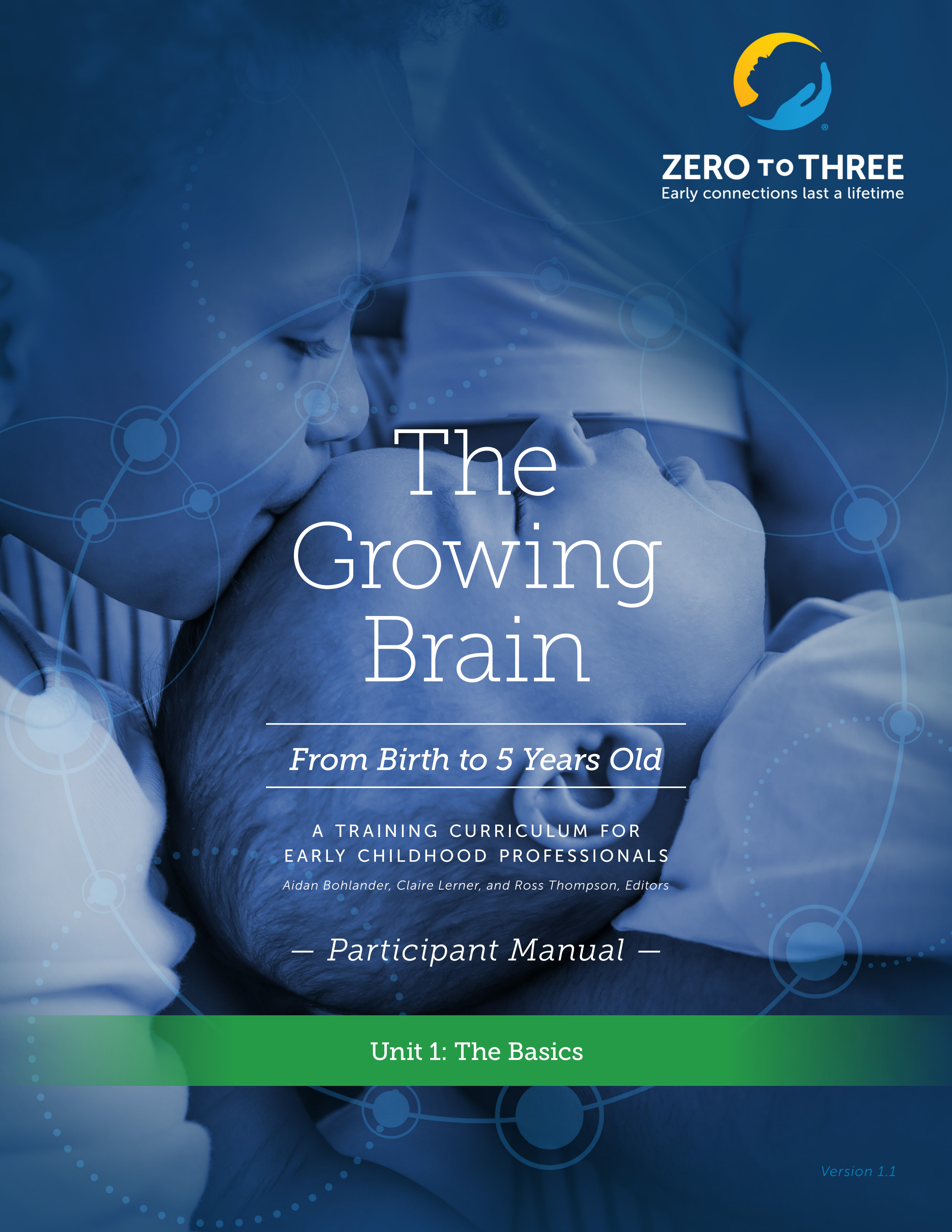

ZERO TO THREE
Early connections last a lifetime

The Growing Brain

From Birth to 5 Years Old

A TRAINING CURRICULUM FOR
EARLY CHILDHOOD PROFESSIONALS

Aidan Bohlander, Claire Lerner, and Ross Thompson, Editors

— Participant Manual —

Unit 1: The Basics

Version 1.1

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Preface

"The brain is a social organ of adaptation built through interactions with others." (Cozolino, 2014, p. xvi)

The development of the growing brain is one of the most important topics in early childhood development, with significant implications for early childhood professionals. Research on infant brain development is exploding. With the advent of the magnetoencephalography (MEG) for infants, researchers can now see more clearly into a young child's brain activity and learn what impact interactions have on certain aspects of development.

The greatest rate of brain growth and development is during the first few years of life. This rapid development occurs at the same time a child is making critical connections with his or her outside world. Because of such rapid brain growth during the first few years, early experiences have a disproportionately greater impact on the newly growing brain's development.

Often, an early childhood professional provides one of the earliest human interactions an infant or young child will experience. The professional will play a significant role in determining the experiences and environment that shape and influence the construction of the early brain. When an early childhood professional and an infant interact together, each is inducing the other's internal states of being. It's the basic day-to-day experiences, be they nurturing or non-nurturing, that set the young child on his or her course of brain development.

It is for these reasons that ZERO TO THREE, in partnership with the University of Arkansas Early Care and Education Projects, developed The Growing Brain (TGB) curriculum for early childhood professionals. Since 1977, ZERO TO THREE has been translating research that helps us understand how the young¬est children think, learn, and interact with the important adults in their lives. We turn that scientific knowledge into helpful tools and practical resources for parents, policymakers, and professionals, like yourself, to help make the lives of babies, toddlers, and their families better.

This Participant Manual, along with the other curriculum materials you've received, is intended to support your learning experience. In the Manual you will find key points from each presentation as well as discussion questions. Please use this Manual as a workbook during the course to record presentation and discussion highlights. Together with the other TGB materials, we hope it will serve as a valuable record of your learning and resource on early brain development that you will return to again and again as you work with young children.

Thank you for what you do each and every day to support the youngest and most vulnerable members of our society. Each interaction that you have with each young child is helping to shape the very structure of his or her brain. That is an incredible responsibility and privilege! Thank you for your participation in this course and your commitment to be a positive influence on the children and families you serve.

Reference

Cozolino, L. (2014). *The neuroscience of human relationships: Attachment and the developing social brain* (2nd ed.). New York, NY: WW Norton & Company.

Introduction

How wonderful to have this new resource on the brain and child development! I remember when we wrote our curriculum, *Early Development and the Brain: Teaching Resources for Educators* (Gilkerson & Klein, 2008), a colleague asked: "Is the brain a fad? What will be next?" The brain has hardly been a fad; as one of the central regulators of the body and of our experience with the world, its critical importance in understanding young children's development and how best to nurture their growth will always be supremely important for anyone who cares about young children and is invested in nurturing their healthiest development.

We wrote the former curriculum for early childhood faculty and trainers so they could confidently teach about the brain and its role in early development to their students. While early educators had long focused on the whole child, brain imaging brought a seismic shift in our understanding about biopsychosocial development. Now students in early childhood development, as well as faculty, fully appreciate the power of brain health and functioning and are eager to learn how they can best build the brainpower of the children they serve.

