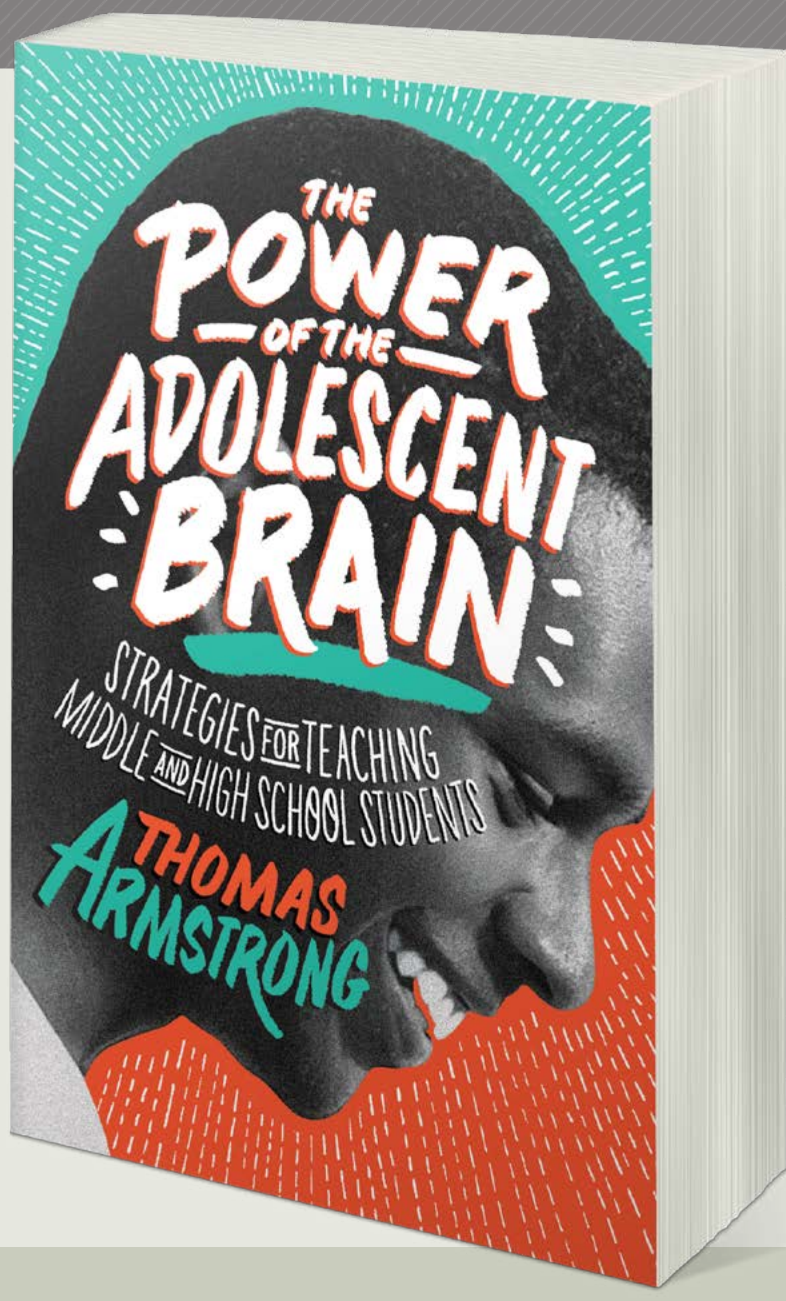
ASCD
LEARN. TEACH. LEAD.

Free Sample

FROM ***The Power of the Adolescent Brain***

Strategies for Teaching Middle and High School Students

BY **Thomas Armstrong**



ASCD is a global community dedicated to excellence in learning, teaching, and leading.

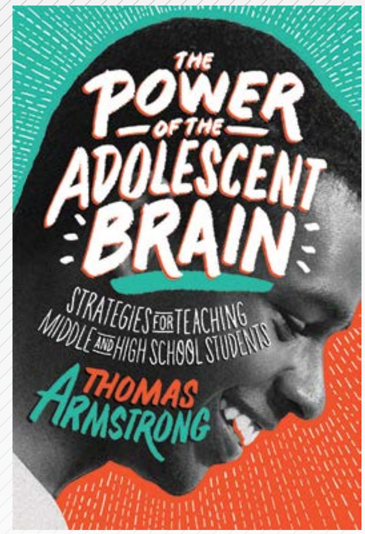
Comprising 115,000 members—teachers, principals, superintendents, and advocates from more than 126 countries—the ASCD community also includes 51 affiliate organizations.

Learn more about how ASCD supports educators who are making a difference and ensuring students' success.
www.ascd.org

Available from ASCD

The Power of the Adolescent Brain: Strategies for Teaching Middle and High School Students

by Thomas Armstrong



MOODY. RECKLESS. IMPRACTICAL. INSECURE. DISTRACTED. These are all words commonly used to describe adolescents. But what if we recast these traits in a positive light? Teens possess insight, passion, idealism, sensitivity, and creativity in abundance—all qualities that can make a significant positive contribution to society.

In this thought-provoking book, Thomas Armstrong looks at the power and promise of the teenage brain from an empathetic, strength-based perspective--and describes what middle and high school educators can do to make the most of their students' potential.

