Science of Learning and Development

April 2017

The following document contains two scientific articles produced as a part of the **Science of Learning and Development (SoLD) Project**. Both articles have been submitted to *Applied Developmental Science* and are currently undergoing peer review. Please do not copy or circulate without permission.

The Science of Learning and Development Project

Recent research – from leading scientists in a number of fields – is telling a new converging story about the scientific underpinning of how children develop, how they become learners, and how their environments can nourish or hinder their progress. This knowledge from the science of learning and development opens the door for new, creative approaches to education that have the potential to address some of the most intractable challenges facing our children, teachers, and school leaders.

The Science of Learning and Development (SoLD) Project is a new collaborative effort focused on elevating and translating this science to systems that educate children from birth to adulthood. The project is led by American Institutes for Research, the Center for Individual Opportunity, EducationCounsel, Learning Policy Institute, Opportunity Institute, and Turnaround for Children, along with our partners at the Chan Zuckerberg Initiative and a growing coalition of leaders from education research, developmental science, practice, and policy.

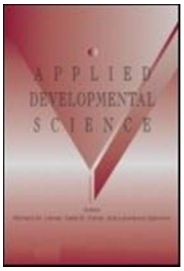
The SoLD coalition has worked with a number of scientists to synthesize cross-disciplinary research into a comprehensive paper. The paper tells a powerful story of human development from the prenatal period to early adulthood, including the role of environments, adversity, and relationships in understanding a child's unique trajectory. Translating this science to educational practice and policy is the foundation of the SoLD Project.

Supporting all students will require classrooms and schools that are child-centered, innovative, and personalized. To support this transformation in systems that educate children from birth to adulthood, the SoLD Project aims to:

1. **Broaden the coalition** committed to making SoLD a core pillar of education practice, policy, and research to transform education systems.
2. Engage leading scientists from diverse disciplines to **articulate and spread this science** to practitioners, families, policymakers**,** and the broader public.
3. Develop a **shared research and development (R&D) agenda** that identifies and begins to address crucial next-generation questions about the science of learning and development and its implications for classroom practice and school design.
4. Translate the necessary shifts in education practice into **concrete, actionable principles and tools for practitioners** to **implement** science-informed approaches to teaching and learning.
5. Identify and support the **federal, state, and local policies** that will best enable these shifts.

The SoLD Project is bringing together diverse leaders in science, practice, and policy to transform our nation's education systems. The science of learning and development is revealing what we must do for each child to be successful in school and beyond. We must now ensure that what we know drives what we do for our children.

If you would like to learn more about the SoLD Project and get involved in our work, please contact Jess Wood at jess.wood@educationcounsel.com.



Malleability, Plasticity, and Individuality: How Children Learn and Develop in Context

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Malleability, Plasticity, and Individuality: How Children Learn and Develop in Context

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Abstract

The paper synthesizes foundational knowledge on how the human brain develops, the major constructs that define human development, and the opportunities for resilience. A companion paper focuses on the role of relationships and context in supporting and/or undermining the healthy development of children and youth. The complex relations between our genes, biology, and physiological systems, the social environments we are exposed to, and how we interpret and internalize them, affect the expression and fulfillment of our individual genetic potential. An understanding of neural malleability and plasticity, the dynamics of resilience, and the interconnectedness of individuals with their social and physical contexts offers a transformational opportunity to influence the trajectories of children's lives. This scientific understanding of development opens a path for new, creative approaches that have the potential to solve seemingly intractable learning and social problems.

Malleability, Plasticity, and Individuality: How Children Learn and Develop in Context[1]

Recent decades have witnessed an explosion of knowledge about how children grow and develop into whole individuals, how they become learners, and the contextual factors that nourish or hinder that development. This knowledge comes from diverse fields including neuroscience, epigenetics, early childhood, the social sciences, psychology, adversity science, and the learning sciences. This powerful scientific research has the potential to offer valuable insights for the practices of educators and caregivers. Nevertheless, it remains largely under-utilized, contributing to persistent disparities, challenges, and inadequacies in our education systems, other child- serving systems, and the supports that we provide to families.

Recent advances represent the accumulation of research, theory, and practice-based knowledge (e.g. Osher, Kidron, Brackett, Dymnicki, Jones, & Weissberg, 2016), advances in our ability to measure and model biological, human, and social factors (e.g., Rose, Rouhani, & Fischer, 2013), and advances in the array of data and methods now available (e.g., Entwisle, Hofferth, & Moran, 2017).

The ability to realize the fullest potential of this knowledge is limited, paradoxically, by both the richness of the knowledge itself as well as the particular disciplinary structures, paradigms and traditional incentives that have supported the accumulation of this rich knowledge—issues that affect the social and intellectual construction of knowledge (e.g., Kuhn, 1970). Disciplinary paradigms reflect and beget delimited questions, measures, epistemes, and

[1] The authors limited the citations in this version of the paper due to space constraints. Only one citation was kept in the cases where more than one citation was originally listed. A set of decision rules was used to narrow the list of references. The rules and order in which they were applied are as follows: 1. Preference was given to references that were cited more than once. 2. No more than two references by the same first author were kept. 3. For each list of multiple citations, the most recent reference was kept. The full list of references will be available online.

frameworks. Publishing in one's own disciplinary journal is often more highly rewarded than interdisciplinary work; funders often have narrow priorities; and research teams often lack cultural diversity or direct knowledge of the matters and/or contexts that are studied. There is a need to align, synthesize, and conciliate knowledge that has been accumulated in biology, psychology, and the social sciences (e.g., Fedyk, 2015). This work has begun to be pursued in such fields as life-course studies (e.g., Mortimer & Shanahan, 2006) and developmental systems theory (e.g., Lerner & Overton, 2008).

