The more we learn, the better we may be able to understand the abilities and vulnerabilities of teens, and the significance of this stage for lifelong mental health.

The fact that so much change is taking place beneath the surface may be something for parents to keep in mind during the ups and downs of adolescence.

A clue to the degree of change taking place in the teen brain came from studies in which scientists did brain scans of children as they grew from early childhood through to adolescence. The scans revealed unexpected late changes in the volume of gray matter, which forms the thin, folding outer layer or cortex of the brain. The cortex is where the processes of thought and memory are based. Over the course of childhood, the volume of gray matter in the cortex increases. This is the equivalent of a building’s footprint increasing as it matures. In the early 20s, the rate of gray matter increase slows down, and then declines. A decline in volume is normal at this age and is in fact a necessary part of maturation.

The assumption for many years had been that the volume of gray matter was highest in very early childhood, and gradually fell as a child grew. The more recent scans, however, revealed that the high point of the volume of gray matter occurs during early adolescence.

While the details behind the changes in volume on scans are not completely clear, the results push the timeline of the brain’s maturation into adolescence and young adulthood. In terms of the volume of gray matter seen in brain scans, the brain does not begin to resemble that of an adult until the early 20s.

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The Visible Brain

Many factors act in the context of a brain that is changing, and to investigate the connections between brain function, development, and behavior. The research has turned up some surprises, among them, inborn traits, among them, inborn traits, the environment in which other ages. Even though most adolescents come through the early teenage years reflect growth and pruning of synapses.

The “Visible” Brain

Connections between different parts of the brain increase throughout childhood and well into adulthood. As the brain develops, the fibers connecting nerve cells are wrapped in a protein that greatly increases the speed with which they can transmit impulses from cell to cell. The resulting increases in myelin—little like providing a growing city with a fast, integrated communication system—shapes how well different parts of the brain work in tandem. Research is finding that the extent of connectivity is related to growth in intellectual capacities such as memory and reading ability.

Several lines of evidence suggest that the brain circuitry involved in emotional responses is changing during the teen years. Functional brain imaging studies, for example, suggest that the responses of the brain to emotionally laden images and situations are heightened relative to younger children and adults. The brain changes under- lying patterns of signal transmission and the signaling molecules that are part of the reward system with which the brain motivates behavior. These age-related changes shape how much different parts of the brain are activated in response to experience, and in terms of behavior, the urgency and intensity of emotional reactions.

Enormous hormonal changes take place during adoles- cence. Reproductive hormones shape not only sex-related growth and behavior, but overall social behavior. Hormone systems involved in how a brain responds to stress are also changing during the teens. As with reproductive hormones, stress hormones can have complex effects on the brain, and as a result, behavior.

In terms of sheer intellectual power, the brain of an adolescent is a match for an adult’s. The capacity of the teen brain, it is not yet possible to know to what extent a particular behavior or ability is the result of a feature of brain structure—or a change in brain structure. Changes in the brain take place in the context of many other factors, among them, inborn traits, personal history, family, community, and culture.

One interpretation of all these findings is that in teens, the parts of the brain involved in emotional responsiveness are fully online, or even more active than in adults, while all parts of the brain involved in keeping emotional, impulsive responses in check are still reaching maturity. Such a changing balance might provide clues to a youthful appetite for novelty, and a tendency to act on impulse—without regard for risk.

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Research using many different approaches is showing that more than gray matter is changing.

Connections between different parts of the brain are changing rapidly, with young people at this age close to a lifelong effect on the brain, and as a result, behavior.

The Changing Brain and Behavior in Teens

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One of the ways that scientists have searched for the causes of mental illness is by studying the development of the brain from birth to adulthood. Powerful new technologies have enabled them to track the growth of the brain and to investigate the connections between brain function, development, and behavior.

The research has turned up some surprises, among them the discovery of striking changes taking place during the teen years. These findings have altered long-held assumptions about the timing of brain maturation. In key ways, the brain doesn’t look like that of an adult until the early 20s.

