National Institute on Drug Abuse (NIDA)

Brain Power: Grades 2-3

Last Updated September 2012

https://www.drugabuse.gov

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Brain Power: Grades 2-3

Ooey Gooey! Making Sense of Scientific Inquiry (Module 1)

You can also download this entire module in PDF format by clicking the following link: Module 1 (PDF, 6.3MB).

Introduction

"Scientific inquiry" is a broad term that refers to the varied ways that all scientists - from biologists to physicists to chemists - study the natural world and develop theories based on their ideas. According to the National Science Education Standards (NSES), inquiry involves the following:

- Making observations;
- Posing questions;
- Planning investigations;
- Examining books and other sources of information to see what is already known;
- Using tools to gather, analyze, and interpret data;
- Proposing answers, explanations, and predictions and communicating the results.

The purpose of the mission in the program's first module is to introduce students to these key processes of science. The students' challenge is to identify the contents of the mystery goo. To solve the problem, students must make observations, record their observations, ask questions, develop experiments to answer their questions, and draw conclusions from their results. Students will use these processes as a starting point for completing the missions in subsequent modules.

Learning Objectives

- Students experience the processes of science.
- Students learn how to ask appropriate scientific questions.
- Students learn how to develop investigations to answer their questions.
- Students discover how information is transmitted through their senses.

Relationship to the National Science Education Standards

This mission aligns with several standards identified in the NSES: overall physical science standards, the history and nature of science, and standards for science as inquiry. The charts below show how the mission aligns with the standards.

Physical Science Standards

Levels K–4	**How Mission Is Aligned**
Properties of objects and materials	Students observe the mystery goo, identify its properties, predict what it is made of, and develop an investigation to check their predictions.

History and Nature of Science

Levels K–4	**How Mission Is Aligned**
Science as a human endeavor	After viewing the DVD showing different kinds of scientists, students begin to understand that science encompasses many disciplines. Because they, too, will be working as scientists, they also start to realize that anyone who asks questions and tries to find the answers to their questions is a scientist.

Science as Inquiry

Levels K–4	How Mission Is Aligned
Abilities necessary to do scientific inquiry	Students go through the steps of scientific inquiry: observing, making predictions, experimenting to test their predictions, and drawing conclusions.
Understandings about scientific inquiry	Students learn about different kinds of scientists who ask different questions and develop original experiments to answer their questions.

Background

This mission has two purposes: to introduce students to the process of science and to illustrate how information is transmitted through the senses. During this mission, students will use their senses—seeing, hearing, smelling, and touching—to describe the properties of an object. Properties are those characteristics that describe an object, such as color, shape, and texture. For safety, the sense of taste will not be used in this module. After completing the mission, students will brainstorm about the brain, where the information gathered by the senses is processed. The brainstorming session prepares students for module 2, which focuses on the parts of the brain and what each part does.

Scientific inquiry has a distinct benefit for young students: It does not rely solely on traditional vehicles of learning, such as reading and listening. Children who learn best through hands-on activities and the visual arts also have an opportunity to excel.

Materials/Preparation

Materials

- Five or six bags of goo
- Cornstarch
- Sugar
- Talc
- Water
- Five or six medium-sized bowls
- Five or six measuring cups and spoons
- Plastic bags with a seal
- NIDA Junior Scientist DVD, or online video
- Stirrers
- Instruction Sheet (PDF, 79KB)
- Log Sheets (PDF, 35KB)

Preparation

> You may want to have parent volunteers or instructional assistants available to help in the preparation of the bags of goo.

1. Prepare five or six bags of goo by following the instructions below:
    - Measure 1/4 cup of cornstarch and put it in a bowl.
    - Add about 3 1/2 teaspoons of water to the cornstarch. The mixture should be thick enough to shape into a ball. You may have to adjust the amount of water so that it is not too dry and not too wet.
    - Duplicate the recipe so that you have five or six bags of goo, one for each group.
    - Make sure you put each batch of goo in a plastic bag with a seal. If not, the water may evaporate, and the goo will dry out.

If possible, have at least one other adult in the room while the children are working on the experiment.

2. For the second half of the activity, measure the following materials and lay them out for each group of students:

    - 1/4 cup of cornstarch
    - 1/4 cup of sugar
    - 1/4 cup of talc
    - 3 1/2 teaspoons of water
    - Spoons and stirrers

3. This activity will take 2 days to complete. On the first day, show the students the DVD, hand out the log sheets, and have them work on the experiment. On the second day, students can record their results and discuss what they learned.

Procedures/Discussion Questions

Procedures

1. Show the class the introductory segment of the DVD or read the story on page 1-16 of this guide. Make sure the students understand their mission.
2. Divide the class into five groups of about five or six students. Give each group a bag of goo. Remind the groups of their mission - to figure out what the goo is made of.
3. Tell the groups to observe the contents of the bags. Ask them to consider the following questions:

    - What does the goo look like?

- What does it smell like?
- What does it feel like?
- Can you roll it into a ball? Does it break apart?

4. After the groups have thoroughly observed the goo, have them record their observations on the log sheet.
5. Have each group make a prediction of what they think the goo is made of. Have students write their predictions on the log sheet.
6. Point out the ingredients on the table. Using their observations as a guide, have the groups select ingredients that they think they need to make a fresh batch of goo. If the two goos match, the students will have succeeded in uncovering the identity of the mystery material.
   Make sure you put each batch of goo in a plastic bag with a seal. If not, the water may evaporate, and the goo will dry out.

> The biggest decision students have to make is which solid to use. There are equal measurements of three different solids - cornstarch, sugar, and talc - laid out on the table, as well as containers of water. If they pick the wrong solid, they will have to throw the mixture away and prepare another one using water and a second solid.

7. Let students work independently as much as possible. After they have completed the investigation, have them record what ingredients they think are in the goo. Make sure they include reasons why they think the goo is made of those ingredients.
8. Have each group present its findings to the class. Each presentation should include the evidence students have that supports their conclusions.

> These presentations do not have to include any written materials, and they can be very short. The idea is for the children to try to articulate what they learned and begin to give reasons for their thinking.

9. The mission is now accomplished!

Discussion Questions

1. Discuss with the students what information about the mystery goo they got from their senses.
2. Ask students what they think happens to the information their senses gather. Where does it go? Help students understand that the information is processed in the brain, the control center for our bodies.
3. Ask students what they know about the brain. Record their responses on a piece of newsprint. You may want to revisit their ideas later in the program.
4. Start a class list about the functions of the brain. Plan to add to this list in subsequent modules.

Extensions

The activities listed below provide a link to other areas in the curriculum. These activities also make use of the trading cards included in the module.

1. Divide the group into pairs. Make copies of the trading cards and give each pair a set. Have them look at the scientists shown and imagine what a typical day would be like for each one. Students also can think about the differences and similarities among the scientists.
2. Divide the class into groups of five or six. Have the groups draw a large picture of what they have learned about scientific inquiry. Or students could pretend that they are reporters for the local newspaper assigned to describe scientific inquiry. Individually or in pairs, students can either write or draw their findings.
3. Have students draw a picture of what they think the brain looks like.
4. Read *Bartholomew and the Oobleck*, by Dr. Seuss, to the class.

Assessment

1. This activity can be viewed as an embedded assessment of how well students are grasping the concepts of scientific inquiry. As they work, look for the following:

    - Are students able to make observations that are clear and specific? For example, can they note the color and shape of the material instead of saying, “It’s weird?”
    - Are students able to make a prediction based on their observations?
    - Are students able to figure out which materials to test to try to recreate the goo? Do they approach the problem logically and methodically?
    - Are students able to record their results in either words or pictures?
    - Can students support their conclusions with evidence gained from their investigations?

2. Keep track of what students know about the senses and the brain. Are they beginning with any prior knowledge, or is this subject completely new to them? If it is completely new, you may want to review what you discussed about the brain before proceeding to module 2.

3. After students complete their log sheets, you may want to make copies of them as part of a portfolio of their work. After completing each module in the NIDA Junior Scientists Program, students will be completing a log sheet. You can use the sheets to track their development as scientific investigators.

Additional Activities

Below are some additional activities that can be used after completion of the first mission. These activities are extensions to many other areas of the curriculum.

1. Have the students make a comic strip describing the steps involved in scientific inquiry. Make sure that each step is explained clearly.

2. Have the students write a letter to a friend comparing the NIDA Junior Scientists Mission Control Center with the brain, the body's "mission control." How are they similar? How are they different? Have students include in their letters additional information they would like to learn about their brain.

3. As a class, look at the recipe used to make the goo. Then discuss the following questions:

    - What would you have to do to make twice as much goo as you did?
    - What would you have to do to make half as much goo?
    - What would happen if you added vinegar to the goo? Make a prediction, then perform the experiment to find out.

4. Ask students how they know that it's cold outside on a winter's day. What part or parts of their bodies let them know? How is the brain involved?

5. Ask students to draw a concept map showing what they have learned about the brain and their senses. Have students think about how the senses are connected to the brain. Make sure they indicate these connections on their concept maps.

6. Have students put on a play demonstrating what they have learned about scientific inquiry. Encourage them to explain the different elements of inquiry in creative ways. They also may want to include information about what they have learned about the brain.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

- NIDA DrugPubs
  drugpubs.drugabuse.gov , 877-NIDA-NIH (877-643-2644)
  DrugPubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

- National Clearinghouse for Alcohol and Drug Information (NCADI)
  store.samhsa.gov, 1-800-729-6686
  NCADI provides information and materials on substance abuse. Many free publications are available here.

- Eisenhower National Clearinghouse (ENC)
  www.sciencepioneers.org/resource/eisenhower-national-clearinghouse-math-science-education, 1-800-471-1045
  This Web site provides useful information and products to improve mathematics and science teaching and learning.

- National Academy of Sciences. *National Science Education Standards*. Washington, DC: National Academy Press, 1995. Book and a brochure summarize the key ideas in the Standards; provides good places to learn more about science education.

- National Science Teachers Association and Miami University. *Dragonfly*. Science magazine for children that may include some relevant stories and activities; published as a pullout section in *Scientific American Explorations*.

- National Science Teachers Association (NSTA)
  www.nsta.org, 703-243-7100
  Provides resources and information for science teachers.

Resources for Students

- Churchill, E.R., Loeschnig, L.V., & Mandell, M. *365 Simple Science Experiments With Everyday Materials*. New York, NY: Black Dog & Leventhal Publishers, Inc., 1997. Includes easy projects with step-by-step instructions for using materials around the house to explore science.

- Dr. Seuss. *Bartholomew and the Oobleck*. New York, NY. Random House, 1970. This book tells the tale of a king that is bored with rain and snow so he orders his royal magicians to create oobleck. This ooey-gooey substance is

not exactly what the king had in mind.

- *Science Series: Kitchen Chemistry*. Monterey, CA: Evan Moor Educational Publishers, 1996. Includes activities and experiments that help students learn about the basic principles of chemistry with materials found in the kitchen.
- VanCleave, J. P. *Chemistry for Every Kid: 101 Easy Experiments That Really Work*. New York: John Wiley & Sons, Inc., 1991. A collection of more than 100 chemistry experiments showing how chemistry is part of our lives.
- Wiese, J. *Head to Toe Science*. New York, NY: John Wiley & Sons, Inc., 2000. Includes over 40 activities and experiments that teach kids about the human body.
- Houghton Mifflin Science Center
  www.eduplace.com/science
  Links to science-based activities and lessons.
- The Why? Files
  whyfiles.org
  Explanations for scientific phenomena discussed in the news.

Introductory Story for Module 1

> If you do not have a DVD player, read this story to your class to introduce the mission.

"Hi, everyone. I'm Kevin, better known as ‘'Brain Teaser.' They call me that because I love a good joke. Meet my friend, Ami. We call her 'Brain Trust' because she’s what we call smart, and I mean REAL smart. We're both in a really cool club called '*Brain Power!* NIDA Mission Control sends us missions to solve."

"Wait a minute, Teaser," said Ami. "Let me talk, too. We go on missions with Corty to solve problems. Our trusty friend Corty usually lets us know what to do."

"That's right. Hi to all. I'm the famous Corty. And I see on my trusty computer monitor that *Brain Power*! has a riddle to solve."

"Great," said Teaser. "Riddles are right up my alley."

"Okay, you ready? Here comes the riddle:

"We map the stars in outer space.
And chart the bottom of the deep blue sea.
We even teach animals to talk to us, and study how drugs can affect your brain.
Everybody on this list truly is..."

"A scientist," shouted Kevin and Ami.

"You got it," said Corty. "Now ask me what science is."

"Okay," said Ami. "What's science?"

"Gee, I'm so glad you asked," replied Corty. "Science involves observing, asking questions and making predictions, doing experiments, and collecting information through the use of scientific inquiry."

"Cool," said Kevin. "I'm off to do science right now. I'm really interested in that experiment part."

"Kevin may be ready, but I'm not sure I understand what scientific inquiry is. Could you run it by me again?" asked Ami.

Before Corty had a chance to reply, Kevin came running back into the room. He was covered in sticky, icky white goo.

"What happened to you?" asked Ami.

"I'm not sure," said Kevin. "I was looking in the closet for something to experiment with, but instead, all I found was this white goo."

"This is a big problem," said Corty. "We've got to figure out what this stuff is before we're all stuck together. Ami, come on. Think of something."

"Okay, but the kids in the class are going to have to help," said Ami. "Let's try out this scientific inquiry thing. I think we're supposed to 'observe' first. That should be easy enough. The stuff is all over Kevin."

"Then you need to guess what this goo is made of," said Kevin.

"Right. Next, test your guess by trying to make more goo. Then you can decide if your guess was right. Observe, predict, experiment, and conclude - the four big steps," finished Ami.

Now it's up to you, kids. Use the materials on hand to make the goo. Kevin is counting on you to work fast.

Good luck. And remember, *Brain Power!* rules.

Brain Power News

Parent Newsletter
Volume 1, Number 1

Welcome to the NIDA Junior Scientists Program

Your child has been working on the first module of the National Institute on Drug Abuse (NIDA) Junior Scientists Program. Geared to students in second and third grades, the program is made up of six modules introducing the following key concepts:

- The steps of scientific inquiry—observing, making predictions, performing experiments to test predictions, and making conclusions;
- The parts of the brain and how information is transmitted throughout the body;
- The differences between drugs used as medicines and drugs used for other purposes;
- The effect that nicotine and other drugs have on the body and the brain.

By teaching young children about how drugs affect the body, we can lay a foundation for students to make better decisions about their own health in the future.

This newsletter is designed to provide you with information so that you can reinforce at home what your child has been learning in school. Each module has a parents' newsletter that includes the following:

- The content of the module;
- Activities you can do at home;
- Additional resources;
- A suggestion for your child to share some thoughts through words or pictures.

We hope that you and your child enjoy working on the program together and that the knowledge gained now will serve your family well in the future.

What is Scientific Inquiry?

The term "scientific inquiry" sounds pretty sophisticated, but actually, it simply refers to a systematic way of approaching a problem. The four steps of scientific inquiry are:

- Observing the features of an object or phenomenon;

- Predicting what the object or phenomenon is;
- Experimenting to check the prediction; and
- Figuring out what the results mean.

