DRUGS and the Developing Brain

The Science Behind Young People’s Substance Use

Ken C. Winters, Ph.D., and Jeff Lee, M.Ed.
with Mary K. Winters, M.Ed.
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Facilitator’s Guide

Ken C. Winters, Ph.D.
Jeff Lee, M.Ed.

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Developed in collaboration with the Mentor Foundation

Hazelden®
Hazelden
Center City, Minnesota 55012
hazelden.org

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Editor's note
This publication is not intended as a substitute for the advice of health care professionals.

Cover design by David Spohn
Interior design and typesetting by David Farr, ImageSmythe

Hazelden, a national nonprofit organization founded in 1949, helps people reclaim
their lives from the disease of addiction. Built on decades of knowledge and experience,
Hazelden offers a comprehensive approach to addiction that addresses the full range
of patient, family, and professional needs, including treatment and continuing care
for youth and adults, research, higher learning, public education and advocacy, and
publishing.

A life of recovery is lived “one day at a time.” Hazelden publications, both educational
and inspirational, support and strengthen lifelong recovery. In 1954, Hazelden published
Twenty-Four Hours a Day, the first daily meditation book for recovering alcoholics, and
Hazelden continues to publish works to inspire and guide individuals in treatment and
recovery, and their loved ones. Professionals who work to prevent and treat addiction
also turn to Hazelden for evidence-based curricula, informational materials, and videos
for use in schools, treatment programs, and correctional programs.

Through published works, Hazelden extends the reach of hope, encouragement, help,
and support to individuals, families, and communities affected by addiction and related
issues.

For questions about Hazelden publications, please call 800-328-9000 or visit us online at
hazelden.org/bookstore.

The Mentor Foundation is an international non-government organization with a focus on the
prevention of substance abuse and the promotion of the health and well-being of children
and young people. For further information, please see www.mentorfoundation.org.
What Is the Purpose of This Facilitator’s Guide?

The purpose of this facilitator’s guide is to provide step-by-step instructions on how to use *Drugs and the Developing Brain*. It is important that you read through this guide before you begin the program. You may find it helpful to print this facilitator’s guide.

In this facilitator’s guide, you will see:

**Teacher Tips**
Be even more successful with *Drugs and the Developing Brain* by using these practical tips and strategies.

**Thumbnails**
Thumbnails of the slides and parent information pages show when to use these items as you use the curriculum with your students.

**How to Use the CD-ROM**
The *Drugs and the Developing Brain* CD-ROM contains all the components of this curriculum, including the printable facilitator’s guide, a short PowerPoint presentation with notes for each lesson, parent information handouts, and a list of additional resources. Except for the PowerPoint presentation, all of these components are in PDF format, which can be accessed using Adobe Reader. If you do not have Adobe Reader, you can download it free of charge at [www.adobe.com](http://www.adobe.com).

Whenever you see this icon 🎨, it signals that a copy of the resource being discussed is on the *Drugs and the Developing Brain* CD-ROM.

To access the program, put the disc in your computer’s CD-ROM player. Open your version of Adobe Reader, and then open the files by clicking on the ones you wish to use. The documents cannot be modified, but they can be printed for use in individual classroom settings. For a complete list of the resources included on your *Drugs and the Developing Brain* CD-ROM, please see page 74 of this guide. This list is also on your CD-ROM.
What Do People Say About Drugs and the Developing Brain?

Drugs and the Developing Brain is a fun way to educate teens about cutting-edge brain science. The material is presented in a colorful, accessible way that highlights its relevance to personal substance use decisions. Counselors, teachers, and therapists will appreciate the easy-to-use facilitator’s guide, as well as the “wow” likely escaping the mouths of their teenage students and clients when they take in the exciting graphics. The scientific accuracy of the material is excellent, and provided at a level that even younger teens can understand.

Susan F. Tapert, Ph.D.
Professor of Psychiatry, University of California, San Diego
Associate Chief of Psychology Service and Director of Substance Abuse/Mental Illness, VA San Diego Healthcare System

Drugs and the Developing Brain will introduce young people to neuroscience, teach them about brain development during the teen years, and help them understand why drug use is harmful to their development. Rather than using scare techniques that often exaggerate the facts, this program provides scientifically accurate information in an engaging and instructive fashion. I highly recommend it.

Laurence Steinberg, Ph.D.
Professor of Psychology, Temple University
Author, You and Your Adolescent
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The authors express their deep gratitude to the numerous researchers who have studied brain development and the neurobiology of addiction. These include Carlton Erickson, Jay Giedd, Susan Tapert, and Linda Spears. We also extend a heartfelt thanks to graphic designers Johanna Winters and Don Krupmos and to our editor Nicole Post.
Welcome to Drugs and the Developing Brain

Drugs and the Developing Brain is Hazelden’s brief program about brain development and the science behind young people’s substance use. It was designed by specialists in the field to support prevention and treatment efforts for teens and young adults.

What Are the Program’s Goals?

Drugs and the Developing Brain was created to

- teach young people about recent discoveries in brain science that help explain behaviors and experiences typical of their age
- educate young people about how this science helps researchers better understand substance abuse issues
- improve the outcomes of prevention and treatment efforts
- promote health and well-being among young people

What Is Drugs and the Developing Brain?