An understanding of how the brain of an adolescent is changing may help explain a puzzling contradiction of adolescence: young people at this age are close to a lifelong peak of physical health, strength, and mental capacity, and yet, for some, this can be a hazardous age. Mortality rates jump between early and later adolescence: twice as many deaths by injury between 15 and 19 are about six times that of the rate between ages 10 and 14. Come rates among young males and rates of alcohol abuse are high relative to other ages. Even though most adolescents come through this transitional age well, it’s important to understand the risk factors for behavior that can have serious consequences. Genes, childhood experience, and the environment in which a young person resides all contribute to all these behaviors.

Adding to this complex picture, research is revealing how all these factors act in the context of a brain that is changing, and to investigate the connections between brain function, development, and behavior.

The Visible Brain

The more we learn, the better we may be able to understand the abilities and vulnerabilities of teens, and the significance of this stage for life-long mental health.

The fact that so much change is taking place beneath the surface may be something for parents to keep in mind during the up and downs of adolescence.

A clue to the degree of change taking place in the teen brain came from studies in which scientists did brain scans of children as they grew from early childhood through age 20. The scans revealed unexpectedly late changes in the volume of gray matter, which forms the thin, folding outer layer or cortex of the brain. The cortex is where the processes of thought and memory are based. Over the course of childhood, the volume of gray matter in the cortex increases. In the teens, this is the period when gray matter connections form in the brain (gray matter is made up of the cell bodies of neurons, the nerve fibers that project from them, and support cells. One of the features of the brain’s growth in early life is that there is an early pruning of synapses—the connections between brain cells or neurons—followed by pruning as the brain matures. Synapses are the means with which neurons communicate with each other and are the basic blocks in the working circuitry of the brain. Already numerous and not as an adult, synapses multiply rapidly in the first year or two of life. At 2, a child has about half as many synapses as an adult. For an idea of the complexity of the brain, a cube of brain matter, 1 millimeter on each side, can contain between 35 and 70 million neurons and an estimated 500 billion synapses.) Scientists believe that the loss of synapses as a child matures is part of the process by which the brain becomes more efficient. Although a general play a role in helping to get a hold of the synapses, animal research has shown that experience also shapes the decline. Synapses “wired” by experience survive and are strengthened, while others are pruned away. Scientists are working to determine to what extent the changes in gray matter on brain scans during the teen years reflect growth and pruning of synapses.

Connections between different parts of the brain increase throughout childhood and well into adulthood. As the brain develops, the fibers connecting nerve cells are wrapped in a protein that greatly increases the speed with which they can transmit impulses from cell to cell. The resulting increase in the speed of transmission provides a growing city with a fast, integrated communication system—shapes how well different parts of the brain work in tandem. Research is finding that the extent of connectivity is related to growth in intellectual capacities such as memory and reading ability.

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In terms of sheer intellectual power, the brain of an adolescent is a match for an adult’s. The capacity of a person to learn will never be greater than during adolescence. At the same time, behavior, traits, sometimes combined with functional brain imaging, suggest differences in how adolescents and adults carry out mental tasks. Adolescents and adults seem to engage different parts of the brain to different extents during tests requiring creative thinking or impulse control, or in reaction to emotional content.

Research suggests that adolescence brings with it brain-based changes in the regulation of sleep that may contribute to teens’ tendency to stay up late at night. Along with the obvious effects of sleep deprivation, such as fatigue and difficulty maintaining attention, inadequate sleep is a powerful contributor to irritability and depression. Studies of children and adolescents have found that sleep deprivation can increase impulsive behavior; some researchers report finding that it is a factor in frequency. Adequate sleep is central to physical and emotional health.

A Spectrum of Change

Behavior in Teens

One interpretation of all these findings is that in teens, the part of the brain involved in emotional responses are fully online, or even more active than in adults, while parts of the brain involved in keeping emotional, impulsive responses in check are still reaching maturity. Such a changing balance might provide clues to a youthful appetite for novelty and a tendency to act on impulse—without regard for risk.

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The scans also suggest that different parts of the cortex mature at different rates. Adolescents involved in more basic functions mature first: those involved, for example, in the processing of information from the senses, and in controlling movement. The parts of the brain responsible for more “top-down” control, controlling impulses, and planning ahead—the hallmarks of adult behavior—are among the last to mature.