Students used these four steps to figure out what a mystery goo was made of. This activity aligns with the National Science Education Standards (NSES), guidelines developed in 1996 by the National Academy of Sciences to help schools know what science information should be covered in kindergarten through high school. The standards stress the importance of using scientific inquiry as a tool for approaching and solving problems. Throughout the NIDA Junior Scientists Program, we will let you know how each activity fits in with the NSES recommendations.

Science at Home

Ask your child what he or she learned about scientific inquiry. Then try a science experiment with your child. Mix 1/3 cup of cornstarch and 1/3 cup of baking soda . What happens when you add water? Try it again, but add vinegar instead. What do your results tell you about the differences between water and vinegar? What do they tell you about the properties of the liquids? Try to use the steps of scientific inquiry to answer these questions.

What Does Your Child Think?

Have your child write or draw a picture about something related to scientific inquiry.

Additional Resources

You and your child may want to try some of the science experiments included in some of these resources.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124

This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

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Wiese, J. Head to Toe Science. New York: John Wiley & Sons, Inc., 2000. Includes over 40 activities and experiments that teach kids about the human body.

Houghton Mifflin Science Center
www.eduplace.com/science
Links to science-based activities and lessons.

The Why? Files
http://whyfiles.org
Explanations for scientific phenomena discussed in the news.

Edible/Inedible Experiments Archive
www.madsci.org/experiments

Lists of both simple and more complex experiments.

Parent Newsletter (PDF, 425KB)

Brains in a Box: What Your Brain Can Do (Module 2)

You can also download this entire module in PDF format by clicking the following link: Module 2 (PDF, 9MB).

Introduction

During the second *Brain Power!* mission, students learn about four major parts of the brain and their functions. The students work in small groups to create a three-dimensional model of the brain made of Play-Doh. Using the trading cards supplied in the module, students discover what each part does.

This mission has the following goals:

- To give students an opportunity to visualize the brain;
- To make students aware that the brain has different parts that perform different functions;
- To help students understand that the brain is the control center for the body.

Learning Objectives

- Students learn that the brain has different parts.
- Students create a model of the brain showing its four major parts.
- Students identify the function of each of these parts of the brain.

Relationship to the National Science Education Standards

This mission aligns with several standards identified in the NSES: unifying

concepts and processes, life science content standards, and standards for science as inquiry. The charts on the next page identify how the mission aligns with each of these standards.

Unifying Concepts and Proceses

Levels K–4	How Mission Is Aligned
Systems, order, and organization	The mission introduces students to the idea that the brain is one system that is part of a larger system–the human body–and that both systems work together to enable people to function.

Life Science Standards

Levels K–4	How Mission Is Aligned
Characteristics of organisms	This mission introduces students to the concept that all animals have some kind of brain and that there are similarities and differences among the brains of different organisms.

Science as Inquiry

Levels K–4	How Mission Is Aligned
Abilities necessary to do scientific inquiry	Students go through the steps of scientific inquiry: observing, making predictions, completing an investigation to test their predictions, and drawing conclusions.

Background

In module 2, students will be asked to identify and learn about four parts of the brain: the cerebral cortex, composed of the right hemisphere and the left hemisphere; the cerebellum; the brain stem; and the limbic system. These parts are explained in more detail below.

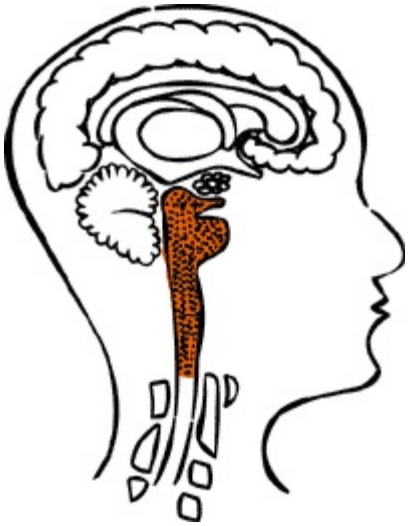
Cerebral Cortex

The brain's largest part, the **cerebral cortex**, makes up almost 90 percent of the brain. It has two hemispheres. The **left hemisphere**, which controls the right side of the body, is largely responsible for analytical thinking, such as solving problems and comparing information needed to make decisions. It also is the brain's language center.

The **right hemisphere**, which controls the left side of the body, is largely responsible for artistic expression and understanding relationships in space. A bundle of fibers called the **corpus callosum** serves as a bridge to pass messages back and forth between the two hemispheres.

Cerebellum

The **cerebellum** controls posture, movement, and the sense of balance. Such activities as playing ball, picking up objects, and playing musical instruments fall under its domain.



Brain Stem

The brain's most primitive part is the brain stem. The two main parts of the brain stem are the **pons** and the **medulla**. The pons contains fibers that link the cerebral cortex with the cerebellum and the spinal cord. It also controls sleep, awakening, and dream impulses.

The medulla controls heart rate, respiration, and blood pressure. The brain stem also is responsible for body temperature control, simple reflexes (like coughing and sneezing), and digestion.

Limbic System

The two main parts of the **limbic system** are the **hippocampus** and the **amygdala**. The hippocampus is mainly responsible for learning and memory. The amygdala plays an important role in emotional behavior. The limbic system is greatly affected by drugs.

Materials/Preparation

Materials

- Five or six boxes with tops
- Play-Doh (four colors)
- Trading cards of brain parts
- NIDA Junior Scientists DVD, or online video
- Instruction Sheets (PDF, 241KB)
- Log Sheets (PDF, 58KB)

Preparation

1. Make sure you have four different colors of Play-Doh or clay for this activity. If you don't have any available, follow the recipe below to make your own:

- In a saucepan, heat 2 tablespoons of vegetable oil. Add 1/2 cup of flour, 2 teaspoons of cream of tartar, and 1 cup of water.
- Cook for 3 minutes, stirring constantly.
- Divide the mixture into four parts. Use food coloring to make each part a different color.
- Let the dough cool, then store in plastic wrap in the refrigerator.
- Make one batch of this Play-Doh for each group.

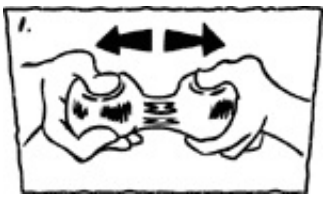
2. Put the four different colored clumps of Play-Doh in each of the boxes.
3. Divide the students into groups to complete this activity.
4. This activity will take 2 days to complete. On the first day, show the students the DVD and have them build their models of the brain. On the second day, hand out the log sheet. Students can work on labeling the parts, discussing what each part does, and filling in the log sheet.

Procedures/Discussion Questions

Procedure

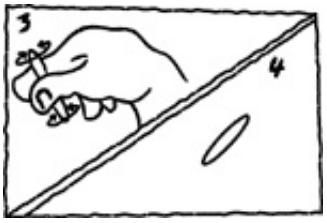
1. Before dividing the class into groups, show the first part of the DVD. If you don't have a DVD player, read the introductory story at the back of this module. Turn the DVD off at the appropriate time and ask the children what they think they are supposed to make with the Play-Doh. After helping them figure out that they will be making a model of the brain, lead a brainstorming session about what the brain does. You might want to refer to the students' ideas from the earlier brainstorming session.
2. After eliciting ideas from the children, turn the DVD back on and have them view examples of what the brain does.
3. Divide the class into groups. Give each group a box and a set of trading cards. Explain the mission - to build a simple model of the brain and to find out what each part does. Point out that the trading cards have all the information they need to finish the activity.

4. To build the models of the brain, students should do the following:



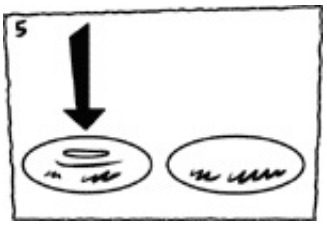
First, make the hemispheres of the cerebral cortex. Take a large clump of Play-Doh. Split it into two parts. Roll each part into an oval.

These two ovals are the hemispheres of your model brain. Students can make wrinkles on the hemispheres with their fingernails to make the brain look more realistic.

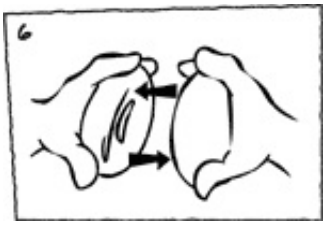


Next, make the limbic system. Using a different color of Play-Doh, make a

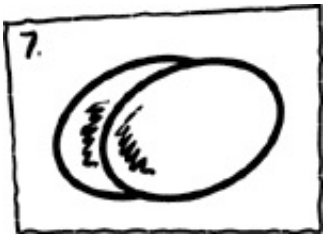
small piece that is shaped like a bean.



Lay the bean shape on one of the hemispheres.

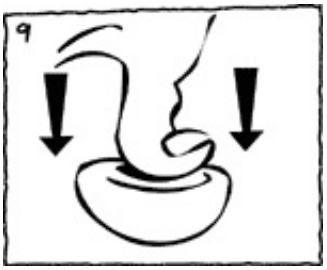


Put the two hemispheres together with the bean inside, like a sandwich. Press them together.

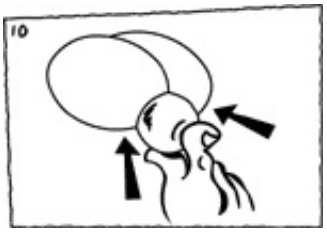


The limbic system is located deep inside the cerebral cortex.

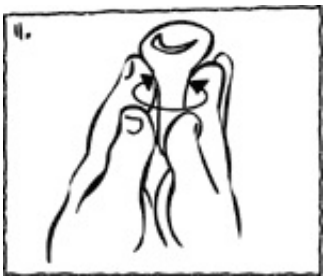
Third, make the cerebellum. Using a third color, make a ball about one-third the size of each hemisphere.



Flatten the ball slightly with your thumb.

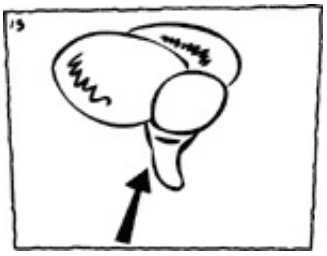


Put the ball on the bottom and underneath the hemispheres. The cerebellum is at the lower back end of the hemispheres.



Finally, make the brain stem.

Using the fourth color, make a shape that looks like a small trumpet.



Stick the trumpet at the bottom of the cerebellum. The brain stem leads into the spinal cord at the back of the brain.

5. Give the students between 15 and 20 minutes to complete the activity. At the end of that time, each group should have a model of the brain.

6. On the second day, have each group use the trading cards to label each part of the brain. Ask each group to identify at least one function of each part.

7. Have each student complete the Log Sheet (PDF, 58KB).

> Have the students save their model brains. They will need them for module six.

8. CONGRATULATIONS! YOUR CLASS HAS COMPLETED THE SECOND MISSION.

Discussion Questions

1. Ask the students if they have any other ideas they want to add to the class list of what the brain does.
2. Discuss with the students their impressions of this mission. Were they surprised that the brain does so many things? Did they know about the brain before the mission? What other questions do they have about the brain?
3. Then ask students the following question: How do they think information gets to the brain? Keep a record of their responses. Conclude by telling the class that they will be learning more about how information travels in the next module.

Extensions

The following activities provide a link to other areas in the curriculum. They also help reinforce what was learned during the module and make use of the trading cards.

1. Have the students, either individually or in groups, draw a picture of the brain. Have them label each part and identify at least one function of each part.
2. Have the students, either individually or in groups, write a couple of sentences in response to the following prompt: “My brain is amazing

because..."

3. Divide the class into pairs. Have one student give clues to the other about each part of the brain. Students may want to act out what that part of the brain does. Have students use the trading cards to play.
4. Have students, either individually or in groups, create new trading cards about the brain. They can be on different parts of the brain, scientists who study the brain, or different activities the brain enables us to do.

Assessment

1. As students work on this activity, look for evidence of the following:
    - Are students grasping that the brain is one organ that performs a range of functions?
    - Do students understand that the brain is the "control center" of the body?
2. Put each student's log sheet in his or her student portfolio.

Additional Activities

Below are some additional activities that can be used after completion of the second mission. These activities are extensions to many other areas of the curriculum.

1. Make a class poster of the brain. Encourage the students to be creative and to use materials of different textures, such as felt, cotton, beads, and foam. Try to make the picture of the brain as accurate as possible. Make sure the parts are labeled.
2. Play a "game show" using questions about the brain. Students can take turns being the player. The rest of the class can be the audience, which is sometimes called on during the game. (The player has the option of polling the audience, having two possible choices taken away so that it's easier to guess correctly, or choosing a friend from the audience to help answer the

question.) Make sure that everyone has a chance to be the player. Some sample questions are listed below.

The cerebral cortex is responsible for the following activities:

1. Breathing
2. Emotions
3. Thinking
4. All of the above

The limbic system is responsible for the following activities:

1. Solving problems
2. Seeing and hearing
3. Balance
4. Emotions

Why is the brain stem important?

1. It controls breathing and heart rate.
2. It helps out with balance.
3. It is responsible for problem-solving.
4. It enables us to talk.

A PET scan is useful because it shows:

1. The outside of the brain.
2. Just the parts of the brain.

3. Which parts of the brain are working.
4. The colors of the brain.

Phineas Gage had an accident that made him:

1. Nasty
2. Nice
3. Smart
4. Dumb

3. Have your students put on a class play about the brain. Different students can play different parts of the brain, while other students can act out what the different parts do. Encourage the students to let their imaginations go!
4. Conduct a class brainstorming session about how we should take care of our brains. Help students understand that by taking care of our bodies - eating right, getting enough exercise, getting enough sleep, for example - we are also taking care of our brains. You might want to draw a class Venn diagram, with one side labeled “What You Should Do to Take Care of Your Brain” and the other side labeled “What You Should Do to Take Care of Your Body.” Then the students will be able to clearly see how taking care of your body means that you also are taking care of your brain.
5. Have your students try to figure out this math problem: A baby’s brain weighs 1 pound. By the time a child turns 6, however, the brain has reached its full size and weighs 3 pounds. How much bigger is a full-sized brain than a baby’s brain? How long did it take to grow to full size?
6. Play brain “Simon Says.” For example, you could say: “Simon says that if the left side of your brain helps with thinking, hop on one foot.” The children will enjoy moving around while learning about the different parts of the brain.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

- NIDA DrugPubs
  drugpubs.drugabuse.gov , 877-NIDA-NIH (877-643-2644)
  DrugPubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

- National Clearinghouse for Alcohol and Drug Information (NCADI)
  store.samhsa.gov, 1-800-729-6686
  NCADI provides information and materials on substance abuse. Many free publications are available here.

- Eisenhower National Clearinghouse (ENC)
  www.sciencepioneers.org/resource/eisenhower-national-clearinghouse-math-science-education
  This Web site provides useful information and products to improve mathematics and science teaching and learning.

- Greenfield, S. A. *The Human Brain: A Guided Tour*. New York: Basic Books, 1998. Written for a lay audience, provides a holistic view of the brain as an integral part of the body; part of the Science Masters Series.

- Wade, N., ed. *The Science Times Book of the Brain*. New York: Lyons Press, 1998. A collection of articles about the brain from the science section of the New York Times.

