Chapter 1

Ten things every teacher needs to know about the teenage brain

This is a book for teachers, but what can teachers gain by learning about the teenage brain? How will this subject assist teachers in their work? In the process of writing this book, I have asked many teachers what it is about the teenage brain that they would like to know. I have had many different answers, but one teacher got to the heart of things by asking:

"Can you tell me how to engage the reasoning side of a teen's brain?"

This is a great question – a two-pronged question. At first, it appears to refer to logical thinking. It seems to concern the rational part of the brain. How can we improve the young person's ability to solve problems, to reason, to engage in scientific thinking?

However, on second thoughts, there is something else here. The question could be asking about the awareness of consequences. How can we stop teenagers behaving thoughtlessly? The question raises the idea of a "reasoning side" of the brain as opposed to the emotional side of the brain. What does this mean? Where does it reside? How can we best facilitate it and support its development?

Other teachers asked a wide range of questions. Here are just a few.

- "Can knowing about the brain help me motivate my students?"
- "Is there such a thing as left-brain thinking?"
- "How to get through to an individual who is in a heightened emotional state?"
- "At what age does the fear factor kick in, so that they understand consequences?"
- "Is it really true that the brain shrinks during the teenage years? How can this be?"

There has been a lot of debate about whether neuroscience – the science behind brain development – can actually lead to more effective teaching and learning. My answer to this is a categorical YES! Knowing about the brain will not answer all teachers' questions. It will not address everything you need to know about teaching. It may not necessarily help you with lesson planning, curriculum design or the use of technology in the classroom.

It will, however, make a profound difference to your teaching. The reason for this is that knowledge about the brain during the teenage years has altered the way we understand young people. It has given us new insight into their development during these critical years.

- Did you know that the teenage brain is especially responsive to rewards?
- Did you know that the brain matures from back to front?
- Did you know that the grey matter in the brain does actually reduce by about 17% during this stage?
- Did you know that memory processes are active during sleep, thus contributing to learning during the day?

If you are interested in these questions, and many others – read on. However, just before we get to my first of ten things – "A thing of wonder" – I want to outline the structure of this book. In this first chapter, I will describe ten ideas concerning the brain. This is a short introduction to some key concepts, many of which will be explored in greater detail later in the book. There will then be a chapter on other aspects of teenage development, and this will be followed by a description of my journey from thinking about the baby's brain to considering the teenage brain.

Next will come a series of chapters detailing some major areas of research, including learning and memory, the social brain, sleep and so on. Finally, at the end of the book you will find three chapters with a more practical slant. Here I discuss the development of workshops and training on the teenage brain for teachers, students and parents. These chapters outline the background and activities that have made it possible for me to create these learning materials. More detail about the workshops can be found in Appendix 2 and the accompanying website (www.routledge.com/cw/coleman).

One last point. This book has been written during the pandemic of 2020–21. It is hard to know what the long-term impact will be

on young people and on their lives in the future. I will refer to the pandemic in Chapters 2 and 8. At this stage we can only guess at how education, employment, health and social life will be impacted in the future. No matter how challenging and stressful the experiences of these years, young people will continue to change and develop. I know that the information in this book, describing the development of the brain during the teenage years, will remain relevant to teachers and to all who live and work with young people.

1. A thing of wonder

The human brain is a wonder and a mystery. It is a thing of magic, yet it is a concrete object. It is extraordinary – the most complex thing you can imagine. There is nothing in nature that has any parallel. Today, science is beginning to unravel a tiny fraction of the mystery, but only a tiny fraction.

To begin with the brain contains billions of cells, known as neurons. Your brain contains perhaps 80 or possibly 100 billion neurons. More than all the stars in the galaxy, more than the entire global population, more than the human brain can comprehend.

How is it possible to make sense of such an organism? It is of such complexity, yet weighs less than three pounds, and is something that you could easily hold in your hands.

All these billions of neurons are connected to other neurons in patterns and networks. We still understand very little about how these networks function, and how the multitudes and multitudes of neurons work together in systems to ensure that humans walk, talk, learn, memorise and collaborate together in social groups.

The brain operates by sending messages along pathways between neurons. Each neuron has branches that connect to other neurons. A neuron sends messages to other neurons by passing an electrical current, or impulse, along these branches. Remarkably, there is a tiny gap in the middle of each branch, known as the synapse. The message, the impulse, has to jump over this gap in order to reach the next neuron. There will be more about this in a minute.