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An understanding of how the brain of an adolescent is changing may help explain a puzzling contradiction of adolescence: young people at this age are close to a lifelong peak of physical health, strength, and mental capacity, and yet, for some, this can be a hazardous age. Mortality rates jump between early and late adolescence. Rates of injury between ages 15 to 19 are about six times that of the rate between ages 10 and 14. Crime rates are highest among young males and rates of alcohol abuse are high relative to the proportion of people of any age in the population. The parts of the brain involved in controlling new neural networks are not complete until well into adolescence. Connections between different parts of the brain increase throughout childhood and well into adulthood. As the brain develops, the fibers connecting nerve cells are wrapped in a protein that greatly increases the speed with which they can transmit impulses from cell to cell. The resulting increases in connectivity—little like providing a growing city with a fast, integrated communication system—shapes how well different parts of the brain work in tandem. Research is finding that the extent of connectivity is related to growth in intellectual capacities such as memory and reading ability.

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One interpretation of all these findings is that in teens, the parts of the brain involved in emotional responses are fully online, or even more active than in adults, which may partly fill the brain involved in keeping emotional, impulsive responses in check during reaching maturity. Such a changing brain balance might provide clues to a youthful appetite for novelty and a tendency to act on impulse—without regard for risk. A Spectrum of Change

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An understanding of how the brain of an adolescent is changing may help explain a puzzling contradiction of expectations about the timing of brain maturation. In key ways, the brain doesn’t look like that of an adult until the early 20s.

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The theore...
The Adolescent and Adult Brain

Scientists continue to investigate the development of the brain and the relationship between the changes taking place, behavior, and health. The following questions are among the important ones that are targets of research:

- How do experience and environment interact with genetic preprogramming to shape the maturing brain, and as a result, future abilities and behavior? In other words, to what extent does what a teen does and learns shape his or her brain over the rest of a lifetime?

- In what ways do features unique to the teen brain play a role in the high rates of illicit substance use and alcohol abuse in the late teen to young adult years? Does the adolescent capacity for learning make this a stage of particular vulnerability to addiction?

- Why is it so often the case that, for many mental disorders, symptoms first emerge during adolescence and young adulthood?

This last question has been the central reason to study brain development from infancy to adulthood. Scientists increasingly view mental illnesses as developmental disorders that have their roots in the processes involved in how the brain matures. By studying how the circuitry of the brain develops, scientists hope to identify when and for what reasons development goes off track. Brain imaging studies have revealed distinctive variations in growth patterns of brain tissue in youth who show signs of conditions affecting the brain, perhaps helping to explain the elevated risk of binge drinking in youth. Drinking in youth, and intense drinking are both risk factors for later alcohol dependence. Findings on the developing brain should help clarify the role of the changing brain in youthful drinking, and the relationship between youth drinking and the risk of addiction later in life.

The Adolescent and Adult Brain: More Questions for Research

Understanding the changes taking place in the brain at this age presents an opportunity to intervene early in mental illnesses that have their onset at this age. Research findings on the developing brain may also serve to help adults understand the importance of creating an environment in which teens can explore and experiment while helping them avoid behavior that is destructive to themselves and others.

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This last question has been the central reason to study brain development from infancy to adulthood. Scientists increasingly view mental illness as developmental disorders that have their roots in the processes involved in how the brain matures. By studying how the circuitry of the brain develops, scientists hope to identify when and for what reasons development goes off track. Brain imaging studies have revealed distinctive variations in growth patterns of brain tissue in youth who show signs of conditions affecting the brain in striking ways. Scientists emphasize that the fact that the teen brain is in transition doesn’t mean it is somehow not up to par. It is different from both a child’s and an adult’s in ways that may equip youth to make the transition from dependence to independence. The capacity for learning at this age, an expanding social life, and a taste for exploration and limit testing may all, to some extent, be reflections of age-related biology.

Understanding the changes taking place in the brain at this age presents an opportunity to intervene early in mental illnesses that have their onset at this age. Research findings on the developing brain should help clarify the role of the changing brain in youthful behavior and the importance of creating an environment in which teens can explore and experiment while helping them avoid behavior that is destructive to themselves and others.