- Sylwester, R. *A Celebration of Neurons: An Educator's Guide to the Human Brain*. Alexandria, VA: Association for Supervision and Curriculum Development, 1995. The book discusses the structure and function of the

brain, and explains how we think, dream, digest food, and much more.

- Are We Unique?
  www.fi.edu/qa97/spotlight5/spotlight5.html
  Page from the Franklin Institute Web site talks about the science of the human mind.

- Brain Briefings
  www.sfn.org/briefings
  Part of the Society for Neuroscience Web site; gives scientific information on different parts of the brain and brain disorders.

Resources for Students

- Friedman, D. *Focus on Drugs and the Brain*. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series; gives a good overview of the brain, neurotransmission, effects of drugs on the brain, and addiction.

- Rowan, P. *Big Head! A Book About Your Brain and Your Head*. New York: Alfred A. Knopf, 1998. Gives an overview of the different parts of the brain; includes detailed color pictures and transparencies.

- Neuroscience for Kids
  http://faculty.washington.edu/chudler/neurok.html
  Contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources for students and educators.

- Bill Nye the Science Guy
  billnye.com/
  See Episode 34 on the brain.

Introductory Story for Module 2

If you do not have a DVD player, read this story to your class to introduce the mission.

"Hi again. Welcome back to the *Brain Power!* clubhouse. You've already met Brain Teaser and Brain Trust, but you haven't met us. I'm Beth, better known as 'Brain Storm' because I'm full of ideas. Meet my good pal, Juan, nicknamed 'Brain Wave.' He got his nickname because he's always on a roll - on his skateboard or anything else that moves."

"Hi, all," said Brain Wave. "Look what I found outside our door. A box."

"Oh, goody, a present," said Brain Storm. "Does it have my name on it?"

"Nope. It must be for all of us. Let's open it."

"What are these lumps of Play-Doh for?" asked Brian Storm. "I haven't used this stuff in years."

"Wait, there's something at the bottom of the box. It's a DVD player. Let's turn it on and see if we can find out what's going on here."

"Hello, Brain Storm and Brain Wave. This is Corty, your friendly brain, speaking. NIDA has a mission for the *Brain Power!* Club."

"Wow! A mission - for us," said Brain Storm.

"You have just received Play-Doh in a gift-wrapped box," continued Corty. "When you make something with the Play-Doh, it becomes one amazing thing that is truly a gift."

"I wonder what it is," said Brain Wave.

"You're probably wondering what it is," said Corty. "Here are some clues. Take some deep breaths. (*The kids in the class can do this.*) Now sing the scales (*do, re, mi, fa, so, la, ti, do*) and tumble across the floor. Can you answer this? 4+5? 6+8?"

(Pause as the class does all this)

"If you can figure out what all these activities have in common, you'll know what the Play-Doh becomes. Oh, and be sure to use your brains."

"Gosh, Brain Wave. Do you have any idea what we're supposed to make?" asked Brain Storm.

"No, but I bet all those kids out there know. Come on, guys. Help us out. Make something wonderful with the Play-Doh - something that represents an amazing gift," Corty said. "I know you can do it."

"That's right," replied Brain Storm. "So go for it, and remember, *Brain Power!* rocks the world."

Brain Power News

Parent Newsletter
Volume 1, Number 2

What Your Brain Can Do

Your child has just completed module 2 of the NIDA Junior Scientists Program. He or she put together a three-dimensional model of the brain, identified its four key parts, and learned about what each part does.

Our goal is to show children how amazing the brain really is. Most children this age know that the brain helps them think, but they don't realize that the brain is also responsible for just about everything else, too—from regulating heartbeat and breathing to controlling emotions and artistic expression. By teaching them about "*Brain Power!*," we hope that they will think twice about doing anything that might harm their brains.

The Brain is Truly Amazing

Here's a quick summary of what your child learned about the brain:

Part of the Brain	Function
Left hemisphere, cerebral cortex	Responsible for analytical thinking such as solving problems and comparing information needed to make decisions. It also is the brain's language center.
Right hemisphere, cerebral cortex	Responsible for artistic expression and understanding relationships in space.
Cerebellum	Controls posture, movement, and the sense of balance. Such activities as playing ball, picking up objects, and playing musical instruments fall under its control.
Brain stem	Controls heart rate, breathing, blood circulation, and digestion.
Limbic system	Responsible for emotions and also involved in memory and memory storage. Drugs can change how the limbic system works.

Science at Home

Ask your child what he or she learned about the brain. See how many parts he or she can identify. Throughout the day, as you perform different activities together, ask your child which part of the brain is being used. Then ask your child to draw a picture of the brain and label it.

What Does Your Child Think?

Have your child draw or write something about the brain.

Additional Resources

The books and Web sites listed below have more information about the brain.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
This Web site contains information about drug abuse and a section designed specifi-cally for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

Friedman, D. *Focus on Drugs and the Brain*. Frederick, MD: Twenty-First Century Books, 1990. This book is part of the "Drug-Alert Book" series. It provides a good overview of the brain, neurotransmission, the effects of drugs on the brain, and addiction.

Rowan, P. *Big Head! A Book About Your Brain and Your Head*. New York: Alfred A. Knopf, 1998. An overview of the different parts of the brain. Includes detailed color pictures and transparencies.

Simon, S. *The Brain: Our Nervous System*. New York: Morrow Junior Books, 1997. An overview of the brain and neurotransmission, with a focus on the function of the brain.

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
This Web site contains information on the brain and neurotransmission,

activities, experiments, pictures, and other resources for students and educators.

How Your Brain Works
www.howstuffworks.com/brain7.htm
Pictures and descriptions of the history of neuroscience and different parts of the brain.

Are We Unique?
www.fi.edu/qa97/spotlight5/spotlight5.html
This subpage from the Franklin Institute Web site talks about the science of the human mind.

Bill Nye the Science Guy
billnye.com/
See Episode #34 on the brain.

Brain Briefings
www.sfn.org/briefings
This page is part of the Society for Neuroscience Web site. It provides scientific information on different parts of the brain and brain disorders.

Parent Newsletter (PDF, 606KB)

Sending and Receiving Messages (Module 3)

You can also download this entire module in PDF format by clicking the following link: Module 3 (PDF, 5.4MB)

Introduction

In module 1, students learned how to use scientific inquiry to solve problems. In module 2, they learned about four key parts of the brain and what each part does. During the third mission, students will simulate the process of neurotransmission: how information gets to and from the brain.

Learning Objectives

- Students simulate neurotransmission.
- Students discover how messages travel throughout the body.
- Students learn about the relationship between the brain and the rest of the nervous system.

Relationship to the National Science Education Standards

This mission aligns with two standards identified in the NSES: unifying concepts and processes and science as inquiry. (They use only parts of scientific inquiry for this mission.) The charts below identify how the mission aligns with each of these standards.

Unifying Concepts and Processes

Levels K–4	How Mission Is Aligned
Systems, order, and organization	This mission builds on what students learned in module 2 about the brain as a system by illustrating how neurotransmission is part of that system. Students begin to understand how the brain works with the other parts of the nervous system to perform many key functions.

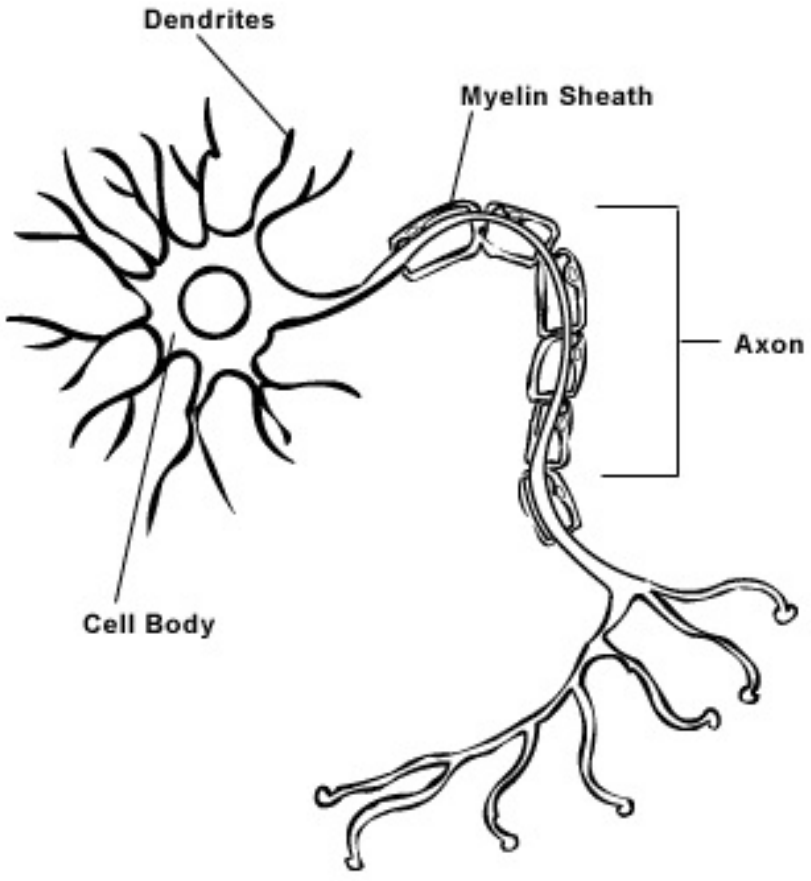
Life Science Standards

Levels K–4	How Mission Is Aligned
Abilities necessary to do scientific inquiry	Students go through some of the steps of scientific inquiry: observing, making predictions, completing an investigation to test their predictions, illustrating a concept, and drawing conclusions.

Background

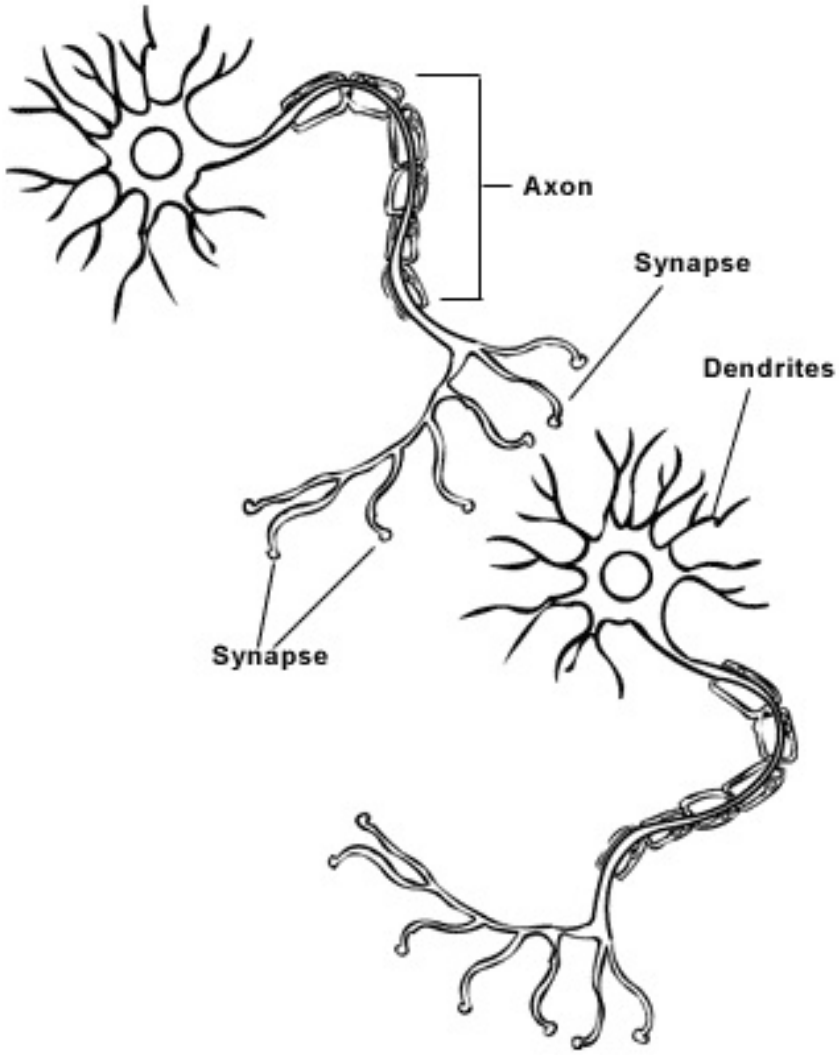
Messages, in the form of electrical impulses, constantly travel back and forth between the brain and other parts of the body. A special cell called a *neuron* is responsible for carrying these messages. There are about 100 billion neurons in the human brain.

A neuron has three main parts. The *cell body* directs all activities of the neuron. *Dendrites* extend out from the cell body and receive messages from other nerve cells. An *axon* is a long single fiber that transmits messages from the cell body to the dendrites of other neurons or to other body tissues, such as muscles. A protective covering called the *myelin sheath*, covers most neurons. Myelin insulates the axon and helps nerve signals travel faster and farther.

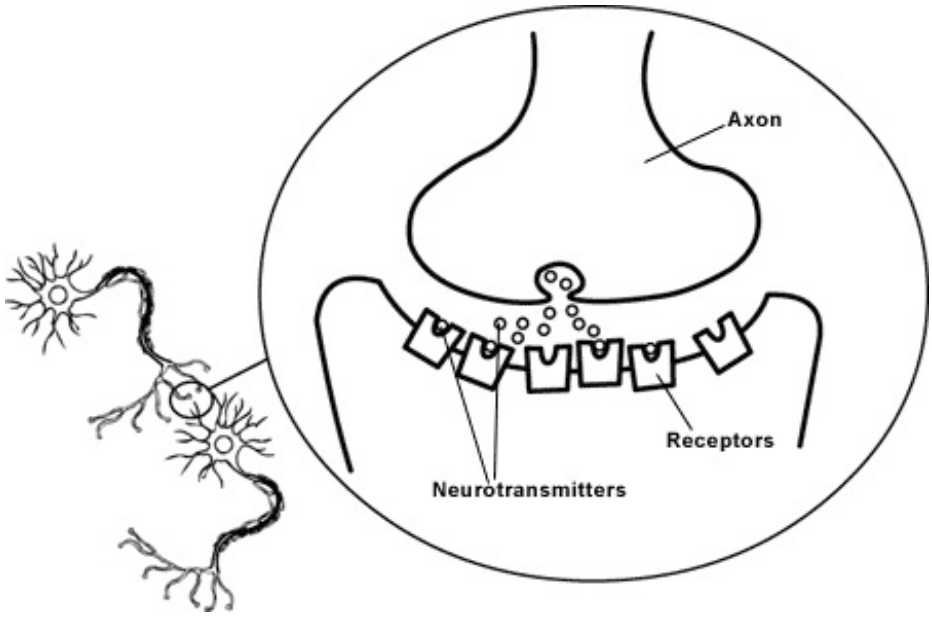


Messages travel along a single neuron as electrical impulses, but messages between neurons travel differently. The transfer of information from neuron to neuron takes place through the release of chemical substances into the space between the axon and the dendrites. These chemicals are called *neurotransmitters*, and the process is called *neurotransmission*. The space between the axon and the dendrites is called the *synapse*.

