pattern of its colored stripes, from head to tail —

"Red then yellow,
Kill a fellow.
Red then black,
Friend of Jack."

The snake on the floor of the Isley twins' bedroom was clearly striped red, then yellow, then black — a poisonous coral snake! It was inches away from Isley II's hand!

We are always learning. Every day, new information enters our brains and is stored in ways that let us find it and use it again. The storerooms in our brains hold information about people we have known, experiences we have had, emotions we have felt, and skills we have mastered, including languages. These are our memories. There are many different ways of learning.

We learn by copying what we see or hear, like learning baseball from a brother or sister. This is learning by imitation.

We also learn by making connections between experiences. This is learning by association.

And we learn by repetition—doing something over and over.

Suddenly, from somewhere in the distance, came a sound — "Beep-beep, beep-beep, beep-beep, beep-beep...." In an instant, the coral snake vanished and, for that matter, so did Isley II. The terrible dream was over.

Brain Power

The beeping alarm clock showed the time to be 9:30 a.m., as Isley I reached over and shut it off. The bright morning sun shone in through the open curtains. Now things were becoming clear to him. Yes, he had been dreaming. "Thank goodness," he thought. He had to tell his best friends, the NeuroExplorers, about this dream. He climbed down off the bunk bed and noticed a note from Isley II taped to the door.

Good morning, Sleepzombie.
My turn to clean up the yard. NeuroExplorers Club meeting
at Kyle's house at 10:30. Don't be late.

At 10:30, all the NeuroExplorers except Shiloh, who was in Africa with her father, were gathered around Isley I as he told them about his nightmare.

"You must have been really scared!" said Lakeisha.

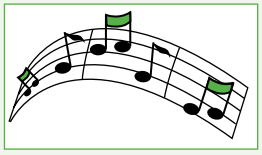
The Brain looked thoughtful, then stated quietly, "This subconscious nocturnal adventure imparts a potentially consequential lesson."

"Whaaat?" the others asked, all together.

Max Miller, as usual, the only one who could understand The Brain without a dictionary, explained, "He said we could learn something interesting from Isley I's dream."

Memories of what we have learned about people, events and facts of the world are processed in the part of the brain known as the cerebrum. By thinking about them, we can recall these stored memories.

We can boost our abilities to remember things. Try making a song or poem that includes the things you are learning.



Or create a word or phrase from the first letters of the names of the things you want to remember. You even can create a picture in your mind to help you remember a difficult word or concept.

"Never sleep on the bottom bunk?" suggested Isley II.

"Actually, I was reflecting on the storage and retrieval of information," The Brain said.

"He was thinking about learning and memory," Max interpreted for the others.

"What do learning and memory have to do with a dream about a coral snake?" asked Josh. The room was quiet as they waited for The Brain's answer.

"Isley I," said The Brain, "do you recall the time you were distressed because you couldn't recall a list of things Max asked you to purchase for him at the hobby shop?"

"Yeah, I can never remember stuff like that. I'm not a good memorizer," Isley I said.

"Yet you remembered quite graphically and quite correctly, I might add, that coral snakes are striped red then yellow," The Brain continued. "How did you do that?"

"Well, I'm not sure, really," Isley I said. "It was the rhyme, I guess. Red then yellow, kill a fellow... that means it's a poisonous coral snake. I like rhymes. I suppose that's what made it easier to learn."

"Your memory got better because of a rhyme?" Lakeisha asked.

"Rhythm and rhyme — they help all the time," B.J. rapped with her drumsticks on the table.

"Precisely my point," The Brain said. "A previously poor memorizer now benefits from the use of an ingenious device for the purpose of memory enhancement. It would behoove the NeuroExplorers to acquire more data

regarding the nature of information storage and retrieval, which are, of course, significant and fascinating functions of the human brain."

Before anyone could ask, Max translated, "The Brain says there are ways to improve your memory, like Isley I did with the rhyme. He says that learning and memory are really neat and important things the brain does, and it would be good for us to find out more about them."

"And for NeuroExplorers," Josh added, "understanding the brain is all in a day's work!"

Remembering an Old Friend

"It's settled then," Lakeisha said. "We'll learn about learning."

"And remembering," Kyle added. "I love to be able to remember all kinds of trivia that nobody else knows."

"Yeah, like all the baseball players' records," added the Isleys, almost at the same time.

"Who should we ask to help us learn about learning and remembering?" Josh asked.

"How about a scientist?" suggested Kyle.

"Hey, why not Professor Ottzinger from the university?" said B.J. "We haven't seen him since he took us to the Skull Caves, and besides, he said we could come to his office anytime we wanted. How about now?"

Without hesitation, Kyle ran up the stairs, shouting back to his friends, "I'll call and see if he's there."

In a few minutes, Kyle came back and announced, "He says to come on over right now. He'll wait for us. Let's go!"

The NeuroExplorers picked up their helmets and piled out of the house.

Soon they were pedaling their bikes toward Dargate University. They rode through the gate and up to the ivy-covered old building where Professor Ottzinger had his office.