Drugs and the Developing Brain is a curriculum designed to teach young people about emerging brain science and how brain development may make them more vulnerable to the harmful effects of alcohol and other drug use. New brain imaging technologies provide scientists with ways to study brain development as never before. As a result, we now have a clearer understanding of how the adolescent brain works and how teens make decisions, including whether or not to use drugs. This information is critical for youth as they strive to understand themselves better and make healthy decisions about their future. It is also important information for the significant adults in young people’s lives, such as parents and teachers.

A substantial body of research now shows that the human brain continues developing in important ways until the midtwenties. This discovery helps us understand why young people may be particularly vulnerable to the effects of alcohol and other drugs. It also may explain ways that the
Drugs and the Developing Brain uses science as a vehicle to engage young people in learning about the specific effects of drugs on their neurobiology.

What Are the Components of the Program?
The program includes
- this facilitator’s guide
- slides
- slide notes for the facilitator
- parent information pages
- a list of resources to learn more about the developing brain

All you need to implement this program is the Drugs and the Developing Brain CD-ROM, a projector, and a screen. Instructions for presenting the slideshow are included both in the notes section of each slide and in the facilitator’s guide. (As stated before, you may find it helpful to print the guide.) Instructions for using the CD-ROM are on page iii, and a complete list of the CD-ROM materials may be found on page 74. A detailed table describing each lesson and recommended preparation is on pages 9–11.

What Do the Lessons Include?
Drugs and the Developing Brain presents state-of-the-art brain science over eight concise lessons. Each lesson features
- a five-minute teacher-directed lesson that conveys factual information
- a digital slideshow that provides an engaging visual focus
- a fun and dynamic extension activity that may be used to reinforce learning

On the first page of each lesson, you will find a lesson description, learner outcomes, an at-a-glance summary of all the lesson parts, and a checklist of the materials and preparation needed. Background information is provided, and the lesson plans include scripted text for teachers and facilitators, with detailed instructions about how to present each activity.

Who Is the Intended Audience?
Drugs and the Developing Brain is intended for use with teens and young adults. It may be used in school, treatment, or juvenile justice settings. Drugs and the Developing Brain is designed for all students, putting it in the category of universal prevention efforts (also known as primary prevention). The needs of most students for information and skills are met at this level. However, the program may also be used effectively as
part of selective prevention programs, specially designed for students identified as at risk for substance abuse, and with indicated prevention efforts for students already experiencing drug or alcohol problems (see figure 1 above).

In school-based settings, *Drugs and the Developing Brain* fits well into science, health education, homeroom, career and life management, social studies, advisory, or general life skills classes. Related academic standards are listed on pages 8–9. Classroom teachers, prevention specialists, health educators, counselors, volunteers, or others may facilitate the program.

**Is Drugs and the Developing Brain Relevant to the Young People I Work With?**

Yes, *Drugs and the Developing Brain* is relevant and important for your students and clients. It may also be useful to the significant adults in their lives. Adolescence is a period of major brain development. When we as adults have an accurate understanding of the developmental process, we can better respond to adolescent behavior. When teens are informed about brain development, they may be able to better understand themselves and their own choices. Brain science provides insights on why adolescents may
make decisions that seem unreasonable to adults
- take risks that put themselves in harm’s way
- be prone to sudden emotional outbursts
- be particularly vulnerable to the effects of drugs

The emerging science of brain development may help explain why, despite the risks, many young people experiment with drugs and make other dangerous decisions. Neuro-developmental factors may contribute to tendencies for adolescents to seek out, use, and even abuse alcohol and other drugs. Also, the negative effects of drugs may be more detrimental to a teenager’s developing brain than to an adult’s. These effects may contribute to a quicker onset of addiction and may impair the young person’s memory and ability to learn.

U.S. surveys indicate that young people have more alcohol problems than adults (see figure 2 below). For American youth ages fifteen to twenty, 12.2 percent met the definition of alcohol dependence disorder within the twelve months prior to the survey. This is much higher than for the other age groups. For adults ages thirty to thirty-four, the rate of alcohol dependence was 4.1 percent.

Also in the United States, 15.9 percent of adolescents used alcohol in 2007, 9.5 percent used illicit drugs, and 6.7 percent used marijuana. Teens’ nonmedical use of the narcotics Vicodin and OxyContin has peaked in recent years. All of these substances can be dangerous for adolescents. Alcohol itself is involved with all three leading causes of death among young people: traffic accidents, homicide, and suicide. Early use is linked with a wide range of other health and social

**Figure 2** Prevalence rates (%) of past-year alcohol dependence defined by official diagnostic criteria; based on a national representative, 2001–2002
problems, including violence and injuries, vandalism, truancy, and risky sexual behavior.

The new scientific findings about how the teen brain works—and the effects that drugs can have on it—are very important in helping us understand and respond to teen behavior. They show that effective programs that provide prevention education and develop related knowledge, skills, and healthy attitudes in young people are essential. Drug use and its potential impact on the developing brain present substantial risks. *Drugs and the Developing Brain* helps you address these risks.