When neurons communicate, an electrical impulse triggers the release of neurotransmitters from the axon into the synapse. The neurotransmitters cross the synapse and bind to special molecules on the other side, called *receptors*. Receptors are located on the dendrites. Receptors receive and process the message.



What's particularly interesting about neurotransmission is that each neurotransmitter can bind only to a very specific matching receptor. A neurotransmitter binds to a receptor in much the same way a key fits into a lock. After transmission has occurred, the neurotransmitter is either broken down by an enzyme (a chemical that speeds up some of the body's processes) or is reabsorbed into the neuron that released it. The reabsorbed neurotransmitters can be reused at a later time.



Materials/Preparation

Materials

- NIDA Junior Scientists DVD, or online video
- One set of signs for each group
  - 6 *Neuron Team* signs
  - 1 *Neurotransmitter* sign
  - 1 *Sore foot* sign
  - 1 *Brain* sign
- One set of messages for each group
  - 1 *"Why does my foot hurt?"* message
  - 1 *"Sit down. You hurt your foot on a tack."* message
- Instruction Sheet (PDF, 285KB)
- Log Sheet (PDF, 105KB)

- Paper and pencils
- Masking Tape

Preparation

1. To familiarize yourself with the subject of neurotransmission, read the Background section of this guide.
2. If possible, reserve the gym or all-purpose room. Or you could do this activity outside on the blacktop.
3. Make copies of the messages and signs found at the bottom of this page. You will need six *Neuron Team* signs, one *Neurotransmitter* sign, one *Sore Foot* sign, one *Brain* sign, one *"Why does my foot hurt?"* message, and one *"Sit down. You hurt your foot on a tack."* message for each group. The students will use these messages during the activity.
4. Set up and label three areas of the room for this activity as shown on the previous page. Each area has a set of two lines of masking tape with a space between the rows. Each masking tape row represents a neuron. The space between "neurons" represents a synapse.
5. Divide the class into groups of nine students, who will be working together as a team. If you have "extra" children, add them as extra members of a neuron team.

Procedures/Discussion Questions

1. Conduct a brainstorming session about how students think messages are carried throughout the body. For example, ask students the following: How does your brain "know" to perform an activity, such as raise your head? When we talk about messages traveling, what do we mean? Do you know what a neurotransmitter is? Write down any ideas students may have. Don't be surprised if they don't know too much about this process.
2. Before beginning the activity, briefly explain neurotransmission. Explain what the terms "neuron" and "neurotransmission" mean. You may want to show the first part of the DVD to accomplish this goal.

3. Tell each group of nine students to go to an activity area. In each area, have three students sit in each masking-tape outlined area. Tell them that they are a neuron team and give each student a *Neuron Team* sign. Each group of three represents one neuron.

4. Designate one student at each area as the neurotransmitter student. Have each neurotransmitter student sit in the space between the rows of masking tape. Give the neurotransmitter students their signs.

5. Then designate one student at each area as a person with a sore foot and one student as the brain, where the information is processed. The sore foot student should stand at one end of the neurons, and the brain should stand at the other end. (Refer to diagram 3a.)

6. Hand the student with the sore foot the message that says, "Why does my foot hurt?" Have the student begin the activity by pretending to have a sore foot. Then have the "foot" student hand the message to the first member of the neuron team.

7. Have the students quickly send the message down the line of neuron team members. The last student hands the message to the neurotransmitter student. After receiving the message, he or she gets up and hands it to the next neuron team. This neuron team leads to the brain. When the message reaches the last member of the neuron team, he or shegets up and hands the message to the student pretending to be the brain. (Refer to diagram 3b.)

8. When the "brain" receives the message, that student quickly exchanges it for the message saying, "Sit down. You hurt your foot on a tack." The message then proceeds down the line of students back to the student with a sore foot.

9. When the student with the sore foot reads the message, he or she discovers why his or her foot hurts and what to do about it. (Refer to diagram 3c.)

10. Have students go through the simulation one more time. They may want to switch roles the second time around or think of other messages to send.

11. CONGRATULATIONS! YOUR STUDENTS HAVE JUST COMPLETED MISSION 3 OF BRAIN POWER!

Diagram 3a

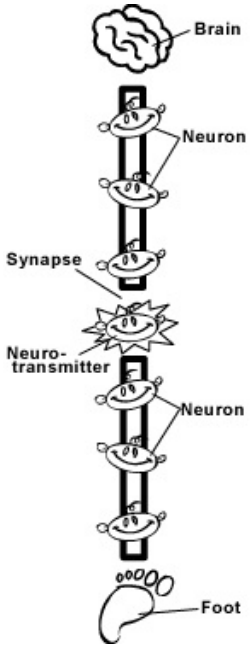


Diagram 3b

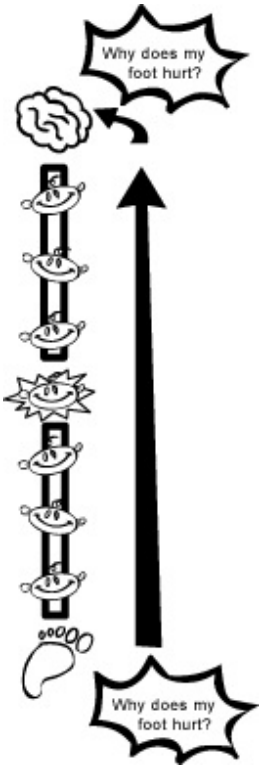
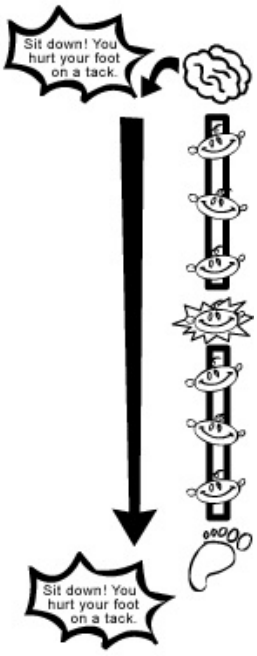


Diagram 3c



Discussion Questions

1. Using the simulation, have the students describe how they think messages travel throughout the body. Give several students an opportunity to explain the process in their own words.
2. Have the students think of different kinds of messages that travel throughout their bodies. Examples include the following:
    - What am I touching?
    - What is that sound?
    - Is the water hot or cold?
3. To reinforce what students learned, show the second segment of the DVD again. Then have the students figure out which part of the brain the message is going to. They may want to identify each section on their models of the brain.

Extensions

The activities listed below provide a link to other areas in the curriculum. These activities also make use of the trading cards included in the module.

1. Work with your students to develop a class newspaper. Ask the groups to write articles about the parts of the brain, what each part does, how messages travel throughout the body, and how the brain works with the nervous system to perform key functions.
2. Ask the students to guess how many neurons they think are in their bodies. Then write down the answer - 100 billion (100,000,000,000). Discuss why so many neurons are needed. Then point out that each neuron has about 10,000 contacts with other neurons. Help the students grasp the enormity of this communication system.
3. Divide the students into groups and have each group draw a large poster showing the vast communication networks in our nervous system. They also may want to draw an outline of the human body and put the brain in the head. Then they can use string to show the relationship between the brain and other parts of the body. They also may want to compare our internal network to telephone wires, the power grid, or the Internet. Encourage each group to develop its own way to explain this network.

Assessment

1. Neurotransmission is a very difficult subject and may be a challenge for some second - and third-grade students. Our goal is for each student to understand by the end of the activity that messages travel from different parts of the body to the brain, where they are processed and sent back through the body.
2. In addition, look for the following indicators of understanding of key concepts:

    - Are the students able to simulate neurotransmission without difficulty? Can they describe in their own words how neurotransmission works?
    - Are the students able to apply what they learned to another message, such as "What does the flower smell like?"

- Are students able to explain in pictures or words how neurotransmission works?

3. Put each student's log sheet in his or her student portfolio.

Additional Activities

Below are some additional activities that can be used after completion of the third mission. These activities are extensions to many other areas of the curriculum.

1. Divide the students into pairs and give each pair a set of trading cards. Have the pairs read the cards together and discuss them. Ask them if they have a favorite card. If so, have them give reasons for their choice.
2. Have each student design a trading card. The cards can show an activity, a brain, or a picture of how messages travel. Encourage students to use what they learned in the previous two modules when developing their trading cards.
3. Play neuroscience "Jeopardy." Possible categories could be "Scientific Inquiry," "Parts of the Brain," "How Messages Travel," and "Different Kinds of Scientists." Using all the materials learned to date, develop questions in each category. This is a good way to find out how much students have learned.
4. Have students make a three-dimensional communication network in your classroom. Have students create connections using string or rope to show how information travels. Make sure that students have messages traveling in one direction to a location designated as the brain, then back in the other direction.
5. Put on a class play about how messages travel throughout the body. Encourage students to create a scenario where having messages travel fast makes a big difference. For example, smelling smoke and then calling 911 prevents a house from burning down.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse as well as a section designed specifically for parents, teachers, and students.

- NIDA DrugPubs
  drugpubs.drugabuse.gov , 877-NIDA-NIH (877-643-2644)
  Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

- National Clearinghouse for Alcohol and Drug Information (NCADI)
  store.samhsa.gov, 1-800-729-6686
  NCADI provides information and materials on substance abuse. Many free publications are available here.

- Nicholls, J.G., Wallace, B.G., Fuchs, P.A., & Martin, A.R. *From Neuron to Brain.* Sunderland, MA, Sinauer Associates, 2001. Developed for readers with an interest in the human nervous system with little or no background in the biological sciences; describes how nerve cells transmit signals and messages.

- Woolsey, T.A., Hanaway, J., & Gado, M.H., *The Brain Atlas: A Visual Guide to the Human Central Nervous System.* Hoboken, New Jersey, John Wiley & Sons: Fitzgerald Science, 2003. This book is a comprehensive and accurate atlas of the brain. It includes nearly 400 images of the brain and its pathways.

- History of Neuroscience
  http://faculty.washington.edu/chudler/hist.html
  Lists the history of neuroscience from 4000 B.C. to the present.

Resources for Students

- Friedman, D. *Focus on Drugs and the Brain*. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series; gives a good overview of the brain, neurotransmission, effects of drugs on the brain, and addiction.
- Neuroscience for Kids
  http://faculty.washington.edu/chudler/neurok.html
  Contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources for students and educators.

Introductory Story for Module 3

> If you do not have a DVD player, read this story to your class to introduce the mission.

"Oh, no," said Beth, looking at the flashing light of the *Brain Power!* answering machine. "I bet that means trouble. I'd better listen to it and see what's going on."

"Hi, Brain Storm. It's me, Teaser," said the voice on the answering machine. "I'm going to be a little late because I hurt my foot, and my mom wants me to get it checked out. I'll be there soon."

"I hope he's all right," Beth said to herself.

Just then, she heard dinging from the computer. Who should appear but Corty!

"Oh, Corty," said Beth. "Did you hear about Brain Teaser? Isn't it the worst news?"

"Yes, but it just so happens that it leads in really nicely to your next mission."

"What do you mean?" Beth asked.

"NIDA wants you to find out how Teaser knew that his foot hurt."

"That's easy," Beth replied. "He just, I mean, wow, it just hurt. Now I see you what you mean. That is a good question. But I don't want to do the mission without Brain Teaser."

Just then, Kevin - Brain Teaser - came limping into the clubhouse.

"Hi, guys," said Kevin. "I'm back."

"Good to see you," Corty and Beth said together. "Are you ready to get started?"

"Sure. Now what's this I hear about NIDA Mission Control wanting us to find out how my brain knew that I had hurt my foot? If that's the only question, I already know the answer. My brain heard me say, 'Ouch.'"

"Very funny. Somehow, I think it's more complicated than that," said Beth.

"You're right, Beth. It is," said Corty. "The way to find out how messages travel is to act it out. Here's what you should do. Kevin, you pretend you're a foot."

"A what?" asked Kevin.

"A foot," Corty calmly replied. "Beth, you be the brain. And now we need help from all those kids watching this DVD. Ask your teacher how to play the game. You'll need kids pretending to be neurons and a neurotransmitter, as well as a foot and a brain. If none of this makes sense to you right now, don't worry. It will soon."

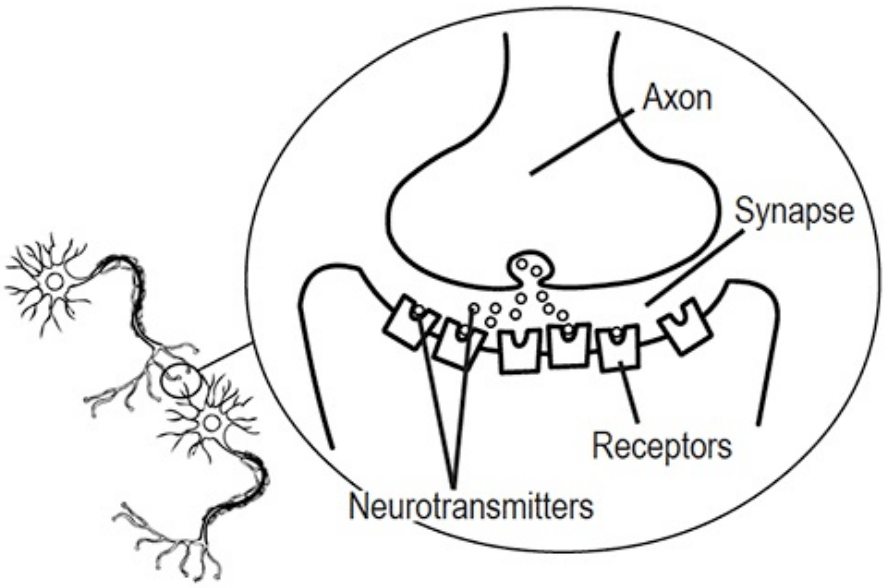
Beth and Kevin nodded their heads in agreement. "Have fun," shouted Brain Storm and Brain Teaser. "And one more thing. What you're about to find out is really cool."

Brain Power News

Parent Newsletter
Volume 1, Number 3

Sending and Receiving Messages

How do we know if we hurt our foot? The way the brain receives information like this is explained in module 3 of the NIDA Junior Scientists Program.



Messages are sent throughout the body and received by the brain through a process called *neurotransmission*. The drawing below explains how neurotransmission works.

1. The cells shown here are called *neurons*. There are billions of neurons throughout the body. The illustration in the circle is an example of the process of neurotransmission. A graphic showing how neurotransmission works. A graphic showing how neurotransmission works. A graphic showing how neurotransmission works. A graphic showing how neurotransmission works.

2. If you hurt your foot, a message travels from your foot, via the neurons, to the brain. For communication between neurons to take place, an electrical impulse triggers the release of chemicals called *neurotransmitters*. Neurotransmitters are released into the space between the two neurons. This space is called the synapse.
3. When neurons communicate, the neurotransmitters from one neuron are released, cross the synapse, and attach themselves to special molecules in the next neuron called *receptors*. Receptors receive and process the message, then send it on to the next neuron.
4. Eventually, the message reaches the brain. The brain then gives directions about what to do next. In this case, the directions would be, “You hurt your foot on a tack. Sit down.”