Tricks of the Memory

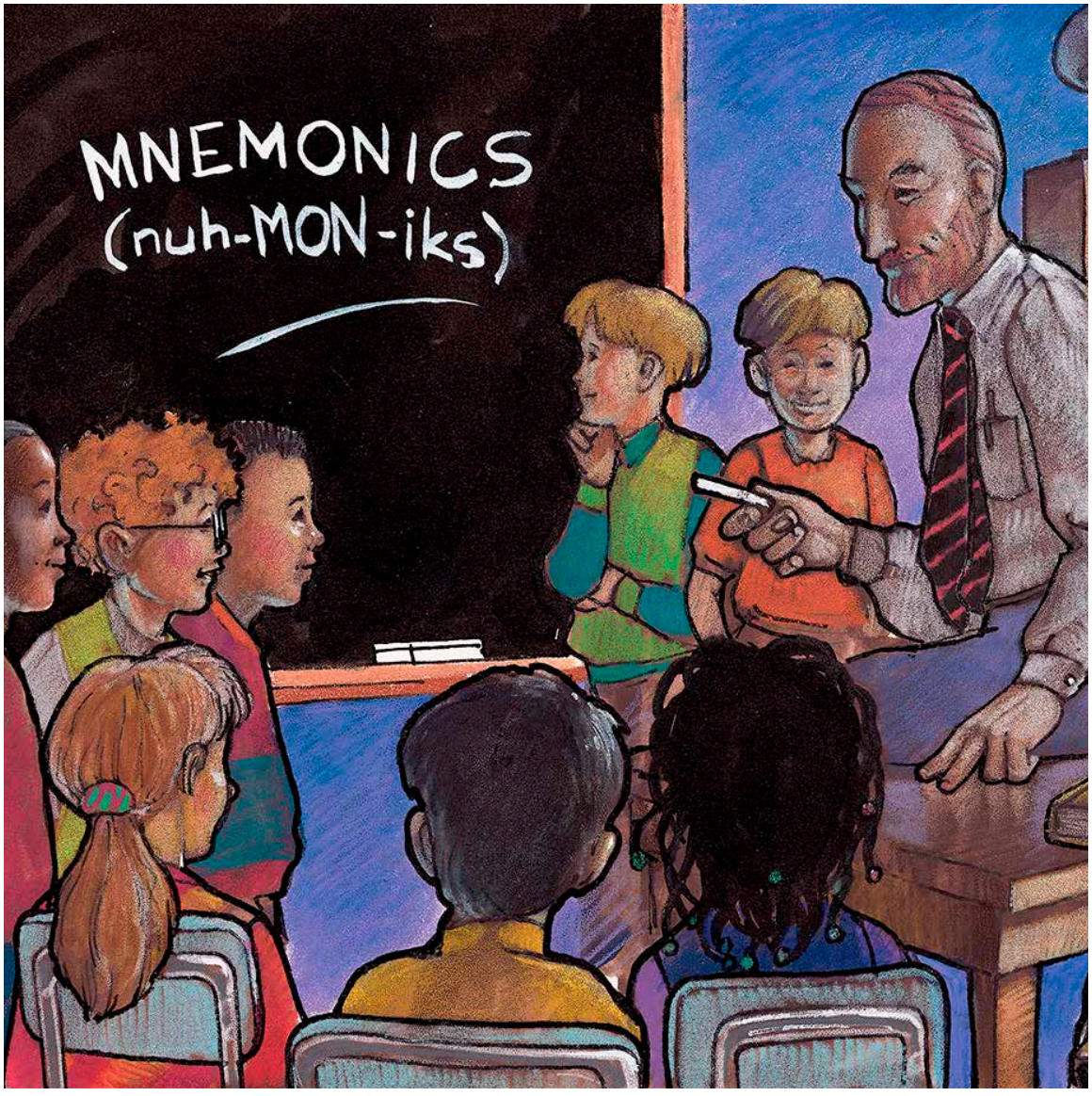
Professor Ottzinger listened closely, stroking the head of the dog sleeping at his feet, as Isley I finished telling about his dream of the night before.

"Frightening!" the Professor said with a shudder. "I certainly wouldn't want a poisonous coral snake in my bedroom! But tell me — you said on the phone that you wanted to know more about learning and memory."

"Yes, it's because of Isley I's dream," Max said, looking toward his friend.

"I usually have trouble memorizing stuff," Isley I explained, "but I remembered the color pattern of coral snakes right away, even in my dream. The Brain thought that the rhyme our teacher taught us helped me to remember."

Memories associated with disagreeable experiences often are very strong. Blue jays, for example, learn to avoid Monarch butterflies — which taste extremely bad — after trying to eat just one. After the first experience, a jay will never try to eat Monarch, or anything that even looks like one, ever again!



"You NeuroExplorers never cease to amaze me!" said the Professor. "That's exactly right. It's much easier to learn and remember something if you can associate what you're trying to remember with a picture, or put the facts into a rhyme."

"Or how about making a word from the first letters of all the words in a list?" Josh said. "Did you ever hear of ROY G. BIV? It stands for red, orange, yellow, green, blue, indigo, violet — the colors in a rainbow. Just remembering the name is a lot easier than trying to remember all the colors in the right order."

"Exactly!" agreed the Professor. "All of these tricks, or ways to improve memory, are known as mnemonics." He got up and wrote the word on the blackboard. "It looks funny, but you say it like this — nuh-MON-iks." Then everybody said it. It was a pretty strange word.

"I like to make up rhymes with drum rhythms," said B.J. "Sometimes I use them to help me remember things."

"Great idea!" agreed the Professor.

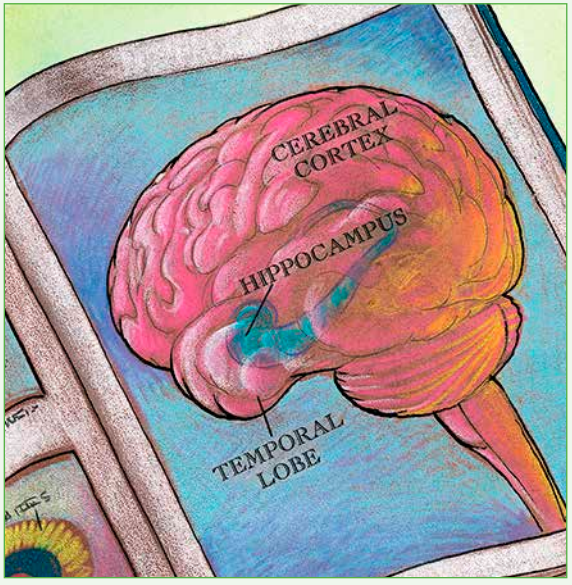
Lakeisha spoke up. "So if I wanted a 'nuh-MON-ik'," she said slowly, "to remember a grocery list of bread, rice, apples, ice cream, and napkins, I could use the word, BRAIN."

"NeuroExplorers learn fast!" said the Professor. "Did you know you're using your hippocampi?"

"Hippo whose eye?" asked Kyle.

"Hippocampi," the Professor repeated. "The hippocampus is a part of the brain that is very important for learning and memory," he explained as he wrote and said the word slowly — "hip-uh-KAM-puhs."

The NeuroExplorers looked at each other. Josh scratched his head, and everyone but The Brain looked very puzzled.



Several areas of the brain are important for processing memories. Memories of what we have experienced or learned are processed through the hippocampus. This group of neurons, deep inside the brain, is shaped somewhat like a sea horse.

Each person has two hippocampi (plural of hippocampus), one in each half of the brain. When both hippocampi become diseased or damaged, it is not always possible to learn new things and remember them.

The Hippo Takes a Dive

Professor Ottzinger pulled a book from his shelf, opened it and pointed to a drawing of the brain. "Here's a picture that shows the hippocampus. It's deep inside the temporal lobe of the brain. We'd have a hard time remembering anything if we didn't have our hippocampi. Do you think you can remember that word?" he added.

"I bet I can!" said Isley I. "I can picture a big fat hippo jumping off a diving board at summer camp, remembering at the last minute that he forgot to take off his hat!"

Isley II laughed and poked his brother in the ribs.

"What?" asked Josh, twisting his face in confusion.