**Is *Drugs and the Developing Brain* Based on Research?**

Yes, *Drugs and the Developing Brain* is based on the best current research in neuroscience, education, and prevention.

Emerging research about how the human brain matures during adolescence yields interesting findings. Significant neuro-developmental changes during this period include substantial pruning of the major regions of the brain, and the neural connections of the prefrontal cortex (the brain’s center of judgment and reasoning) finish this pruning maturation process later than other brain regions (including the emotion center). These scientific discoveries affect how we understand teens’ decision making and their vulnerabilities to drug use. Developmental psychologists suggest that this pattern of brain development may increase the likelihood of risk taking, sensation seeking, and emotional changes during the teenage years.

Forty years of education research on metacognition reveal the importance of students’ knowledge and control of their own cognitive processes. Best practices in prevention education indicate that the teacher is effective as a source of factual information (though social behavior and attitudes tend to be shaped by peers) and education research shows that teacher-led direct instruction should be brief and highly focused. For these reasons, *Drugs and the Developing Brain* delivers essential scientific material about the teen brain during five-minute teacher-led lessons.

Best practices in education include multimodal approaches to teaching. With *Drugs and the Developing Brain*, slideshows central to each lesson tap into both visual and verbal learning modalities. This method of delivery is thought to increase student engagement, especially for visual learners. Several of the extension activities include kinesthetic experiences as well.

**What Challenges Might Teachers Meet with This Program?**

For a variety of reasons, some teachers may be reluctant to talk about alcohol and other drugs with their students. Some may feel that the
topic is not appropriate in a school setting. Some may question whether prevention education has a positive impact on students’ health and well-being. Teachers may also feel unqualified to present the subject matter or pressured by myriad demands on their time.

Before getting started with this program, it’s important to understand that prevention education can be highly effective when delivered by teachers in schools. *Drugs and the Developing Brain* provides an opportunity for teachers to learn along with their students. It provides scientific evidence that links healthy choices with healthy brain development—all without involving values or judgments. The program helps promote a healthy community in which young people make better informed decisions about their behavior with respect to substance use.

The teacher does not need any prior knowledge of neuroscience to use this program. Its format and design make it easy for teachers to share the essential information with their students. Teachers only need to review the facilitator’s guide and commit to implementing the program over eight brief lessons. It is recommended that teachers review each lesson in advance and prepare any materials needed. A chart summarizing all eight lessons and preparation required may be found on pages 9–11.

**Does Hazelden Provide Additional Prevention Resources?**

Yes, Hazelden offers a comprehensive line of K–12 prevention materials and youth-oriented treatment resources and is the leading publisher of evidence-based prevention programs. Descriptions of several items related to *Drugs and the Developing Brain* are available on the CD-ROM. For complete information, visit hazelden.org/bookstore online.

**Does the Mentor Foundation Provide Additional Prevention Resources?**

Yes, the Mentor Foundation, one of the supporters of this product, provides additional prevention resources. Mentor works internationally to identify and support promising and best practice programs in drug abuse prevention. Full details of Mentor’s work, activities, and projects are available at www.mentorfoundation.org.
## Drugs and the Developing Brain Scope and Sequence

In *Drugs and the Developing Brain*, students will:

<table>
<thead>
<tr>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 3</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain Basics</td>
<td>The Teen Brain—All Systems Go</td>
<td>Dopamine and the Brain’s Reward System</td>
<td>How Drugs Harm the Brain</td>
</tr>
<tr>
<td>▶ describe parts of a neuron (body, axon, dendrite)</td>
<td>▶ understand what the prefrontal cortex does and where it is located</td>
<td>▶ understand the role dopamine plays in the brain’s reward system</td>
<td>▶ examine a series of brain scans</td>
</tr>
<tr>
<td>▶ understand how messages travel through the brain (neurotransmission)</td>
<td>▶ know the brain completes development around age 25</td>
<td>▶ review neurotransmission</td>
<td>▶ know that drugs target dopamine in the limbic system of the brain</td>
</tr>
<tr>
<td>▶ understand that the teen brain is “under construction” (synaptic pruning and myelination)</td>
<td>▶ understand what the limbic system does and where it is located</td>
<td>▶ examine how drug use can make it difficult for users to experience normal pleasure</td>
<td>▶ understand that repeated drug use changes the way dopamine is used in the brain</td>
</tr>
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</table>