This new curriculum, *The Growing Brain (TGB),* addresses the same vital areas that we covered: the structure and function of the brain; factors and experiences that can harm the growing brain, especially stress, and how to protect the brain from harm; and the connections between the brain, language development, and sensory functioning.

In the 9 years since we wrote our curriculum, much more has been discovered about the brain, especially regarding emotional regulation, the role of caregiving relationships, and the impact of trauma. Evidence that young children's early experiences shape the actual architecture of the brain and how it functions has grown dramatically, and it has put a spotlight on the importance of the interface between the brain and the environment and on the centrality of human interaction and relationships in brain development. Accordingly, *TGB* focuses heavily on the growing field of "affective neuroscience"—the science of emotions and the brain—and how the earliest interactions shape lasting patterns of relatedness. The link between brain, body, and behavior is ever clearer. Unmediated adverse childhood experiences (ACEs) are linked with problems in adult physical and mental health in ways we might not have imagined. Synchrony in mother-infant behavioral interactions also has a significant influence on the growing brain, as this synchrony is mirrored physiologically in the child's heart rate synchrony—heart to heart and brain to brain. This early synchrony relates to self-regulation in infancy and toddlerhood and even shapes the adolescent's capacity for empathy. In this *TGB* curriculum, you will learn about the impact of disrupted synchrony and how factors such as maternal depression affect the child's ability to read emotions. *TGB* also includes very important content on the impact of stress on the developing brain, which is heavily influenced by the availability of a caring adult to help mediate the stress—to provide protection and help make the experience manageable. One of the most powerful features of this curriculum is that it translates very complex concepts in a way that is digestible, is meaningful and relevant, and provides a range of interactive exercises that enable trainees to integrate and apply these concepts in their daily work supporting young children. In short, it engages trainees' brainpower in active learning!

Further, while professionals must be critical consumers of neuroscience, how do we help parents absorb this new information from science and build their confidence in what *they know* about their child? How can we help protect and grow parents' intuitive competence—a concept well-documented decades ago in studies of parenting? While brain and behavior research will continue to bring new discoveries, we are reminded of one of the most fundamental ideas of early care and education: the essential value of observation as a way of knowing. A child's behavior is one of the best windows into brain functioning. Our role is to encourage parents, teachers, and other caregivers to pause, watch, and truly notice the child's responses to his world—to see what this child can take in at this moment on this day. What experiences does he approach? What experiences does she pull away from—even a bit? What is too much input for him? What is too little for her? Where is the sweet spot—the space for moderate novelty in which the brain thrives?

The science of early development is an integrated science, and you are an integrated professional. Enjoy deepening your understanding of child development and the brain and sharing that knowledge with others!

Linda Gilkerson, PhD
Professor, Erikson Institute

Note for Participant Manual: Unit 1

This section of the participant manual is comprised of important content and reflections related to Unit 1, The Basics of *The Growing Brain.* All 7 Units are available separately from ZERO TO THREE, as well as available as a complete publication package. Please see the participant manual table of contents on page 3 for a list of all 7 Units.

We are proud of the participant manual as a way of enhancing participants' understanding of *The Growing Brain* as an interactive curriculum: it is a fully designed and functional workbook for learners to explore and exchange ideas. They can be purchased individually, or as a group purchase. Your learners can make the purchases or you can on their behalf.

Unit 1 covers:

- how the brain is not fully developed at birth but grows in size and connectivity;
- how the brain grows from front to back;
- how the brainstem develops through everyday functions;
- the role of the forebrain in early developmental experiences; and
- how adults and the surrounding caring community fosters healthy brain growth when the brain is most plastic.

The participant manual is available from the ZERO TO THREE bookstore as a digital download. This download is a single-use license for either you or your learners to print—in order to make best use of the workbook features.

Teaching *The Growing Brain: Birth to 5 Years Old*

The Growing Brain: From Birth to 5 Years Old is a 21-hour course. The following is a suggested time schedule for teaching each unit based on the field test. Times may vary from trainer to trainer and based on the needs of participants.

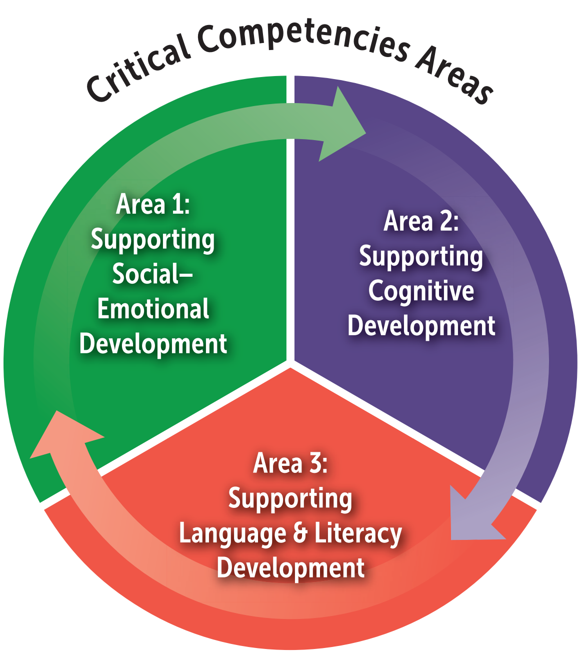
Unit 1: The Growing Brain: The Basics	3 hours
Unit 2: The Growing Brain: The Factors Affecting Brain Growth and Development	3 hours
Unit 3: The Growing Brain: Communication and Language Development	3 hours
Unit 4: The Growing Brain: Cognition and Executive Function	3 hours
Unit 5: The Growing Brain: Social-Emotional Development	3 hours
Unit 6: The Growing Brain: Understanding Behavior	3 hours
Unit 7: The Growing Brain: Everyday Play	3 hours

*Note: The 21 hours is training time and each unit includes only one 10-minute break. *Additional time must be scheduled for additional breaks of any kind.*

Critical Competencies Areas and Sub-Areas

The *ZERO TO THREE Critical Competencies for Infant-Toddler Educators*™ define the specific evidence-based teaching methods and practices that support and nurture young children's social-emotional, cognitive, and language and literacy development and learning.

ZERO TO THREE has completed a crosswalk between the *ZERO TO THREE Critical Competencies for Infant-Toddler Educators*™ and *The Growing Brain: From Birth to 5 Years Old* training curriculum. Significantly for learners, these two professional development curricula and resources now closely align and complement each other. For more information on the *Critical Competencies* and how you can use them to inform your professional development goals, visit www.zerotothree.org/criticalcompetencies.