"Hippo — camp! That reminds me of hippocampus. And the hippo's remembering something. That helps me to remember that the hippocampus is a part of the brain used for memory. It's a mnemonic!" Isley I said with a proud smile.

"Excellent!" exclaimed the Professor.

B.J. began to tap her drumsticks in rhythm as she made up a rhyme —

"Hippo camp, just think of that.
A hippo's diving with his hat!
The hippocampi in my brain
Let me remember this refrain."

Suddenly the NeuroExplorers heard a low growl. A large, furry object sprang to life from across the room. "Oh no!" exclaimed the Professor, "I forgot...."

The angry animal bolted toward them, fierce eyes burning like fire, fangs bared in a primitive growl that sent shivers up their spines. The dog was headed directly for B.J.!

"B.J., drop the drumsticks — now!" yelled the Professor.

The dog leapt into the air as B.J. dropped her sticks, frozen in terror.

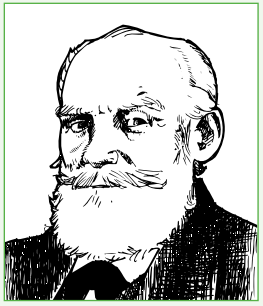
Good Dog With a Bad Memory

It all happened so fast. The big dog landed at B.J.'s feet, scooped up the drumsticks, and ran from the room. The NeuroExplorers let out a big sigh of relief.

"Whew!" exclaimed Professor Ottzinger. "I apologize for Pavlov! Before I got him from the pound, someone had beaten him with a stick, and he still remembers it," he explained. "To this day, sticks make him crazy. He'll try to take them away from anyone. He wouldn't have bitten you, but I know it was pretty scary there for a few seconds. I'm terribly sorry."

"I'll say it was scary!" said B.J. "I thought he was going for my throat."

The NeuroExplorers' hearts were still racing when Pavlov trotted back into the Professor's office. He certainly seemed less menacing now. He was the same friendly dog he had been before the attack. He laid down at the Professor's feet, and B.J. walked cautiously toward him. "Poor guy," she said, "I guess I frightened you, too." Pavlov wagged his tail. The terrible moment was over.



Ivan Pavlov, a famous Russian scientist, studied digestion in dogs. He observed that the mere sight of food would make dogs' mouths water. As an experiment, he tried ringing a bell every time he fed the dogs. Normally, dogs' mouths won't water until they see food. But Pavlov found that, after a few times, the dogs' mouths would water when they heard the bell, even without seeing the food.

The dogs had learned to associate the ringing of the bell with being fed! This famous experiment was the first demonstration of "classical conditioning."

How Are Your Hippocampi?

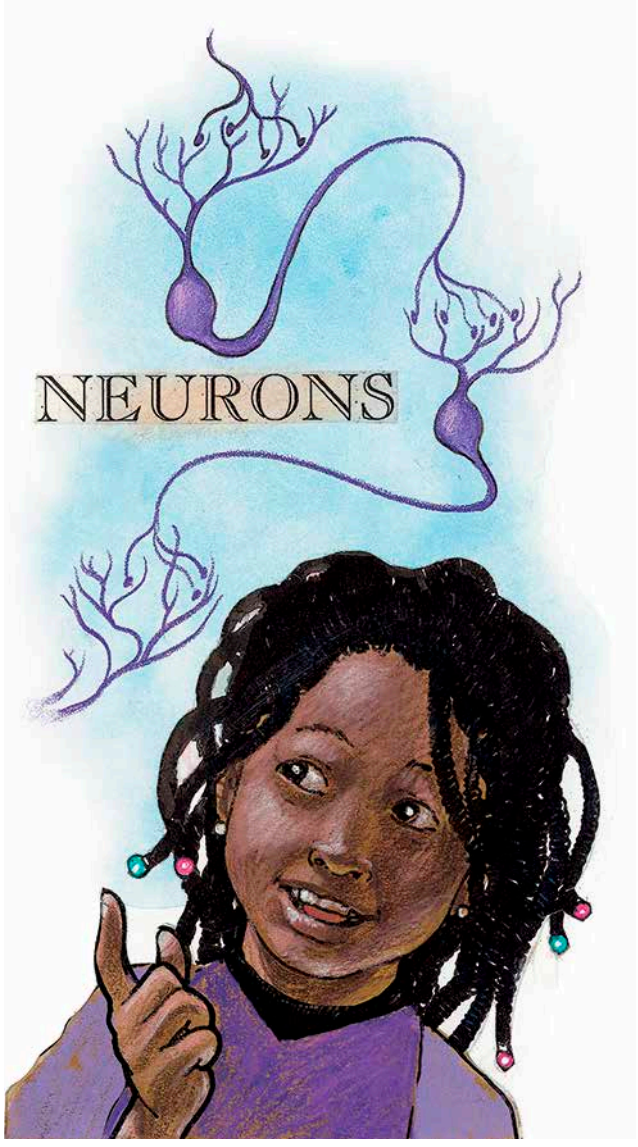
"Do dogs have hippocampi?" asked Josh.

"Yes, they do," said the Professor. All mammals have hippocampi. Just like in humans, dogs' hippocampi are important to help them learn and remember things."

"How about neurons?" Lakeisha asked. "Neurons are important for movement and the senses. Do they also send messages that are related to remembering?"

"Absolutely right," Professor Ottzinger replied. "There is a whole network of neurons in the hippocampus and other parts of the brain that are used for memory. Good thinking, to remember the neurons!" he complimented Lakeisha.

The Brain added, "Lakeisha's proficiency in information storage and retrieval demonstrates the efficiency of neuronal activity in her hippocampi."



The NeuroExplorers looked at Max. "Interpreter..." they groaned.

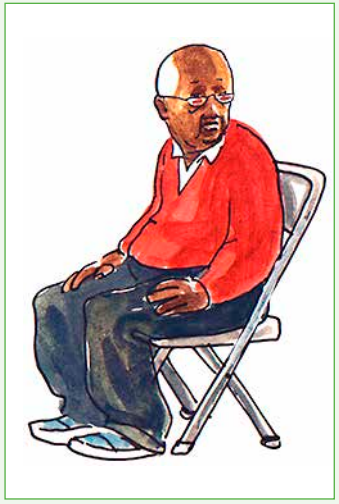
"The Brain says that because of the way Lakeisha learns and remembers things, her hippocampi must work really well!" Max said.

"Probably true," said the Professor. "I'm sure you all have very healthy hippocampi! But, you know, there are some diseases that affect that part of the brain. They destroy neurons in the hippocampi, so that a person has trouble remembering new things. That's part of what happens in Alzheimer's disease."

"What a funny name. Why is a disease called that?" asked Kyle.