During the classroom activity, students simulate the process of neurotransmission. One student pretends to be the brain, another student is the foot, six students are neuron team members, and one student is the neurotransmitter. By acting out this process, students develop an understanding of our internal communication network. They also learn that the brain is the ultimate “information processor.”

We are introducing students to neurotransmission for several important reasons. For one, scientific information about the brain and the nervous system is growing at a rapid rate. By the time your child is an adult, we may understand the mechanisms behind many diseases of the nervous system, such as Alzheimer’s disease and multiple sclerosis. People will need to understand how the brain works in order to make informed decisions about their health and the health of their families.

Another key reason for introducing neurotransmission is that we are paving the way for explaining what happens if people interfere with this process by taking drugs. Drugs have a major impact on neurotransmission. Students will be learning more about this during modules 4 through 6.

Science at Home

As a family, play “Whispering Down the Lane.” One person whispers a sentence to a neighbor, who passes it on to the next person. Did the message arrive at its destination—by going through all your family members down the line—intact? Or did the message get confused? Either way, point out that neurotransmission is something like this game, although it is much more complicated. Messages have to go through neurons to the brain. Ask your child whether most messages are processed correctly by the brain. Then ask if the brain ever garbles messages. Give an example to your child, such as when you might say, “Get into the refrigerator,” when you actually mean “Get into the bathtub.”

What Does Your Child Think?

Have your child draw or write something about neurotransmission.

Additional Resources

The books and Web sites listed below have more information about neurotransmission.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA’s research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

Woolsey, T.A., Hanaway J., Gado, M.H., *The Brain Atlas: A Visual Guide to the*

Human Central Nervous System. Hoboken, New Jersey: John Wiley & Sons, 2003. This book is a comprehensive and accurate atlas of the brain. It includes nearly 400 images of the brain and its pathways.

History of Neuroscience
http://faculty.washington.edu/chudler/hist.html
Lists the history of neuroscience starting from 4000 B.C. to the present.

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
This site contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources.

Parent Newsletter (PDF, 436KB)

Medicines and Drugs: What's Helpful, What's Harmful (Module 4)

You can also download this entire module in PDF format by clicking the following link: Module 4 (PDF, 6MB)

Introduction

In modules 2 and 3, students learned about the parts of the brain and how information is sent throughout the body. This module focuses on drugs - powerful substances that can change both the way the brain functions and how the brain communicates with the body. Some drugs are helpful when used properly: they fall into the category of medicines. Other drugs may have a harmful effect on the body. The purpose of today's activity is for students to begin to understand how different drugs can affect the body.

Learning Objectives

- Students learn about different drugs and how they affect the body.
- Students classify drugs and their effect on the body into two groups: helpful medicines and harmful drugs.
- Students think about whether any drugs can be both helpful and harmful.

Relationship to the National Science Education Standards

This mission aligns with two standards identified in the NSES: science as inquiry and science in personal and social perspectives. The charts below identify how the mission aligns with each of these standards.

Science as Inquiry

Levels K–4	How Mission Is Aligned
Abilities necessary to do scientific inquiry	Students learn about different drugs and how they are used. Then they are invited to question whether they think these substances are helpful or harmful.

Science in Personal and Social Perspectives

Levels K–4	How Mission Is Aligned
Personal health	Students begin to develop an understanding of what drugs are and how they are used so that they can learn how to make decisions that affect their own health.

Background

When we refer to "drugs" during this module, we divide them into two categories, helpful medicines and harmful drugs. These categories are based on the effect they have on the body. Medicines are helpful only when they are given at the right times in the right amounts by people who care about children - parents, doctors, dentists, and other caregivers. In this module, drugs classified as medicines include the following: aspirin or Tylenol, antibiotics, fluoride, and immunizations. With medicines, however, it is extremely important to follow the dosage prescribed by the health care provider. Taking too much medicine or not enough can be dangerous.

Some drugs may be helpful or harmful. Caffeine is one example. Although caffeine itself isn't a drug, it is an ingredient found in some medications. Caffeine in all forms should be used in moderation. Too much of these substances can make people feel uncomfortable and even sick. Nicotine is another substance that may fit into both categories. Nicotine itself is not harmful

in the doses found in cigarettes, but it does produce addiction. This is a negative effect because addiction to nicotine causes people to use tobacco products, which can cause severe health problems with prolonged use. But nicotine is found in very small amounts in some medicines. Finally, some drugs have a harmful effect. These include alcohol and illegal drugs such as cocaine and marijuana.

> Some substances that are acceptable for adults are not acceptable for children because their bodies are smaller and they are still growing. Many substances, however, should be used carefully by adults as well. For example, some people find that drinking a glass of wine with dinner is pleasurable, but drinking a whole bottle of wine could be dangerous.

Using the fact sheets at the back of this guide, students work either in small groups or as a class to identify drugs from riddles. After children guess the name of the substance, ask them whether they think its effect is helpful or harmful. Questions like these will help students better understand whether it is appropriate to take certain substances and, if so, how much is acceptable. They also will consider whether some substances are not good for them at all.

During the discussion portion of the module, you have the option of giving the students a second riddle, which explains how each drug affects the body. The trading cards reinforce the information in both riddles and are an effective way to convey complex, unfamiliar information.

Medicines

Drug	**Other Terms**	**How it is Used**	**Effects on the Body**	**How it Works**
Aspirin or Tylenol	Aspirin is also known as salicylic acid acetate and is found in Bayer, Anacin, and	Taken orally as a liquid, pill or gum form	Both aspirin and Tylenol reduce fever and ease aches and pains;	Aspirin inhibits the production of some chemicals that play a

	Bufferin; Tylenol is made from acetaminophen		aspirin can decrease the risk of heart attacks and strokes	role in blood clotting; aspirin also inhibits the production of certain types of enzymes that cause inflammation and pain; Tylenol raises the body's threshold for pain by interacting with hormones
Flouride	Sodium fluoride	Available as tablets, drops, rinses, gels, and paste	Prevents cavities and can also treat osteoporosis	Hardens the enamel on teeth and reduces the harmful effects of plaque
Immunizations	Vaccinations, inoculations	Injected or taken orally	Boosts the body's resistance to specific diseases	Causes the body to produce antibodies to fight diseases
Antibiotics	Penicillin, cephalosporin, tetracycline	Taken orally as a pill or liquid, or	Fights diseases caused by bacteria	Antibiotics kill bacteria by preventing

		injected		them from constructing cell walls; then bacteria can't reproduce, and die out

Drugs

Drug	Other Terms	How it is Used	Effects on the Body	How it Works
Alcohol	Ethyl alcohol or ethanol	Consumed by drinking	Impairs concentration, slows reflexes, impairs reaction time, reduces coordination, and causes drowsiness when used in excess	Depresses the central nervous system and can kill brain cells when used in excess
Caffeine	Found in coffee, tea, cocoa, soft drinks, and some medications	Taken orally in pill form or consumed in food and drinks	Increases alertness, reduces fine motor coordination, alters sleep patterns, and can cause headaches, nervousness, and dizziness	Stimulates the central nervous system

Nicotine	Tobacco; found in cigarettes, cigars, and smokeless tobacco	Smoked or chewed	Reduces appetite and can cause nausea and vomiting; increases alertness	Acts as a stimulant, speeding up the heart and raising blood pressure
Illegal Drugs (marijuana & Cocaine)	Marijuana is referred to as grass, pot, reefer, and weed; cocaine is also called crack	Marijuana is usually smoked but can be baked into brownies or cookies or brewed like tea; cocaine or crack can be snorted, smoked, or injected	Marijuana impairs memory, concentration, perception, and movement; cocaine causes dizziness, headache, anxiety, insomnia, depression, and increased heart rate	Marijuana acts on receptors in the brain, causing decreased blood pressure, sleepiness, and disruption in attention; cocaine stimulates the brain and spinal cord

Materials/Preparation

Materials

- Drug fact sheets

- NIDA Junior Scientists DVD
- Trading cards
- Riddle Sheet (PDF, 362KB)
- Log Sheet (PDF, 61KB)
- Instruction Sheets
- Paper and pencils

Preparation

1. Decide how you want to conduct this activity. You could do it as a whole-class exercise, by dividing the class into two teams, or by dividing the class into groups of three students each.
2. Make copies of each fact sheet as needed. (See Procedure.)

Procedures/Discussion Questions

1. Conduct a class brainstorming session about drugs. Ask students what drugs they are familiar with and what they know about each drug. For example, do they know what the drug does? Do they know whether the drug is effective? Write down their responses on a sheet of paper.
2. Tell the students that they will be learning about the following drugs: aspirin/Tylenol, fluoride, immunizations, antibiotics, alcohol, caffeine, nicotine, and illegal drugs. Explain that they will be solving riddles about these substances.
3. Decide how you want to conduct this activity.
    - One option is to read the riddles to the class and have them solve the riddles as a group.
    - Another is to divide the class into teams, read the riddles, and then give a point to whichever team comes up with the correct answer first.
    - You could also divide the students into groups of three and have each

student perform one of the following jobs: reader, responder, or recorder. The reader will ask the questions identified on the fact sheet; the responder will answer them; and the recorder will write down the responses on the recording sheet. If you decide to do the activity this way, make sure that each student has a chance to do each job.

4. The fact sheets for each substance are at the end of the guide. If you are going to do the activity as a class, you probably don't have to make extra copies. Depending on your teaching approach, decide whether you are going to distribute them to the class.
5. THE MISSION IS NOW COMPLETED!

Discussion Questions

1. Use the riddles on the handout "Learn More About Drugs" to give the students more information about each of these substances. Use the teaching strategy that works best with your students.
2. Lead a discussion about the different drugs the students learned about and answer any questions they may have. As a class, make a Venn diagram. One circle should say "Drugs That Help the Body," and the other circle should say "Drugs That Hurt the Body."
3. Are there any drugs that are in both circles? Which ones are they? Are some more helpful than harmful? More harmful than helpful? Discuss how a drug can be both helpful and harmful.
4. Have each student or group make a list of the most important things to know about the effects of drugs on the body. Then have each student or group share the lists. Students may want to create a brochure or poster identifying the effects different drugs have on the body. Students can use the trading cards to reinforce what they learned.

Extensions

The activities listed below provide links to other areas in the curriculum. These activities also make use of the trading cards included in the module.

1. Make several extra sets of the trading cards. Divide the students into pairs and have them test each other until both students have really grasped the information about each substance. Have students take turns being the "asker" and the "responder."
2. Have each student select a drug from the group he or she studied. Then have each student make a large drawing showing the setting in which that drug would be used. For example, immunizations may be given at the doctor's office, a clinic, or the hospital.
3. Have the students write a class play about one of the drugs studied during the mission. The play could be about how a drug was discovered, how it is used, and what impact it has had on our lives.
4. Play drug charades with the class. Have one student act out something about the effect of the drug on the body. Have the rest of the class guess what it is. Try to give as many students a turn as possible.

Assessment

1. As students work on this activity, look for evidence of the following:
    - Are students able to understand what each drug does?
    - Do students understand the difference between a drug that has a helpful effect and one that has a harmful effect?
    - Do students think that their study of drugs has any relevance to their lives? Why or why not?
2. Were students able to answer the riddles? Were they able to grasp the information in the second group of riddles?

Additional Activities

Below are some additional activities that can be used after completion of the fourth mission. These activities are extensions to many other areas of the curriculum.

1. As a class, go to the Library/Media Center and look for books or Web sites about one or more of the drugs studied during the module. Take the books back to the class and read them together. Discuss what they mean and how they apply to what the students learned during the module.
2. Bring out the list the class generated during module 2, describing what the students wanted to learn about the brain. How much have they learned? What haven't they learned? What additional things have they learned that are not included on the list? Do students have anything they would like to add to the list?
3. Play a "game show" using questions about drugs and how they are used. Students can take turns being the player, and the rest of the class can be the audience. If the player doesn't know the answer, he or she has the option of asking the audience for help. Make sure that everyone has a chance to be the player. Some sample questions are listed below.

Which drug can help prevent cavities?

1. Tylenol
2. Aspirin
3. Fluoride
4. Antibiotics

Which drug would a person take if he or she had an ear infection?

1. Immunizations
2. Fluoride
3. Marijuana
4. Antibiotics

In what common product is nicotine found?

1. Cigarettes
2. Beer
3. Coffee
4. Candy

Why do people take caffeine?

1. To help them feel tired
2. To help them feel peppy
3. To help them feel angry
4. To help them feel sad

What do people take for a fever?

1. Caffeine
2. Tylenol
3. Fluoride
4. Immunizations

4. Have the students write a class story about the substances they learned about during this module. Begin with the prompt, "If I was stranded on a desert island, I would like to have _____ with me."
5. Have students think back to what they learned about the parts of the brain in module 2 and neurotransmission in module 3. Have them make up riddles describing the parts of the brain or the process of neurotransmission. Have students see if they can guess the answer to each riddle.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse as well as a section designed specifically for parents, teachers, and students.
- National Institute on Drug Abuse (NIDA): Mind Over Matter
  http://teens.drugabuse.gov/educators/curricula-and-lesson-plans/mom-teachers-guide
  This Web site was developed to educate children about the biological effects of drug abuse on the body and brain.
- NIDA DrugPubs
  drugpubs.drugabuse.gov , 877-NIDA-NIH (877-643-2644)
  Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA's publications or download electronic versions in multiple formats.
- National Clearinghouse for Alcohol and Drug Information (NCADI)
  store.samhsa.gov,1-800-729-6686
  NCADI provides information and materials on substance abuse. Many free publications are available here.
- Eisenhower National Clearinghouse (ENC)
  www.sciencepioneers.org/resource/eisenhower-national-clearinghouse-math-science-education
  This Web site provides useful information and products to improve mathematics and science teaching and learning.

Resources for Students

- Friedman, D. *Focus on Drugs and the Brain*. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series, gives a good

overview of the brain, neurotransmission, the effects of drugs on the brain, and addiction.

- Neuhaus, D. & DeStefano, S. *Focus on Medicines*. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series. Gives a good overview of medicines and how various medicines work with the body and brain to help heal.
- Perry, R. & Nehaus, D. *Focus on Nicotine and Caffeine*. Frederick, MD: Twenty-First Century Books,1990. Part of the “Drug-Alert Book” series. Gives a good overview of nicotine and caffeine and how each of these drugs affect the body and brain.
- Neuroscience for Kids
  http://faculty.washington.edu/chudler/neurok.html
  Contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources for students and educators.

Introductory Story for Module 4

> If you do not have a DVD player, read this story to your class to introduce the mission.

The *Brain Power!* Club was sad. Brain Teaser hasn't been able to make it to the club for a couple of days because he sprained his ankle. Brain Wave said that Brain Teaser's mom wants him to stay home and rest. He also said that Teaser’s mom gave him some aspirin for the pain.

Then, they heard the familiar "Computer Alert! Computer Alert!" Corty jumped out of the computer screen and landed next to the microscope, where Brain Trust was looking at tiny creatures magnified 50 times. "What's up, guys?" said Corty.

"We're just talking about poor Brain Teaser," said Brain Trust. "He can't be here today because he hurt his foot. But his mom gave his some Tylenol, and he's

feeling a lot better now."

"Funny you should mention Tylenol," said Corty. "Today's mission involves aspirin and other substances. In fact, the whole idea is to get you kids thinking about the difference between drugs used as medicines and drugs used for other purposes."