Thoroughly grounded in current neurological research, the book explains what we know about how the adolescent brain works and proposes eight essential instructional elements that will help students develop the ability to think, make healthy choices, regulate their emotions, handle social conflict, consolidate their identities, and learn enough about the world to move into adulthood with dignity and grace.

Armstrong provides practical strategies and real-life examples from schools that illustrate these eight key practices in action. In addition, you'll find a glossary of brain terms, a selection of brain-friendly lesson plans across the content areas, and a list of resources to support and extend the book's ideas and practices.

There is a colossal mismatch between how the adolescent brain has evolved and the passive, rote learning experiences that are all too often provided at the secondary level. See the amazing differerence—in school and beyond—when you use the insights from this book to help students tap into the power of their changing brains.

Author

THOMAS ARMSTRONG, PHD, is an educator, a psychologist, and a writer who has worked in the education field for more than 40 years. He is the author of 16 books, including 7 for ASCD. During the last 30 years, he has delivered more than 1,000 presentations on learning and human development in 29 countries across six continents and in 44 U.S. states.

ORDER NOW!

Quantity Discounts
10–49 copies 10%
50+ copies 15%

For Special Sales Discounts, contact your ASCD Regional Program Manager or Sales Consultant, or call 1-800-933-2723, ext. 5773. E-mail: programteam@ascd.org.

Print edition is also available from Amazon, Barnes & Noble, and other bookstores.

E-books are also available from Amazon, Apple, Barnes & Noble, Google, Kobo, and other distributors. See full list at www.ascd.org/epubs.

2016 ASCD Book, 6" x 9" 202 pgs.

List Price	**$27.95**
ASCD Member Price	**$22.36**
Stock	**#116017**
ISBN	**978-1-4166-2187-4**

Call toll-free: 800-933-ASCD or 703-578-9600
www.ascd.org/brainpower

ASCD® LEARN. TEACH. LEAD.

Table of Contents

We hope you enjoy this free sample of *The Power of the Adolescent Brain: Strategies for Teaching Middle and High School Students*. To learn more about this book or to purchase online, visit **www.ascd.org/brainpower**.

The Power of the Adolescent Brain

Strategies for Teaching Middle and High School Students

Introduction

I began my career in education 40 years ago as a junior high special education teacher in Montreal, Canada. The experience shaped me in a profound way. I will never forget the names, faces, and personalities of my first students. There was Helen: sullen, sometimes angry, occasionally up for a little learning. Then there was Bernice, a sly, catlike girl of 13 who seemed to prowl rather than walk around the class looking for little mischiefs that she could cook up and get away with scot-free. I also remember Vince, with his bright, cheery face, his welcoming demeanor, and his ability to pull the wool over my eyes at unexpected moments. He was helped in this endeavor by his partner in crime, George, a first-generation Portuguese immigrant from the Azores Islands, who charmed his way through the curriculum and should never have been in special education in the first place. Finally, I remember Manny, especially on that day when he painted a poster emblazoned with the slogan "Parents treat you like pets." This phrase was a powerfully understated manifestation of the adolescent rebellion that left me feeling exhausted at the end of each school day. What saved me from burnout were cross-country skiing and hiking.

Since that time, I've learned a great deal about adolescence. I've engaged in a lot of reminiscing about my own adolescence, visited and taught demonstration lessons at middle schools and high schools throughout the United States, and taught courses in childhood and adolescent development at several graduate schools in the San Francisco Bay Area. During the last 40 years, I've always felt that there was something extraordinary about the years between 11 and 18 that I couldn't quite put my finger on. Then I began to do my research for this book.

Combing through thousands of documents both online and offline, my eyes were opened by the revelations that had been coming out of neuroimaging labs since the start of the 21st century. I discovered that the adolescent brain was something very special, its 100 billion cells having been naturally selected over the course of millions of years to accomplish tasks that were absolutely necessary for the continuation of our species; tasks such as leaving the nest, mating, hunting, gathering, and fighting or fleeing from predators. Most significantly, these prehistoric genes are still part of teenagers' hereditary makeup, and they manifest in the classroom as inattention, rebellion, recklessness, charm, passion, insight, fatigue, and a seemingly insatiable need for approval from peers. Now I understood why we often joke about the teen years (e.g., "I teach 7th graders." "Well, good luck with that!"). What are we to do with all that energy and misdirection?

This book tries to answer that question by providing hundreds of ideas, tips, strategies, programs, and resources that are based on what we now know about how the adolescent brain works. This research-based data can empower us as educators to more fully engage middle and high school students in the classroom, so that instead of doing drugs, getting pregnant, dying in gang fights or car crashes, or binging on alcohol, they will develop the ability to think, make good choices, regulate their emotions, handle social conflict, consolidate their identities, and learn enough about the world to move into adulthood with dignity and grace.

In the first two chapters, you'll learn a lot about what's been discovered over the past 15 years about the adolescent brain, particularly its neuroplasticity (its ability to wire itself in response to environmental inputs), and why this knowledge is important for us to integrate into our practice as educators. In Chapters 3 through 10, I focus on how to take research on the adolescent brain and use it in the classroom by presenting eight basic interventions that I believe are critical to the optimal functioning of the adolescent brain in the classroom. They include

- Opportunities to choose.
- Self-awareness activities.