Critical Competencies Sub-Areas

Area 1: Supporting Social–Emotional Development

- SE-1 Building Warm, Positive, and Nurturing Relationships
- SE-2 Providing Consistent and Responsive Caregiving
- SE-3 Supporting Emotional Expression and Regulation
- SE-4 Promoting Socialization
- SE-5 Guiding Behavior
- SE-6 Promoting Children's Sense of Identity and Belonging

Area 2: Supporting Cognitive Development

- C-1 Facilitating Exploration and Concept Development
- C-2 Building Meaningful Curriculum
- C-3 Promoting Imitation, Symbolic Representation, and Play
- C-4 Supporting Reasoning and Problem Solving

Area 3: Supporting Language & Literacy Development

- L&L-1 Promoting Communication Exchange
- L&L-2 Expanding Expressive and Receptive Language and Vocabulary
- L&L-3 Promoting Early Literacy

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Unit 1

UNIT 1 The Basics

Goal: To understand how the brain grows and develops from conception through 5 years old

Objectives

1: Learn the Parts of the Brain and Their Functions

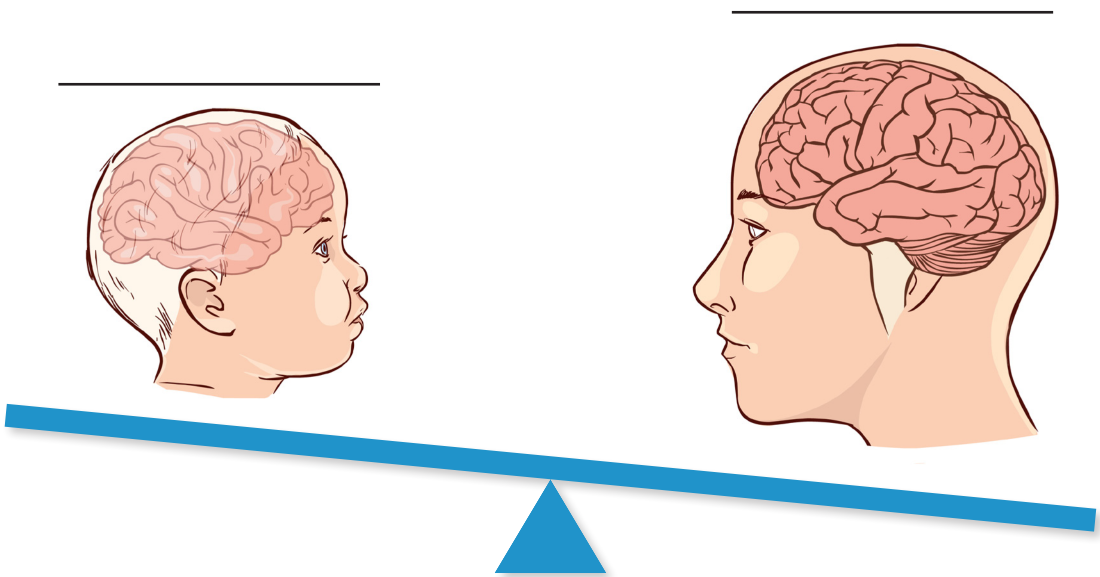
2: Understand How Nerve Cells Communicate and Connect

3: Understand Neuroplasticity and the Role of Early Experiences in Making Connections Between Areas of the Brain

1 Learn the Parts of the Brain and Their Functions

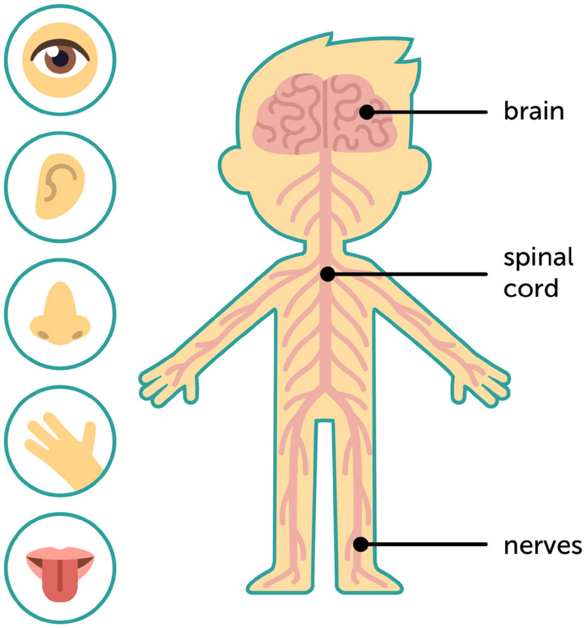
How much does a baby's brain weigh? An adult's brain?

Fill in the answers below:



Size is just one way that a human **brain** grows; it also grows in connectivity. These connections are established through loving, positive experiences young children have with their caregivers. SE-1

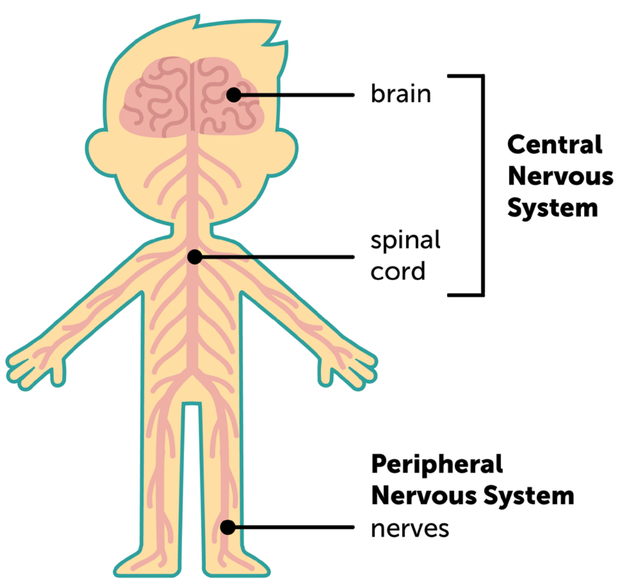
The Basics



The Nervous System

The brain is part of the **nervous system.** The nervous system consists of the brain, **spinal cord,** and a complex network of **neurons,** or nerve cells, that extend throughout the body.

The nervous system is responsible for sending, receiving, and interpreting information from all parts of the body. The nervous system monitors and coordinates internal organ function and responds to changes in the external environment (Society for Neuroscience, 2016).