The purpose of this article and a companion article to follow entitled "Drivers of Human Development: How Relationships and Context Shape Learning and Development" is to identify and synthesize the most salient research and knowledge regarding learning and development, with emphasis on where there is a convergence of evidence across multiple disciplines and lines of inquiry. We intend to clarify what this convergence suggests for a comprehensive, integrated science of learning and development.

Our methodology included systematically gathering and reporting findings that showed consistency across sources. The findings presented in the paper come from a variety of correlational, longitudinal, and causal studies. Our approach was not to rely solely on causal evidence, but to triangulate our findings across multiple sources. We first solicited and reviewed recommendations for critical works from experts in the areas of science identified in this paper. In addition, we conducted a search of systematic reviews, meta-analyses, peer-reviewed literature reviews, and handbook chapters that synthesized the latest research. In some cases, we supplemented these papers with empirical and theoretical studies to nuance and validate our findings. Our sources either synthesized an area of research with an established body of knowledge or presented findings that have been reproduced in multiple studies. We tempered the

language where the literature showed less consistency because the science is more nascent. Finally, we sent out a first draft of the paper to established experts in the relevant areas of science to vet our findings and ensure that they agreed with the evidence presented in the paper.

In this synthesis, we first summarize the key findings of our study. We then synthesize a broad and deep literature of how the human brain develops, including the role of epigenetics in shaping such development. Next, we present the major constructs that define human development, with specific attention to both affective and cognitive dimensions, the role of adversity, and the opportunities suggested by research on resilience. The paper concludes with an integrated summary across these lines of research and introduces its associated paper.

The companion paper focuses on the role that relationships and micro- and macro-contextual factors play in supporting or undermining the healthy development of children and youth. Specifically, the paper examines: important contexts (e.g., families and schools) and actors (e.g., teachers and peers); the characteristics of such contexts and actors that affect development; social factors that undermine development (e.g., institutionalized racism, poverty, and lack of support for adults who must attune to the needs of children); and strategies and contextual supports that can buffer the effects of those undermining factors. This companion paper concludes with a summary of the entire body of work and suggestions for the important R and D effort that is needed to aggressively translate this knowledge into settings and practices that ensure healthy development and successful educational and life outcomes for all children.

Key Findings

This paper synthesizes foundational knowledge about human development and the effects of context (both positive and negative) on that development. This knowledge includes how the complex relations between nature (our genes, biology, and physiological systems) and nurture

(the physical and social environments we are exposed to), as well as how these are interpreted and internalized—all of which vary across time, place, and among individuals –affect how individuals express and fulfill their genetic potential (e.g., Knafo & Jaffee, 2013).

Development is a cascade of changes over time that emerge through increasingly novel and complex transactions between an individual and his or her social and physical contexts (e.g., Lavigne, Gouze, Hopkins, & Bryant, 2016). In this way, the developing brain draws on relationships and environments to build layer upon layer of representational templates over time (Siegel, 2012). An understanding of neural malleability and plasticity, the dynamics of resilience, and the interconnectedness of individuals with their social and physical contexts offers a transformational opportunity to influence the trajectories of children's lives. This scientific understanding of development opens a path for new, creative approaches that have the potential to solve seemingly intractable learning and social problems. In synthesizing the research across diverse disciplines, some overarching themes emerge. These are summarized in Table 1.

Brain Structure and Function[2]

The brain is organized from the inside out. There are four major parts: the brainstem, the diencephalon, the limbic system, and the cortex. The lower, more central regions of the brainstem and the diencephalon are the simplest. They evolved first and they develop first in children, followed by the limbic system, and finally the cortex—the structure that defines us as humans. The brainstem maintains our core regulatory functions, like heart rate and temperature. The diencephalon and the limbic system handle emotions and regulation. The cortex regulates the most complex and highly human functions, like speech and abstract thinking. All of these functions become progressively more integrated and complex as we grow.

[2] This section is a synthesis of work by Dan Siegel, M.D., and Bruce Perry, M.D., who have synthesized their own and the work of many other researchers.

The brain has an estimated 100 billion neurons, which are collectively over two million miles long. Each neuron has an average of 10 thousand connections that directly link it to other neurons. Thus there are about one million billion of these connections, making the brain "the most complex structure, natural or artificial, on earth" (Siegel, 2012, p. 15). Electrical impulses transmitted over these connections create the interconnections in the brain; this web of interconnections means that activation of one neuron can influence an average of 10,000 neurons, creating an immense number of "on/off" patterns.

The brain's development is an "experience-dependent" process. In fact, neurons and neural tissue are the most susceptible to change from experience of any tissue in the body. Experience is a "stressor" to brain growth. Relational connections activate neural pathways, generating "energy flow" through electrical impulses, strengthening the connectivity among brain structures and creating new ones. This energy flow is driven by interpersonal experiences throughout life. Neurons change is based on repetitive experience; the importance of this molecular gift in children's development cannot be overestimated. Experiences can shape not only what information enters the mind, but the mind's ability to process that information. Experience creates representations, and those representations stimulate the brain's ability to process and make meaning out of new information. If experiences are interpersonally rich, predictable, and patterned, stress makes the brain stronger and more functionally capable, increases connectivity and integration, and increases resilience to stress.