- Peer learning connections.
- Affective learning.
- Learning through the body.
- Metacognitive strategies.
- Expressive arts activities.
- Real-world experiences.

For each of these interventions, I provide several evidence-based action steps that teachers and administrators can take, and I illustrate each step with practical examples from middle and high schools around the United States and the world to demonstrate that these practices have already been successful in supporting adolescent learning and development. I've taken particular care to include student voices as much as possible so that we can learn directly from teens about what works and what doesn't work as far as helping them thrive in the classroom.

Because I use a lot of brain terminology, especially in Chapters 1 and 2, I've provided a glossary in Appendix A that you can use as a point of reference (these terms have been italicized when they first appear in the text). I've also included several lesson plans in Appendix B based on the eight interventions covered in this book, and in Appendix C, I provide a number of resources—books, organizations, and websites—to support further investigations in adolescent learning.

I hope that by reading this book and implementing some of the practices outlined in it, you will begin to see remarkable changes in the behaviors, attitudes, and achievement levels of your adolescent learners. Even more than this, however, I hope that you will feel recharged in your own teaching at the secondary level. More than anything else, it's your own excitement about what you're teaching that engages your students in the adventure of learning.

1

The Amazing Adolescent Brain

It appears that the brain changes characteristic of adolescence are among the most dramatic and important to occur during the human life span.

—Laurence Steinberg, "Commentary: A Behavioral Scientist Looks at the Science of Adolescent Brain Development," in *Brain and Cognition* magazine

There has never been a more exciting time to be a middle school or high school educator. New discoveries about the adolescent brain have completely transformed our understanding of how students between the ages of 11 and 18 need to learn in order to be successful in school and function optimally in the world.

As recently as the late 1990s, most scientists regarded the development of the brain as pretty much finished by age 5 or 6. By that age, 95 percent of the brain's volume is complete, and by around age 10, the brain has reached adult size. But during the last 15 years, largely because of advances in neuroimaging technologies, especially those involving *structural* and *functional magnetic resonance imaging* (sMRI and fMRI), a whole new picture of the adolescent brain has emerged.

In this chapter, we'll look at some of the major discoveries that have been made about the developing adolescent brain since the turn of the millennium. This survey will help lay the foundation for subsequent chapters' discussions of the educational implications of this research.

Raging Hormones and Beyond

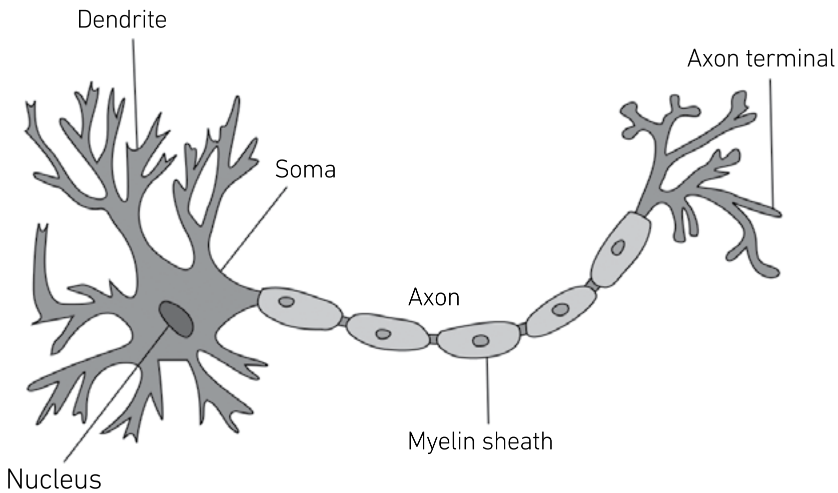
It used to be thought that the erratic behaviors of adolescents stemmed from the "raging hormones" accompanying puberty. It's true that hormones do play a role in driving adolescent behaviors: sex hormones fuel sexual striving, sensitivity to physical attractiveness, and interest in romantic partners. Both *estrogen* and *testosterone* (the latter of which increases by a factor of 10 in adolescent boys) appear to organize structural connections in the brain (Arain et al., 2013) and directly affect *neurotransmitters* (chemicals that travel over the synaptic cleft and help pass information from one neuron to another), shaping brain maturation and cognitive functioning in adolescence (Sinclair, Purves-Tyson, Allen, & Weickert, 2014). However, direct links between testosterone and aggression have been called into question. Recent evidence (Eisenegger, Haushofer, & Fehr, 2011) suggests that testosterone has more to do with the search for and maintenance of social status, which may result in aggression but could also induce other actions, such as bargaining and cooperation.

More important than the specific effects of hormones are the broader developmental changes that occur in the adolescent brain. Perhaps the most fundamental change—and the discovery that seems to have driven us to rethink how the teenage brain works—comes from neuroimaging studies revealing that white matter and gray matter in the brain undergo significant changes during the adolescent years.

White Matter Increases in the Adolescent Brain

White matter in the brain consists primarily of glia and myelinated axons. *Glia* are cells that create *myelin,* the fatty protective coating around *axons,* or the nerve fibers coming out of neurons in the brain. Axons conduct electrical impulses away from the neuron's cell body (see Figure 1.1). When an impulse reaches the *presynaptic terminal* of a neuron (see Figure 1.2), it helps activate a chemical message (carried by a neurotransmitter) that takes place between brain cells.