I will now turn to the structure of the brain. During the teenage years, three areas are especially important. One is the prefrontal cortex, associated with thinking, reasoning, problem-solving and other intellectual activities. The second is the amygdala, an area buried deep in the brain and associated with emotion, sensation and reward-seeking. The third is the hippocampus, the area most associated with

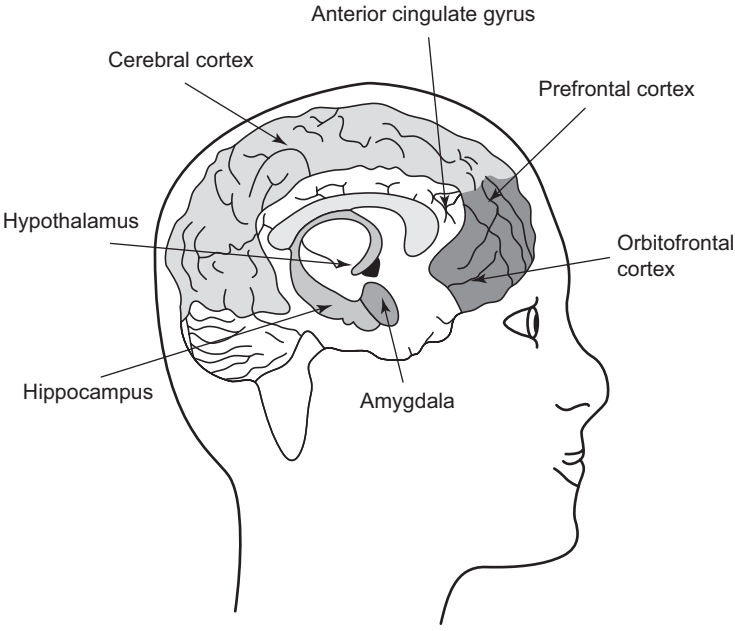


Figure 1.1 Simplified image of the structure of the brain, showing the pre-frontal cortex, the amygdala and the hippocampus.

memory processes. These areas of the brain undergo major development and change at this time. You can see where these are located in Figure 1.1.

The last 20 years have seen a giant leap forwards in our understanding of the human brain. This is because of the development of scanning technology. It is now possible to take pictures of the brain as it functions, without any great distress or discomfort. The technology is known as magnetic resonance imaging.

The development of brain imaging has provided amazing insights into the teenage brain. However, I have called this section "A thing of wonder" for a reason. Scanning can only tell us so much. Scanning allows us to see how much oxygen is going to different parts of the brain at any one time, which is a huge advance on what was possible 20 years ago. Nonetheless, this is still very limited. In the next sections, I will describe what we have learnt about the teenage brain. In the last section of the chapter, I will discuss what adults can do to assist with healthy brain development during the teenage years.

2. How the brain works

As I have said, the brain is enormously complex. While it is not necessary for a general reader to understand too much of the technical stuff, it is useful to have some basic knowledge about the brain and how it works. I will try and make this section as simple as possible.

I will start with neurons. Each neuron has branches that connect to other neurons. One branch is called the axon, while others are called dendrites. For each neuron, there is one axon, but many dendrites. A pulse, or signal, is sent out by the neuron, it travels along the axon, crosses the synapse and connects to a dendrite on the other side that takes it on to the next neuron. It is hard to comprehend, but this is happening millions of times in your brain during the course of any one second (Figure 1.2).

The synapses play a central part in the story, as they can be seen as the on/off mechanism in the brain. Within the synapse are what are known as chemical messengers (or neurotransmitters). These are hormones that either help or hinder the transmission of neural messages. Synapses are designed to act as either facilitators or inhibitors of further travel of an impulse.

This is hugely important because there are simply too many stimuli entering the brain at any one time. The brain needs a filter mechanism. Without such a mechanism you would not be able to concentrate or pay attention, as you would be constantly distracted by other messages

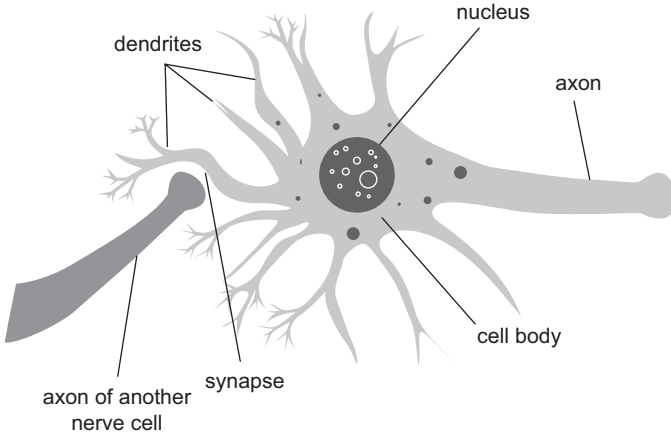


Figure 1.2 Image of a neuron, showing axon, dendrites and synapse.