At birth, an infant's brain is the most undifferentiated organ in the body. Genes and early experience shape the way neurons connect to one another and form the circuits that give rise to increasingly complex mental processes. The differentiation of circuits within the brain involves a number of different processes, including the growth of axons, the establishment of new and more

extensive synaptic connections among neurons, the growth of myelin along the length of the neuron (which increases "processing speed"), and the modification and sensitivity of receptor density for the "receiving neuron." All of this is balanced against the amount of "pruning" (cell death). This pruning occurs naturally, but is greatly increased under prolonged stressful conditions. Enriched environments do the opposite—they lead to enhanced synaptic connections. Interpersonal experience influences the growth of the brain throughout childhood and early adulthood; the early period is particularly important for self-regulatory processes.

From an information-processing perspective, signals come to the brain from inside the body, from other parts of the brain, and from the outside world. The sending areas include deep physiological structures inside the body; limbic structures, including memory; and neocortical structures processing language, emotion, sensation, and perception. The processing function of the brain is to integrate this information so that it becomes increasingly useful and gains meaning. To accomplish this, the brain creates templates—"representations"—of these types of stimuli. Templates are drawn from prior experience, both emotional and cognitive (including some experiences that are not remembered consciously). If an experience is predicted and patterned, the brain tags it as normal and does not continue to focus on it. But if something is not normal or predictable, or is hurtful, the brain pays attention to it. This is particularly important with respect to the templates caused by early traumatic experiences: the brain can become "habituated" to negative templates from prior experience and not recognize them as abnormal.

The brain is a complex system whose own internal processes organize its functioning. This property is called "self-organization." Subtle and rapid shifts in synaptic strength come about because of new learning from experience. The driving force of development is the movement from simplicity toward complexity. Think about the baby that rolls over, maintains a

sitting position, stands, and ultimately walks, runs, or dances. The brain's drive to complexity is consistent with the principles of nonlinear dynamic systems: such systems have self-organizing properties, are nonlinear, and are recursive. Patterns emerge constantly in interaction with the environment, and some become reinforced and continue to influence future experiences, consistent with Donald Hebb's notion that "neurons which fire together, wire together". This is how repeated states of activation shape neuronal circuits, which then form enduring states of mind for individuals. These systems are stable and predictable, but also malleable and flexible, having the capacity for variability, novelty, and uncertainty. It is the healthy balance between stability and flexibility that allows us to use experience for adaptation and growth. Pathological states like severe recurrent stress bring greater rigidity in the system.

Relationships, Epigenetics and Human Development

Human development represents the interconnectedness of experience, gene expression, gene regulation, neurobiological and biological systems, perceptions, and behavior. Our genes are inseparable from other dynamic developmental systems that involve individuals, social contexts, culture, and history (Lerner, in press). "Positive development" emerges from the integration of several individual and contextual systems, from the biological and physiological to the cultural and historical (e.g., Spencer, 2007). The neural circuitry in the brain is intricately linked with the other physical systems of the body—the immune, endocrine, metabolic, cardiovascular, and musculoskeletal systems—as well as with ecological systems (e.g., Overton, 2015). Consequently, factors that affect one system, affect others. These, in turn, are affected by structural and historical factors (e.g., Ruiz, Quackenboss, & Tulve, 2016).

In this contextual and relational developmental systems framework, our genes are followers, not the prime movers, in developmental processes (e.g., Fischer & Bidell, 2006).

Genes are packages of biological instructions, requiring signals to determine which processes are carried out (Center on the Developing Child at Harvard University, 2016). Genes determine the number of neurons we are born with, but social and physical contexts influence which genes are expressed, how, and when (Keating, 2016).

Epigenetic signatures (chemical signals derived from environmental influence) affect how easily genes are switched on and off and whether the change is temporary or permanent. This process is called epigenetic adaptation, and it shapes how our brains and our bodies develop. Epigenetic adaptation is part of a system of ongoing, two-way exchanges between human beings and the physical and social world that create qualitative changes to our genetic makeup over time, both within and across generations (Lerner, in press). Epigenetic adaptation is the biological process through which the environment of relationships, experiences, perceptions, and physical and chemical toxins get under the skin and influence lifelong learning, behavior, neural integration, and health (Bernstein, Meissner, & Lander, 2007). Epigenetic adaptation can begin during pregnancy and even preconception (through the mother's experiences), and contributes to the transmission of behaviors and experiences to future generations (e.g., Keating, 2016). Encouragement of adaptive epigenetic signatures and buffering the factors that contribute to maladaptive epigenetic signatures are powerful levers to realize children's genetic potential.

The brain is built from the bottom up. "Skills beget skills" (Heckman & Masterov, 2007, p. 447), with increasingly complex circuits building on simpler circuits, and increasingly complex adaptations emerging over time. Foundational social, emotional, and cognitive competencies accumulate in a cascading way, and interact with individual and environmental risk factors and assets to allow children to act in ways that optimize or interfere with their

development and their physical and emotional wellbeing (Nagaoka et al., 2015). Critical neurobiological processes, including neural integration (the perpetual experience-dependent remodeling of the brain) and neurogenesis (the formation of new brain cells), drive the growth and adaptability that are essential to healthy development and learning. Synaptic connections can grow in number and strength, and neural integration can increase through strong inter-personal connections, development of reflective skills, and focused attention (Siegel, 2012). This developmental integration occurs when the strengths of children and youth are aligned with the resources for positive growth in families, schools, and communities (e.g., Benson, Scales, Hamilton, & Sesma, 2011). These resources are promotive when they are developmentally appropriate, culturally competent, and a good fit with the child (e.g., Allen & Kelly, 2015).