Figure 1.1 | Structure of a Neuron



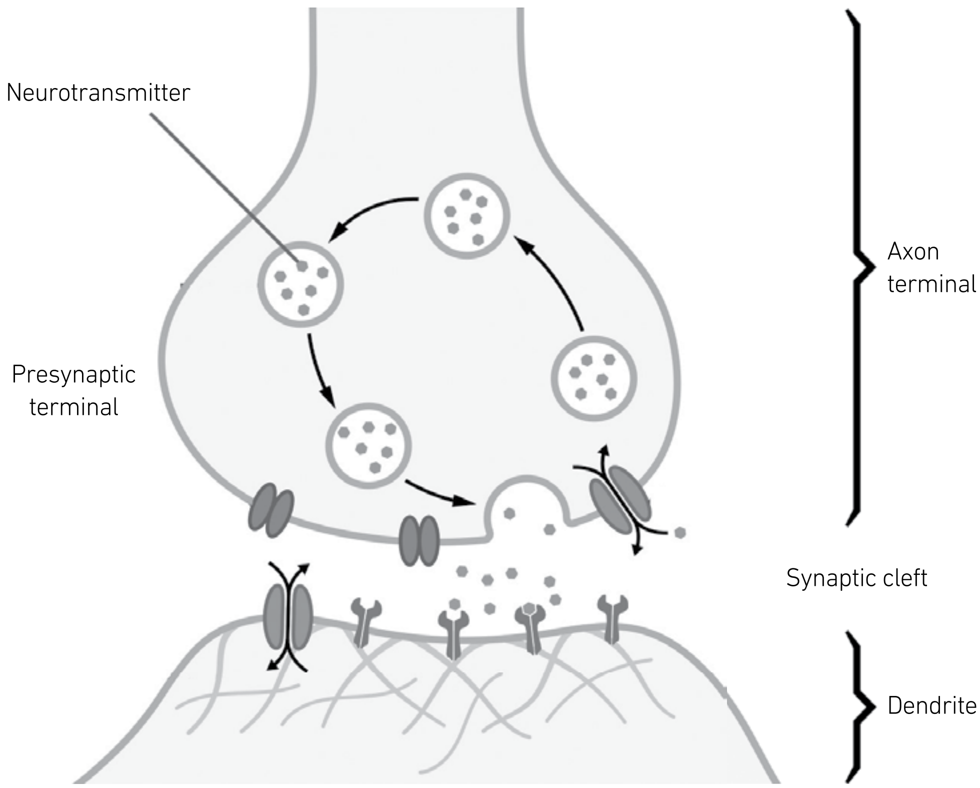
Source: Creative Commons Attribution-ShareAlike 3.0 Unported license. © Quasar Jarosz at English Wikipedia, https://commons.wikimedia.org/w/index.php?curid=7616130.

Think of myelin as wire insulation for axons. An axon that is myelinated can conduct electrical impulses up to 100 times faster than an unmyelinated one. Moreover, myelination allows the axon to recover more quickly after firing—a feature that, combined with the quicker firing, represents a 3,000-fold increase in the nerve fiber's bandwidth. Myelin also helps calibrate the coordination of inputs from other neurons. As Jay Giedd (2009), former chief of the Brain Imaging Section of the Child Psychiatry Branch of the National Institute of Mental Health, puts it,

> In order for input from nearby and more distant neurons to arrive simultaneously, the transmission must be exquisitely timed. Myelin is intimately involved in the fine-tuning of this timing, which encodes the basis for thought, consciousness and meaning in the brain. The dynamic activity of myelination during adolescence reflects how much new wiring is occurring. (p. 4)

Advanced imaging techniques confirm an increase in white matter organization during adolescence in regions of the brain associated with

Figure 1.2 | Structure of a Synapse



Source: Creative Commons Attribution-ShareAlike 4.0 International license. © Thomas Splettstoesser: www.scistyle.com.

cognition and behavior. As a result of myelination, the amount of white matter in the brain increases in a linear fashion throughout adolescence and into the late 20s.

Gray Matter Decreases in the Adolescent Brain

Gray matter refers to the cell bodies of neurons, the nerve fibers that project from them (axons and *dendrites*), and support cells (see Figure 1.1). *Synapses* are the structures at the ends of axons and dendrites that allow for the chemical transmission of information from one neuron to the next (see Figure 1.2). When an electrical impulse travels along a neuron's axon, it can activate the flow of neurotransmitters across the *synaptic cleft*, sending a signal to the dendrite of an adjacent neuron. In this way, information travels from one neuron to another.

A baby's brain contains almost twice the number of synapses that an adult brain has. After the age of 2 or 3, however, the brain undergoes a process of *pruning*, which eliminates synapses that are not used or stimulated by the environment. By diminishing the number of connections in the brain, pruning actually results in a more efficient brain, unencumbered by a lot of unnecessary neuronal connections. Think of a gardener pruning a bush, clearing out the dead wood, and creating space for new growth to occur. The process of pruning continues during the elementary school years, particularly in the areas of the brain concerned with sensory and motor functions.