"It's named after the person who discovered it," said Professor Ottzinger.

"I've heard of Alzheimer's," exclaimed B.J. "My brother



Alois Alzheimer, a German doctor and neuroscientist, described Alzheimer's disease, or A.D., in 1906. It usually affects older people, destroying neurons in their brains. At first, they might have trouble with their short-term memories (like what someone just told them) but not with old, long-term memories, like things that happened in their childhoods.

Later, memory and reasoning can get much worse as more neurons are damaged in the hippocampus and the cerebral cortex. Even long-term memories may become confused or lost, and A.D. patients may need constant help with their daily lives.

told me about it, and I can remember the name by thinking, 'Alzheimer's — old-timers.' Only old people get Alzheimer's disease, right?"

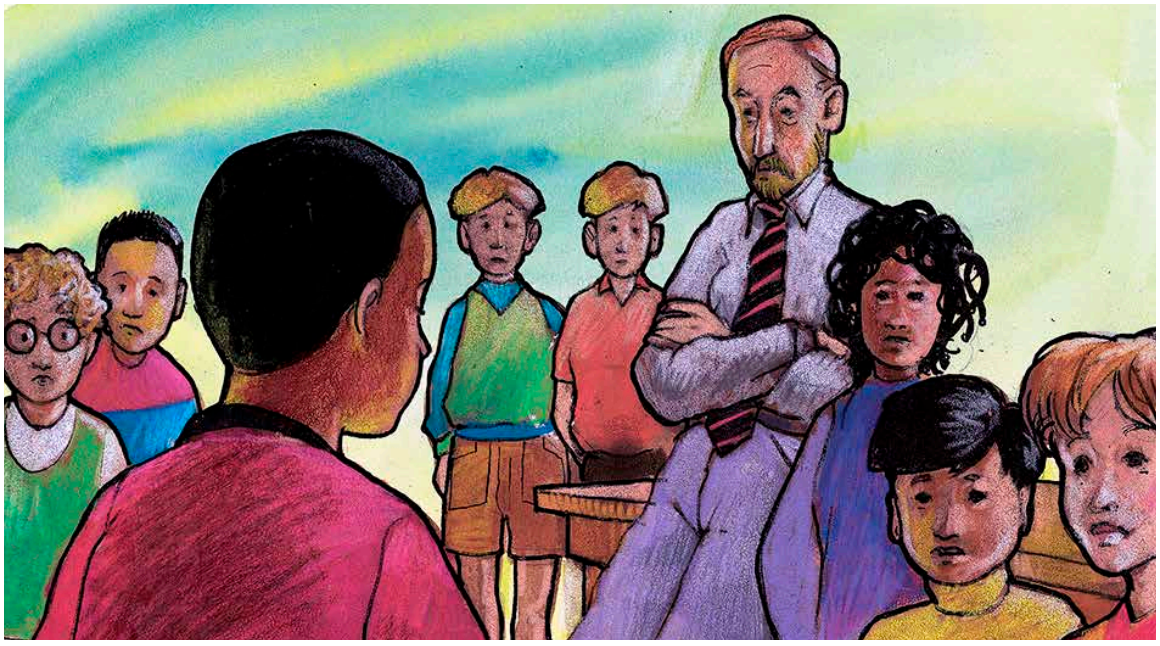
"Usually, people your grandparents' ages or older get A.D.," the Professor answered.

"It sounds terrible!" said Kyle.

"Our grandparents could get that disease!" Lakeisha added, with a shudder.

"Don't worry — most older people don't get Alzheimer's," said Professor Ottzinger. "While the memory normally tends to fade a little as we get older, only about ten percent of people between 65 and 85 actually have Alzheimer's disease."

"My Grandpa Miller has Alzheimer's disease," whispered Max. There was silence. You could have heard a pin drop.



Max's Fear

All eyes were on Max. No one knew what to say. Finally, The Brain broke the silence.

"I'm sorry, Max." No one needed to translate The Brain's kind words to his best friend, "Are you okay?"

"I'm okay," Max replied. "I'm worried about my Grandpa, though. The doctor told us he had Alzheimer's disease almost two years ago. It's just like the Professor said — he started having trouble with his memory. He would go to the store, and then when he got there he would forget what he was looking for. That wasn't so bad, but once he went for a walk after dinner and he

got lost. The police found him at midnight, walking in the middle of the road."

Everyone was listening quietly to Max's story. He continued, "After that, Grandpa went to live with my Uncle Ed in Crystal City. That worked out fine for a while, but just last month he had to move to a place where someone is there to help him all the time. Mom says it's nice there, and he likes it pretty well, but I'm afraid he must get lonesome without any of us around."

"Can't you visit him?" asked Lakeisha.

"Yes, I can," said Max quietly, staring down at the ground, "but..."

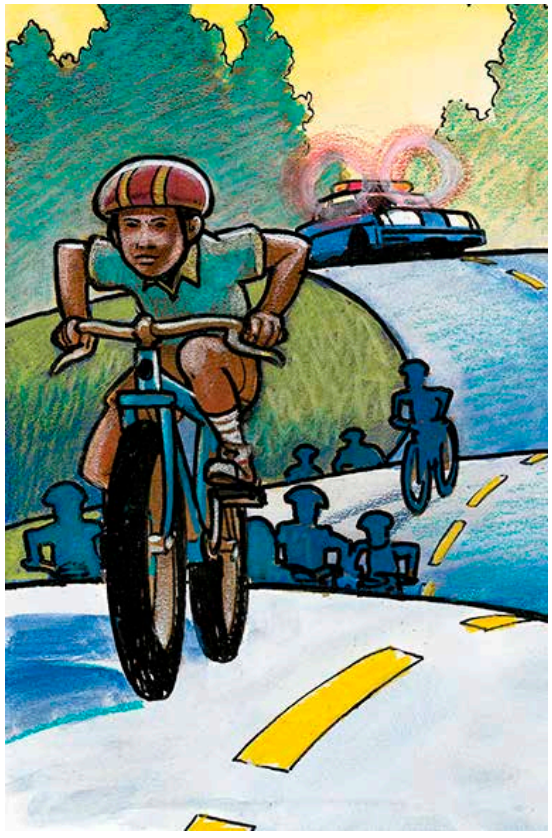
"So why don't you go see him?" asked Kyle.

There was a long pause. Max looked at his friends for a second and then quickly looked away and gazed out the window. His eyes filled with tears. "Because I'm scared that he won't remember who I am," Max said quietly.

He told his friends that, only a few years ago, his grandfather used to take Max fishing and hiking. He taught him about different kinds of fish and birds and plants. Now Max's Grandpa could not always remember where he was or what he was doing.