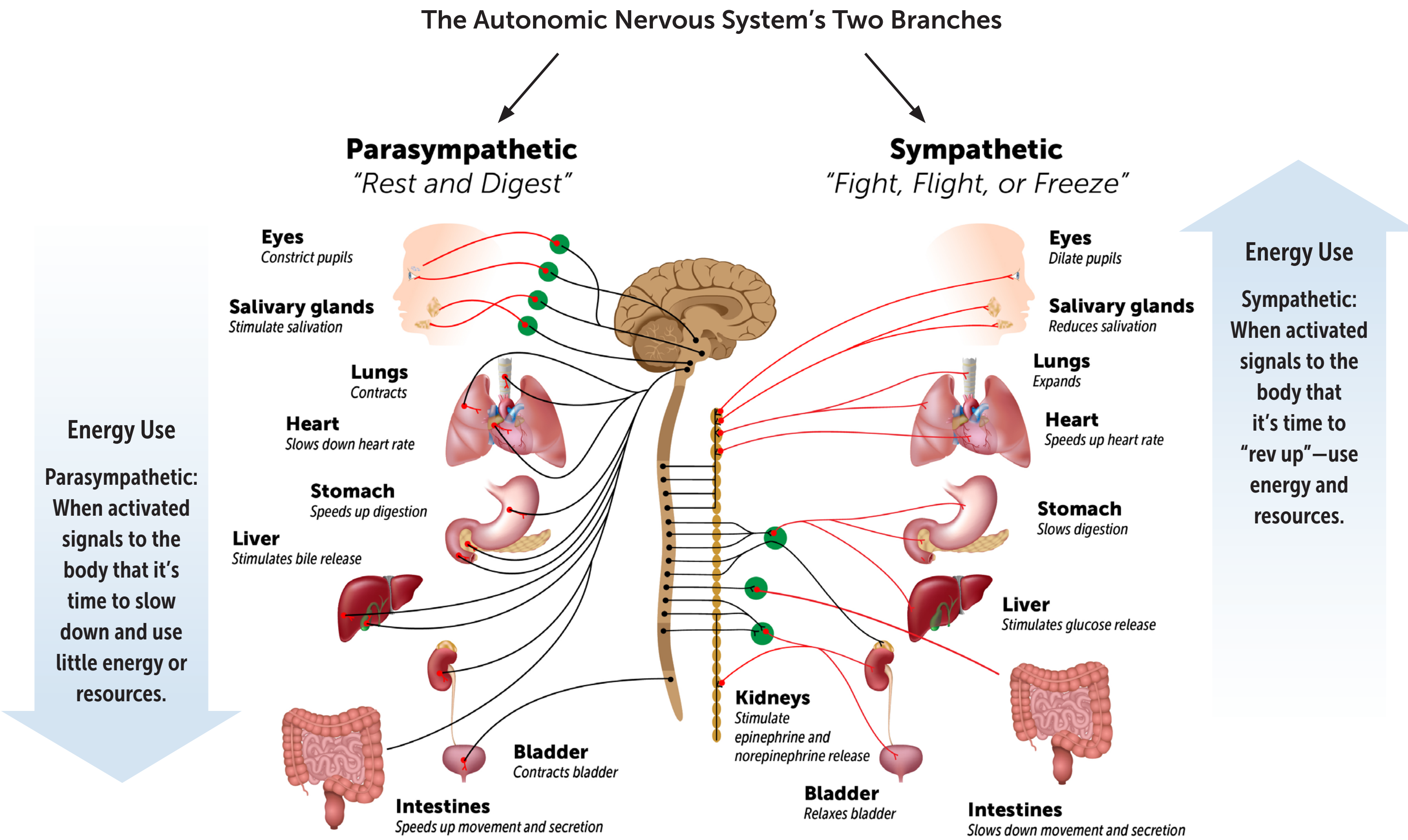
The Central, Peripheral, and Autonomic Nervous Systems

The **central nervous system** is made up of the spinal cord and brain. The spinal cord is the main highway for information to and from the brain. The brain decides how to react to all the information.

The **peripheral nervous** system is made up of the nerve fibers that branch off from the spinal cord and extend to all parts of the body. You might think of these like the local roads to the rest of the parts of the body. Information comes to the nerve cells of the peripheral nervous system. The information is passed to the spinal cord and finally to the brain, where decisions or reactions occur and then are communicated back out to the body via the spinal cord and to the rest of body via the peripheral nervous system.

The **autonomic nervous system** is a part of the peripheral nervous system. It regulates automatic bodily functions such as heart rate, digestion, and respiratory rate. One part of it is automatically activated when the brain interprets information coming from the senses as needing to act, while the other is activated when the brain interprets information as coming from the senses as a time to rest.

The Autonomic Nervous System: Regulates automatic bodily functions. These are the functions of the body that we do not need to consciously think about in order to work—such as heart rate or breathing. This system has two branches. One part of it is automatically activated when the brain interprets information coming from the senses as a time to act—the sympathetic nervous system, while the other is activated when the brain interprets information as coming from the senses as a time to rest—the parasympathetic nervous system.



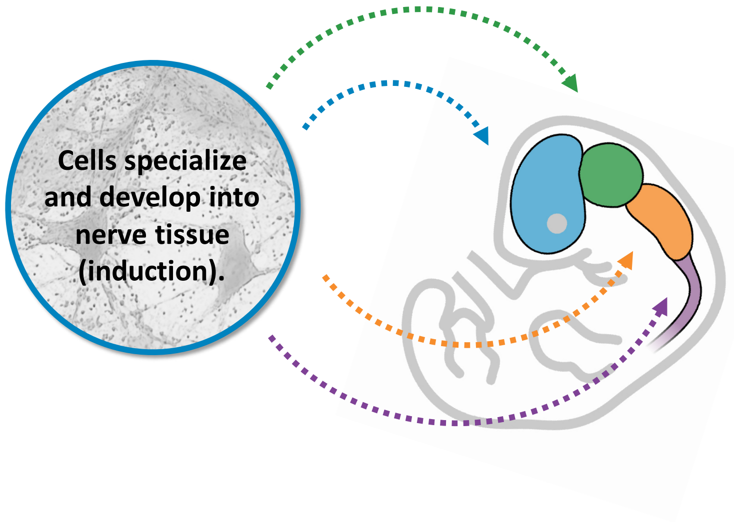
➡ What are some times when you know you've activated your sympathetic nervous system—an event that is stressful or triggers an energetic, revved-up response?

➡ What are some examples of when a child's sympathetic nervous system might get activated?

➡ What are some situations in which your parasympathetic nervous system might be activated—when your system is triggered to calm down?

➡ What are some examples of when a child's parasympathetic nervous system becomes activated?

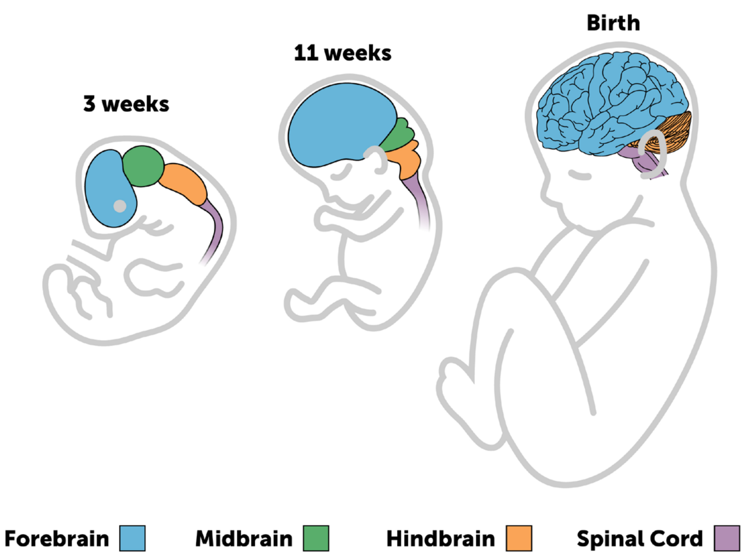
The Basics



Neural Induction

The development of the brain starts *in utero* through a process known as **neural induction.** As the embryo grows, certain cells specialize, developing into nerve tissue (Society for Neuroscience, 2016).

Once induction has occurred, the cells are then signaled to move, or migrate, to particular positions to form different areas or regions of the brain (Society for Neuroscience, 2016).