At around the age of 11 for girls and 12 for boys, there is a short period when the amount of gray matter increases again. After this period, during adolescence, the brain undergoes a second round of pruning, during which time the volume of gray matter continues to decrease (Giedd, 2008). During adolescence, the brain may lose 1 percent of its gray matter every year yet maintain the same volume because of a corresponding increase in the amount of white matter.

The Adolescent Brain: Pedal to the Metal Without Suitable Brakes

Most pruning in adolescence takes place in the brain's frontal lobes, especially in the *prefrontal cortex*. The prefrontal cortex is the area responsible for planning, making decisions, setting priorities, forming strategies, and inhibiting impulses and inappropriate behavior. These activities are often referred to collectively as *executive functions*. A notable feature of brain development is that both pruning and myelination move in slow waves *from back to front*. This means that the prefrontal cortex (situated behind the forehead) is the last part of the brain to be pruned and myelinated.

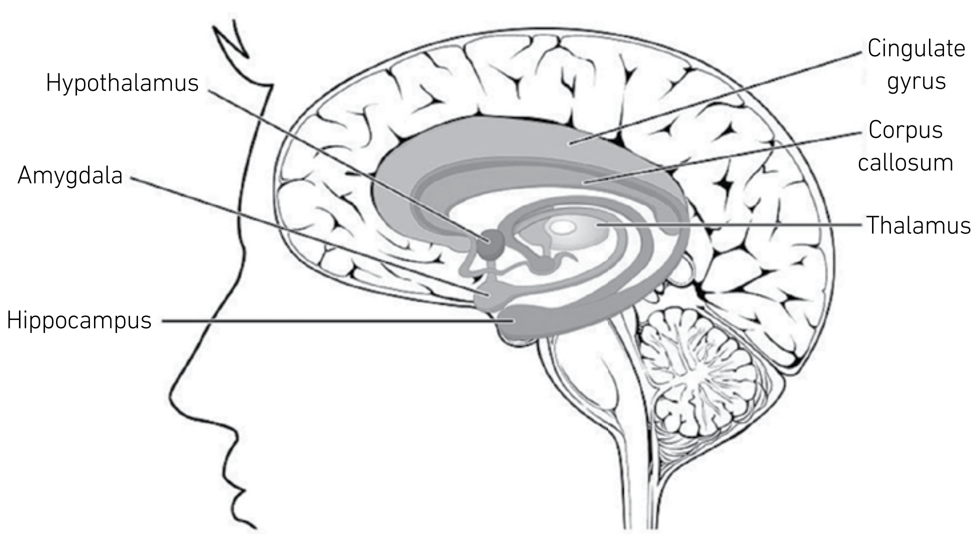
In other words, the areas of the brain that are responsible for decision making, impulse control, and other skills necessary for effective functioning in the world do not reach their peak of efficiency until mid-adolescence. By the age of 15 or 16, an adolescent can pretty much perform as well as an adult in laboratory tests of executive function, with one important caveat: the adolescent can think as maturely as an adult *under laboratory conditions,* or in what has been termed a “cold” cognition setting—that is, in circumstances where there are no emotions or social interactions or pressures involved. Under conditions of “hot” cognition, where feelings come into play or people who are significant to the individual are involved, all bets are off: the thinking process of the adolescent becomes complicated by these other factors. This distinction is significant because most of an adolescent’s life is spent in circumstances involving “hot” cognition contexts.

An important source of this more emotionally and socially diffused thinking process is a set of *subcortical* (i.e., located underneath the prefrontal cortex) structures that frequently work at cross-purposes with the more rational prefrontal cortex during adolescence. These structures of the *limbic system,* or “emotional brain,” include the *hippocampus, amygdala, cingulate gyrus, thalamus,* and *hypothalamus* (see Figure 1.3).

Here’s a rundown of the roles of these structures:

- The hippocampus is a center of emotion, memory, and certain autonomic functions.

Figure 1.3 | Structures of the Limbic System



Source: Creative Commons Attribution-ShareAlike 3.0 Unported license. © OpenStax College-Connexions website: http://cnx.org/content/col11496/1.6.

- The amygdala is associated with emotional reactivity and strong feelings, such as anger, fear, and joy.
- The cingulate gyrus is instrumental in processing emotion, learning, and memory.
- The thalamus relays sensorimotor signals to the cerebral cortex and helps regulate sleep and alertness in the brain.
- The hypothalamus links the nervous system to the stress-sensitive endocrine system and plays a key role in the initiation of puberty.

While the limbic system finishes developing around puberty, pruning and myelination of the prefrontal cortex proceed more slowly and continue into late adolescence and even into the 20s. It might be helpful to think of the limbic system as an accelerator propelling a car along the highway, and the prefrontal cortex as the car's steering wheel and brakes. Because of the gap in the timing of the development of these two systems, adolescence is a time when the accelerator is being pushed down to the floor while the brakes have yet to be fully installed. Figure 1.4 provides a comparison of the functions of the limbic system and the prefrontal cortex.

Research conducted during the last 15 years supports the finding that adolescent decision making, reasoning, planning, and other forms of deliberative thinking do not function as optimally as the thought processes of adults. fMRI scans have revealed that when adolescents are shown photos of people with fearful expressions, the amygdala is activated, whereas in adults it's the prefrontal cortex that is activated (Casey, Jones, & Hare, 2008). This suggests that in social contexts involving strong feelings, adolescents may be more emotionally reactive and less capable of relying on rational faculties.