Relationships and experiences are the signals to which our genes respond. They help guide the genetically programmed maturation of the nervous system, which shapes the structure and function of the developing brain (e.g., Siegel, 2012). These relationships take place within proximal, bidirectional, interpersonal contexts that are themselves nested within larger micro- and macrosystems. These contexts powerfully influence how adults in a setting interpret and respond to the needs of children and youth (e.g., Brody, Miller, Yu, Beach, & Chen, 2016).

Three relationship characteristics have the potential to build strong brain architecture: (1) warm, consistent, and attuned relationships in which learning is fostered and scaffolded; (2) positive experiences inside and outside the home; and (3) positive perceptions of these experiences (e.g., Center on the Developing Child at Harvard University, 2016). Relationships with these characteristics are necessary for developing the emotional, social, behavioral, and cognitive competencies foundational to learning and development—including those we often take for granted, such as language development and literacy (e.g., Sroufe, 2005). Over time, a combination

of skills, knowledge, dispositions, and social and self-awareness, as well as physical and mental wellness, work together to enhance children's wellbeing and opportunities for success in learning and life (e.g., Nagaoka et al., 2015).

Epigenetic adaptation is not confined to a finite period in childhood. Nor is development a progression of fixed stages, like a ladder. The epigenetic-adaptation perspective views the developing brain and emerging mind as constantly organizing and integrating experience and building connectivity and mental representations of experience and identity across time (Siegel, 2013). The process continues into adolescence and adulthood, allowing malleability in development and behavior for far longer than once believed possible. We know today that there are several periods of brain "remodeling," such as in adolescence, during which fundamental brain processes become increasingly integrated through heightened connectivity among brain structures (NRC, 2015). This development is exquisitely sensitive to the relationships and experiences that are present when it is taking place, as well as to the presence of chronic stress (Center on the Developing Child at Harvard University, 2016).

The contemporary model of epigenetic adaptation runs counter to the genetic reductionist view of evolutionary change that sees genes as the primary mover in human development, and counter to trait theories that posit that temperament and personality are determined by genes (see Lerner, in press). Dynamic developmental theory (Fischer & Bidell, 2006) suggests that human attributes are only partially biological; they are affected by multiple and constant relations with people and contexts (e.g., Osher, Kidron, Brackett et al., 2016). The reciprocal and dynamic interactions that support the development of the brain provide something that nothing else in the world can provide—experiences that become individualized to, and ultimately shape, children's identities, awareness of self and others, and potential (e.g., Rose et al., 2013).

The Science of Attachment

The early child–caregiver attachment relationship is particularly influential in infancy, and continues to be important as children develop (e.g., Sroufe, 2005). Although prenatal development is important, a significant part of the mammalian brain emerges after a child is born, and becomes organized over time through the social context (Siegel, 2012). The first year of life is especially important, as sensory, social, and emotional interactions provide learning opportunities for the optimization of low-level brain circuits, which are the foundation for increasingly complex circuits that emerge in later years, particularly for self-regulation (Center on the Developing Child at Harvard University, 2016). Early interactions create patterns of organization as neural circuits and hormone levels change in both the infant and caregiver. This establishes blueprints for coordinated interpersonal behavior, attitudes, and expectations about the self, others, and relationships that become the foundation for short-term and long-term functioning (e.g., Knafo & Jaffee, 2013). Shared experiences, attunement, and co-regulation provide a foundation for a healthy early caregiver–child relationship. Longitudinal research on attachment reveals that early relational patterns between infants and parents, absent effective intervention, greatly influence how children will interact later on with teachers and peers (Sroufe, Egeland, Carlson, & Collins, 2005). However, key adults—parents, teachers, and other providers—have the capacity to attune to, reorient attachment to, and establish positive relationships with children and youth into adulthood (e.g., Siegel, 2012).

Pattern-making is thought to occur through sequences of attunement, mis-attunement, and re-attunement that involve emotional responses, attention, executive functions, the reward and motivation system, and sensorimotor systems (Kim, Strathearn, & Swain, 2016). In the first months of life, social synchrony—the coordination of social behavior between caregiver and

infant in gaze, vocalization, affect, and touch—triggers biological synchrony (via heart rhythms and oxytocin levels), which helps parent and infant bond. During that time, the caregiver co-regulates her own and her infant's emotional arousal and physical needs (e.g., Kim et al., 2016). Attunement—the capacity of each to sense what the other needs and thinks—creates a resonance between adult and child. At toddler age, co-regulation gives way to a "caregiver-guided" form of regulation, and this then transitions to an increasing ability to autonomously regulate the self. Emotion and the development of the ability to regulate emotional states moves the self, over time, into increasingly complex forms of interrelationship with environment and experience (Siegel, 2012).

Co-regulation is particularly important in the first years of life, as the child develops the capacity to self-regulate (e.g., Halfon et al., 2001). Attachment relationships with parents, family members, and other caregivers support development through opportunities to: (1) explore surroundings; (2) build language skills, through language-rich and responsive interactions; and (3) build social competence, through successful social interactions (e.g., IOM & NRC, 2015). Neurobiological research suggests that attuned communication between caregiver and child balances excitatory and inhibitory systems in the brain. This balance is critical for the development of the neurobiological systems involved in processing emotion, cognition, modulating stress, and self-regulation, all of which provide the foundation for later healthy functioning (e.g., Feldman, 2015).

Certain characteristics of the caregiver–child relationship and the home environment can threaten attunement as well as relational and neural integration, and can result in disorganized attachment patterns. Some characteristics that result in disorganized attachment are emotional or physical rejection, hostility, lack of appropriate responsiveness, and unpredictability. One cause

of dysregulation is postpartum depression, which affects 10 to 20 percent of new mothers and somewhere between 4 and 26 percent of new fathers. The percentage can be drastically higher in parents with histories of depression and stress hormone dysregulation (e.g., Kim et al., 2016).