"Wow, I never thought about that," said Brain Trust. "What are the differences?"

"I don't want to tell you too much because then it will give the mission away. But there is something important you should know."

"What?" said Brain Trust and Brain Wave together.

"Pay attention to who gives you medicine," said Corty. "You don't want to take it from just anyone."

"He's right," said Brain Trust and Brain Wave together.

"Oh, and there's one more thing I forgot to mention. You will be learning about medicine and drugs through riddles."

"Riddles!" said Brain Trust. "Can you give us an example?"

"Okay, but then I really must sign off. Here goes:

You can use me on waffles and pancakes,
I'm brown, sweet, sticky, and with me a mess you can make.
Who am I?

"Oh, I see," said Brain Wave. "The answer to that one is syrup. We'll have to answer riddles about Tylenol and other things like that?"

"You got it," said Corty. "Now I really must go. Good luck with the riddles."

"Thanks. We're off, ready to meet our latest challenge."

Brain Power News

Parent Newsletter
Volume 1, Number 4

Medicines and Drugs: What's Helpful, What's Harmful

The goal of module 4 of the NIDA Junior Scientists Program is to introduce children to the topic of medicines and other drugs. During the first three modules, we introduced the parts of the brain and the process of neurotransmission so that now, by module 4, the children have some understanding of the complexity of the central nervous system. Children are learning information about the effects of drugs on the body. Drugs can be divided into two categories: helpful medicines and harmful drugs. One group of drugs, with a beneficial effect on the body, includes medicines that they have probably taken—aspirin/Tylenol, antibiotics, immunizations, and fluoride. The other category, which can have harmful effects on the body, includes alcohol, nicotine, and illegal drugs, such as marijuana and cocaine.

One of the points we emphasize in the module is that all these substances are powerful. Even helpful drugs must be taken under the right conditions and given by trusted individuals—parents or health care professionals, for example. If too much medicine is given, that can be just as dangerous as taking an illegal substance. For example, the drug Adderall is an effective treatment for ADHD, but when it is taken in doses higher than prescribed or without a prescription, it can cause many harmful effects and even death. Drugs and medicines can be both helpful and harmful. Therefore, all substances must be handled with care.

We encourage you to ask your child about this learning experience. Try to find out how much he or she understands and what is still fuzzy. Work with your child to clarify points that he or she hasn't yet grasped. Help provide your child

with more knowledge so that when the time comes, he or she will make a solid, science-based decision not to take drugs.

Science at Home

Discuss certain lifestyle choices made in your home. For example, if you have a glass of wine with dinner, explain that your choice is okay because you are an adult, are drinking in moderation, and are not doing anything dangerous, such as driving after drinking. Emphasize that adults can make these choices, while children are not yet old enough. By learning about how the brain works and about drugs, however, your child is getting a foundation to make thoughtful decisions in the future.

What Does Your Child Think?

Have your child draw or write something about drugs.

Additional Resources

The books and Web sites listed below have more information about drugs.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

National Institute on Drug Abuse (NIDA)—Mind Over Matter
http://teens.drugabuse.gov/educators/nida-teaching-guides/mind-over-matter
This site is designed specifically for young people to learn about the effects of drug abuse on the body and brain.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686

NCADI provides information and materials on substance abuse. Many free publications are available here.

Friedman, D. Focus on Drugs and the Brain. Frederick, Maryland: Twenty-First Century Books, 1990. This book provides a good overview of the brain, neurotransmission, the effects of drugs on the brain, and addiction.

Neuhaus, D. & DeStefano, S. Focus on Medicines. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series. Gives a good overview of medicines and how various medicines work with the body and brain to help heal.

Perry, R. & Nehaus, D. Focus on Nicotine
and Caffeine. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series. Gives a good overview of nicotine and caffeine and how each of these drugs affect the body and brain.

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
This site contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources.

Parent Newsletter (PDF, 6MB)

The Science Behind Smoking (Module 5)

You can also download this entire module in PDF format by clicking the following link: Module 5 (PDF, 3.6B).

Introduction

In Module 4, students were introduced to a wide range of medicines and drugs. They learned about the importance of taking the proper dosage of medicine given by a parent or a health care professional. They also learned about some substances that are harmful. In this module, students focus on tobacco, which causes harm to the body, and nicotine, a drug found in the leaves of the tobacco plant. By performing a controlled experiment, students see for themselves the unhealthy residue that tobacco leaves. They also learn about nicotine and how it can cause addiction.

Learning Objectives

- Students perform a controlled experiment to discover the effect that tobacco has on the body.
- Students discuss the effect that nicotine has on the body.
- Students gain experience developing a hypothesis, performing a controlled experiment, and drawing conclusions from the experiment.

Relationship to the National Science Education Standards

This mission aligns with two standards identified in the NSES: science as inquiry and science in personal and social perspectives. The chart below identifies how the mission aligns with each of these standards.

Science as Inquiry

Levels K–4	How Mission Is Aligned
Abilities necessary to do scientific inquiry	Students go through a series of steps in the process of scientific inquiry: developing a hypothesis, completing an experiment to test their hypothesis, and drawing conclusions.

Science in Personal and Social Perspectives

Levels K–4	How Mission Is Aligned
Personal health	Students observe the unhealthy residue that tobacco leaves. They discuss how this residue is left in the lungs and other parts of the respiratory system and the impact it has on the health of smokers. In the future, students can refer back to this information to make wise decisions about the personal habits that affect their health.

Background

Tobacco is a very potent substance. It contains more than 4,000 chemicals, many of which are released during smoking. Tar and carbon monoxide are two particularly dangerous chemicals in cigarette smoke. Tar can cause lung cancer, emphysema, and bronchial diseases, while carbon monoxide can cause heart problems. Other serious health problems linked to smoking include digestive cancers, gastric ulcers, and cancers of the throat, tongue, lip, esophagus, and pancreas.

In addition to dangerous substances like tar and carbon monoxide, the leaves of the tobacco plant contain a drug called nicotine. Nicotine is found in all tobacco products: cigarettes, cigars, pipe tobacco, chewing tobacco, and snuff. It is a strong drug that acts on the nervous system. It also causes an increase in

blood pressure, heart rate, and respiration. Nicotine is very addictive. It is what causes people to continue to smoke, even though they know the health consequences of doing so.

Different drugs have various effects on the body. People take drugs because of the feeling of euphoria they experience as the drugs change the way the brain normally works. Some of the changes that happen in the brain following drug use are short-term, while other changes can last a long time.

Prolonged drug use can change the brain in such a way that addiction results. Addiction is a disease that is characterized by changes in the structure and functioning of the brain. Addiction results in:

- A strong compulsion or need to use drugs despite negative consequences (someone keeps using drugs even though he or she is having problems);
- Loss of control over the amount of the drug used (someone uses more than he or she plans) and other drug-related behavior (someone does or says things he or she would not ordinarily say or do);
- Intense craving for the drug when it is not available. This craving is due to changes in the brain. Once a person is addicted, he or she must have the drug just to keep from feeling bad. This is because drugs can cause changes in the functioning of neurotransmitters in the brain.

When a person stops using a drug, it takes a while for the brain to get back to normal. During that time, the person may feel bad and have an intense craving for the drug. Research in animals and some humans is beginning to suggest that some drugs may cause changes that are permanent. Addiction is considered a disease because the drugs have changed the normal functioning of the brain. Addiction can be successfully treated. However, the best way to avoid addiction is to never start using drugs.

The nicotine molecule is shaped like a neurotransmitter, acetylcholine. Acetylcholine and its receptors are involved in many functions, including muscle movement, breathing, heart rate, and learning. Acetylcholine also causes the release of other neurotransmitters and hormones that affect mood, appetite, and

memory. When nicotine gets into the brain, it attaches to acetylcholine receptors and mimics its actions, overstimulating the brain.

Nicotine also activates areas of the brain that are involved in producing feelings of pleasure and reward by raising the levels of another neurotransmitter, dopamine. Increased levels of dopamine produce the strong, pleasurable feelings that lead to nicotine addiction. In fact, nicotine is so addictive that it is usually very hard for people to quit using tobacco products. When smokers do try to stop, they often experience cravings for cigarettes, anger, frustration, irritability, restlessness, anxiety, fatigue, headaches, and depression.

Nicotine enters the body very rapidly. After the smoke is inhaled, it takes only 8 seconds to reach the brain. Within about 40 minutes, half of the effect of nicotine is lost. This is the reason people feel the need to smoke another cigarette. Therefore, many smokers light up a cigarette about every 40 minutes. These smokers almost always have measurable amounts of nicotine and carbon monoxide in their bodies.

There are 1.1 billion smokers in the world, and they smoke 6 trillion (6,000,000,000,000) cigarettes each year, according to the World Health Organization. According to the National Survey on Drug Use and Health, there are about 58.3 million cigarette smokers over the age of 12 and 8.9 million tobacco “chewers,” or users of smokeless tobacco, in this country. More than 440,000 people die each year from tobacco use. Because people do have control over whether they begin to smoke, smoking can be viewed as the most preventable cause of death in the United States.

Materials/Preparation

Materials

- NIDA Junior Scientists DVD, or online video
- Newsprint
- For each group (four students per group):

    - three clear cups
    - one cigarette
    - one small bunch of green leaves (gathered from outside)
- Water
- Bucket (if you don't have a sink in the class)
- Instruction Sheets (PDF, 55KB)
- Log Sheets (PDF, 61KB)
- Trading cards
- Paper and pencils
- Labels
- Markers
- Neurotransmission poster or overlay from Module 3
- Poster: The Effects of Nicotine on Neurotransmission (PDF, 47KB)

Preparation

1. Divide the class into groups of four students. Each group of students will get three cups, one cigarette, and one leaf.
2. Decide how to distribute the materials for the experiment. One approach is to set up a materials center and have one student from each group collect the materials needed.
3. Make one copy of the log sheet and one copy of the student instruction sheet for each student.
4. If you don't have a sink in your classroom, decide how you will bring water into the class. One possibility is for two students to fill up a bucket and bring it into the class. Another approach would be for a parent volunteer or an instructional assistant to bring in the water.
5. Make a poster or an overlay of the neurotransmission diagram from Module

3 and a copy showing how nicotine acts (PDF, 47KB). You will use them during the Discussion Questions part of the mission.

Procedures/Discussion Questions

Procedures

1. Conduct a brainstorming session about smoking. Have the students make a chart of what they know, what they want to know, and what they have learned. Ask students what they know about smoking. Do they know that it is harmful? Do they know why it is harmful? Have they heard of nicotine? Have they heard of the concept of addiction? Write down their responses on a sheet of newsprint. You will refer to it after students complete the experiment.
2. To introduce the experiment, show the first segment of the DVD. Then discuss the experiment with the class. By the end of the discussion, students should understand that they will be doing an experiment to test the effect that tobacco has on a cup of water. After observing that the water turns yellow, students will have a better understanding of what effect tar and nicotine have on the body. The lungs, for example, become blackened from excessive smoking.
3. Hand out the instruction sheet and go over the procedure with the class. Tell students that they will be working in groups to perform the experiment. Each group will begin with three cups of water. Students should put a cigarette in one cup, a leaf in the second cup, and nothing in the third. The cups should be labeled "Cigarette," "Leaf," and "Water." Explain to the students that the third cup is a control, a standard against which to judge the other two cups. Help students understand that a control is an integral part of a scientific experiment because it provides a baseline against which to compare results.
4. Have students go to their groups. Give each student a log sheet. Before setting up the experiment, ask the groups to develop a hypothesis about what is going to happen to the cups of water. Have each student record his or her group's hypothesis on the log sheet.

5. Using the instruction sheet as a guide, each group should set up the experiment. Students should label their cups and leave them in a safe place in the classroom. Have students observe the cups over a week's time and write down their observations on their log sheets. Suggest that students include the following:

    - The color of each cup of water on the first day;
    - Changes in color in each cup over time;
    - The odor of each cup of water on the first day;
    - Changes in odor over time.

6. After they have completed the experiment and recorded their observations, have the students discuss the following questions in their groups:

    - Which cup changed the most? Which cup changed the least? Why?
    - Now that you've seen what the cigarette did to the water, what effect do you think it might have on your body? You may have to guide students a bit on this question. Explain to them that what happens to a cup of water and what may happen in our bodies is quite different.

7. After students have completed the experiment and filled out their log sheets, have them work in their groups to develop conclusions. Ask them what this experiment made them think about cigarette smoking. Have each group present its findings and conclusions to the class by creating posters or writing a report.
8. As a class, write a summary describing the results of the experiment. To reinforce their ideas, show the final segment of the DVD.
9. CONGRATULATIONS! YOUR STUDENTS HAVE JUST COMPLETED MISSION 5 OF BRAIN POWER!

Discussion Questions

1. Take out the list of ideas about tobacco and nicotine that students developed before they did the experiment. Ask if their ideas have changed. If so, how? Then ask if they have additional ideas about tobacco that they

would like to add to the list.

2. Show the students a poster or an overlay of the neurotransmission model from module 3. Ask the students if they remember what neurotransmitters do. Discuss the role neurotransmitters play in receiving and processing messages sent throughout the body.

3. Bring out the poster showing the effect of nicotine on neurotransmission (PDF, 47KB). Ask students what they think it means if nicotine takes the place of a neurotransmitter. Explain that when nicotine takes over the functions of a neurotransmitter, it is the beginning of addiction.

4. Tell students that nicotine affects the body in another way. It makes people feel as though they need nicotine to feel good. This is another important fact about addiction, and it helps explain why being addicted to nicotine means that it is very difficult to stop smoking. In addition, because the body has become used to nicotine, it has a physical reaction when nicotine is taken away. These reactions include restlessness, hunger, depression, and headaches. Point out that the best way to avoid addiction to nicotine is to never start smoking in the first place.

Extensions

The activities listed below provide links to other areas in the curriculum. These activities also make use of the trading cards included in the module.

1. While being careful not to touch it, take the "cigarette" water from the experiment and put it in a spray bottle. Put clear water in a second spray bottle. Place two house plants in the same spot outside. Spray one with the cigarette water and the other with the clear water. Observe the two plants for a week. Are bugs staying away from the plant sprayed with cigarette water? If so, that is not a surprise. The chemicals in tobacco are pesticides. (Note: Be very careful when conducting this experiment. The students may be disturbed by the thought of killing bugs.)

2. Discuss with the class what an advertisement is. What are the elements of an ad? What are ads designed to do? Then ask students to design an ad for kids with the purpose of convincing them to never start smoking. Students

can use pictures from magazines, drawings, or computer art to create an attractive and convincing ad.

3. Using the neurotransmission model from Module 3, have students simulate what happens when nicotine replaces the neurotransmitter in the synapse. Have students discuss what functions nicotine affects. (Nicotine changes heart rate, blood pressure, and respiratory functions.)

Assessment

1. Students used a variety of skills during this mission: developing a hypothesis, performing an experiment, drawing conclusions from the experiment, and developing a basic understanding of addiction. In assessing students' performance, look for the following indicators of understanding of key concepts:

    - Is each group able to develop a hypothesis before beginning the experiment?
    - Are students able to work together in a group to perform the experiment?
    - Are students able to figure out how to set up the experiment?
    - Are students able to write clear, precise observations in scientific language? For example, are they writing, "By the second day, the water is beginning to turn yellow" instead of "The water looks weird"?
    - Are students able to explain what addiction is? Do they have a basic understanding of how nicotine affects the process of neurotransmission?