Rewards and Risks Bring Adolescent Highs and Lows

Teenagers also have a different neural pattern in seeking pleasure and reward than either adults or children. In one experiment conducted at Cornell University (Galvan et al., 2006), scientists offered subjects

Figure 1.4 | A Tale of Two Brain Systems

Limbic System	**Prefrontal Cortex**
Mostly developed by early adolescence.	Mostly developed by mid-adolescence, but the capacity to function smoothly with the limbic system and other parts of the brain doesn't mature until the early 20s.
Functions include • Risk taking. • Motivation. • Hunger. • Sleep cycle. • Long-term memory. • Sensation seeking. • Reward seeking. • Novelty seeking. • Impulsivity. • Primacy of emotional expression. • Immediate needs.	Functions include • Decision making. • Planning. • Working memory. • Prioritizing. • Inhibiting impulses. • Reflecting. • Organizing. • Strategizing. • Self-control. • Coordinating thought and emotion. • Delaying gratification.

being scanned in an MRI machine a small, a medium, or a large reward after successfully completing the task of identifying a photo's orientation. When the adolescents received a large reward, the *nucleus accumbens*—an area in the brain associated with aversion, reward, pleasure, motivation, and reinforcement learning—responded more dramatically than did the same area in children's or adults' brains. But when the teens were offered a small reward, their nucleus accumbens activation decreased to a level *below* that of children and adults, and their prefrontal cortex displayed a more diffused pattern than that of either of the other two groups. These results suggest that adolescents are primed for big rewards, not little ones. Educators who use behavior modification techniques involving reinforcement learning should take note!

Another fMRI study (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011) suggests that teenagers may be willing to take big *risks* for those big rewards, especially when they are in the presence of their peers. In a computerized simulation game called the Stoplight Game (played while in an MRI machine), participants raced an automobile to a finish line. Subjects were instructed to reach the end of the straight track as quickly as possible. At each of 20 separate intersections, they were presented with the option of pressing the STOP button or taking a risk by pressing the GO button and running a yellow or red light. A successful outcome that came from taking risks had no penalty attached to it, but an unsuccessful one resulted in a crash and a relatively long delay. When tested alone, adolescents performed pretty much as adults did, with minimal risk-taking activity. But when they were told that there were two same-age, same-sex peers watching them play on a monitor in a nearby room, their risk taking increased significantly compared with that of adults, and their brains displayed more activation in areas involved in reward valuation.

In another fMRI study (Masten et al., 2009), subjects played a computerized simulation game called Cyberball in which the adolescent being scanned believed that he or she was playing a game of ball toss with two other adolescents. In reality, the subject was playing with a preset computer program, not real people. At a certain stage, the subject was cut out of the game and observed the two peers tossing the ball to each other on the screen. The subject's emotional distress at being excluded activated the *subgenual anterior cingulate*, a region in the brain associated with mood, anxiety, and self-esteem that plays an important role in the incidence of major depression.

All these studies seem to suggest that adolescents are neurologically primed to experience "the thrill of victory and the agony of defeat" more deeply than are adults or children. One dramatic example of adolescent willingness to take big risks for big rewards is demonstrated in a study that asked adolescents and adults if they would be willing to play a game of Russian roulette in return for $1 million. Every one of the adults said no. Half of the adolescents said yes. Cornell University researcher Valerie Reyna (quoted in Shute, 2009) comments on the adolescents' responses: "They'll tell you with a straight face that there's a whole lot of money, and they're probably not going to die. It's very logical on one level, but on another level, it's completely insane" (p. 38).

The Role of Neurotransmitters

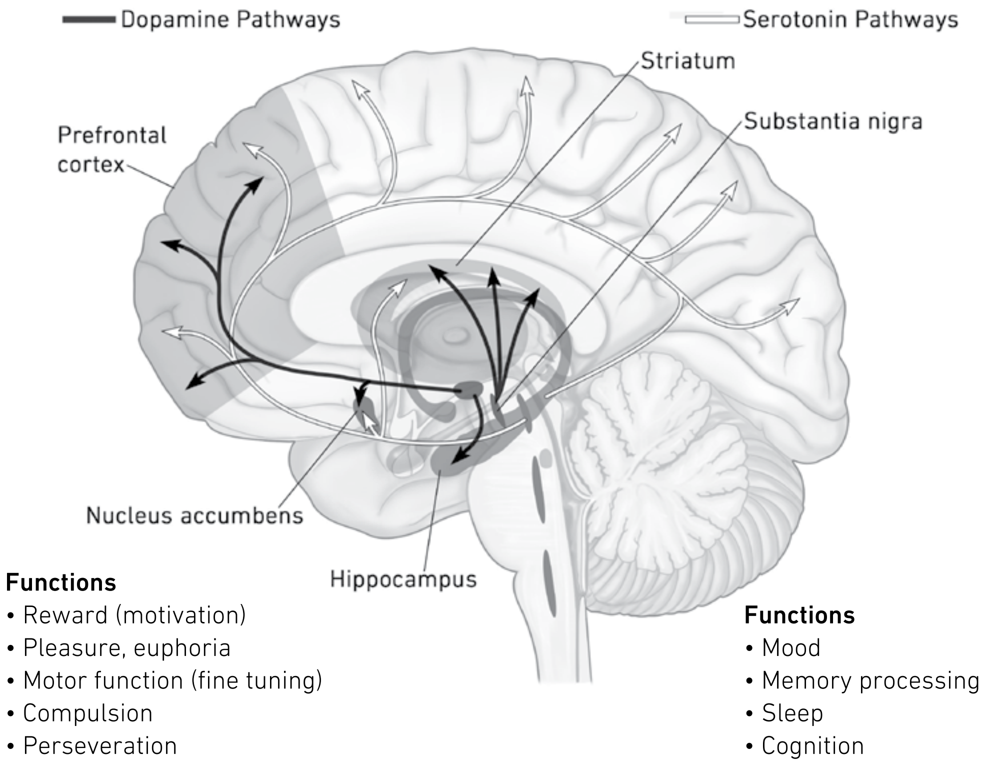
An important system in the adolescent brain that fuels these out-of-proportion reactions to the presence or absence of reward or social interaction is represented by the dopaminergic pathways. *Dopamine* is a neurotransmitter that plays a major role in reward-motivated behavior and sensation seeking. As science writer David Dobbs (2011) points out,