Prolonged periods of unbuffered, unregulated child stress can affect a child's capacity to learn to self-regulate and disrupt the structure and processes of the child's brain, neuroendocrine system, and immune system (e.g., Bucci, Marques, Oh, & Harris, 2016). Disorganized attachment endangers the development of foundational competencies (e.g. executive functions, emotion recognition, and social information processing) (e.g., Blair & Raver, 2016). Children with disorganized attachment patterns in their families can meet their needs for later attachment in ways that are positive (e.g., strong adult and peer relations) or negative (e.g., early pregnancy and gang involvement).

Many interventions can help families at risk for poor attachment relationships create positive, reciprocal, and nurturing relationships with their young children (Furlong et al., 2012). Some examples include the ABC Intervention (Bernard, Hostinar, & Dozier, 2015) and the Positive Parenting Program (Triple P) (Sanders, Kirby, Tellegen, & Day, 2014).

The Science of Self-Regulation

Self-regulation skills and attributes, referred to here under the umbrella term self-regulation, have a strong base of correlational and causal evidence to support their malleability, developmental progression, and vital contribution to short-term and long-term social, emotional, cognitive, academic, financial, and health outcomes (e.g., Siegel, 2013). A large base of research shows the importance of the intentional development of self-regulation skills, such as executive functions and effortful control and the specific vulnerability of these skills to the experience of prolonged unbuffered stress (e.g., Center on the Developing Child at Harvard University, 2016).

Self-regulation encompasses a set of foundational skills that involves interrelated emotional, cognitive, social, and attentional systems that aid in managing cognition, attention, behavior, and emotions, and support goal-directed behaviors (e.g., Blair & Diamond, 2008). Self-regulation encompasses many different regulatory-related attributes that range from basic, automated, physiological functions (e.g., circadian rhythm) to more complex, intentional processes (Gestsdottir & Lerner, 2008). Intentional self-regulated behavior, motivation, and cognition are initiated when a person consciously sets out to attain a goal or when routine activities are impeded. Intentional self-regulation includes well-researched skills such as "delay of gratification" and effortful control, as well as the ability to implement goal-related strategies, optimize goals to meet personal and social values and desired abilities, and compensate in the face of blocked or lost goals (e.g., Jones, Bailey, Barnes, & Partee, 2016). Intentional self-regulation in learning, is a constructive process whereby people set goals for their learning and then continue to monitor or control their cognition, motivation, and behavior based on the assessment of success or failure in attaining their goals.

Executive functions are the set of neurocognitive attention-regulation skills involved in the conscious goal-directed modulation of thought, emotion, and action (e.g., Blair & Diamond, 2008). Executive functions involve top-down, intentional control of behavior, as well as bottom-up, automatic reactions. They are defined as having three components: cognitive or mental flexibility (switching from one demand to another and considering others' perspectives), working memory (holding and manipulating information in the short term), and inhibitory control (mastery and filtering of thoughts and impulses to resist habits, temptation, distractions, and thinking before acting) (Center on the Developing Child at Harvard University, 2016).

Executive functions are necessary for more complex self-regulation-related skills such as problem-solving, focus and self-control, perspective-taking, communication, making connections, critical thinking, taking on challenges, and self-directed and engaged learning (e.g., Jones et al., 2016). Executive functions are so fundamental to learning and school readiness because they prepare children to be engaged learners, to pay attention, and to follow rules, all of which are essential for school success (Zelazo, 2015).

Self-regulation skills and attributes are themselves critical for success in school and life, but they also underlie or are intricately linked with other foundational competencies, such as attention, memory, and stress management (Center on the Developing Child at Harvard University, 2016). They are important prerequisites for developing (with some contextual support) perseverance and contribute to resilience (e.g., Stafford-Brizard, 2015).They are considered responsible for many of the skills necessary for higher-order learning and social competence, including problem solving, decision making, organizing behavior, self-direction, learning from educational experiences and practice, and conflict resolution (e.g., Jones et al., 2016). Self-regulation-related skills and attributes underlie interpersonal competencies and school readiness, promote better relationships with teachers and peers, (Raver, Garner, & Smith-Donald, 2007) and are seen by teachers as evidence of greater academic and social competence (Blair & Diamond, 2008). These factors are associated with greater engagement in school (e.g., Zelazo, 2015). Self-regulation-related skills and attributes are associated with greater likelihood of graduating from college, and better health and wealth in adulthood (e.g., Zelazo, 2015).

A growing body of research suggests that self-regulation, including executive functions, is a particularly important target for intervention for children who are challenged by attentional issues and impulsivity (e.g., Jimenez, Wade, Lin, Morrow, & Reichman, 2016). Research in

diverse fields has found that effective interventions that address self-regulation can help children who have experienced a variety of poverty-related adversities to be better prepared to successfully engage in learning and better succeed in school (Center on the Developing Child at Harvard University, 2016).

Self-regulation of emotion, in particular the regulation and synchrony of emotional states, is central to the overall regulatory and integrative processes of the developing brain (Siegel, 2012). To accomplish this, the developing brain exists in a continuous feedback loop between emotion regulation (emotional self-regulation), executive functions (response inhibition, attention shifting, and working memory), motivation, and the stress response. This feedback loop helps these systems mutually organize each other and establish increasingly complex representations of the meaning of experiences. (e.g., Siegel, 2013). Indeed, the associations between self-regulation and important child outcomes such as school readiness and academic competence are thought to be due to the coordination and mutual reinforcement of each of these subsystems (emotional regulation, executive functions, stress regulation) (e.g., Jones et al., 2016).