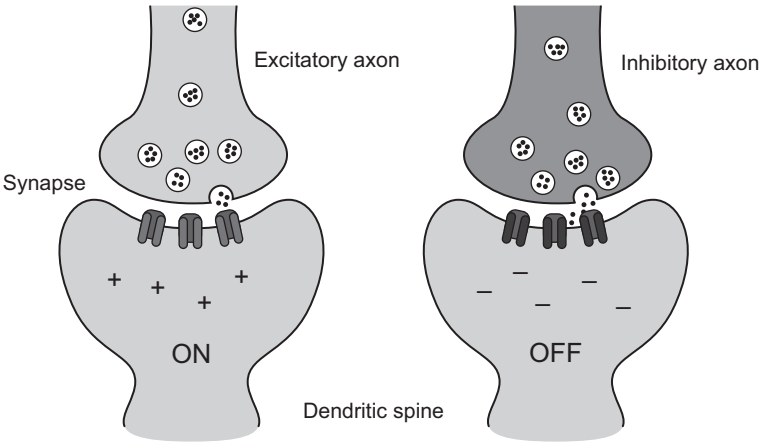


Figure 1.3 Image of two types of receptor.

arriving in the brain. Some people like to say that the synapses are the air traffic control system for the brain, preventing constant mid-air collisions! (Figure 1.3).

In addition, myelin is important. This is the substance that covers the axon, and it has two purposes. First, it helps speed up the transmission of a message. This is significant in adolescence, as the myelin around the axons increases in size during this stage, allowing faster transmission of signals from one part of the brain to another. Myelin also plays a big role in helping to keep the neurons, axons and dendrites separate from each other. You may be able to imagine what a tangle of connections there must be in such an extraordinarily small space in your brain. The myelin helps to keep things apart and function effectively.

It is now time to think about what makes the teenage years special as far as brain development is concerned.

3. What is special about the teenage years?

It is a remarkable fact that it is only in the last 20 years that we have learnt how much change occurs in the brain during the teenage years. Previously, it had been assumed that the brain had matured by the end of childhood. Now, as a result of studies using scanning technology, we understand that the teenage years are a period when the brain

alters more than at any other time apart from the first three years of life.

This is important because a time of such change is a critical period. The experiences that a young person has at this stage will affect brain development to a greater extent than at other times in life. It is for this reason that the more teachers and other adults understand what is happening to the teenage brain, the better it is for healthy adolescent development.

This is the period when the brain goes through a major process of maturation. It becomes more efficient, and a variety of new skills and abilities develop. Memory, language, thinking and reasoning all improve. How does this happen?

I have already mentioned the change in the thickness of the myelin around the axon. This change allows impulses to travel around the brain in a faster and more efficient manner. In addition, all areas of the brain mature, and this applies especially to the three key areas of the brain I have already mentioned: the prefrontal cortex, the amygdala and the hippocampus. These areas do not necessarily mature at the same rate. As a general rule, it can be said that the brain matures from back to front, with the prefrontal cortex being the last to become fully mature.

In order to understand how we measure maturation, I need to point out that the brain is in two halves, two hemispheres as they are known (Figure 1.4). As a result, the two sides of the brain have to work together. How do they do that? They are connected by a bridge,

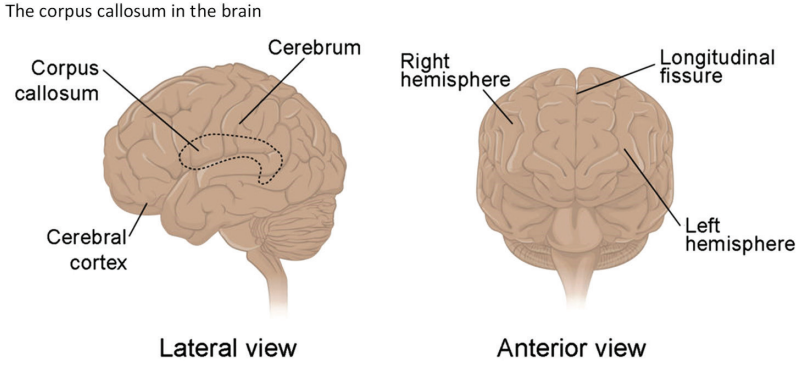


Figure 1.4 Image showing two hemispheres of the brain, with the bridge (the corpus callosum) in the middle.

but you can imagine how much traffic that bridge has to carry if the two halves of the brain are to function effectively.

A key change that takes place at this time is a maturation of this bridge, allowing the connections to increase and become more varied. This assists the young person to develop new neural pathways and to draw upon more areas of the brain when thinking and reasoning. We call this element of brain function connectivity. As connectivity increases, so the brain becomes more efficient and skilful.