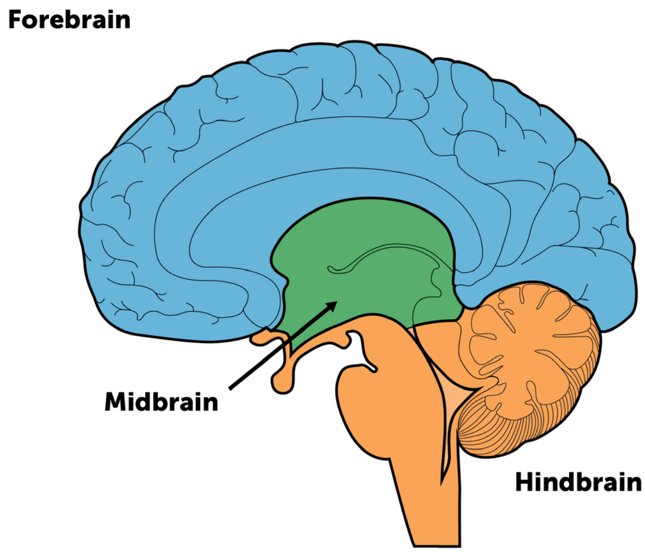


Prenatal Brain Development

The **migration** of the cells that form different brain regions **(forebrain, midbrain, hindbrain)** is a delicate process and is influenced by experiences—such as maternal substance use or exposure to toxins—as well as genetic differences that the child has inherited (Society for Neuroscience, 2016).

Nerve cell migration is also guided by the genetic blueprint that we share with all other people.

The Basics



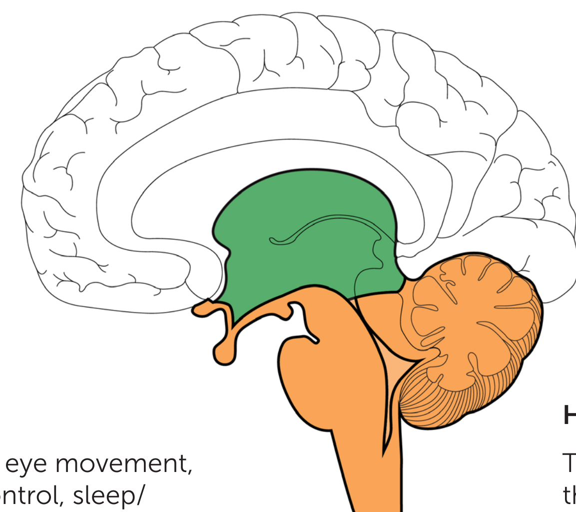
Three Major Regions of the Brain

While the basic structures of the brain are present at birth, they are not fully mature or well-connected (Society for Neuroscience, 2016).

When the brain grows and matures in functionality, it does so from the bottom up, and from the back to the front (Society for the Neuroscience, 2016).

Hindbrain + Midbrain = **Brain Stem**

Let's start from the bottom up!



Midbrain:

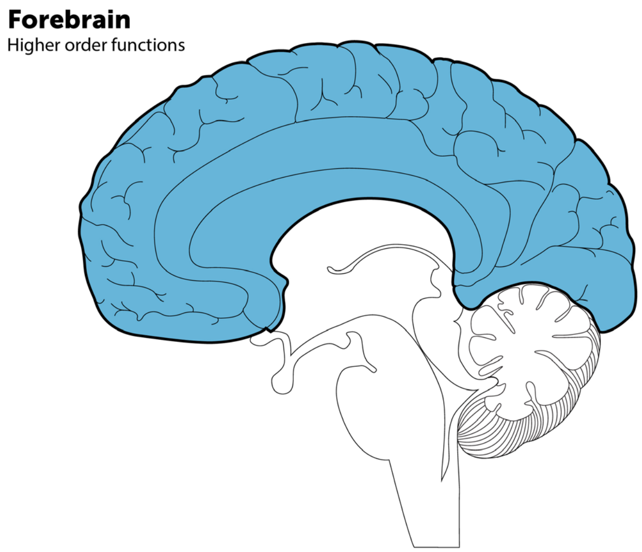
Functions include eye movement, hearing, motor control, sleep/wake patterns, alertness, and temperature regulation.

Hindbrain:

The hindbrain is responsible for the basic functions for human life. It controls breathing, heart rhythm, and blood sugar levels. It is intact and well developed at birth (Society for Neuroscience, 2016).

Brain Stem

The Basics



Forebrain

Responsible for more complex functions of the body. Most of the forebrain is made up of the cerebrum whose functions include thinking, perceiving, planning, and processing language.

Think About It: The most frontal part of the forebrain, the **prefrontal cortex,** which is responsible for higher order functions such as thinking, planning, and problem solving, continues to develop in function through our mid-20s. Reflect on your own abilities for thinking, planning, and problem solving in your teen years, versus your mid to late 20s. How much stronger were these skills as you grew beyond your mid-20s?

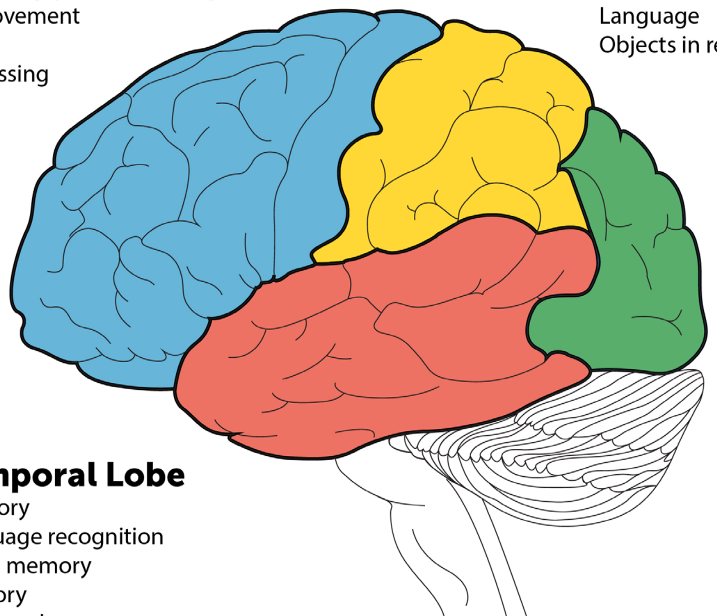
UNIT 1

The Basics

Now let's take some time to consider an area of the brain called the **cerebral cortex,** which is continuing to develop in early childhood and beyond. The cerebral cortex is the most outer layer of the **cerebrum** of the forebrain. If the forebrain was an orange, the cerebral cortex would be the peel. It is the part of the brain and its functions we often hear about the most. It includes the lobes in the diagram below.

Frontal Lobe
Higher order cognitive skills
(thinking, planning, problem solving)
Coordinating movement
Personality
Emotional processing

Parietal Lobe
Sensory processing
Attention
Language
Objects in relation to others



Occipital Lobe
Visual processing

Temporal Lobe
Auditory
Language recognition
Visual memory
Memory
Emotional responses

Review of Key Points

Wow! We just learned a lot of new information about the nervous system, the role of the brain, and the different functions of parts of the brain. Let's review:

1. The brain is part of the nervous system.
2. It processes information from the peripheral nervous system (our senses) and "decides" how to respond.
3. The brain is separated into regions or zones with different functions.
4. The brain develops from the back to the front, from the bottom to the top.
5. The brain stem, or midbrain and hindbrain, is responsible for functions of everyday survival, or lower order functions. It develops more fully before the forebrain.
6. The forebrain is the last part of the brain to develop fully.
7. The cerebral cortex is in the forebrain. Its four lobes are the last part of the brain to fully develop and are responsible for higher order functioning such as cognition (needed for thinking, planning, problem solving, and language processing), as well as some motor and social–emotional functions.
8. The brain's main structures are present at birth. Some of these structures are fully grown, while others (e.g., parts of the forebrain) continue to grow in size and connectivity. This growth in the brain, after birth, is most rapid in early childhood. It includes not just areas of the brain maturing but also growth in the neural networks as they become more interconnected which allows thinking to become more complex.