2. Put each student's log sheet in his or her student portfolio.

Additional Activities

Below are some activities that can be used after completion of the fifth mission. These activities are extensions to many other areas of the curriculum.

Note: During this demonstration, smoke and its odor fill the room. To minimize

the deleterious effects, you might want to do this activity outside.

1. You may want to perform the following demonstration to illustrate how dangerous smoking can be.

    - Take a plastic soda bottle with a top. Puncture a hole in the top just big enough for a cigarette.
    - Light the cigarette and place the lit end on the outside of the bottle, with the filter end inside. Make sure the bottle is sealed tightly.
    - Squeeze the bottle 25 times, simulating smoking. Try to keep the squeezes as uniform as possible. Have the students watch as smoke fills the bottle.
    - After you are done squeezing, let the bottle sit for about 20 minutes. Then have students observe the bottom of the bottle. They will see dark residue, which is similar to what builds up in the lungs of smokers.
    - Discuss with the class what this demonstration illustrates about cigarette smoking.

2. Have each student create a new trading card to go with this module. The card can be on any aspect of smoking or addiction.
3. Go to the Library/Media Center and do some research about the effects of smoking on people's health. Students may look in books, in magazines, or on Web sites. Have students write a paragraph describing the research they found.
4. Have students go to another second- or third-grade class in the school and teach this lesson to those students. Have the students take the lead in helping the students from the other class set up the experiment, perform the experiment, and draw conclusions from it. Discuss whether the second class reached the same conclusions as the first one did.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

- NIDA DrugPubs
  drugpubs.drugabuse.gov , 877-NIDA-NIH (877-643-2644)
  Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

- Sara's Quest
  teens.drugabuse.gov/sarasquest/index.php
  This site from NIDA contains a multiple choice game on a variety of drug related categories.

- National Clearinghouse for Alcohol and Drug Information (NCADI)
  store.samhsa.gov, 1-800-729-6686
  NCADI provides information and materials on substance abuse. Many free publications are available here.

- Eisenhower National Clearinghouse (ENC)
  www.sciencepioneers.org/resource/eisenhower-national-clearinghouse-math-science-education
  This Web site provides useful information and products to improve mathematics and science teaching and learning.

- Lynch, B. S. *Growing Up Tobacco Free: Preventing Nicotine Addiction in Children and Youth*. Washington, DC: National Academy Press, 1994.
  Addresses tobacco prevention programs for youth, the effect of tobacco advertising, controls and bans on tobacco sales, and taxation as a prevention strategy; also explains nicotine's effects on the brain and body and the process of addiction.

- Scientists Find How Nicotine Affects Brain
  www.columbia.edu/cu/record/archives/vol21/vol21_iss4/record2104.14.html
  A brief discussion of scientists' discovery of how nicotine affects the brain.

- Neuroscience Resources for Kids—Nicotine

faculty.washington.edu/chudler/nic.html
A discussion of the history of tobacco and effects of nicotine on the body.

- Tobacco-Free Sports Playbook
  www.cdc.gov/tobacco/youth/sports/playbook/
  Designed for school administrators and others who work with children; includes information on smoking and how to develop smoke-free sports activities for youth.

Resources for Students

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse, with sections designed specifically for students.
- National Institute on Drug Abuse. *Mind Over Matter: The Brain's Response to Nicotine*, 1998. Part of the NIDA's "Mind Over Matter" series on drugs for middle school students; focuses on nicotine and nicotine addiction. Available at teens.drugabuse.gov/mom/)
- Friedman, David. *Focus on Drugs and the Brain.* Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series; includes a section on nicotine and addiction.
- Neuroscience for Kids
  faculty.washington.edu/chudler/nic.html
  Presents the history of tobacco and cigarette smoking, nicotine addiction, and the effect of nicotine on the brain.

Introductory Story for Module 5

"Oh, gosh," gasped Kevin. "I feel like I'm choking."

"What's wrong?" asked Ami. "Do you have a bad cold?"

"No," said Kevin. "I just ate in the smoking section of a restaurant."

"Now that you mention it," said Ami, "you do smell kind of funny."

"You know, you're right - however much I hate to admit that," said Kevin. "I had no idea that just being around smokers could affect me so much."

Just then, Ami and Kevin heard a dinging noise coming from the computer. It was Corty; who else?

"Hi, gang," said Corty. "I heard you talking about smoking. You probably didn't know this, but being around smoke is almost like smoking yourself."

"It is?" exclaimed Ami and Kevin in unison. "How can that be?"

"I'm glad you asked," said Corty, "because you're about to find out all about it during the fifth mission of Brain Power!"

"How are we supposed to do that?" asked Kevin.

"Come right this way and you'll find out," said Corty. "Over here, you'll find water, three cups, cigarettes, and leaves. Using the steps of scientific inquiry, you're going to do an experiment to find out why smoking affected poor Kevin over here so much."

"Let me see," said Ami. "I think the first step is to observe. We should probably take a look at all that stuff over there."

"And I think the second step is to make a prediction, or a hypothesis," said Kevin. "So maybe the point is to see what happens to the water when we put a cigarette in it for a few days."

"If we put leaves in a second cup and nothing in the third cup, we can compare the cigarette water with two other cups," finished Ami.

"Let's try it," said Kevin. "Hey, kids. Why don't you do it, too? I'll bet you'll learn

some things that you'll find very useful."

"That's right," said Ami. "I think we all have a chance to get to the bottom of this smoking thing once and for all."

Brain Power News

Parent Newsletter
Volume 1, Number 5

The Science Behind Smoking

Most adults have known for years about the dangers of smoking. Nonetheless, smoking is still portrayed in the media as something glamorous and sophisticated, and many young people are still starting to smoke. While cigarette smoking among youth has declined, it still remains at unacceptably high levels. Furthermore, studies have shown that the younger a child starts smoking, the more likely they are to become daily smokers. In fact, those teenagers who smoke typically start at age 14 and become daily smokers by age 18.

Clearly, there is a strong need to keep adolescents from starting to smoke. Module 5 of the *Brain Power!* program addresses this issue by having students perform an experiment that illustrates the unhealthy residue that tobacco leaves behind. Students begin with three cups of water. They put a cigarette in one cup, a leaf in a second cup, and nothing in the third cup. The third cup serves as a control against which to compare changes in the other two cups. Students will observe that the water with the cigarette turns yellow, mimicking what happens inside the lungs after smoking.

Students also discuss nicotine, the highly addictive drug found in the leaves of the tobacco plant. The nicotine molecule is shaped like the neurotransmitter acetylcholine (remember from module 3 that neurotransmitters are chemicals in the brain that carry messages), which is involved in functions such as muscle movement, breathing, heart rate, and learning. Acetylcholine also causes the

release of other neurotransmitters and hormones that affect mood, appetite, and memory. When nicotine gets into the brain, it attaches to acetylcholine receptors and causes them to become active. Nicotine is addictive; it changes the way the brain works so that the brain and body don't feel normal without it.

Nicotine also stimulates areas of the brain that are involved in producing feelings of pleasure and reward by raising the levels of another neurotransmitter, dopamine. Increased levels of dopamine produce the strong, pleasurable feelings that lead to addiction. Because nicotine is so addictive, once people start smoking, it is hard for them to quit. When smokers do try to stop, they often experience craving for cigarettes, anger and frustration, irritability, restlessness, difficulty sleeping, difficulty concentrating, hunger and weight gain, anxiety, fatigue, and depression.

We encourage you to ask your child about this learning experience. What were his or her reactions to the results of the experiment? Was your child surprised by the results? Did the experiments raise questions for your child? Our hope is that the experiment will lead to lively discussion that will reinforce the message that smoking is not healthy.

Science at Home

Discuss choices about smoking made by family members. Do you or does anyone in your extended family smoke? If so, would that person be willing to discuss with your child when he or she started, whether he or she has tried to stop? If the smoker is older, discuss whether the scientific information about smoking was available when he or she started smoking. If not, ask about his or her reaction to the news when it first appeared in the 1960s. Social influences on smoking (for example, parent, sibling, peer, neighborhood, and school influences) have an enormous impact on adolescent smoking. By discussing these issues with your child now, while he or she is still young, you are preparing him or her to make wise decisions in the future.

What Does Your Child Think?

Have your child draw or write something about tobacco or nicotine.

Additional Resources

The books and Web sites listed below have more information about tobacco and nicotine.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

National Institute on Drug Abuse (NIDA)—Mind Over Matter
http://teens.drugabuse.gov/educators/nida-teaching-guides/mind-over-matter
This educational series, developed by NIDA, includes a section that focuses specifically on tobacco and its effects.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

Friedman, D. Focus on Drugs and the Brain. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series; includes a section on nicotine and addiction.

Lynch, B.S. Growing Up Tobacco Free: Preventing Nicotine Addiction in Children and Youths. Washington, DC: National Academy Press, 1994. Addresses tobacco prevention programs for youth, the effect of tobacco advertising, controls and bans on tobacco sales, and taxation as a prevention strategy; also explains nicotine's effects on the brain and body and the process of addiction.

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
This site includes a section on the history of tobacco, cigarette smoking, nicotine addiction, and the effect of nicotine on the brain.

Parent Newsletter (PDF, 552KB)

How Drugs Affect the Brain (Module 6)

You can also download this entire module in PDF format by clicking the following link: Module 6 (PDF, 4.7MB).

Introduction

Students are nearing the end of the *Brain Power!* program. Over the last five modules, students have learned how to use scientific inquiry to perform experiments (Module 1 and Module 5), how to identify the parts of the brain and their functions (Module 2), what neurotransmission is (Module 3), the difference between medicines and harmful drugs (Module 4), and the effects nicotine has on the brain and the body (Module 5). This final module serves as a culminating activity and as an embedded assessment for the entire program. Using the information provided on four fact sheets, along with their prior knowledge, students will explain how cocaine, marijuana, alcohol, and nicotine affect the brain and the rest of the nervous system. Students may use the model of the brain, the neurotransmission simulation they performed, or any other activity - such as putting on a play, making a poster, or developing a comic strip - to explain their ideas.

Learning Objectives

- Students review information about four drugs - cocaine, marijuana, alcohol, and nicotine.
- Students apply what they have learned in the previous modules to explain how these drugs affect the brain and the rest of the nervous system.
- Students present their findings to members of their class.

Relationship to the National Science Education Standards

This mission aligns with the following two standards identified in the NSES: science as inquiry and science in personal and social perspectives. The chart that follows identifies how the mission aligns with each of these standards.

Science as Inquiry

Levels K–4	**How Mission Is Aligned**
Abilities necessary to do scientific inquiry	Students experience some of the steps in the process of scientific inquiry: developing a hypothesis, completing an investigation to test the hypothesis, and drawing conclusions.

Science in Personal and Social Perspectives

Levels K–4	**How Mission Is Aligned**
Personal health	Students observe the effects that four drugs have on the brain and the nervous system. They discuss the impact this information has on their lives and how they can use it to make wise decisions about their own health.

Background

Different drugs have various effects on the body. People are motivated to take drugs because of the feeling of euphoria they experience as the drugs change the way the brain normally works. Some of the changes that happen in the brain

following drug use are short-term, while other changes can last a long time.

Prolonged drug use can change the brain so that addiction results. Addiction is a disease caused by changes in the structure and functioning of the brain. Addiction is characterized by:

- A strong compulsion or drive to use drugs despite negative consequences (someone keeps using drugs even though he or she is having problems);
- Loss of control over amount of the drug used (using more than he or she plans) and over drug-related behavior (someone does or says things he or she would not ordinarily do);
- Intense craving for the drug when it is not available. This craving is due to changes in the brain. Once a person is addicted, he or she must have the drug just to keep from feeling bad. This is because drugs can cause changes in the functioning of neurotransmitters in the brain.

When a person stops using a drug, it takes a while for the brain to get back to normal. During that time, the person may feel bad and have intense craving for the drug. Research in animals and some humans is beginning to suggest that some drugs may cause changes that are permanent. Addiction is considered a disease because the drugs have changed the normal functioning of the brain. Addiction can be successfully treated. However, the best way to avoid addiction is to never start using drugs.

Cocaine

Cocaine is a stimulant made from the leaf of the coca plant. Cocaine speeds up activity in the brain and the spinal cord, causing an increase in blood pressure and heart rate and a decrease in the flow of blood and oxygen to the heart. When someone snorts, injects, or smokes cocaine, it travels to the brain very quickly. It reaches all areas of the brain but has its greatest effects in the front part of the cerebral cortex and on part of the limbic system.

A very complicated process takes place in the brain after it is exposed to cocaine. In a normal brain, the neurotransmitter dopamine is released by

neurons to carry messages in the limbic system. After the message has been carried to the next neuron, dopamine is reabsorbed from the synapse back into the neuron that released it. Cocaine blocks the reabsorption of dopamine, leaving too much dopamine in the synapse. The excess dopamine is what causes the pleasurable feelings associated with taking cocaine and the increased motor activity seen with higher doses.

After a person abuses cocaine for a while, the brain tries to compensate for the excess dopamine, and the normal processes that take place are disrupted. The brain will no longer function normally without cocaine.

Marijuana

Marijuana is the dried leaves and flowers of the cannabis plant. More than 400 chemicals can be found in the average cannabis plant. The active ingredient in marijuana that produces changes in brain messages is called tetrahydrocannabinol (THC). The brain has receptors for a specific chemical, anandamide, which is naturally produced by the brain. THC is able to attach to and activate these same receptors. These receptors are called THC receptors rather than anandamide receptors because scientists knew that THC attaches to these receptors long before anandamide was discovered.

Scientists know less about how marijuana affects the nervous system than they do about other drugs. However, scientists know that some areas of the brain have a lot of THC receptors, while other areas have very few or none. When a person uses marijuana, the chemicals in the drug travel through the bloodstream and attach to the THC receptors, activating them and interfering with normal neurotransmission.

The areas of the brain with the most THC receptors are the cerebellum, the cerebral cortex, and the limbic system. This is why marijuana affects thinking, problem solving, sensory perception, movement, balance, and memory.

Alcohol

Alcohol is found in beer, wine, and spirits, e.g., gin, vodka, or whiskey. It affects the brain and almost every other organ in the body. The parts of the brain affected by alcohol are the cerebral cortex, limbic system, and brain stem. Alcohol interferes with messages carried by many neurotransmitters in the brain. Because these neurotransmitters are found throughout the brain, alcohol affects many functions, including thinking, coordination, and emotions.

If a person becomes dependent on alcohol, he or she might be diagnosed with the disease known as alcoholism. Alcoholism can be life-threatening. The long-term use of alcohol results in the depletion of certain vitamins and minerals in the body. These deficiencies can result in diseases like Wernicke-Korsakoff syndrome, a disease that affects the short-term memory and, in some cases, can result in a permanent loss of memory.

Nicotine

Nicotine comes from tobacco leaves and is found in all tobacco products—cigarettes, cigars, pipe and chewing tobacco, and snuff. Nicotine acts on the central and peripheral nervous systems. It also causes an increase in blood pressure, heart rate, and respiration.