The fascinating thing about this process of increased connectivity is that it does not occur in a uniform way across the brain. So, when I said that the brain matures from back to front, I could have said that the increasing connectivity starts in the back of the brain – in the area to do with physical activity – and gradually moves forward towards the prefrontal cortex.

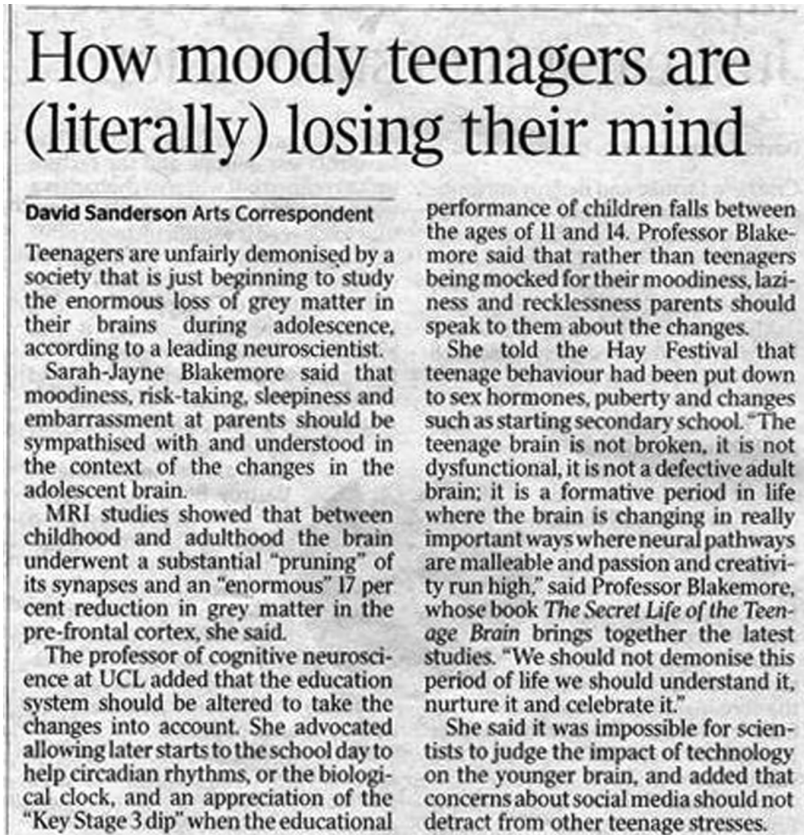
This is a central fact in understanding the teenage brain. The difference in rates of maturation in different parts of the brain is sometimes used to explain risky or thoughtless behaviour. I shall have more to say about this later.

One other key aspect of the teenage brain has to do with white and grey matter. The grey matter lies on the outside of the brain and is where most of the neurons exist. The white matter is in the centre and is where most of the connections between neurons occur.

You will remember that I mentioned earlier that some parts of the brain shrink during this period. Let me explain. One very important aspect of brain development at this stage is that there is a major increase in grey matter in late childhood. This mainly happens just before puberty. However, this increase leads to the brain having too many neurons and synapses.

As a result, during the next few years there is a process known as pruning. Gradually, the unwanted connections are allowed to die away, while the useful connections become reinforced. This process is a fundamental part of brain development, allowing useful connections to thrive and removing connections that serve no purpose. You may have heard the phrase "use it or lose it". This refers to the pruning process.

Scientists have shown that there is a 17% reduction in grey matter over this period. I cannot emphasise enough how significant this is. In order for this to be achieved the brain has to undergo a major reorganization and restructuring. It is no wonder then that young people experience times of uncertainty and confusion (Figure 1.5).



How moody teenagers are (literally) losing their mind

David Sanderson Arts Correspondent

Teenagers are unfairly demonised by a society that is just beginning to study the enormous loss of grey matter in their brains during adolescence, according to a leading neuroscientist.

Sarah-Jayne Blakemore said that moodiness, risk-taking, sleepiness and embarrassment at parents should be sympathised with and understood in the context of the changes in the adolescent brain.

MRI studies showed that between childhood and adulthood the brain underwent a substantial "pruning" of its synapses and an "enormous" 17 per cent reduction in grey matter in the pre-frontal cortex, she said.

The professor of cognitive neuroscience at UCL added that the education system should be altered to take the changes into account. She advocated allowing later starts to the school day to help circadian rhythms, or the biological clock, and an appreciation of the "Key Stage 3 dip" when the educational performance of children falls between the ages of 11 and 14. Professor Blakemore said that rather than teenagers being mocked for their moodiness, laziness and recklessness parents should speak to them about the changes.