> Physiologically, adolescence brings a peak in the brain's sensitivity to dopamine, a neurotransmitter that appears to prime and fire reward circuits and aids in learning patterns and making decisions. This helps explain the teen's quickness of learning and extraordinary receptivity to reward, and his keen, sometimes melodramatic reaction to success as well as defeat.

Other neurotransmitters that play a significant role in adolescence include *oxytocin* and *serotonin*. Oxytocin often works synergistically with dopamine to link social connections to feelings of reward. Puberty-related increases in sex hormones have been linked to a proliferation of *receptors* (the receiving end of a synapse) for oxytocin in the amygdala, the *striatum* (an important reward center), and other subcortical areas. The chemical's abundant presence during adolescence heightens the value that teenagers attach to being with and bonding with others, particularly their peers (Suraev et al., 2014).

Serotonin is a neurotransmitter that is associated with mood, appetite, and sleep. When optimally functioning, serotonin leads to well-being and happiness. Low serotonin levels in adolescence have been linked to loneliness, eating disorders, depression, and self-harming behaviors like cutting. Girls seem to be particularly hard hit by these serotonin fluctuations, perhaps because rising levels of sex hormones, especially estrogen, are linked to the regulation of serotonergic

Figure 1.5 | Dopamine and Serotonin Pathways



Source: National Institutes of Health, U.S. Department of Health and Human Services.

pathways in the brain (Bethea, Lu, Gundlah, & Streicher, 2002). Figure 1.5 illustrates the dopamine and serotonin pathways in the brain.

Nature's Design for an Adaptive Adolescent Brain

The studies cited above paint a picture of adolescents as sensation seekers, risk takers, and attention cravers who are vulnerable to countless insults and injuries on the road to maturity. However, the stereotype of the adolescent as an impulsive, erratic, moody, and hypersensitive creature, although partly true, ignores an important question: if adolescence is such an unstable period of life, why weren't the behaviors associated with this stage eliminated from the gene pool long ago? The answer to this question is that the traits associated with adolescence have been

Figure 1.6 | Evolutionary Advantages of Adolescent Traits

Adolescent Traits	Evolutionary Advantages
Risk taking	Drives them out of the parental nest and into the world
Sensation seeking	Ignites a desire to explore the world of which they will become an integral part
Preference for being with peers	Creates affiliations with the people they will be spending most of their time with in adulthood
Reward seeking	Impels them to seek, find, and consume survival-essential natural rewards such as food, water, and warmth
Romantic and sexual attraction to others	Connects them with possible mates with the potential to procreate and pass along genes to the next generation

designed by nature to meet specific tasks that teenagers need to accomplish to become contributing members of society (see Figure 1.6). From an evolutionary point of view, risk taking is an essential trait that helps launch adolescents out of the parental nest and into the world. The combination of sex hormones, which propel adolescents toward finding a mate (and thus perpetuating the species), and a brain designed to take risks during these precious years means that adolescents will find "the world out there" more attractive and rewarding than the childhood home in which they have spent their whole lives.

Adolescents' attraction to spending more time with their peers and less time with their parents and other authority figures (including teachers) likewise has a sound evolutionary basis. The people with whom adolescents will actually spend most of their time once they reach maturity will be peers, not authority figures. Consequently, nature has built into the teen brain a propensity to seek out friends, link up with partners, and affiliate with groups of their peers as preparation for adulthood, when bonds of friendship, group affiliations, and relationships with significant others will form a major part of their social world. It is no accident that many of the ancient rites of passage indigenous cultures have developed over the millennia have involved taking young adolescents away from their parents and putting them with teens of their own age to undergo feats of strength, courage, and endurance and, at the end of the rites, to claim their reward, usually through a grand celebration attended by all the adult members of the community (see Eliade, 1998; van Gennep, 1961).