2 Understand How Nerve Cells Communicate and Connect

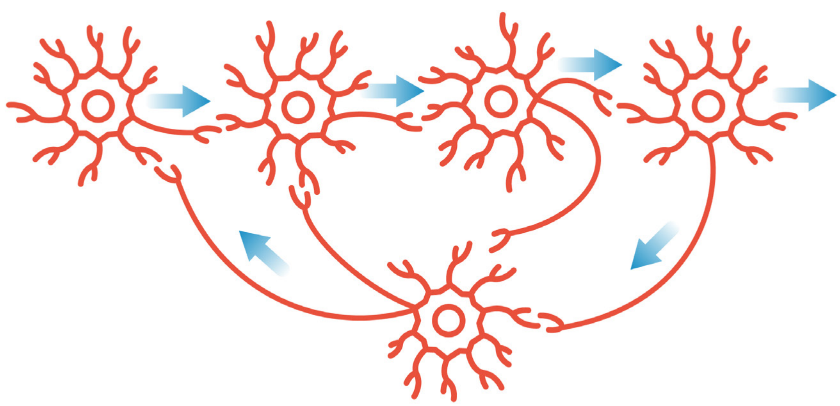
Brain Connectivity

In the beginning of today's unit, we talked about one important way the brain grows—in size, or volume. The other way it grows is through the connections made within the brain between the nerve cells, or neurons.

How does this growth in brain connections take place? Well, we know that the rate at which these connections are made is astounding! Scientists estimate that the brain is making around 1 million new neural connections per second in the first few years of life (Center on the Developing Child, 2017).

Neurons communicate, or connect, with one another by sending nerve impulses from one neuron to another, forming long chains. These chains eventually create complex networks.

The more often the neurons in a chain communicate, or send impulses to each other, the stronger the chain becomes, making faster, stronger networks that pass information between areas of the brain.



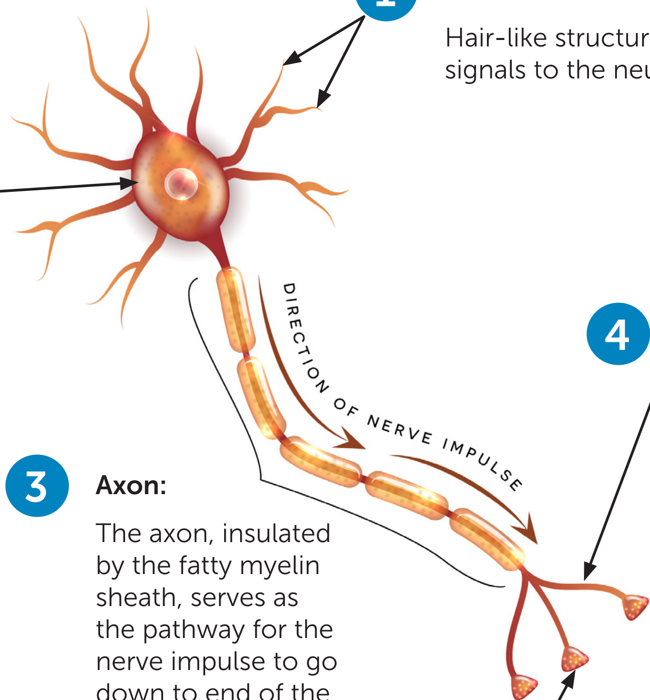
So, what does this mean for us in working with young children? The experiences that young children have in the world stimulate the neurons to communicate with each other, forming connections. So the experiences we provide young children are literally helping to develop their brains. We will further explore this later when we talk about how "plastic" the brain is in the early years. But first, let's learn a little bit more about the brain cells, or neurons, and how they communicate. SE-1 SE-6 C-1 C-4 L&L-1 L&L-3

The Basics

Neuron

A neuron is a specific name for a cell in the nervous system. Let's learn about its parts and how it works! Follow the numbered parts of the neuron to see the order of how messages are passed down one neuron to the next.

Source: Society for Neuroscience, 2016



1 Dendrites:

Hair-like structures that bring in the signals to the neuron from other cells.

2 Cell body:

The cell body and nucleus "decide" whether to pass the impulse down the **axon** or not.

3 Axon:

The axon, insulated by the fatty myelin sheath, serves as the pathway for the nerve impulse to go down to end of the neuron, to the **axon terminals.**

4 Axon terminals:

The nerve impulse tells the axon terminals to release or not release little message packages, which are called **neurotransmitters.**

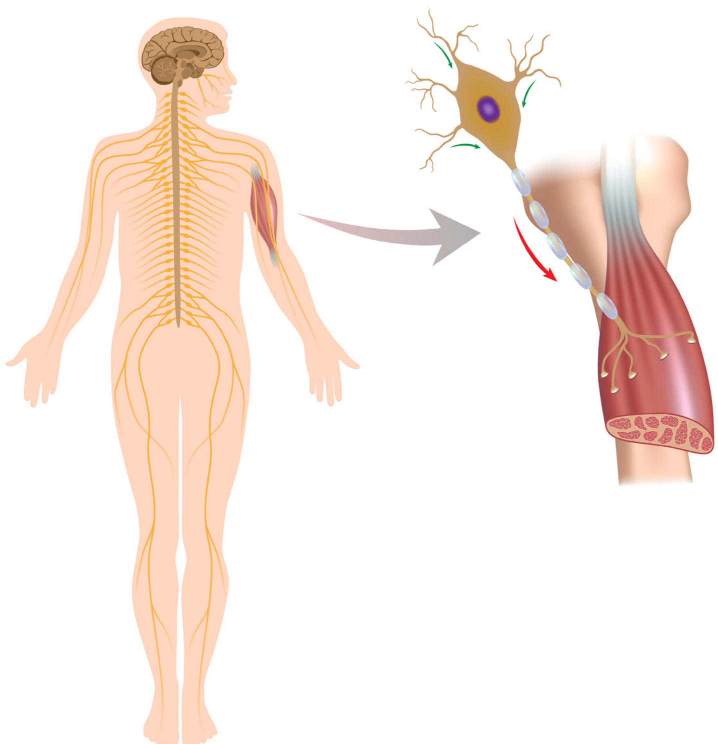
5 Synapse:

To reach the next neuron, the neurotransmitters must cross a tiny, tiny space called the **synapse** (Society for Neuroscience, 2016).

The neurotransmitters cross the synapse to the dendrites of the next nerve cell.

UNIT 1

The Basics



Synaptogenesis—The creation of connections between neurons. Neurons that communicate with each other more often form stronger connections across their synapses (Society for Neuroscience, 2016).

These connections can cross short distances in the brain or very long distances across the brain, or still longer distances from the brain down the spinal cord (Society for Neuroscience, 2016).