She told the Hay Festival that teenage behaviour had been put down to sex hormones, puberty and changes such as starting secondary school. "The teenage brain is not broken, it is not dysfunctional, it is not a defective adult brain; it is a formative period in life where the brain is changing in really important ways where neural pathways are malleable and passion and creativity run high," said Professor Blakemore, whose book *The Secret Life of the Teenage Brain* brings together the latest studies. "We should not demonise this period of life we should understand it, nurture it and celebrate it."

She said it was impossible for scientists to judge the impact of technology on the younger brain, and added that concerns about social media should not detract from other teenage stresses.

Figure 1.5 Article from the *Times* newspaper. © The Times/ News Licensing. Originally published 30 May, 2018.

Because this is a time of such major change, the environment around the young person is especially important. This means that key adults, such as teachers, have a big role to play in assisting healthy brain development. This may appear fanciful. While we know that adults can make a difference to things like health and learning, we do not pay much attention to the brain, as it is invisible and has until recently been largely unknowable.

Now that we are learning more about the brain, however, we are beginning to discover that there are experiences that assist brain development, and experiences that are not so helpful. A look at the different hormones in the brain will help to explain this in greater detail.

4. The role of hormones in the brain

We all know something about hormones, probably because of sex hormones such as oestrogen and testosterone. The levels of these hormones increase at puberty, and they have a profound effect on our sexual development and sexual behaviour. In addition to these hormones, there are dozens of other hormones that affect the way the brain functions. There are a few that are particularly important in relation to the teenage years, and I will outline these shortly.

First, however, we should recognise that the teenage years are often linked with an upset of the hormone balance. Adolescence is sometimes described as being a time when "hormones are all over the place". We can see this in common behaviours such as mood swings and the flip-flop of emotions.

One of the things we have learnt as a result of research on the teenage brain is that there is a marked level of variation in the hormone balance in this age group. All of us have some degree of daily variation in the balance of hormones in our brains. The variation for teenagers, however, is much greater than for other age groups. Thus, the level of any of the key hormones may be going up and down to a significant extent during any 24-hour period. It is not surprising then that this affects behaviour and means that at times emotion regulation can be hard for young people.

Let us now look at some of the most important hormones. Serotonin is a hormone that is released when we feel good, happy, relaxed and at ease. This is the hormone that helps keep our mood steady. Low levels of serotonin can be a factor in depression. Variation in serotonin levels may play a part in leaving teenagers at the mercy of feelings of sadness or misery. Young people who have extreme reactions to minor setbacks ("What's the point? I might as well give up right now!") may be experiencing significant variation in levels of serotonin.

Cortisol is one of the major hormones released when we are anxious, stressed or vulnerable. On a short-term basis, cortisol can be useful. When we are under threat it is the hormone that prepares our body to respond appropriately. This is the famous "fight or flight"

response. However, too much cortisol has a detrimental effect on our bodies and leads to poor functioning. There will be more about this in Chapter 8 on stress and mental health.

Two other hormones are useful to know about. One is melatonin, and I will discuss this later when I cover the topic of sleep. The second hormone that is important to mention is dopamine. You may have heard people speak of something called a "dopamine rush". Dopamine is known as the reward hormone, the hormone that is released when an individual gets pleasure, a reward or a thrill.

We now know that there are more dopamine receptors in the teenage brain than in brains of people of other ages. This means that dopamine is an especially active hormone during these years. This can lead to a sensitivity to rewards, as well as a motivation to seek rewards. There will be more about this later in the book.

5. Risk-taking and reward-seeking

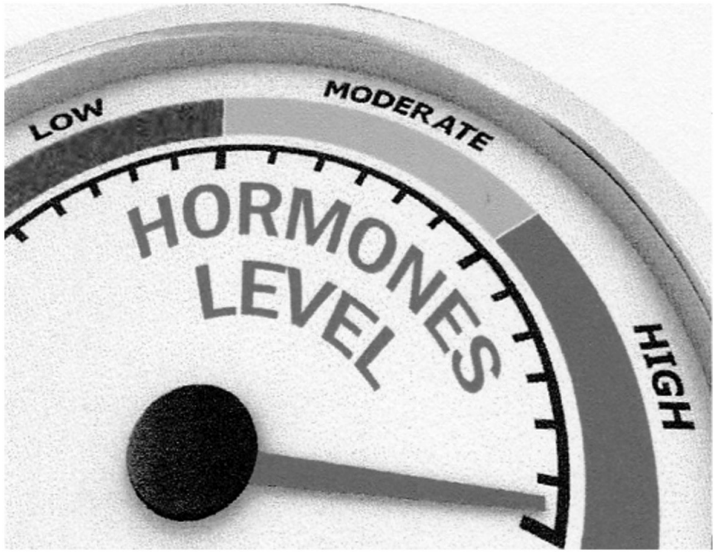
The mention of the hormone dopamine is a helpful lead-in to a discussion of risk-taking and reward-seeking. There are two aspects of brain development that may play a part here. In the first place, there is the possible difference in the rate of maturation between the thinking part of the brain, the prefrontal cortex, and the emotional part of the brain, the amygdala.