The Brain put his hand on Max's shoulder. "Why don't you go see him? We'll go with you," he said.

Max took a deep breath. He knew he was not alone. For that moment he was not so frightened of the terrible disease that was taking his grandfather away from him. "Okay," he said, "let's go today. Meet at Kyle's right after lunch."



A Warning

It was a good thirty minute bike ride out to Riverbend Gardens Retirement Center. Now that he had decided to visit his grandfather, Max was in a hurry. He was pedaling so fast, it was hard for the others to keep up with him.

"Hey, slow down," B.J. called, "and move over. There's a car coming."

A car with flashing lights pulled up beside them. It was the county sheriff. He rolled down his window and asked, "Where are you kids going?"

"We're going to Riverbend Gardens," said Max, "to see my grandfather."

"Okay, the road is safe up to there," said the sheriff. "I'm going over to the river to close off the county road. It's been raining pretty heavy up north, and the water's getting high at some of the river crossings. Just stay out of the lowlands. It may be dangerous around Rocky River." He sped up again and disappeared down the road.

"Isn't it funny," Josh thought aloud, "that he's talking about flooding when it's not even raining? The sun's shining."

"I remember a couple of years ago," Kyle said, "when it rained for days in the hills above the lake, north of here. They had to open the dam, and Rocky River got so high that it flooded into some houses, even though it never rained around here. I hope that doesn't happen again."

Games and Grandparents

The NeuroExplorers reached the retirement center, parked their bikes and walked up the flower-lined path to the lobby. A woman came to greet them. "Hello there!" she said cheerfully. "I'm Ms. Garza, director of Riverbend Gardens. Are you here to visit one of our residents?"

"We're here to see my Grandpa, Isaac Miller," said Max.

"Super!" exclaimed Ms. Garza. "Mr. Miller will be thrilled to have so many guests. I think he's taking his afternoon walk, but he should be back in a few minutes. Why don't you wait in the game room?"

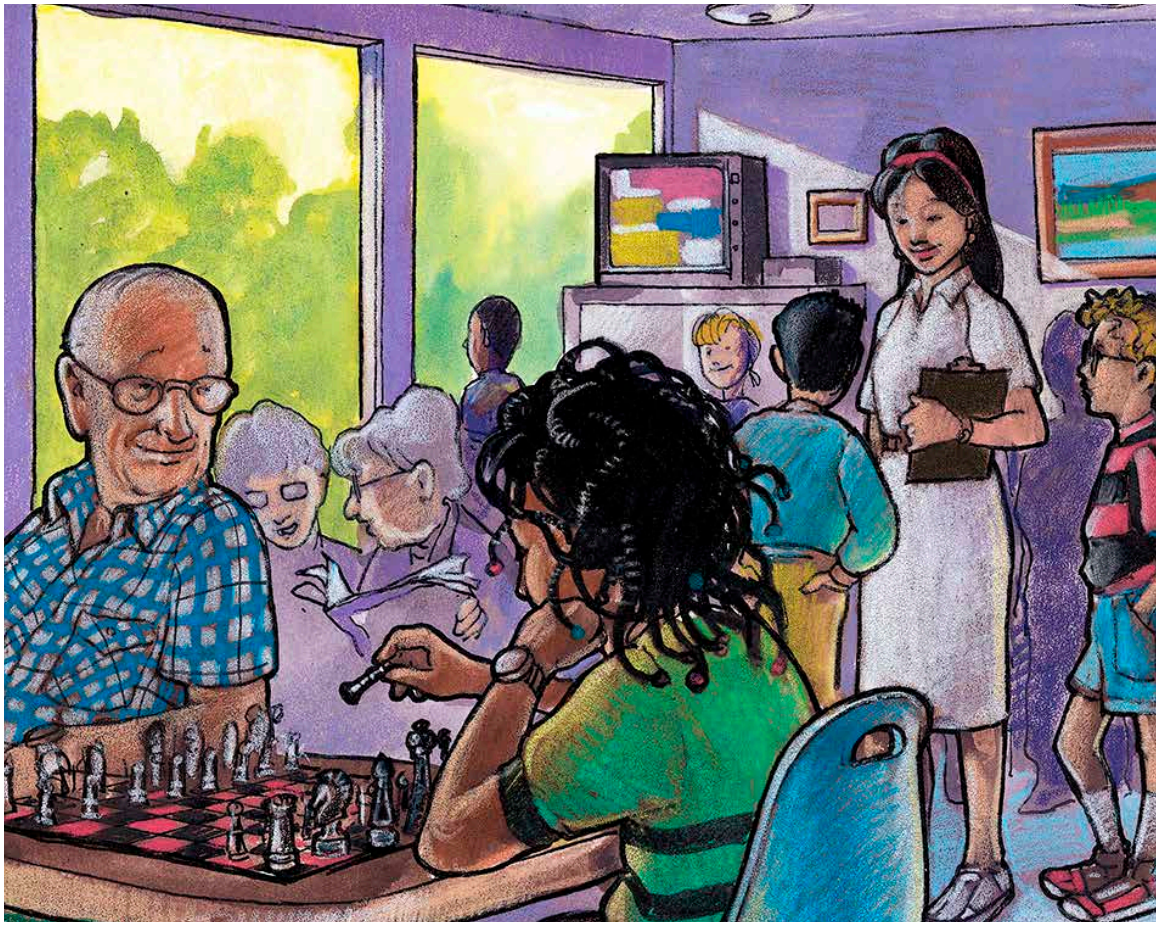
"Games?" asked Isley II, a glimmer of excitement in his eyes.

"Follow me," said Ms. Garza.

They entered a brightly lit room. Two women with white hair were sitting in front of a big-screen TV playing a video game, and four or five other residents were sitting on the couch, cheering them on. Isley II immediately introduced himself and sat down by the ladies.

A man was sitting at a table in front of a chessboard. "Any of you kids play chess?" the man asked.

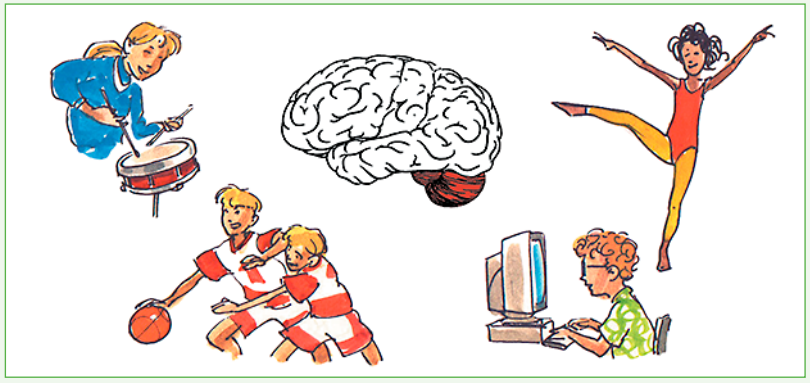
Lakeisha spoke up, "Well, I've played some chess." She turned and winked at the other NeuroExplorers. Lakeisha was good and she knew it.