Self-regulatory capabilities interact continuously within the microsystems of relationships in which children develop. Self-regulatory capabilities are distinct from attitudes, beliefs and mindsets. Alone and together, all of these factors contribute to healthy social, emotional, cognitive, metacognitive, and academic development, enable productive engagement with the social and physical world, and modulate the experience of stress (e.g., Almlund et al., 2011; Dweck, Walton, & Cohen, 2011; Farrington et al., 2012; Nagaoka et al., 2015).

The Science of Individuality

The science of individuality is grounded in dynamic systems theories (e.g., Thelen & Smith, 2006), and starts with the premise that individuals vary in how they learn, behave, and develop; that these processes vary according to the context; and that there are patterns within that variability (e.g., Rose et al., 2013). The individual–context interaction is part of a holistic, integrated, and self-constructing system that includes actions that take place at the cellular level (in cells within microenvironments in the body), the genetic level (in gene–context interactions), and the neurobiological, phenomenological, emotional, and behavioral levels (Overton, 2015). Although individual patterns exist, these patterns change according to context, which includes microenvironments within the same overall context (e.g., schools or families) (e.g., Osher, Kidron, DeCandia, Kendziora, & Weissberg, 2016). The science of individuality has implications for diverse areas of research, from exploring development of cancer cells to the development of literacy and social behavior in children. Its principles are consistent with a range of fields of study, including research on the differential effects of interventions (Kellam, Koretz, & Mościcki, 1999) and on the historical and phenomenological factors that affect and differentiate individual responses to the experience of adversity (Spencer, 2007), as well as research that suggests that individual differences in developmental plasticity and susceptibility to environmental influences are part of an integrated system that includes a neurobiological component (e.g., Johnson, Riis, & Noble, 2016).

A major implication of the science of individuality and the idea of relative plasticity is that there is not one ideal developmental pathway for everyone; there are multiple pathways to healthy development, learning, academic success, and resilience (e.g., Rose et al., 2013). Rather than study averages, research should start with a focus on understanding patterns in individual

variation across contexts, and from there build toward generalizable models of growth and learning (Rose et al., 2013).

Plasticity and susceptibility to the environment can work in beneficial or harmful ways (Cole, 2014). Some children (and certain developmental periods) are more vulnerable to adversity and stress, but those same children may also benefit the most from support and enrichment in their environment. For example, more susceptible children can realize better outcomes when securely attached, and more negative outcomes with disorganized attachment (e.g., Bakermans-Kranenburg & Van IJzendoorn, 2007). The idea of differential susceptibility implies that great opportunity exists in intervening in the lives of children who experience the most dysregulation in the face of stress and adversity. It also implies that although children may be more susceptible to adversity in the first few years of life (and other sensitive periods), they also are likely more malleable in the context of interventions (e.g., Johnson et al., 2016).

The Science of Learning

Research in multiple fields of study has led to the development of a set of principles regarding how students learn (e.g., Goldman & Pellegrino, 2015). These fields of study include: neuroscience, cognitive science, and the learning sciences; research on social, emotional, and academic learning; and research on the social and emotional conditions for learning. The resulting principles can help align instruction with the way the brain works and facilitate the personalization of learning. The principles address 8 sets of factors: student background and knowledge; cognitive load and the limits of working memory; metacognition; social, emotional and cognitive development; motivation; interpersonal factors that affect learning; the social and emotional conditions for learning; and cultural responsiveness and competence.

Although these principles are distinct, learners experience them simultaneously and interactively. Learning depends on relations and supports within and among individuals, classroom and school contexts, and other opportunities to learn. Theoretical and empirical evidence on the interconnection among emotional, cognitive, social, and affective functioning suggests that students learn most deeply in environments that promote intrinsic motivation; where they see themselves as competent and capable learners; where they have high expectations for themselves; where they have the capacity to persist at challenging tasks; and where they feel they can take risks, reflect on and learn from their mistakes, and persist through challenges (e.g., Goldman & Pellegrino, 2015). "Skill, will, and thrill" are important (Hattie & Donoghue, 2016). Skill involves prior or subsequent achievement; will relates to dispositions towards learning; and thrill refers to motivations to learn. Timely, clear, and specific feedback that is focused on the task, centered around improvement, and experienced as supportive can link the social, emotional, and cognitive aspects of learning (e.g., Deans for Impact, 2015). Ecological resources such as social networks, cultural beliefs, cultural assets, and institutional practices also shape these variables (Lee, 2009).

Many examples highlight the interconnections among these principles. For instance, students learning to comprehend texts are influenced by their teachers' perceptions of them, the importance to them of making sense of the text, their ability to understand the text, and their interpretation of success or failure, all of which are impacted by prior knowledge, their experiences with reading at school and at home, and their social and academic identities (Lee et al., 2015). Reading comprehension also depends on classroom and school factors—most notably, relationship-building and instructional strategies that are developmentally appropriate and personalized (Lee, 2010).

The neural systems that underlie learning exhibit plasticity throughout the lifespan, vary between individuals, and respond to environmental stressors, culture, societal norms, and social interactions (Center on the Developing Child at Harvard University, 2016). Cognitive development occurs through the acquisition of new knowledge and experiences, and not through a linear age-related progression (e.g., Deans for Impact, 2015). Neural integration and the mastery of new information is more likely to occur when different parts of the brain are strengthened and exercised through appropriate learning opportunities, social support for learning, modeling, scaffolding, reflection, and practice (Deans for Impact, 2015).