How does a neuron know which other neurons to connect with? A developing neuron responds to neurotransmitters and other signals in the environment, which help guide its path.

Some neurons have specific functions. For example, the motor neurons in our bodies drive our muscles. As a child learns to crawl and walk, connections between neurons in the brain, the motor neurons in the body, and the muscles they target strengthen and grow more efficient with practice (Society for Neuroscience, 2016).

The same is true of neurons in the regions of the brain that process language and identify faces. As a child has experiences and receives sensory information from the environment, the brain fine-tunes connections between neurons that help him learn a language or identify a familiar face.

The more often a child has a particular experience, the stronger the connections will be in her brain. This is true of both positive and negative experiences. For example, if an adult responds with eye contact and words when a baby coos, the connections in the brain that process language are being strengthened. L&L-1 L&L-3 If a baby is shouted at every time she cries, the connections in her brain that process fear are strengthened, which means she is likely to expect to be shouted at and experience fear when she cries to communicate her needs.

Think About It: The experiences that children have affect the actual structure of their brain. In other words, brains are built through experience.

3 Understand Neuroplasticity and the Role of Early Experiences in Making Connections Between Areas of the Brain

Neuroplasticity

Neuroplasticity—*the brain's potential to create or change networks of neurons based on experiences (Society for Neuroscience, 2016).*

Infants have a great deal of flexibility, or **neuroplasticity,** in their brains. (Society for Neuroscience, 2016).

Fill in the definitions of the types of neuroplasticity:

- Experience-expectant:

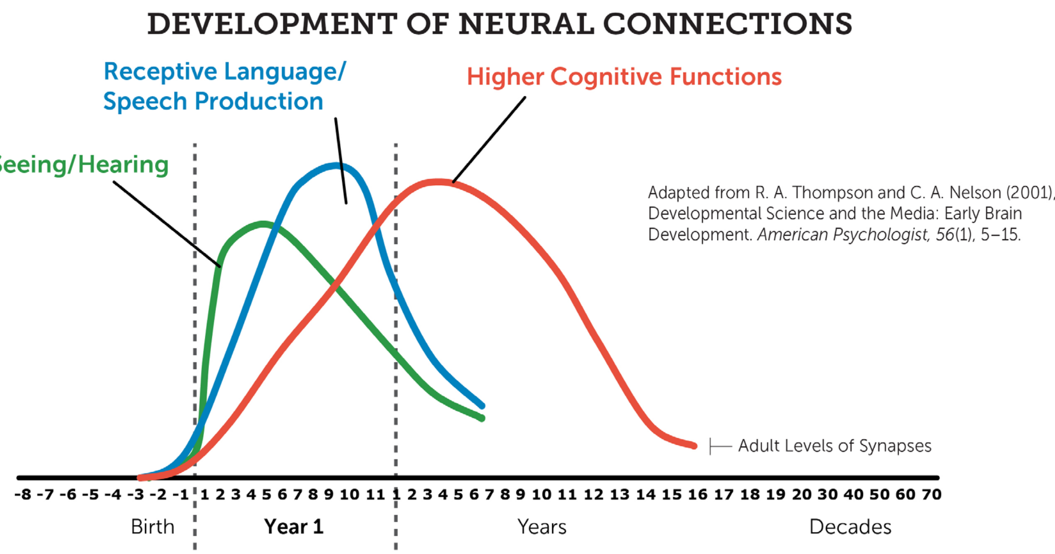
- Experience-dependent:

Timing—Windows of Opportunity

We know that the timing of WHEN a person is exposed to certain environmental stimuli can affect the development of neural connections. Scientists have identified that some areas of development have windows of time that close more quickly, often called **critical periods,** while others stay open longer, often called **sensitive periods.**

Sensitive periods are the time in development when a brain region is most open to learning or refining a particular skill or brain function. Different parts of the brain have different sensitive periods based on when those regions of the brain are developing and maturing. For example, early in life, the sensory regions of the brain have a burst of synaptic growth.

Look at the chart below and reflect on what these sensitive periods mean for the types of experiences children need at what ages.



The Efficient Brain—Pruning

So many new connections are being made between neurons and so many networks of neurons are forming across the brain in early childhood. This process of synaptogenesis peaks around 6 years old. If we think of making new connections like forming new roads or paths, by 5 or 6 years old the brain has formed MANY roads or paths, some to destinations that they no longer go to, or don't go down often based on their experiences. We want our brains to be efficient and they are built to be so. In early adolescence the excess synapses are removed by **pruning,** a process by which a path falls away. This process peaks in adolescence and continues into adulthood (Grigorenko, in press). Pruning allows us to keep the pathways that we use, based on our experiences in life, making our brains more efficient in how they react to the world.

During the early years of brain development, the foundation for the architecture of the brain is being laid. It is solidified through the early experiences we provide for very young children, which influence whether the brain's architecture will be strong or fragile. This is why researchers believe that early childhood, particularly the first years of life, is a prime opportunity to positively influence the course of a person's life.

What YOU can do to support healthy brain development:

- Set realistic expectations based on brain development.
- Be aware that the experiences we provide are building brain architecture.
- Provide positive relationships and supportive, enriching environments.

Let's Review! Key Messages:

- The brain is not fully developed at birth. It grows in size and connectivity.
- The brain grows from the back to the front, from the bottom up.
- The brainstem is largely formed at birth, giving us the ability to go through everyday functions.
- The forebrain is shaped by experiences in early childhood and is responsible for higher order functions such as thinking, planning, problem solving, sensory processing, emotional regulation, and language development.
- We play a key role in providing children developmentally apropriate stimulation and responsive care to foster healthy brain growth in early childhood, when it is most plastic.

Notes

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Handout 1.3

Key Terms

- **Amygdala:** A structure located in the temporal lobe of the forebrain that perceives and evaluates a potentially threatening event or circumstance. Its functioning can be affected by an increase in stress-induced cortisol. The amygdala matures early in life and plays a critical role in the body's learned response to fear (National Scientific Council on the Developing Child, 2010; Society for Neuroscience, 2016).
- **Autonomic nervous system (ANS):** The part of the peripheral nervous system that regulates automatic bodily functions such as heart rate, digestion, and respiratory rate. The ANS is composed of two branches: the sympathetic nervous system and the parasympathetic nervous system (Society for Neuroscience, 2016).
- **Axon:** The long tail of the neuron that carries the nerve impulse to the other end of the neuron from the dendrite.
- **Axon terminals:** The ending of the axons which contain the neurotransmitters.
- **Brain stem:** The part of the brain made up of the hindbrain and midbrain. Its functions include those needed for daily living, such as controlling breathing, heart rhythm, blood sugar levels, sleep/wake patterns, alertness, motor control, and eye movement.
- **Central nervous system (CNS):** The CNS is made up of the spinal cord and brain (Society for Neuroscience, 2016).
- **Cerebellum:** The part of the brain at the back of the skull that is responsible for the coordination and regulation of muscular activity.
- **Cerebral cortex:** The outer layer of the cerebrum that consists of four lobes: frontal, parietal, occipital, and temporal. The four lobes of the cerebral cortex are responsible for the important functions of processing cognitive, emotional, behavioral, and sensory information (Society for Neuroscience, 2016).
- **Cerebrum:** The largest part of the brain, which is responsible for higher order, more complex functions than our brainstem, including thinking, perceiving, planning, and processing language.
- **Critical period:** Periods with distinct windows of time when they start and stop. After the time period ends, the window of opportunity for the skill to develop closes.
- **Dendrite:** Hairlike or branched extensions at the end of the neuron. Its job is to be available to bring in signals, called neurotransmitters, from neighboring cells. Once the dendrite receives the message from a neighboring cell, it triggers the cell body to create a nerve impulse, like an electric current.
- **Dyslexia:** Dyslexia is a learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities.
- **Executive functioning:** A set of cognitive skills that controls impulses and filters out distractions. Executive functions allow children to focus their attention, organize information, put a plan into action, and also have a back-up plan if necessary (Diamond, 2006).
- **Experience-dependent:** This describes connections in the brain that happen only if the child receives the environmental stimuli to build those connections.
- **Experience-expectant:** This describes connections made in the brain that form based on exposure to experiences that most people or animals would have in their environment.
- **Forebrain:** The forward or front part of the brain. It includes the cerebrum—the largest part of the brain—which is responsible for higher order, more complex functions like thinking, perceiving, planning, and processing language.