I noted earlier that the brain matures from back to front. This means that the amygdala, part of the limbic system in the central area of the brain, may mature earlier than the prefrontal cortex. In the first wave of research reports (say from 2000 to 2010), it was often suggested that "a developmental mismatch" occurred in the teenage brain, leading to risk-taking behaviour. This was because the behaviour was more likely to be governed by the need for sensation or reward, rather than by cognitive control.

In recent years, scientists have become cautious about this, as more research evidence has become available. This "developmental mismatch" may be true of some individuals, or it may be true on some occasions, but it is probably not the case for everyone all the time.

The second possible reason for risk-taking and reward-seeking has to do with the hormone balance in the brain at any one time. In the previous section I mentioned dopamine. For some young people, at some points in time, higher levels of dopamine may lead to a push for rewards and exciting experiences. At these times, the prefrontal cortex is less effective at controlling behaviour. We all know young

people who, when asked why they did something apparently senseless, respond by saying: "I just didn't think".



One other factor to be taken into account is that the brain is undergoing an enormous amount of change. As a result, there will inevitably be a period of adjustment. It may not be easy to be sensible and mature on every occasion. If adults instinctively feel critical of young people, it is helpful just to remember how much is happening in the brain at this time.

When thinking about reward-seeking and risk-taking, it is important to keep in mind the role of the environment. The brain is clearly very important, but there is an interaction between brain and environment. The family context and the role models available to the young person play a part. It is also relevant to consider social pressures, as they too exert an influence on these less than positive behaviours.

The role of the peer group offers a good example of this. Research clearly shows that during this stage young people are more likely to take risks or to respond impulsively, if they are with peers, rather than on their own. Young people appear to be more affected by peer group influences than adults. This is an illustration of the role played by social factors in risk-taking behaviour. The brain plays its part, but it does not act in isolation from the environment.

6. New skills

When thinking about the teenage brain there is a tendency to emphasise the enormous change that takes place. This encourages us to think about the difficulties that the young person faces at a time of such major adjustment. However, there is another side to the story. This is also a time when very positive things are happening. Important areas of the brain are maturing, allowing new skills to develop.

In the first place, the areas and networks in the brain that are to do with memory and learning alternate to allow new thinking and an increased capacity. If we think for a moment about the changes in the curriculum in Key Stage 3 (ages 11 to 14), we can see that the teenager would not be able to manage all this new schoolwork without being able to draw on new capabilities. There needs to be some development in thought processes, as well as the ability to develop scientific reasoning. During these years, the maths and science curriculum becomes more complex, and so new thinking skills are essential in order to cope with increasing intellectual demands in lessons.

Memory capacity is also advancing during these years. While this is not something that is routinely tested in school, research on memory has shown a marked change with age. As young people move through secondary school their memory develops in order to cope with the increasing demands made on them in tests and exams.

Of course, it is possible to train the memory, and no doubt experiences at school add to the increasing capacity. However, we also know that changes in the brain allow this process to happen more easily. We should note that the area of the brain most often associated with memory, namely the hippocampus, is one that has been identified as undergoing major change and maturation during the adolescent years.

Another new skill that develops during this period is language. At the beginning of the teenage years, an individual will have about 75% of an adult's vocabulary. During the years that follow, vocabulary will increase significantly, as will skills to do with communication.

Some readers may find this hard to comprehend because many teenagers come across as either tongue-tied or unwilling to talk to adults. Nonetheless, communication skills will be maturing during the adolescent years as areas in the brain related to language go through a process of development. A teenager's unwillingness to communicate may be more to do with a dislike of being interrogated, or a need for privacy, than any failure of language development.

Thinking, language and memory are not the only skills developing at this time. The young person is also developing a much greater

awareness and concern with social relationships, and this increased concern is linked to other aspects of brain development. I will now turn to what is known as the social brain.

7. The social brain

As we have learnt more about the changes that are going on in the adolescent brain, we have understood that some of these changes take place in areas to do with social functioning. The term "social brain" refers to the regions that have to do with understanding other people. On the one hand, the development of the social brain leads to the development of new skills. On the other hand, some short-lived deficits make it difficult for the young person to see the wider picture. Some commentators have described teenagers as having "tunnel vision" for a period when they seem to be focussed more on themselves than on other people.