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<thead>
<tr>
<th>Lesson 5</th>
<th>Lesson 6</th>
<th>Lesson 7</th>
<th>Lesson 8</th>
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<tbody>
<tr>
<td>How Drugs Change the Brain—Cravings and Addiction</td>
<td>How Drugs Can Impair Learning</td>
<td>Teens, Drugs, and Decision Making</td>
<td>Making the Most of Your Developing Brain</td>
</tr>
<tr>
<td>▶ understand how drugs can change the brain, causing cravings and addiction</td>
<td>▶ understand how brain development can be disrupted by drug use</td>
<td>▶ review the role of the prefrontal cortex</td>
<td>▶ understand that they can help their brains develop in a healthy way</td>
</tr>
<tr>
<td>▶ know that changes in dopamine transmission contribute to cravings</td>
<td>▶ understand that drugs may prevent the adolescent brain from developing in a normal way</td>
<td>▶ understand how an immature prefrontal cortex may affect decision making</td>
<td>▶ understand the unique opportunities teens have to make healthy choices</td>
</tr>
<tr>
<td>▶ know that drugs affect the limbic system to the point that drug-induced pleasure may be preferred over pleasures experienced naturally during real-life experiences</td>
<td>▶ understand that such harm may make learning more difficult</td>
<td>▶ understand how the amygdala may affect decision making</td>
<td>▶ understand the unique ways that teens and their brains are vulnerable to the effects of drugs</td>
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<tr>
<td>▶ understand that dependence develops when drugs “teach” the brain to keep using even when there are serious social, legal, or other consequences</td>
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Academic Standards Supported by Drugs and the Developing Brain

Using Drugs and the Developing Brain will help students and educators meet the following academic standards:

Science Standards

- Understand the structure and functions of nervous systems in multicellular animals (e.g., nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves; nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules)

Health Standards

- Know conditions that may put people at higher risk for substance abuse problems (e.g., genetic heritability, substance abuse in family, low frustration tolerance)
- Know factors involved in the development of drug dependence and the early, observable signs and symptoms (e.g., tolerance level, drug-seeking behavior, loss of control, denial)
- Know the short- and long-term consequences of the use of alcohol, tobacco, and other drugs (e.g., physical consequences such as shortness of breath, cirrhosis, lung cancer, emphysema; psychological consequences such as low self-esteem, paranoia, depression, apathy; social consequences such as crime, domestic violence, loss of friends)
- Know how the abuse of alcohol, tobacco, and other drugs often plays a role in dangerous behavior and can have adverse consequences on the community (e.g., house fires, motor vehicle crashes, domestic violence, date rape, transmission of diseases through needle sharing or sexual activity)

Technology Standards

- Understand the relationships among science, technology, society, and the individual
- Understand the nature and use of different forms of technology
Life Skills Standards: Self-Regulation

- Consider risks
- Restrain impulsivity

Life Skills Standards: Thinking and Reasoning

- Evaluate major factors that influence personal decisions (e.g., personal priorities, environmental conditions, peer groups)
- Analyze the impact of decisions on self and others and takes responsibility for consequences and outcomes of decisions

Lesson Descriptions and Preparation

This overview shows the preparation needed before each Drugs and the Developing Brain lesson:

<table>
<thead>
<tr>
<th>Lesson Title</th>
<th>Lesson Description</th>
<th>Materials/Preparation Needed</th>
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</thead>
<tbody>
<tr>
<td>Lesson 1: Brain Basics</td>
<td>Students learn about brain science basics: neurons, neurotransmission, synaptic pruning, and myelination. Slides 1.1a: Group of Neurons 1.1b: Pair of Neurons 1.2: Neurotransmission (animation) 1.3: Proliferation, Pruning, and Myelination Optional Extension Activity: The Neuron Game</td>
<td>Lesson 1 slideshow  Projector and screen  Make one copy of Parent Hotline 1 for each student  If you choose to use the optional extension activity, read through it in advance so you are prepared to have fun with it in class. You may also choose to use a timer with this activity.</td>
</tr>
<tr>
<td>Lesson 2: The Teen Brain—All Systems Go</td>
<td>Students learn that different parts of the brain mature at different ages. They learn what the various parts of the brain do, and they explore how the different speeds at which the prefrontal cortex and limbic system develop can affect the experience of being a teenager. Slides 2.1: Brain Development (animation) 2.2: Maturing Brain: Ages 5 to 20 2.3: Here Comes Trouble: The Limbic System 2.4: Comparing Adults and Teens 2.5: Handy Brain Model (optional) Optional Extension Activity: Handy Brain (with slide 2.5)</td>
<td>Lesson 2 slideshow  Projector and screen  Make one copy of Parent Hotline 2 for each student  If you choose to use the optional extension activity, you will need a piece of paper and a pencil for each pair of students.</td>
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<td>Lesson Title</td>
<td>Lesson Description</td>
<td>Materials/Preparation Needed</td>
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<td>Lesson 3</td>
<td>Students learn about dopamine and the brain’s reward system. They begin to examine how drug use affects this system.</td>
<td>▶ Lesson 3 slideshow</td>
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<tr>
<td>Dopamine and the Brain’s Reward System</td>
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<td>▶ Projector and screen</td>
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<td></td>
<td>▶ Make one copy of Parent Hotline 3 for each student</td>
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<td></td>
<td><strong>Slides</strong></td>
<td><strong>If you choose to use the optional extension activity, you will need a piece of paper and a pencil for each student.</strong></td>
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<tr>
<td></td>
<td>3.1: Dopamine</td>
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<td>3.2: Normal Neurotransmission (animation)</td>
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<td>3.3: Neurotransmission with Drugs (animation)</td>
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<td>3.4: Cocaine Brain</td>
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<td>3.5 Dopamine Receptors</td>
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<td></td>
<td><strong>Optional Extension Activity:</strong></td>
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<td></td>
<td>The 10 Percent Difference</td>
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<tr>
<td>Lesson 4</td>
<td>Students examine brain scans from research studies that reveal how drugs can harm the brain.</td>
<td>▶ Lesson 4 slideshow</td>
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<td>How Drugs Harm the Brain</td>
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<td>▶ Projector and screen</td>
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<td>▶ Make one copy of Parent Hotline 4 for each student</td>
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<td></td>
<td><strong>Slides</strong></td>
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<td></td>
<td>4.1: Two Boys</td>
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<td>4.2: Dopamine Transporters</td>
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<td>4.3: Methamphetamine and Cocaine</td>
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<td>4.4: Normal Brain and Cocaine Brain</td>
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<td></td>
<td><strong>Optional Extension Activity:</strong></td>
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<tr>
<td></td>
<td>What Have You Got to Lose?</td>
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<tr>
<td>Lesson 5</td>
<td>Students learn that neurological changes caused by drug use can create drug cravings and lead to addiction.</td>
<td>▶ Lesson 5 slideshow</td>
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<td>How Drugs Change the Brain—Cravings and Addiction</td>
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<td>▶ Projector and screen</td>
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<td>▶ Make one copy of Parent Hotline 5 for each student</td>
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<td></td>
<td><strong>Slides</strong></td>
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<td></td>
<td>5.1: Drugs Trick the Brain</td>
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<td>5.2: Dopamine Receptors</td>
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<td>5.3: A Lasting Effect</td>
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<td>5.4: Imposters</td>
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<td><strong>Optional Extension Activity:</strong></td>
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<td>A Sensitive Time</td>
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<tr>
<td>Lesson 6</td>
<td>Students examine brain scans and other images to see how drug use may impair memory and learning ability in young people.</td>
<td>▶ Lesson 6 slideshow</td>
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<tr>
<td>How Drugs Can Impair Learning</td>
<td></td>
<td>▶ Projector and screen</td>
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<td></td>
<td>▶ Make one copy of Parent Hotline 6 for each student</td>
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<td></td>
<td><strong>Slides</strong></td>
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<td></td>
<td>6.1: Alcohol and the Hippocampus</td>
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<td></td>
<td>6.2a: Teens and Alcohol: Age 16</td>
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<td></td>
<td>6.2b: Teens and Alcohol: Ages 16 and 20</td>
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<td>6.3: Nicotine, Marijuana, and Memory (optional)</td>
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<td>6.4: Marijuana in the Brain (optional)</td>
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<td>6.5: Alcohol and Memory (optional)</td>
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<td>More Evidence</td>
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<td>Lesson Title</td>
<td>Lesson Description</td>
<td>Materials/Preparation Needed</td>
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| **Lesson 7**<br>Teens, Drugs, and Decision Making | Students review and reflect upon what brain science suggests about vulnerabilities and choices typically faced by young people. They consider the different decision-making processes and brain regions, used by teens and adults, and they consider implications for teen behavior. | - Lesson 7 slideshow
- Projector and screen
- Make one copy of Parent Hotline 7 for each student |

**Slides**
- 7.1: Bike Jump
- 7.2: Cocaine Brain
- 7.3: Think About This

Optional Extension Activity: Ripped from the Headlines

| **Lesson 8**<br>Making the Most of Your Developing Brain | Students review and reflect upon what brain science suggests about opportunities and choices available to young people. They consider ways to nurture their developing brains so they can get what they want in life. | - Lesson 8 slideshow
- Projector and screen
- Make one copy of Parent Hotline 8 for each student |

**Slides**
- 8.1: The Developing Brain
- 8.2: Healthy Teen’s Brain (animation)
- 8.3: Addicted Teen’s Brain (animation)
- 8.4: Healthy Teen’s Brain (animation)

Optional Extension Activity: Super Brain

If you choose to use the optional extension activity, consider local crimes recently committed by teens or young adults. Preselect one or two examples that will resonate with your students, stories the class will take seriously during discussion.

If you choose to use the optional extension activity, students will need paper and pencils. You may also want to prepare 1–3 song clips as models for them to spoof.
Lesson 1
Brain Basics

Lesson 1 at a Glance

Total Time
5 or 15 minutes

Part 1 (4 MINUTES)
Messages and Pathways in the Brain

Part 2 (10 MINUTES)
Optional Extension Activity: The Neuron Game

Part 3 (1 MINUTE)
Closing

Description
Students learn about brain science basics: neurons, neurotransmission, synaptic pruning, and myelination.

Learner Outcomes
Students will
- describe parts of a neuron (body, axon, dendrite)
- understand how messages travel through the brain (neurotransmission)
- understand that the teen brain is “under construction” (synaptic pruning and myelination)

Materials and Preparation Needed
- lesson 1 slideshow
- projector and screen
- Parent Hotline 1, one for each student

For the optional extension activity
- a timer

Background Information
The brain is made of billions of nerve cells, called neurons. Most neurons contain three parts:

1. a central cell body that directs all activities of the neuron
2. dendrites, or short fibers, that receive messages from other neurons and relay them to the cell body
3. an axon, a long single fiber that sends messages from the cell body to other neurons or to other body structures, such as muscles

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Nerve cells communicate by transferring messages from the axon of one nerve cell to the dendrites of another. This transfer is called neurotransmission. Neurotransmission is an essential part of how the brain performs its many important functions.