- **Frontal lobe:** The frontal lobe of the cerebral cortex is located at the very top, front of the brain, and is the last part of the brain to develop fully.

  Functions of the frontal lobe include (Society for Neuroscience, 2016):

  - starting and coordinating motor movement;
  - higher order cognitive skills: thinking, planning, problem solving—all necessary for executive functioning; and
  - personality and emotional processing.

- **Gray matter:** Gray matter makes up most of the parts of the neuron, except the myelin sheath. The growth of gray matter peaks in early childhood (Grigorenko, in press).
- **Hindbrain:** The part of the brain located at the base of the brain near the spine. It includes the cerebellum, pons, and the medulla oblongata. It is intact and well developed at birth (Society for Neuroscience, 2016). The hindbrain is responsible for the basic functions for human life. It controls breathing, heart rhythm, and blood sugar levels (Society for Neuroscience, 2016).
- **Midbrain:** The midbrain is located between the hindbrain and forebrain. Its functions include eye movement, hearing, motor control, sleep/wake patterns, alertness, and temperature regulation. The midbrain and hindbrain together are often called the "brain stem."
- **Migration:** The process of cells moving to form different brain regions.
- **Myelin sheath:** The fatty material that insulates the neurotransmitter that helps it travel smoothly down the axon from the cell body to the axon terminals. The axon serves as the pathway; the myelin sheath keeps the impulse on the path so it doesn't escape and also helps the signal move faster. The more insulated the axon is by the myelin sheath, the more accurately and quickly it is sent (Society for Neuroscience, 2016).
- **Nervous system:** The nervous system consists of the brain, spinal cord, and a complex network of neurons that extend throughout the body. The nervous system is responsible for sending, receiving, and interpreting information from all parts of the body. The nervous system monitors and coordinates internal organ function and responds to changes in the external environment. The nervous system is made up of two parts: the central nervous system and the peripheral nervous system (Society for Neuroscience, 2016).
- **Neural induction:** The process that entails certain cells specializing, developing into nerve tissue, as the embryo grows (Society for Neuroscience, 2016).
- **Neural networks:** Neurons communicate, or connect, with one another by sending nerve impulses from one neuron to another, forming long chains. These chains eventually create complex networks. Neural networks look like long chains, all crossing each other.
- **Neural tube:** The hollow structure from which the brain and spinal cord form (Society for Neuroscience, 2016).
- **Neuron:** A nerve cell used to pass messages across the nervous system.
- **Neuroplasticity:** The phenomenon that connections in the brain are influenced by a person's experiences in the world. The brain is more adaptable during early childhood years and becomes less adaptable as individuals grow older. Two types of neuroplasticity are experience-dependent and experience-expectant.
- **Neurotransmitter:** "Messages" that cross synapses sent from one neuron to another to tell it to either pass the message along to the next cell or to stop there (Society for Neuroscience, 2016).
- **Occipital lobe:** The function of the occipital lobe is to process visual information, such as shapes and colors (Society for Neuroscience, 2016).
- **Parasympathetic nervous system:** A part of the autonomic nervous system which helps to soothe the body and to regain its equilibrium, or homeostasis. It signals the body to conserve energy or "rest and digest," by slowing the heart rate and breathing and relaxing the body to allow digestion, reproduction, and other systems to function again (Society for Neuroscience, 2016).

- **Parietal lobe:** The parietal lobe is one of four lobes of the cerebral cortex. The parietal lobe's functions include sensory processing, such as knowing where your body is in space and how you see print or objects in relation to one another. The parietal lobe also regulates attention, or how well a person is able to tune in and focus on a thought or action. Another important function of the parietal lobe is its involvement in the ability to learn and recall words to communicate at appropriate times (Society for Neuroscience, 2016).
- **Peripheral nervous system:** A system made up of nerve fibers that branch off from the spinal cord and extend to all parts of the body.
- **Prefrontal cortex:** The front part of the frontal lobe. This region of the brain is widely considered the center of executive functions and is responsible for regulating thought, emotions, and actions.
- **Pruning (or synaptic pruning):** The process by which neural connections are refined. Neural circuits and connections that fire more often (i.e., are used more often) are retained, and those that are not used are removed (Society for Neuroscience, 2016). Pruning allows brain circuits to run more efficiently. Early experiences affect the nature and quality of the brain's developing architecture by determining which circuits are retained and which are pruned through lack of use. In this way, each child's brain becomes better tuned to meet the challenges of his or her particular environment (Siegel, 1999; Society for Neuroscience, 2016).
- **Sensitive period:** Sensitive periods begin and end gradually and represent the optimal time for maximum change, although change can occur after the sensitive period ends—it just requires more effort.
- **Spinal cord:** The part of the central nervous system that receives information from the skin, joints, and muscles. It also carries all the nerves that control all of our movements. Via the spinal cord, our brains receive information from our ears, eyes, nose, mouth, and the rest of our bodies.
- **Sympathetic nervous system:** A part of the autonomic nervous system that is responsible for mobilizing the body's physiological capacity to respond to a perceived threat. It is responsible for our "fight, flight, or freeze" reactions that require us to increase our energy expenditure. It tells the body to be on alert and use energy and resources that make the heart beat faster, signals the lungs to take in more air, and shuts down nonessential functions such as digestion and reproduction (Society for Neuroscience, 2016).
- **Synaptogenesis:** The process of creating connections between neurons, also known as synapse formation. Neurons that communicate with each other more often form stronger connections across their synapses (Society for Neuroscience, 2016).
- **Temporal lobe:** The temporal lobe has a variety of important functions, which include (Society for Neuroscience, 2016):
  - processing auditory information—such as hearing different pitches of sound,
  - language recognition—understanding what words mean,
  - storing visual memory—such as remembering a familiar face,
  - short-term and long-term memory—through a structure called the hippocampus, and
  - emotional responses—through a structure of the temporal lobe called the amygdala.
- **White matter:** White matter is the myelin. It gets its name from the white fatty cells it is made up of. White matter continues to develop into early adulthood (Grigorenko, in press).