Looking first at the new skills that develop, these have to do with understanding the thoughts or intentions of others. These include being able to take the perspective of another person, understanding the mental states of others, identifying intentions and recognizing emotions. All these are useful as the young person becomes more involved with the peer group and with close friends. The development of these skills appears to be closely associated with the development of the prefrontal cortex and with other areas to do with thinking and cognition.

However, strangely, at the same time as this is happening, there are also moments when the ability to see another person's side of the story appears to desert the young person. Some writers have used the term "adolescent egocentrism" to describe this state. It is at this stage that the teenager becomes preoccupied with his or her own emotions and sees the world from one perspective only. It is likely that this feature of behaviour has a lot to do with increasing self-awareness, which is another aspect of the changes that are taking place at this time.

We should not be surprised that this all appears very contradictory. We might say: "How is the young person able to understand other people's perspectives at the same time as having a self-centred view of life?" However, this contradictory feature of the teenager's behaviour reflects exactly what is happening. Major structural change is taking place in the brain, and this cannot happen overnight. It takes time for all areas of the brain to function effectively together. There will be occasions when self-awareness will be developing alongside the growth of new social skills.

I will make one final point in relation to the social world. Research has shown that in neutral situations, adolescents have similar cognitive abilities and response times to adults. However, in stressful or emotional situations, young people are more open to influences from the peer group. There will be more about this in Chapter 6.

8. The question of sleep

One of the important findings that has come from work on the brain has to do with sleep in the teenage years. Most parents and carers will have noticed that at times teenagers appear unwilling to go to sleep, while at other times it is impossible to get them out of bed. Teachers may notice students being half-awake in the early part of the school day.

It is only in recent years that we have learnt why this happens. It is not, as was assumed, because young people just want to be contrary. There is a biological reason for the altered patterns of sleep in adolescence.

The hormone that makes us feel sleepy is melatonin. It is released in the brain at roughly the same time each night, signalling that it is time to go to bed. However, we have learnt that melatonin is released later in teenagers than it is in adults. This means that young people do not necessarily feel sleepy at the same time as others in the family and may find it more difficult to get to sleep.

Of course, melatonin is not the only factor that influences whether we feel sleepy or not. The amount of light is important, and what we eat and drink plays a part too. However, levels of melatonin do make a difference, and certainly have an influence on the sleep patterns of many teenagers.

This is significant because teenagers need their sleep. If adolescent sleep is monitored in a laboratory, young people will sleep for more than nine hours. And research also tells us that sleep deficit (having fewer than seven hours a night) can affect school performance as well as behaviour. It will be obvious that if a young person has to get up for school early in the morning, while at the same time having gone to sleep late at night, this will restrict the amount of sleep that is possible.

Over the last few years sleep has been the subject of many research studies. These studies have shown that sleep is not just for rest. A number of significant things happen during sleep, making it even more important for teenagers to get a good night's sleep.

During sleep:

- Growth hormones are released;
- Memory consolidation occurs, allowing the learning that has taken place in the day to be embedded in long-term memory;
- A cleaning-up process takes place, enabling the management and disposal of waste products produced in the brain during the day.

All this illustrates just how important sleep is for us all. Yet the group for whom this is most important is the group attending secondary school and further education. There will be much more detail about sleep in Chapter 7.

9. Vulnerable teenagers and the role of the brain

There are many ways in which young people can show that they are vulnerable. This may be through moods and emotions, through behaviour, through poor health or through troubled relationships. While I cannot cover all aspects of the topic in this brief section, I will mention a few mental health problems. In Chapter 8 it will be possible to explore these issues in more depth.

The main purpose of this section is to show how our knowledge of the brain can help us understand the mental health of young people. Attention deficit is a good place to start. You will remember that, in the brain, electrical impulses travel from one nerve cell to another by moving along the nerve fibre, jumping across the synapse and moving to the next neuron. This is happening millions of times in the brain at any one moment.

Clearly, the brain has to have the capacity to manage all these impulses, allowing some to travel on and shutting down others when they interfere or get in the way. This is the role of the chemical messengers, as they affect how the impulse crosses the synapse.

This may seem a very simplistic model of how the brain works, but in essence, this model enables us to understand something like attention deficit or impulsive behaviour. If for one reason or another the chemical messengers are not functioning effectively, the individual will feel bombarded with impulses and find it difficult to sort out which should be attended to and which should be ignored. A young person who cannot pay attention in class will be in exactly this position. A teenager who acts impulsively may do so because the brain is not being effective in connecting the planning and thinking regions with those that are to do with emotional reactions.

While it is important to note that there are different types of depression, some forms of mood disorder may be affected by the chemical balance in the brain. One type of depression arises because of external events such as trauma or loss, but another type of depression occurs without an obvious external cause. It is this type of depression that may be linked to hormones in the brain. If levels of serotonin, for example, are too low, this may lead to a slowing down of the travel of impulses, making the individual feel sad or disengaged.