As we will see in Chapter 2, adolescence, with its dynamic processes of myelination, pruning of synapses, and new patterns of hormonal, endocrinal, and neurological functioning, represents a critical time for what scientists now refer to as *neuroplasticity*—the ability of the brain to form new neural connections and modify structures in response to environmental events, physical injury, behavior, neural processes, and other influences. This plasticity is a key factor in the transformation not only of individuals but also of cultures and civilizations—in fact, in the evolution of the human species itself. Adolescence is a relatively late entry in our evolution, occurring somewhere between 300,000 and 800,000 years ago in an evolutionary history that extends as far back as our hominid ancestors 9 million years ago (Pearson, 2001). This new stage of life emerged, at least in part, to extend humanity's ability to adapt to an ever-changing environment.

As middle and high school educators, we need to appreciate the fact that although we confront an adolescent's moodiness, impulsiveness, rashness, and quixotic nature, we also encounter the teen's exuberance, passion, idealism, sensitivity, creativity, and caring for others—all qualities that can make a significant positive contribution to the betterment of society.

TAKEAWAYS

- Sex hormones have an important role in affecting adolescent development, both directly (e.g., adolescents' acquisition of sex-specific physical traits and sexual attraction to others) and indirectly (e.g., influencing neurotransmitter activity in the brain).
- Over the course of adolescence, white matter in the brain increases and gray matter decreases.
- The adolescent brain loses gray matter primarily through the pruning of synapses, and it gains white matter primarily through the myelination (or insulation) of axons, or nerve fibers. Both of these processes contribute to a more efficient brain.
- Pruning of gray matter occurs from the back of the brain to the front, meaning that the prefrontal cortex (the site of executive functions like planning, impulse inhibition, and decision making) is the last area of the brain to be fine-tuned in adolescence.
- The limbic system, or emotional brain, matures before the prefrontal cortex does, meaning that emotion, sensation seeking, and social salience often override more rational ways of thinking and behaving until late adolescence or the early 20s.
- Adolescents can reason, make decisions, plan, and engage in other rational modes of thought and behavior as well as adults by mid-adolescence (ages 15–16), but only under "cold" cognition conditions—not under "hot" cognition contexts in which emotions or peer influences are factors.
- Adolescents are more likely to take risks if they believe that their peers are observing them.
- During adolescence, fluctuations in neurotransmitter systems that involve dopamine, oxytocin, and serotonin can contribute to reward-based risk taking, intense desire for social connections, and mood disturbances.
- Many of the natural traits of adolescence (e.g., sensation seeking, need for peer approval, and risk taking) are evolutionary adaptations that were genetically selected for because they lead teenagers away from the safety of home and toward the challenges of the world that they will fully enter in just a few short years.

ASCD®
1703 N. Beauregard St. • Alexandria, VA 22311-1714 USA
Phone: 800-933-2723 or 703-578-9600 • Fax: 703-575-5400
Website: www.ascd.org • E-mail: member@ascd.org
Author guidelines: www.ascd.org/write

Deborah S. Delisle, *Executive Director;* Robert D. Clouse, *Managing Director, Digital Content & Publications;* Stefani Roth, *Publisher;* Genny Ostertag, *Director, Content Acquisitions;* Julie Houtz, *Director, Book Editing & Production;* Miriam Calderone, *Editor;* Donald Ely, *Senior Graphic Designer;* Mike Kalyan, *Manager, Production Services;* Cynthia Stock, *Production Designer;* Andrea Wilson, *Senior Production Specialist*

All web links in this book are correct as of the publication date below but may have become inactive or otherwise modified since that time. If you notice a deactivated or changed link, please e-mail books@ascd.org with the words "Link Update" in the subject line. In your message, please specify the web link, the book title, and the page number on which the link appears.

PAPERBACK ISBN: 978-1-4166-2187-4   ASCD product #116017
PDF E-BOOK ISBN: 978-1-4166-2189-8; see Books in Print for other formats.
Quantity discounts: 10–49, 10%; 50+, 15%; 1,000+, special discounts (e-mail programteam@ascd.org or call 800-933-2723, ext. 5773, or 703-575-5773). For desk copies, go to www.ascd.org/deskcopy.

ASCD Member Book No. FY16-8B (July 2016 PS). ASCD Member Books mail to Premium (P), Select (S), and Institutional Plus (I+) members on this schedule: Jan, PSI+; Feb, P; Apr, PSI+; May, P; Jul, PSI+; Aug, P; Sep, PSI+; Nov, PSI+; Dec, P. For current details on membership, see www.ascd.org/membership.

Library of Congress Cataloging-in-Publication Data

Names: Armstrong, Thomas.
Title: The power of the adolescent brain : strategies for teaching middle and high school students / Thomas Armstrong.
Description: Alexandria, Virginia : ASCD, 2016. | Includes bibliographical references and index.
Identifiers: LCCN 2016010503 (print) | LCCN 2016011818 (ebook) | ISBN 9781416621874 (pbk.) | ISBN 9781416621898 (PDF)
Subjects: LCSH: Educational psychology. | Adolescent psychology. | Cognition in adolescence.
Classification: LCC LB1051 .A727 2016 (print) | LCC LB1051 (ebook) | DDC 370.15—dc23
LC record available at http://lccn.loc.gov/2016010503

23 22 21 20 19 18 17 16   1 2 3 4 5 6 7 8 9 10 11 12