Alcohol and the Teen Brain

Adults drink more frequently than teens, but when teens drink they tend to drink larger quantities than adults. There is evidence to suggest that the adolescent brain responds to alcohol differently than the adult brain, perhaps helping to explain the elevated risk of binge drinking in youth. Drinking in youth, and intense drinking are both risk factors for later alcohol dependence. Findings on the developing brain should help clarify the role of the changing brain in youthful drinking, and the relationship between youth drinking and the risk of addiction later in life.

The Teen Brain: Still Under Construction

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It is not surprising that the behavior of adolescents would be a study in change, since the brain itself is changing in such striking ways. Scientists emphasize that the fact that the teen brain is in transition doesn’t mean it is somehow not up to par. It is different from both a child’s and an adult’s in ways that may equip youth to make the transition from dependence to independence. The capacity for learning at this age, an expanding social life, and a taste for exploration and limit testing may all, to some extent, be reflections of age-related biology.

Understanding the changes taking place in the brain at this age presents an opportunity to intervene early in mental illnesses that have their onset at this age. Research findings on the developing brain may also serve to help adults understand the importance of creating an environement in which teens can explore and experiment while helping them avoid behavior that is destructive to themselves and others.

Why is it so often the case that, for many mental disorders, symptoms first emerge during adolescence and young adulthood? This last question has been the central reason to study brain development from infancy to adulthood. Scientists increasingly view mental illness as developmental disorders that have their roots in the processes involved in how the brain matures. By studying how the circuitry of the brain develops, scientists hope to identify when and for what role in the high rates of illicit substance use and alcohol abuse in the late teen to young adult years? Does the adolescent capacity for learning make this a stage of particular vulnerability to addiction? Why is it so often the case that, for many mental disorders, symptoms first emerge during adolescence and young adulthood?

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Scientists continue to investigate the development of the brain and the relationship between the changes taking place, behavior, and health. The following questions are among the important ones that are targets of research:

- How do experience and environment interact with genetic preprogramming to shape the maturing brain, and as a result, future abilities and behavior? In other words, to what extent does what a teen does and learns shape his or her brain over the rest of a lifetime?

- In what ways do features unique to the teen brain play a role in the high rates of illicit substance use and alcohol abuse in the late teen to young adult years? Does the adolescent capacity for learning make this a stage of particular vulnerability to addiction?

- Why is it so often the case that, for many mental disorders, symptoms first emerge during adolescence and young adulthood?

This last question has been the central reason to study brain development from infancy to adulthood. Scientists increas-ingly view mental illness as developmental disorders that have their roots in the processes involved in how the brain matures. By studying how the circuitry of the brain develops, scientists hope to identify when and for what reasons development goes off track. Brain imaging studies have revealed distinctive variations in growth patterns of brain tissue in youth who show signs of conditions affecting mental health. Ongoing research is providing information on how genetic factors increase or reduce vulnerability to mental illness; and how experiences during infancy, childhood, and adolescence can increase the risk of mental illness or protect against it.

It is not surprising that the behavior of adolescents would be a study in change, since the brain itself is changing in such striking ways. Scientists emphasize that the fact that the teen brain is in transition doesn’t mean it is somehow not up to par. It is different from both a child’s and an adult’s in ways that may equip youth to make the transition from depen-dence to independence. The capacity for learning at this age, an expanding social life, and a taste for exploration and limit testing may all, to some extent, be reflections of age-related biology.

Understanding the changes taking place in the brain at this age presents an opportunity to intervene early in mental illnesses that have their onset at this age. Research findings on the brain may also serve to help adults understand the importance of creating an environment in which teens can explore and experiment while helping them avoid behavior that is destructive to themselves and others.

Addiction of non-Federal Government logos and website links may not have the appearance of endorsement. There is evidence to suggest that the adolescent brain responds to alcohol differently than the adult brain, perhaps helping to explain the elevated risk of binge drinking in youth. Drinking in youth, and intense drinking are both risk factors for later alcohol depen-dence. Findings on the developing brain should help clarify the role of the changing brain in youthful drinking, and the relation-ship between youth drinking and the risk of addiction later in life.

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