Lastly, it is useful to look at anxiety. A chemical that I have not mentioned so far is the GABA neurotransmitter. This is a chemical messenger that plays a key role in reducing the excitability of neurons and thus helping to control anxiety or fear. Where GABA is too low, it may be more difficult to control unhelpful emotions. There are, of course, other chemical messengers involved in anxiety, but GABA is a very common one. Medications to reduce anxiety work to enhance the natural effects of GABA.

I must emphasise that many factors will create vulnerability in an individual. The brain is only one factor, acting in combination with what has happened to the young person in the past, and what is going on around them in the present. Thus, the environment can affect the brain, but what is happening in the brain may, in turn, influence the individual's behaviour, and therefore, on their environment.

10. Adults can make a difference

I have made it clear in this introductory chapter that major changes occur in the teenage brain, and these changes have a profound effect on behaviour and development. The changes are invisible, so it is easy to miss the fact that these developments are happening. In this section, I want to spell out how the adults around the teenager can make a difference to brain development.

The first thing is to do with understanding. Teenagers experience a major upheaval and readjustment of their brains. If they have teachers, parents or carers around them who understand this and take it into account, it can make a significant difference to general well-being. It is also important for adults to know that this is a critical period, and thus what happens at this time will have long-term implications. New patterns and pathways are being laid down, and new ways of thinking and managing emotions are developing. Experiences during this period actually matter for future development.

As one teacher put it to me after she had delivered a workshop on the brain to her colleagues:

> When I delivered it to all staff, they said it made them think differently. They were very positive about it. They said it made them think differently when young people presented with anxiety, or when pupils got frustrated, finding it difficult perhaps to focus. It made them think about doing shorter sharper activities, and about rewards and praise. How we can make sure that pupils are more engaged across the whole curriculum? It was all really helpful.

The second thing to keep in mind has to do with the role of chemical messengers in the brain. A good balance of different hormones is essential if the brain is to manage the process of pruning unwanted connections while developing and embedding useful neural pathways. If the young person experiences too much anxiety or stress, the hormone balance will hinder this fundamental process.

It is here that adults have such a vital role. On the one hand, they can make a difference in the environment surrounding the young person. The more supportive this is, the more likely it is that the hormone balance will facilitate positive growth and development. On the other hand, adults have a part to play in helping young people manage stress and anxiety. If the teenager can learn to manage these emotions, hormones such as cortisol will be kept to reasonable levels. However, high levels of a hormone such as cortisol will inhibit learning and make the management of emotion more problematic.

The next thing to mention relates to the role of the amygdala and the prefrontal cortex. You will remember that these two areas of the brain undergo rapid development, but there may be times when the amygdala plays a more powerful role than the prefrontal cortex. This would mean more emotion and less thinking, and therefore, a greater likelihood of reward-seeking or risk-taking behaviour.

For this reason, it is important to encourage the development of the prefrontal cortex, and here again, adults such as teachers and parents have a part to play. The more enriching the environment, and the wider range of activities the young person is engaged in, the more opportunities there will be for the prefrontal cortex to mature faster. In this way, behaviour is more likely to come under the control of the cognitive part of the brain, rather than being governed by the search for sensation and immediate reward.

I will give one last illustration of the role of adults. As I have explained, emotion regulation can be hard at this time. All aspects of brain development play into this. Different parts of the brain mature at different rates. Hormone variation has its effect, as well as the restructuring caused by pruning. All these things are easier to manage if the young person is helped to create good routines.

In the family, this applies to sleep, eating and other health-related issues. In school, this relates to timetabling, planning and revision for tests and exams. These things are sometimes known as study skills. If students can be helped to create routines for themselves around key educational tasks, this will be of enormous benefit in overcoming some of the challenges resulting from brain development.

In this introductory chapter I have given an overview of what we know about the teenage brain and I have set out how this knowledge can be of value to all engaged in education. All the topics covered here will be explored in greater detail in later chapters. It is now time to turn to Chapter 2, in which I will outline a different perspective on teenage development.

Further reading

Blakemore, S-J (2019) *"Inventing ourselves: The secret life of the teenage brain"*. Transworld Publishers/Penguin, London.

Crone, E (2017) *"The adolescent brain: Changes in learning, decision-making and social relations"*. Psychology Press/Routledge, Abingdon, Oxon.

Galvan, A (2017) *"The neuroscience of adolescence"*. Cambridge University Press, Cambridge.

Jensen, F (2015) *"The teenage brain: A neuroscientist's survival guide to raising adolescents and young adults"*. Harper, New York.