She sat down with the old man and introduced herself.

"Plotsky's the name," the old man said. "You can go first." After ten moves, Lakeisha's jaw nearly dropped to the floor. This man had strategies she had never seen. Lakeisha lost the game and quickly started setting up for another one. She could learn a lot from Mr. Plotsky.

Becoming skilled at playing a video game is an example of creating memories of how to do something. Memories of procedures and movements (like playing games or sports, walking, writing, dancing or playing a musical instrument) are stored in the cerebellum. Repetition, or learning by doing something over and over, often is important for making memories of procedures and movements.



Max was staring out the window, looking for his grandfather. Meanwhile, the other NeuroExplorers were talking to Ms. Garza. "It seems like everybody has a good time around here," Josh said.

"Oh, yes," Ms. Garza agreed. "We have lots of activities and interesting things for the residents to do. Sometimes they get lonesome, though. We really love to have visitors."

All of the residents in the game room did seem glad the NeuroExplorers were there. They kept each one busy talking, laughing and playing games.

I wish my grandfather lived here," said B.J. "Then I could come visit every weekend."

"You're welcome here, anytime you want," said Ms. Garza. "We'd love to have you visit!"

"Aaagh!" Lakeisha exclaimed to her chess partner. "You got me again. Another game?"

"But of course," said Mr. Plotsky. "This is great brain exercise! Use it or lose it, they say."

Just then a young man wearing a white jacket burst into the game room. "Ms. Garza, I need some help!" he said. He was out of breath. "I can't find Mr. Miller! I was taking him for a walk through the woods near the river. I just ran back for two minutes to get a pair of binoculars for us to watch the birds, and he disappeared. He was sitting there, and he said he wouldn't move until I got back. But he's gone, and now the river's rising!"

A Raging River

"What? He can't be gone!" screamed Max. "He might not find his way back! We have to find him."

"Let's be calm about this," said Ms. Garza. "I'm sure he'll be okay. I'll send somebody out with Vince, and they'll find your grandfather — you'll see."

But for Max, it was too late for calm. He raced out the door and headed straight for the woods. The other NeuroExplorers were close behind. They were tearing along the path toward the river, when Max suddenly stopped. His friends almost piled into him.

"Hey, why did you... Wow!" said Josh as he looked ahead.

Rocky River was raging wildly out of its banks. The NeuroExplorers could see the water rising before them. It was about to reach the footbridge that led across the river.

"Do you think your Grandpa crossed the river here?" Lakeisha called over the roar of the water.

"Here are some footprints, with marks made by a cane, leading right up to the bridge," said Max. "I'm going across. I have to find him."

"Are you nuts?" Lakeisha said. "It's too dangerous. Look at that water — it's flooding!"

"I've got to cross," Max repeated. His friends knew he was going, no matter what. There was no way to stop him.

"Not alone!" said The Brain. "I'm going with you."

"Me too!" said B.J.

"OK, let's go," the others chimed in, and they followed Max. The water now covered the bottom of the bridge. Their feet began to slip and slide. They had to hold on to the railing to pull themselves toward the other side. Suddenly Max lost his grip. B.J. was right there, and she grabbed him by the shirt, just in time to stop him from being washed downriver.

Water Power

"He's over here. He crossed the river!" Max shouted as soon as he and B.J. reached the opposite bank and scrambled out of the water. "Here are his footprints!"

All the rest of the NeuroExplorers were right behind them, except for Isley II. He was still on the bridge. He could barely hold on. Suddenly, one side of the handrail broke off in front of him.

"My hands are slipping!" Isley II screamed to his friends. They could see the terror in his eyes.

"Hold on!" yelled Isley I, starting to go into the water after his brother. He was stopped by a long branch that floated between them. Quickly, he caught the branch and pushed it toward Isley II, shouting, "Grab this and I'll pull you out!"

The NeuroExplorers watched in horror. A log was floating rapidly toward Isley II. It knocked him away from the branch, and the current washed him downstream.

"Noooooo!!!" screamed Isley I, and he started to run along the edge of the rushing water. The others were right behind him. Vince, who hadn't made it across the bridge, joined the chase on the opposite bank. They all ran as fast as they could, but they couldn't keep up with the flooding river. They saw Isley II's head in the water, and then they lost sight of him as he plunged through the rapids. They ran for what seemed like a mile before the rapids ended and the river slowed. Then they saw something floating near the shore. It was a high-top basketball shoe — one of Isley II's shoes! But Isley II was nowhere to be seen.

"We've lost him!" Isley I moaned, slumping to the ground. No one answered. They all stared blankly at the river.

Then through the bushes came a familiar voice. It was Isley II, soaked and coughing up some water, but safe! "You guys give up too soon," he spluttered.

Isley I had never been so happy to see his brother. He ran over and gave him a big hug. Isley II was soaked, scratched up and out of breath, but he seemed okay.

"What a ride! Man, those are some rapids," Isley II said. "You guys ought to try it!"

"Those rapids must have rattled your brain! It's not exactly a safe sport right now," Isley I retorted. He grabbed his brother's arm and pulled him farther away from the wild river.

"Come on, let's get out of here," Kyle said. "Boy, I'm never going to forget this day!"

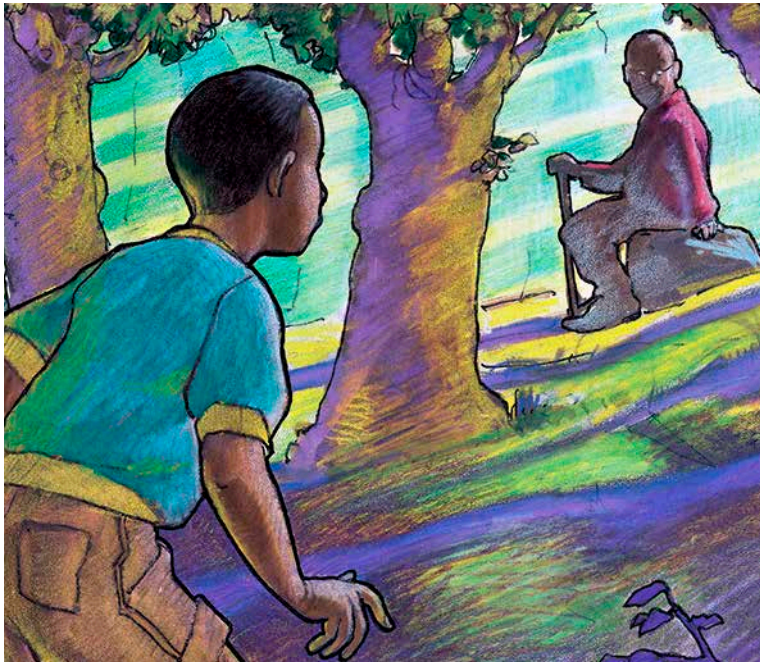
"We've still got to find my Grandpa," added Max, tossing Isley II his missing shoe.