When nerve cells communicate by neurotransmission, axons and dendrites do not come into direct contact. Rather, communication happens mainly when a chemical substance is released into the space between the axon and dendrites of other neurons. This space is called the synapse.

When neurons send a message—in the form of an electrical impulse—it travels down an axon and toward a synapse. There it triggers the release of chemicals called neurotransmitters from the axon into the synapse. The neurotransmitters then move across the synapse and bind to special molecules called receptors. The receptors are located within the cell membrane that encloses the dendrites of the neighboring nerve cell. All of this then either stimulates or inhibits a new electrical response in the receiving neuron.

The axons of many neurons are covered in a fatty substance called myelin. Myelin has several jobs, but one of the most important is to increase how well and how fast nerve impulses travel along the axon. The thicker an axon’s myelin covering, the faster nerve impulses are transmitted. For example, axons that travel long distances, such as those that extend from the spinal cord to the foot, generally contain a thick myelin covering.

During childhood, the brain forms an excessive number of connections among brain cells. By the end of childhood, most of the brain’s structure is in place, and the brain has reached its full size. Although scientists once believed this was the end of brain development, we now know that some neuro-developmental processes continue to be refined throughout adolescence. Indeed, the pioneering work of Jay Giedd and colleagues at the National Institute of Mental Health indicate that the brain continues changing and developing in important ways up to about age twenty-five.11

One of these processes is myelination. The myelin covering on axons continues to thicken and mature during adolescence—improving the rate and efficiency at which nerve impulses travel.

The other main process that occurs during adolescence is synaptic pruning. At the start of adolescence, we have billions of brain cells, each with tens of thousands of connections to other brain cells. A child’s brain has about twice as many neuronal connections as an adult brain. Starting in early adolescence, many connections that are weak or duplicated are eliminated.

According to experts, the pruning process seems to follow the principle of “use it or lose it.” Those neural circuits that are exercised are retained, whereas the connections that are not used are more likely to get pruned away.
The pruning process clears out unneeded wiring to make way for more efficient and faster information processing. It also helps build the long chains of nerve cells that are required for more complex problem solving during adulthood.

To summarize:

- Neurotransmission is how messages travel through the brain.
- Neurotransmission is an essential part of how the brain performs its many important functions.
- Neurotransmitters are chemical messengers that carry information from one neuron to another.
- Myelination is the thickening of insulation around the axons.
- Synaptic pruning is the process of clearing out excess brain circuits.
- Myelination and synaptic pruning are two significant brain changes that continue during adolescence and into the midtwenties.

### Part 1 (4 MINUTES) Messages and Pathways in the Brain

Show the class slide 1.1a: *Group of Neurons.*

**These are neurons. What do you know about neurons?**

Accept all appropriate answers. Say:

*A neuron is a brain cell. Your brain is made of billions of neurons. A neuron has three parts:*

Point to each part in sequence, describing them as follows:

- **Each neuron has a cell body.**
- **Dendrites** [den’tə- drites] *are short threads that receive messages from other neurons and send them to the cell body.*
An axon [ax’- on] is a long single thread that sends messages from the cell body to the dendrites of other neurons.

Notice that there is space between the neurons. This space [point to it] between the axon of one neuron and the dendrites of another neuron is very important. It is called the synapse [sin´- apps].

Show the class slide 1.1b: Pair of Neurons.

Say:

As you know, your brain is what makes you who you are. It contains your thoughts, your memories, your learning, and your dreams. It is also in charge of running your whole body. For your brain to do a good job running your body, it needs to send and receive messages accurately and efficiently. Neurons send their messages throughout the brain and body. They send their messages from the axon of one neuron to the dendrites of another neuron. This is called neurotransmission [noor - oh - tranz - mish´ - un].

Neurotransmission is how cells talk to each other. So, how does this work?

- An electrical impulse travels through the axon.
- The impulse triggers the release of a chemical substance called a neurotransmitter [noor - oh - trans´- mitt - er] into the synapse.
- In the synapse, the neurotransmitter crosses over to the dendrite of the next cell and activates that cell.

Here is an example of how this works . . .
Show the class slide 1.2: *Neurotransmission* (video animation).

![Image of neurotransmission](image)

Say:

When the neurotransmitters reach the synapse, here is what happens:

1. The neurotransmitters spread out across the synapse.
2. In the synapse, the neurotransmitters attach (or “bind”) to special molecules called receptors. Receptors are in the dendrites of the adjacent nerve cell.
3. You can think of neurotransmitters as keys and receptors as locks. The keys (neurotransmitters) are looking for receptors to “unlock.” When the key fits into the lock, transmission is completed.

If time permits, it may be helpful to replay the video for students.