Nicotine is shaped like the neurotransmitter acetylcholine, which is involved in movement, breathing, heart rate, learning, and memory. When nicotine gets into the brain, it hooks onto the place where acetylcholine would normally go and overexcites the brain.

Nicotine also affects the neurotransmitter dopamine. Scientists think that nicotine's effects on dopamine are what cause the pleasurable sensations smokers experience. The long-term effects of smoking include lung cancer, emphysema, heart disease, and addiction. The longer a person smokes, the harder it is to quit. Fewer than 1 in 10 people who try to quit smoking actually succeed.

Drug	Effects on the Brain and Body	Parts of the Brain Affected
Cocaine	1. Increase in blood pressure and heart rate 2. Change in emotional behavior 3. Impaired thinking and decision making	1. Brain stem 2. Limbic system 3. Cerebral cortex
Marijuana	1. Short-term memory loss 2. Impaired thinking and problem solving 3. Impaired movement	1. Limbic system 2. Cerebral cortex 3. Cerebellum
Alcohol	1. Impaired thinking and problem solving 2. Change in emotional behavior 3. Impaired coordination	1. Cerebral cortex 2. Limbic system 3. Cerebellum
Nicotine	1. Increase in respiration rate and blood pressure 2. Increases the amount of the neurotransmitter dopamine present in synapses	1. Brain stem 2. Limbic system

Materials/Preparation

Materials

- NIDA Junior Scientists DVD, or online video
- Fact Sheets (PDF, 118KB)
- Brain model (from Module 2)
- Student instruction sheet (PDF, 98KB) (from Module 3)
- Riddles (PDF, 362KB) (from Module 4)
- Log Sheet (PDF, 178KB)
- Trading cards
- Paper and pencils

Preparation

1. Divide the class into groups of three for this activity.
2. Make one copy of the fact sheets, the instruction sheet, and the log sheet for each student.
3. Make sure you have the materials from the first five modules available for this activity. These include the students' models of the brain, the instruction sheets from the previous modules, the log sheets from the previous modules (in each student's portfolio), and the riddles from Module 4. Lay out the materials on a table so that you can refer to them during the activity.

Procedures/Discussion Questions

Procedure

1. From the previous modules, point out the materials on the table. Briefly discuss the high points of each module, which include: the parts of the brain, neurotransmission, the difference between helpful and harmful drugs, and

what tobacco does to the body. Tell the students that they are going to draw some conclusions about what they have learned during the *Brain Power!* program and to apply that knowledge to substances they did not study. Ask students if they remember what the first step is in scientific inquiry. Help the class remember that the first step is to *observe* and *describe* these materials.

2. After the class shares its ideas, tell students to get into groups of three. Have each group develop conclusions based on all they have learned during the program. Then have each student record his or her group's conclusions on the log sheet. For example, one possible conclusion may be: "It is important to take care of your brain by not putting unnecessary drugs into your body." Each group's conclusion should emphasize the importance of not taking any substance that could harm the way the brain and the nervous system work. Have each group use the information in the previous modules to explain whey they shouldn't put unnecessary drugs into their body.

3. Now give students an opportunity to apply what they learned to two new substances. Give half the groups the fact sheets about cocaine and alcohol and half the groups the fact sheets about marijuana and nicotine. Tell students that their mission is to determine how these drugs affect the brain and the nervous system. Then students will have an opportunity to present their ideas to the class. Their presentations can use the model of the brain, the neurotransmission simulation game, or the riddles. They also can develop a skit, make a poster, write a comic strip, or develop their own unique presentation.

4. CONGRATULATIONS! YOUR STUDENTS HAVE JUST COMPLETED THE LAST MODULE IN THE BRAIN POWER! PROGRAM.

   When your class has completed the *Brain Power!* program, place the reverse sides of all six posters together to create the certificate of completion. The students can all sign their names to indicate that they are now NIDA Jr. Scientists!

Discussion Questions

1. Have each group give its presentation. After the presentations, discuss how cocaine, marijuana, alcohol, and nicotine affect the brain and the nervous

system.

2. Have each student summarize what he or she learned during the *Brain Power!* program. Ask each student to read his or her summary to the class.
3. Ask students to think of one thing they would tell their friends and family about the program. Suggest that they make a poster of their one thought and share it with their families.

Extensions

The activities listed below provide links to other areas in the curriculum. These activities also make use of the trading cards included in the module.

1. Put out the trading cards from all six modules. Have the students look them over and think about other ideas for cards. Then ask each student to create one new trading card on a subject relevant to the *Brain Power!* program.
2. Have the students imagine that a good friend has just started smoking. Ask the students to decide what they would say to their friend to convince him or her to stop smoking. Then ask for volunteers to act out the scene.

Assessment

This lesson is an embedded assessment of what students have learned throughout the Brain Power! program. As students work, observe whether they have mastered the following:

1. Can each student develop conclusions that reflect the work done in the modules?
2. Can groups of students apply what they have learned about a substance to its effect on the brain and the nervous system?
3. Are students approaching the task logically and methodically?
4. Are students able to synthesize the information to create a presentation that is engaging and accurate?

5. Are students able to summarize what they did and develop a clear, crisp statement expressing their conclusions about the program?

Additional Activities

Below are some additional activities that can be used after completion of the sixth mission. These activities are extensions to many other areas of the curriculum.

1. Develop a board game showing how drugs affect the brain and the nervous system. The object of the game could be to match the drug with the part of the body it affects, or to solve problems using the processes of scientific inquiry.
2. Develop or identify a new scientific question or problem and then use the processes of scientific inquiry to solve it. For example, the problem could be how fast your heart beats before and after exercise, or how your tongue knows how different foods taste. Encourage your students to design their own experiments.
3. Build a more complex model of the brain than the one built in Module 2. Use science books or Web sites to find a model. Then use clay or other materials to make a more anatomically detailed model.
4. Write a play summarizing what you have learned about drugs. The play could focus on different drugs and what they do, how drugs affect the brain and the nervous system, or why smoking is a bad habit to start. The students may want to invite other classes in the school to see their play.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

- National Institute on Drug Abuse (NIDA)
  www.drugabuse.gov, 301-443-1124
  This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

- NIDA DrugPubs
  drugpubs.drugabuse.gov , 877-NIDA-NIH (877-643-2644)
  Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

- Sara's Quest
  teens.drugabuse.gov/sarasquest/index.php
  This site from NIDA contains a multiple choice game on a variety of drug related categories.

- National Clearinghouse for Alcohol and Drug Information (NCADI)
  store.samhsa.gov, 1-800-729-6686
  NCADI provides information and materials on substance abuse. Many free publications are available here.

- Eisenhower National Clearinghouse (ENC)
  www.sciencepioneers.org/resource/eisenhower-national-clearinghouse-math-science-education, 1-800-471-1045
  This Web site provides useful information and products to improve mathematics and science teaching and learning.

- Bellenir, K., ed. *Drug Abuse Sourcebook. Health Reference Series*, Vol. 14. Omnigraphics, Inc., 2010. Basic health-related information about the abuse of legal and illegal substances such as alcohol, tobacco, marijuana, and cocaine.

- Greenfield, S. A. *The Human Brain: A Guided Tour*. New York: Basic Books, 1998. Written for a lay audience, provides a holistic view of the brain as an integral part of the body; part of the Science Masters Series.

Resources for Students

- National Institute on Drug Abuse (NIDA)—Mind Over Matter
  teens.drugabuse.gov/mom/index.php

Series developed to educate children about the effects of drug abuse on the body and the brain.

- Friedman, D., & Neuhaus, D. *Focus on Drugs and the Brain*. Frederick, MD: Twenty-First Century Books, 1990. Part of the “Drug-Alert Book” series. Describes the function of the brain and nervous system and how drugs affect the body.
- Neuroscience for Kids
  faculty.washington.edu/chudler/neurok.html
  Explores the brain and spinal cord; lists the effects of drugs on the brain and nervous system.

Introductory Story for Module 6

"I don't know about you, Brain Trust, but my head is spinning," said Brain Wave.

"What do you mean?" replied Brain Trust.

"We've learned so much in such a short period of time. First, we learned about the brain and everything it does. Then we learned about how messages are sent throughout the body. And that's just the beginning!"

"I guess you're right," said Brain Trust. "Then we moved on to find out about medicines, drugs, and nicotine. It has been a lot. No wonder your head is spinning."

"What can we do to make sense of it all?" asked Brain Wave.

"Well, those steps of scientific inquiry could help," suggested Brain Trust. "You know, observe, hypothesize, experiment, and conclude."

"You're right. We could try to figure out what all these different ideas have in common," said Brain Wave.

Just then, they heard the computer dinging, and they saw their trusty friend Corty on the screen. "Couldn't help overhearing your conversation. What do all these ideas have in common? How can we use the steps of scientific inquiry to put all six of the modules together?" Corty said.

Brain Wave and Brain Trust looked at each other. They weren't sure. What do you think? Can you come up with a way to tie all this information together? Talk to your classmates. By figuring out the last problem of the NIDA Junior Scientists Program, you become a member of the club. Good luck, and may the tools of science be with you.

Brain Power News

Parent Newsletter
Volume 1 Number 6

How Drugs Affect the Brain

Your child is nearing the end of the *Brain Power!* science program. Over the last five modules, your child has learned how to use scientific inquiry to perform experiments, how to identify the parts of the brain and their functions, what neurotransmission is, the difference between medicines and harmful drugs, and the effects of nicotine and tobacco on the brain and the body. During the last module, your child had an opportunity to learn about how four substances—cocaine, marijuana, alcohol, and nicotine—affect the brain and the rest of the nervous system.

To help students complete this task, they received fact sheets about two of the four substances. For your reference, this information is summarized below.

Drugs	Effects on the Brain and Body	Parts of the Brain affected
Cocaine	1. Increase in blood pressure and heart rate 2. Change in emotional behavior 3. Impaired thinking and decision making	1. Brain stem 2. Limbic system 3. Cerebral cortex
Marijuana	1. Short-term memory loss 2. Impaired thinking and problem solving 3. Impaired movement	1. Limbic system 2. Cerebral cortex 3. Cerebellum
Alcohol	1. Impaired thinking and problem solving 2. Change in emotional behavior 3. Impaired coordination	1. Cerebral cortex 2. Limbic system 3. Cerebellum
Nicotine	1. Increase in respiratory rate and blood pressure 2. Increases the amount of the neurotransmitter dopamine present in synapses	1. Brain stem 2. Limbic system

Our goal in introducing this material is to provide scientific information about the effects of drugs on the body. By presenting the material to students when they are still young, we hope to lay a foundation upon which they can build ideas as they grow. We also hope that their early exposure to this information will help them make healthful choices about drugs in the future. We encourage you to discuss these issues with your child. Ask your child what he or she learned from the program. What overall impressions has he or she brought away from the Brain Power! program?

Science at Home

At school, your child was asked to write down one message that he or she would convey to family and friends after completing the *Brain Power!* program. Try this activity as a family. What is one message about the brain and drugs that your family would like to convey to others? Then send the message on to a friend and ask him or her to spread the word. Friends and family members are influential people in children's lives. We believe the more people repeat the message about the harmful effects drugs can have, the clearer the message will be for children.

What Does Your Child Think?

Have your child draw or write something about how drugs affect the brain.

Additional Resources

The books and Web sites listed below have more information about drugs.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard

copies of NIDA publications or download electronic versions in multiple formats.

National Institute on Drug Abuse (NIDA)—Mind Over Matter
www.nida.nih.gov/MOM/MOMIndex.html
Series developed to educate children about the biological effects of drug abuse on the body and the brain.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

Bellenir, K., ed. Drug Abuse Sourcebook. Health Reference Series, Omnigraphics, Inc., 2010. Basic health-related information about the abuse of legal and illegal substances such as alcohol, tobacco, marijuana, and cocaine.

Friedman, D. Focus on Drugs and the Brain. Frederick, Maryland: Twenty-First Century Books, 1990. This book, part of the “Drug-Alert Book” series, includes a section on each drug of abuse and addiction.

Neuroscience for Kids
http://faculty.washington.edu/chudler/nic.html
This site includes a section on the history of tobacco, cigarette smoking, nicotine addiction, and the effect of nicotine on the brain.

Parent Newsletter (PDF, 544KB)

Materials/Contact

Contact Information

For questions regarding *NIDA's Science Education Program and Materials*, contact Cathrine Sasek, Ph.D., e-mail: csasek@nih.gov.

Handouts

Module 1: Ooey Gooey! Making Sense of Scientific Inquiry

- Student Instruction Sheet (PDF, 79KB)
- Log Sheet (PDF, 72KB)
- Trading Cards (PDF, 735KB)
- Parent Newsletter (PDF, 425KB)

Module 2: Brains in a Box: What Your Brain Can Do

- Student Instruction Sheet (PDF, 241KB)
- Log Sheet (PDF, 58KB)
- Trading Cards (PDF, 6MB)
- Parent Newsletter (PDF, 606KB)

Module 3: Sending and Receiving Messages

- Student Instruction Sheet (PDF, 285KB)
- Activity Sheets (PDF, 81KB)
- Log Sheet (PDF, 105KB)

- Trading Cards (PDF, 4.2MB)
- Parent Newsletter (PDF, 436KB)

Module 4: Medicines and Drugs: What's Helpful, What's Harmful

- Riddles Sheet (PDF, 362KB)
- Log Sheet (PDF, 64KB)
- Cards (PDF, 884KB)
- Parent Newsletter (PDF, 6MB)

Module 5: The Science Behind Smoking

- Instruction Sheet (PDF, 55KB)
- Log Sheet (PDF, 35KB)
- Trading Cards (PDF, 3.3MB)
- Parent Newsletter (PDF, 552KB)
- Poster (PDF, 47KB)

Module 6: How Drugs Affect the Brain

- Instruction Sheet (PDF, 159KB)
- Fact Sheets (PDF, 118KB)
- Log Sheet (PDF, 178KB)
- Trading Cards (PDF, 3.5MB)
- Parent Newsletter (PDF, 544KB)

T-shirts, Stickers, and Buttons

How do I make a T-shirt?

Download PDF (2.5MB)

1. Ask children to have their parents find a plain white t-shirt or other cotton item that they can use for the iron-on.
2. Pick up iron-on ink-jet transfer paper at your local craft or office supply store. Choose opaque transfer paper for dark-colored items and transparent transfer paper for light-colored items. Transparent transfer paper may help avoid white outlines around artwork. Always read the instructions that come with the transfer paper.
3. Download the free artwork.
4. Use an inkjet printer to print the downloaded artwork onto the transfer paper. The artwork comes as a two-page PDF document. Page one is a flipped,

mirror image (backwards) of the design. Page two is a regular (straightforward) non-flipped image.

5. Use an ordinary iron to transfer the design onto the item. Use caution, the iron will be very hot.

How do I print the stickers?

Download

1. Pick up some blank white labels paper at your local craft or office supply store.
2. Download the free artwork.
3. Place the downloaded artwork onto your labels and resize the art to fit your label.
4. Use an ink-jet printer to print your downloaded design onto the labels. Be sure to read the instructions that come with the labels.