Looking for Grandpa

Vince yelled from across the river that he would go back to the road and try to drive across downriver. He would come and pick them up.

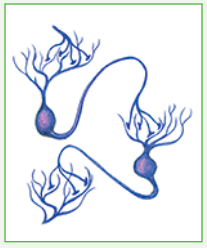
The NeuroExplorers immediately began to look for footprints again. And soon they found them — marks made by a man with a cane — on the high ground above the water! They led into the woods away from the river.

Soon the soft ground ended and the footprints disappeared. "We've lost the prints," said Josh. Max kept walking.



"Max, we've lost the prints," Kyle echoed. "How will we find him without footprints?"

Max kept walking, silently. He seemed to sense something the others couldn't, as he followed a small path in the woods. Suddenly he stopped. There, sitting on a rock in the clearing, was his grandfather.



Memories are stored in the brain as changes in the synapses, or connections among neurons, in different parts of the brain. Remarkably, the brain can combine already-stored information with new input from the senses to make decisions and evaluate new situations.

People with Alzheimer's disease have difficulty with the process of forming new memories. Sometimes it helps for them to write things down or to put signs around their homes to help them remember.

Max stood very still, without moving or saying a word. Finally, The Brain put his hand on Max's shoulder. "We're here for you, Max," he whispered.

As Max finally stepped slowly into the clearing, the man turned his head and looked at him. His grandfather's face gave no sign that he recognized the boy walking toward him. Max froze. It seemed like forever before anyone spoke.

Finally Max said softly, "Hi, Grandpa. It's me, Max."

The old man looked confused. All of a sudden he smiled and said, "Max! Come give your Grandpa a hug!" His voice was as warm as the afternoon sun behind him.

Confusing Questions

The NeuroExplorers all introduced themselves to Grandpa Miller and told him about the flooding river.

"I'm not sure how we'll get back, Grandpa," said Max. "The bridge is under water, and the roads are closed. Vince said he'd pick us up, but I don't know if he can get over here until the water goes down."

"You know, sometimes I get mixed up about where I'm going, Max," his Grandpa said calmly, "but your Grandma and I used to live right over there. I grew up in these woods, and I helped build the dam. It shouldn't be too far from here. There's a walkway right across the top of the dam that will take us to the other side of the river."

It was true. Max's grandfather had grown up here, and he knew this river and the surrounding woods very well. The NeuroExplorers recalled Professor Ottzinger's words about Alzheimer's disease. While people with A.D. have difficulty remembering directions and can easily get lost, they sometimes have no problem recalling old memories from the past. They would trust Grandpa Miller's memories to lead them out of the woods and over the dam.

The old man pointed to an overgrown path, and the whole group hiked toward the dam. Grandpa Miller stopped when they came to a steep, rocky slope. He turned to Kyle and asked, "Larry, can you and Max help me up this hill?"

Kyle looked at Grandpa Miller, puzzled. Max spoke up, "Don't you mean Kyle, Grandpa?"

"Oh — Kyle. I'm sorry about that. Guess I'm not too good with names these days," Grandpa Miller said. Then he took a pen and a small notebook out of his shirt pocket. "I've been using this notebook to help me remember things," he continued. "Kyle — I'll write that down."

When he finished, he pointed to Isley II and said, "I don't know you. Your name is...?"

"Isley II," the boy replied politely.

As Grandpa Miller began to write the name, he looked up and saw both Isleys, standing together. "Oh, dear," he exclaimed, "there are two of you!

Only one is soaking wet." He rubbed his eyes in confusion and stared at the almost identical-looking pair.

"Ah, yes," he said finally, "you must be twins! I didn't know there were twins here." Mr. Miller chuckled, shook his head and wrote in his book, having forgotten that he met the twins only a short time ago. "Okay, let's get going," he continued. "Somebody give me a hand."

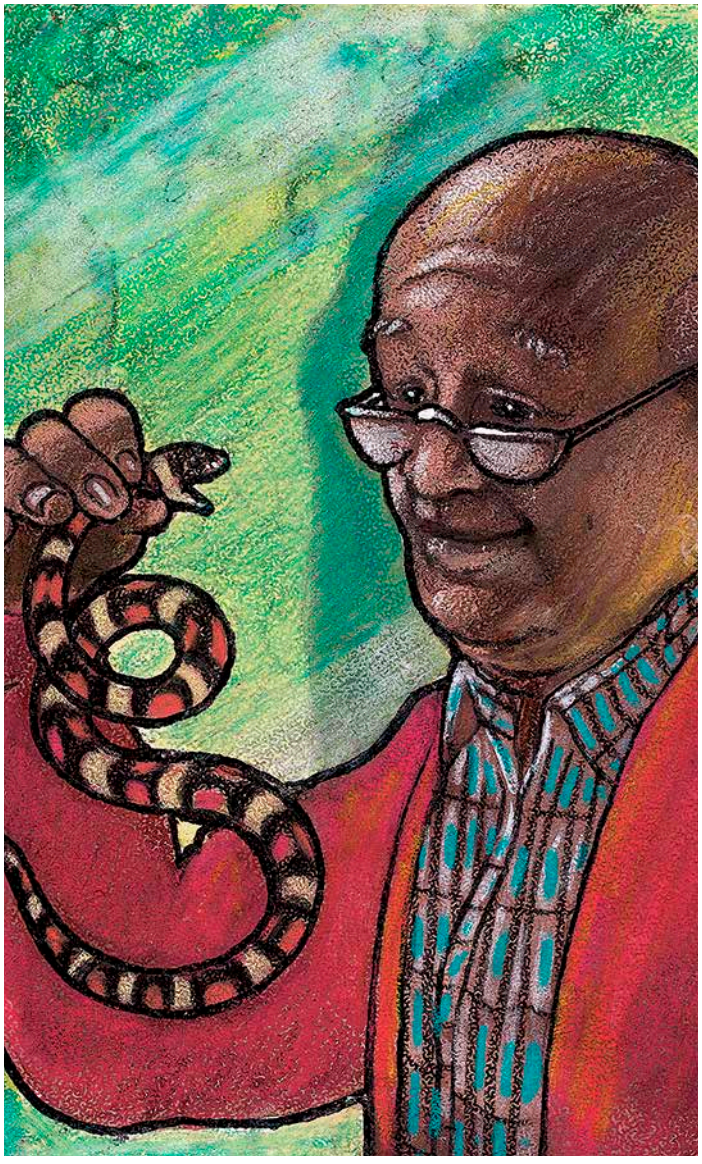
Grandpa Miller put the notebook back in his pocket as Kyle and Max helped him up the steep path. They walked on, looking for the dam. Suddenly, Max stopped and stared at the ground.