Say:

The teen brain pays special attention to which neurons are sending and receiving messages. It figures out which connections get used the most, and it uses this information to make some changes.
Show the class slide 1.3: *Proliferation, Pruning, and Myelination*

Say:

As you grew during childhood, your brain constructed more neurons than you will ever need. By the time you were about twelve, your brain had so many connections from one neuron to the other that it wasn't very efficient. The neural wiring was very crowded and cramped. During the teen years, your brain reduces the clutter and becomes more efficient as it matures. Two things occur to help the brain become more efficient:

- First, the brain *prunes* back many unused connections.
- Second, the brain coats the connections that are the “keepers” with whitish insulation called *myelin* [my´- uh - linn]. *Myelin revs up the speed and efficiency of the remaining connections so they can send zippy messages—at a rate of 250 miles per second! This process is called *myelination* [my - lin - na´ - shun].

If using the optional extension activity, begin that now. Otherwise, continue with the closing on page 20.

**Part 2 (10 MINUTES)**

**Optional Extension Activity: The Neuron Game**

Tell the class:

Let’s play a game to review what happens during neurotransmission. Each of you will be a different neuron in one big brain. Poof! You’re neurons. All of your right arms are axons. Raise your axons—right hands up. All of your left arms are dendrites. Now raise your dendrites—left hands up—with fingers stretched out really wide, like they want to grab something. Remember, neurons don’t touch each other, so leave a synapse, or space, between each other!
We'll send a message through the whole class from [name 1 = starting student] to [name 2 = ending student].

With some classes, you may want to separate into small groups. Small groups can either send several messages simultaneously or take turns and applaud for one another after each group completes a successful “neurotransmission.” Also, depending upon your room arrangement, you may choose to arrange students in a circle.

I’ll tell you how we’ll send the message. First, I’ll be a neuron and send a message to [name student 3] so you get the idea. Here’s my axon.

Raise your right hand slightly. Then raise your left hand and say:

Here is one of my dendrites.

My legs, by the way, are more of my dendrites. Okay, this dendrite [raise left hand again] with these receptors [wiggle left fingers] is going to receive a message. Then my axon [raise right hand] will carry that message to the synapse as an electrical impulse, and [name 3] will receive this message with a dendrite. [Name 3], show us your dendrite [left hand]. Show us the receptors on that dendrite [left fingers].

Clarify that [name 3] knows what to do. The student will need to

- hum and receive the neurotransmitter with one finger, as you will
- send an electrical impulse/buzz down his or her right arm
- release neurotransmitters into the synapse with “Go, neurotransmitters, go!”

When the student is ready to begin the demonstration, say to the class:

I’m receiving a neurotransmitter message with one of the receptors on this dendrite.

Raise your left hand again. Then demonstrate:

- Stand with both arms outstretched and your right hand near the student’s left hand.
- To “receive” a message, bend one finger-receptor on your left/dendrite-hand and make a humming sound.
- Make an electrical buzzing sound as you wiggle your right arm to show the electrical message moving toward the synapse.
- Then quickly clench and release the fingers on your right hand, and say: “Go, neurotransmitters, go!” to release the neurotransmitters into the synapse.
The receiving student should

- hum and receive the neurotransmitter with one finger, as you had
- send an electrical impulse/buzz down his or her right arm.
- release neurotransmitters into the synapse with “Go, neurotransmitters, go!”

Say to the student:

**Great neurotransmission, [name 3]! Thanks for your help. Please return to your seat and join the class in this activity.**

Have this student return to his or her place.

Say to the class:

**Now, before we start for real, everybody will practice.**

- You're neurons. You are each going to receive, and then send, a message.
- Stand with both arms outstretched, left fingers stretched out wide, with enough personal space to avoid touching anyone.

Wait for everyone to stand as directed.

- To “receive” a message, bend one finger receptor on your left dendrite hand and make a humming sound.
- Show the electrical message moving toward the synapse by wiggling your right axon arm and buzzing.
- Then quickly clench and release the fingers on your right hand, and say: “Go, neurotransmitters, go!” to release the neurotransmitters into the synapse.

If needed, repeat. When it is clear that students know what to do, say:

**Nice neurotransmission, everyone! Okay, now make sure you are each standing with your left hand ready to receive a message and your right hand ready to transmit a message. [Monitor as needed.] So, for everyone except [name 1] and [name 2], your right hand is near someone else's left hand, and your left hand is near someone else's right hand.**

Say to [name 2] only:

**When you receive the message, I want you to shout “Ta-da!”**
Say to the class:

Neurons, stand ready to receive a message. After you receive it from the neuron on your left, convert it to an electrical impulse and send it through your axon to the person on your right.

Say to [name 1]:

Ready? Okay, begin!

You may want to use a timer and let students know how long it takes them to transmit this message around the room. If you choose to repeat this game at another time, you may have students try to beat their old time.

Monitor the activity gently, maintaining a sense of calm fun. Offer prompting and narration as needed. Congratulate the group with a round of applause, and have everyone return to their seats.

Tell the class:

In your brain, neurons send and receive messages very quickly. For example, myelinated axons can send a neural-chemical impulse at the speed of about 10 to 100 meters per second.

Pretty amazing, huh? Pat yourself on the brain!