Students are not "blank slates" – they bring to school *prior knowledge* of how the world works; beliefs about themselves, their intelligence, and learning; epistemological beliefs*;* content-specific knowledge; and cultural knowledge, skills, and schema that may be incomplete or inconsistent with instruction, language, and discourse practices (e.g., Ambrose & Lovett, 2014; Yeager, Johnson et al. 2014). Prior knowledge encompasses both metacognitive and cognitive skills as well as conscious and unconscious knowledge, including incorrect knowledge that needs to be unlearned and automated beliefs and attributions from past experiences (e.g., Ambrose & Lovett, 2014). Prior knowledge and skill affect how students receive and process information (e.g., Nihalani, Mayrath, & Robinson, 2011). Teachers can leverage prior knowledge and interests to enhance engagement and support learning; meanwhile, when such factors are not considered, students may be less engaged (Ambrose & Lovett, 2014).

Effective instruction addresses *cognitive load* – the amount of mental effort being used in working memory – as well as the limits of working memory (Alloway, 2006). The presentation of knowledge affects how it is retained and transferred. Though novice learners process and retrieve knowledge less efficiently than experts (e.g., Kalyuga, Ayres, Chandler, & Sweller,

2003), teachers can help students build new disciplinary knowledge by combining intentional and explicit instruction about key ideas with hands-on learning experiences. Thoughtfully organized frameworks that enable novice learners see the whole picture can facilitate the retrieval and application of new concepts and deepen knowledge. Though alleviating cognitive load is important, it should not result in oversimplification; information should be presented germanely (Paas, Renkl, & Sweller, 2004).

Evidence suggests that most learning is non-conscious and automated (Clark, 2006). *Metacognition* supports neural integration and enables students to become active participants in the learning process and learn from their mistakes (e.g., Marcovitch & Zelazo, 2009). Strategies that encourage metacognition help students reflect on their affective states, how well they are learning, and how new knowledge fits into existing knowledge, which support the development of expertise and the ability to transfer knowledge to new situations (e.g., Clark, 2006).

Emotional, affective, social, and cognitive processes impact knowledge acquisition and retention, transfer and application of knowledge beyond the classroom, and performance on standardized tests. Social and emotional competence affects learning and instruction (e.g., Immordino-Yang & Damasio, 2007; Osher , Kidron, Brackett et al., 2016) and is critical to students' school and life success (e.g., Immordino-Yang & Damasio, 2007). Critically, these skills are malleable and can be taught and developed (Osher, Kidron, Brackett et al, 2016).

Contrary to popular belief, cognitive, emotional, affective, and social functions are intricately interrelated (e.g., NRC, 2012) and contribute to learning, memory, and knowledge transfer and application. The interrelationships between such functions are apparent at the molecular and behavioral levels, and these functions can both reinforce and interfere with one another (e.g., Center on the Developing Child at Harvard University, 2016). Neurobiologically,

neural circuits involved in emotion regulation (e.g., anxiety) overlap with those involved in body regulation (e.g., heart rate), sensation (e.g., physical pain), and cognition (e.g., executive control). Behaviorally, emotion affects motivation, engagement (e.g., flow), and academic performance (Meyer & Turner, 2006) through confidence, motivation, persistence, self-control, anxiety, and curiosity (e.g., Immordino-Yang & Damasio, 2007). Moreover, the neurobiological and behavioral processes involved in learning are nested within peer and adult relationships and opportunities that shape experiences and cultural knowledge, which in turn may impact learning, engagement, motivation, challenge, boredom, and frustration (e.g., Hammond, 2016). Each internal and external system contributes to an individual's ability and motivation to formulate ideas, perceptions, and understandings about his or her environment, which are further affected by self-assessment, self-reflection, and self-regulation.

Motivation affects engagement and performance (e.g., Clark, 1998). Three factors that appear to influence motivation are (1) perceived ability to accomplish a task, (2) value of the goals, and (3) mood and emotion (e.g., Hattie & Donoghue, 2016). Students are more motivated to learn – and are more effective learners – when they believe that their intelligence and ability can be improved through hard work (e.g., Linnenbrink & Pintrich, 2003), feel a sense of purpose, control, and efficacy in their learning (e.g., Dweck, Walton, & Cohen, 2011), experience support and belonging (e.g., Deans for Impact, 2015), identify strengths and weaknesses in their own learning (Koriat, 1993), and see value in the task (Linnenbrink & Pintrich, 2003). Intrinsic motivation is associated with deeper engagement, focus, creativity, confidence, and achievement (Patrick, Turner, & Strati, 2016). Interestingly, students who see a prosocial purpose to an academic task are more likely to persist despite difficulty or boredom (Yeager et al., 2014).

The most effective instruction and learning experiences acknowledge the strong *interpersonal components* of learning. Both teachers and peers can extend students' zones of proximal development (Vygotsky, 1978). Though the quality of teacher-student and peer relationships affects learning independent of pedagogical strategy (e.g., Wentzel & Muenks, 2016), some instructional strategies explicitly leverage these relationships. Examples of such strategies include explicit modeling, scaffolding, reciprocal teaching, cooperative learning, cross-age peer tutoring, and situated learning. (e.g., Shanahan & Shanahan, 2008).