Soon the other NeuroExplorers saw what Max saw. Not ten feet away from them, right in the middle of the path, was a colorfully striped snake!

Remembering Rhymes

Grandpa Miller didn't seem to see the snake. He kept walking until he was within two feet of it. Then he stopped and looked down. The NeuroExplorers were horrified. "Grandpa," Max whispered hoarsely.

"Shhh. Be very quiet," Grandpa Miller said, not taking his eyes off the snake. Then he did something none of the NeuroExplorers could believe. He bent down and gently lifted the snake from the ground! He turned around with the snake in his hands. Eight pairs of wide-open, amazed eyes were staring at Grandpa Miller and the snake.



"Red, then black. The snake is striped red, then black!" Isley I shouted, with a look of great relief.

"Red then black, friend of Jack," Grandpa Miller said with a smile.

All the NeuroExplorers chanted the poem about snakes that Isley I had told them that morning —

"Red then yellow,
Kill a fellow.
Red then black,
Friend of Jack."

"You gave us a scare, Grandpa," Max said. "I thought you didn't see that snake and were going to get bit."

"Well, Max, I may have trouble with my memory, but I can see just fine. I learned that poem back when I was in school, you know — red, then black," Grandpa Miller said with a grin. He looked at the snake for a minute and mumbled, "Now, what do you call that kind of snake? Uh... I can't seem to remember... milk snake! Yes, there always were milk snakes around here by the river where we built the dam. They look a lot like coral snakes, but their stripes are different...." His voice trailed off.

Grandpa's Victory

Grandpa Miller looked away then, as though he had forgotten all about the snake, and where they were, and what they were doing. He gazed off into the distance. Finally he turned back to Max and said, "Now, what were we looking for?"

Danger at Rocky River

"Look, there it is! There's the dam just beyond those trees," said Max.

Grandpa put the snake back down on the ground and watched it wriggle off as he said to himself, "I knew the dam was here."

The NeuroExplorers were amazed that, although Grandpa Miller needed a notebook to remember their names and often got lost in new places, he still remembered poems from his school days and the woods he knew so well when he was young. They were glad they'd gotten to meet Mr. Miller. Max was proud of his grandfather, and he smiled as they walked together across the dam.

Just as they noticed the sun getting lower in the sky, they caught sight of Riverbend Gardens. Grandpa Miller paused for a moment and put his hand on Max's shoulder. "You'll come back to see me again, won't you?" he asked.

Max realized that the days he spent with his grandfather now were very important. "Every week, if I can," he answered, putting his arm around his Grandpa's waist. All the NeuroExplorers knew that they wanted to come back, too. This had been a memorable day for everyone!

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

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

association (uh-so-see-A-shun) - to learn by making mental connections among sensations, ideas, memories and/or movements

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

cerebellum (sehr-uh-BEL-um) - part of the brain located directly behind the brainstem that controls the sense of balance and helps the muscles work together for learning and coordination of rote movements

cerebral cortex (suh-REE-bruhl KOR-tex) - the outermost layer of the brain's cerebrum; controls our most advanced abilities, such as speech and reasoning

cerebrum (suh-REE-brum) - the large, rounded outer layer of the brain where thinking and learning occur, sensory input is received and voluntary movement is started

classical conditioning (KLAS-ih-kuhl kon-DISH-uhn-ing) - type of learning by association in which a neutral stimulus (for example, a sound or a light) is paired with a second stimulus that causes a response (for example, the presence of food, which leads to salivation)

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*

disease (diz-EEZ) - sickness; a condition that harms the normal function of some part or parts of the body

epilepsy (EH-pih-lep-see) - a condition brought about by sudden changes in the activity of neurons in the brain; affects a person's awareness and actions, often causing jerking movements of the body and limbs, for short periods of time

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

hippocampus (hip-uh-KAM-pus) - a seahorse-shaped area of neurons in each temporal lobe of the brain; forms and stores new memories [plural: hippocampi (hip-uh-KAM-pye)]

imitation (ih-mih-TA-shun) - type of learning that involves observing someone else and copying his or her activity

learning (LERN-ing) - gaining knowledge or skill by instruction, study or experience

lobe (LOHB) - a curved or rounded part of a body organ

long-term memory (LAWNG-turm MEM-uh-ree) - the type of memory (like your name) that lasts a very long time, even up to a lifetime

memory (MEM-uh-ree) - the act of remembering; information that people or animals have stored in their brains over time

mnemonics (nuh-MON-iks) - systems created to aid memory, such as the use of rhymes or mental pictures that make it easier to remember something

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-jee) - 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 or area of the brain 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

Pavlov, Ivan (PAV-lawv, I-vuhn) - Russian scientist who lived 1849–1936 and is best known for his studies of learning and memory in dogs

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

repetition (reh-puh-TIH-shun) - element of many learning processes that involves doing something over and over

short-term memory (SHORT-turm MEM-uh-ree) - type of memory that lasts only for a short time - for example, a telephone number you have just looked up; may be converted to long-term memory

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

synapse (SIHN-aps) - tiny gap between the axon of one neuron and the dendrite of another neuron, across which messages are transmitted chemically or electrically

temporal lobe (TEM-puh-ruhl lohb) - one of the four lobes in the two hemispheres of the cerebrum; located on the sides of the brain and containing the hippocampi, groups of neurons important for learning and memory; located inside the skull just above the ears

About the Authors and Illustrator

Dane Chetkovich, M.D., Ph.D, lead author, was born in West Virginia, grew up in Texas and now resides in San Francisco. He received his degrees from Baylor College of Medicine, where he was the recipient of Baylor's highest awards and honors. This story was written while he was still completing his M.D. degree. Dr. Chetkovich specializes in neuroscience and has written several scientific articles about the neuronal basis of learning and memory in mammals. In his free time, he enjoys watching movies, playing golf, and traveling in Mexico and Central America.

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

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ISBN: 978-1-944035-99-6