Part 3 (1 MINUTE) Closing

Say:

So, let’s wrap this up:

Neurotransmission is the way brain cells pass messages to each other.

The teenage brain is developing in important ways:

- It is pruning back many unused connections.
- It is strengthening its active connections through myelination.

Distribute Parent Hotline 1 and remind students to share it with their parents or guardians.
Lesson 2
The Teen Brain—All Systems Go

Description
Students learn that different parts of the brain mature at different ages. They learn what the various parts of the brain do, and they explore how the different speeds at which the prefrontal cortex and limbic system develop can affect the experience of being a teenager.

Learner Outcomes
Students will
- understand what the prefrontal cortex does and where it is located
- know the brain completes development around age twenty-five
- understand what the limbic system does and where it is located
- know functions of specific parts of the limbic system (amygdala and hippocampus)

Materials and Preparation Needed
- lesson 2 slideshow
- projector and screen
- Parent Hotline 2, one for each student

For the optional extension activity
- paper and pencil for each pair of students

Background Information
By investigating how the human brain continues changing and developing through adolescence and young adulthood, scientists give us new insights into adolescent behavior. One recent discovery is that the different parts of the brain do not all mature at the same pace. As shown in slide 2.1, maturation occurs in a sequence that tends to move from the back of the
Notes


13. Ibid.

14. Ibid.


About the Authors

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Ken C. Winters, Ph.D., is a Professor in the Department of Psychiatry at the University of Minnesota, a Senior Scientist at Treatment Research Institute (Philadelphia), and Chair of Mentor Foundation’s Scientific Advisory Network. He received his B.A. from the University of Minnesota and a Ph.D. in Psychology (Clinical) from the State University of New York at Stony Brook. His primary research interest is the prevention and treatment of adolescent substance use.

Jeff Lee, M.Ed.

Jeff Lee, M.Ed., has been the Executive Director of the Mentor Foundation (International) since 2004. He joined Mentor as one of its Scientific Advisers in 1994 when Mentor was established and became involved as a consultant and subsequently a staff member to the organization. Mr. Lee has worked in more than seventy countries for government and nongovernment agencies to promote drug abuse prevention policies and programs.

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Mary K. Winters, M.Ed., is an information specialist for substance abuse prevention and treatment organizations, including the Mentor Foundation. She received her master’s degree from the University of Minnesota, School of Education.
Hazelden, a national nonprofit organization founded in 1949, helps people reclaim their lives from the disease of addiction. Built on decades of knowledge and experience, Hazelden offers a comprehensive approach to addiction that addresses the full range of patient, family, and professional needs, including treatment and continuing care for youth and adults, research, higher learning, public education and advocacy, and publishing.

A life of recovery is lived “one day at a time.” Hazelden publications, both educational and inspirational, support and strengthen lifelong recovery. In 1954, Hazelden published Twenty-Four Hours a Day, the first daily meditation book for recovering alcoholics, and Hazelden continues to publish works to inspire and guide individuals in treatment and recovery, and their loved ones. Professionals who work to prevent and treat addiction also turn to Hazelden for evidence-based curricula, informational materials, and videos for use in schools, treatment programs, and correctional programs.

Through published works, Hazelden extends the reach of hope, encouragement, help, and support to individuals, families, and communities affected by addiction and related issues.

For questions about Hazelden publications, please call 800-328-9000 or visit us online at hazelden.org/bookstore.
About the Mentor Foundation

The Mentor Foundation’s mission is to prevent drug abuse and promote the health and well-being of children and young people. Mentor is an international nonprofit organization. During its first fifteen years, Mentor undertook and/or supported over seventy projects in more than eighty countries around the world. It has reached more than two million young children, their parents, caretakers, and teachers and other groups who work with young people. Mentor has developed an international reputation of respect for its professional work and collaborates with several major national and international organizations. Mentor originally supported the World Health Organization’s work in substance abuse prevention. It now has formal relationships with the United Nations Office on Drugs and Crime (UNODC), the Organization of American States (OAS), and the Council of Europe. Mentor has worked to support the developments in prevention for a number of governments and with agencies that include UNESCO, FIFA, IOC, and the European Drug Monitoring Centre (EMCDDA). It plays a lead role in the work and development of the European Drug Abuse Training Faculty (EUDAP) and the Vienna Committee for Non-Government Organisations (VCNGO). Mentor seeks to collaborate and support other organizations to build best practice principles into their prevention work through its Partners in Prevention program. The Mentor International Prevention Award program identifies best and promising prevention practices from around the world and has facilitated significant improvements in the field.
The prefrontal cortex is the area of the brain that governs judgment and decision-making, and it is the last part of the brain to develop. According to the National Institute on Drug Abuse, this could explain why teens are more prone to risk-taking, why they are particularly vulnerable to drug abuse, and why exposure to drugs at this critical time of their lives may cause future substance use issues.

*Drugs and the Developing Brain* is a visually stimulating program for youth in middle school and high school. The CD-ROM contains a facilitator’s guide, a PowerPoint presentation, and parent handouts that provide information about the brain and the neurobiology of addiction—all in an easy-to-understand format.

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