The *social and emotional conditions for learning* (called conditions for learning (CFL)) are those aspects of the learning environment most proximal to learning and development, including safety, connectedness, support, challenge and engagement. A subset of school and classroom climate, they are a product of interactions among members of a class or school community, the interpretation of such interactions, and a school's culture (e.g., Garibaldi, Ruddy, Osher, & Kendziora, 2015). CFL are related to the emotional and affective salience of instruction as well as students' views of the meaning and purpose of education, perceptions of safety and comfort, and willingness to take academic risks. CFL are inextricably linked to social and emotional learning.

CFL, opportunities to learn, and interpersonal relationships affect learning both directly (e.g., through effects on working memory and engagement) and indirectly (e.g., through effects on teacher stress and ability to teach, through effects of bullying) (Swearer, Espelage, Vaillancourt, & Hymel, 2010). For example, lack of safety can heighten anxiety, therein impairing working memory (Shackman et al., 2006). On the other hand, academic challenge and teacher support can enhance engagement and facilitate flow, which involves optimizing absorption, focus, and enjoyment (e.g., Schmidt, Shernoff, & Csikszentmihalyi, 2014).

Feedback is powerful when the classroom climate welcomes errors and focuses on learning and mastery as opposed to performance (Hattie & Yates, 2014). Research has repeatedly demonstrated positive associations between classroom and school CFL and achievement (e.g., Berkowitz, Moore, Astor, & Benbenishty, 2016).

Students' social behaviors affect and are affected by school staff members' perceptions of students as well as students' perceptions of teachers. Staff function as natural raters who reward or sanction students' behaviors (Kellam & Rebok, 1992). Teachers' behaviors toward and expression of explicit expectations of students impact students' self-concept, engagement, motivation to succeed, and school-related behaviors (e.g., Osher, Kidron, DeCandia, Kendziora, & Weissberg, 2016). Interpersonal relationships between and among students and their teachers, and particularly students' perceptions of teacher empathy and trust, also influence student engagement and capacity to persist through challenging academic tasks (e.g., Master, Butler, & Walton, 2017). The mutually reinforcing interactions between and among students and teachers are entwined with the way the nervous system responds to learning, the degree to which students tap their cognitive, emotional, social, and affective resources, and even special education diagnoses and placements (NRC, 2015). When students perceive CFL as unfavorable, they find it harder to engage and can become frustrated, have lower self-concepts and expectations, and lag academically (e.g., Hammond, 2016). This process can be internalized and unconscious, and can affect how students approach new learning challenges (Clark, 2006).

Cultural responsiveness and competence can help address the challenges faced by culturally and linguistically diverse students from non-dominant or marginalized groups. Such students often experience disconnects between curricula and pedagogy, their experiences, cultural capital, and needs (e.g., Gay, 2000). These disconnects place particular cognitive and

emotional demands on students, who must master new content without the explicit or implicit culturally embedded knowledge that students from dominant groups benefit from, and that teachers may take for granted (e.g., Clark, 2006). These cultural disconnects make it harder for students to perceive themselves as learners (or as successful learners) and to visualize the connection between their schoolwork, their lives, and promising futures (e.g., Oyserman & Destin, 2010). Such disconnects have been shown to impact a range of students, from English learners to college undergraduates (e.g., Ambrose & Lovett, 2014).

Culturally responsive approaches can use culturally mediated and situated pedagogy to address these emotional, motivational, interpersonal, and learning needs, build upon strengths, and create learning environments where students feel a sense of belonging, emotional and intellectual safety, and appropriate support and challenge (e.g., Gay, 2000)). Rather than ignoring students' existing assets—including cultural knowledge—or viewing them as deficits (Valenzuela, 1999), culturally responsive approaches leverage cultural resources additively. These approaches acknowledge students' cultural displays of learning and meaning-making, and promote effective information processing by using cultural knowledge as a scaffold to connect existing knowledge to new concepts and content (e.g., Hammond, 2016). Strategies such as cultural modeling (Lee, 2010) can help students integrate new knowledge and connect in-school and out-of-school learning. Culturally responsive approaches can also support learning by reducing educators' likelihood of overestimating students' prior knowledge or familiarity with culturally embedded schemas.

Cultural competence involves congruent behaviors, attitudes, and policies that enable schools, agencies, or providers to work effectively in multicultural interactions (King, Sims, & Osher, 2007). Cultural competence can help schools and agencies systematically address the

disconnects and adversities that culturally and linguistically diverse students and their families face. These barriers exist in both institutionalized processes and individual behaviors, and are related to disparities in educational opportunities and outcomes (e.g., Artiles, Kozleski, Trent, Osher, & Ortiz, 2010). Institutionalized processes include resource allocation, rituals, policies, protocols, and practices. Individual behaviors include harassment, macroaggressions, and negative stereotyping, which negatively affect goals, attention, effort, and self-efficacy (e.g., Solórzano, Ceja, & Yosso, 2000) and drain the psychic energy available to address tasks (e.g., Pennington, Heim, Levy, & Larkin, 2016). Stereotype threat provides an example: it can increase feelings of anxiety, negative thinking, and mind-wandering, and can impair working memory and other executive resources required for successful task execution (e.g., Pennington et al., 2016). While many individuals persevere, these barriers can create stress, place extra demands on working memory, drain cognitive resources, and impact health (e.g., LeBrón, Schulz, Mentz, & Perkins, 2015).

The Science of Stress

As with the human relationship, stress is a process through which the biological and the contextual influence and mutually reinforce each other, literally at the level of the cell (Cole, 2014). When we are threatened, our bodies protect us via a stress response system. The Academy of Pediatrics (AAP) has described three types of stress responses (Burke Harris & Renschler, 2015). A positive stress response "is characterized by brief increases in heart rate and blood pressure, and mild or brief elevations in stress hormone levels." A tolerable stress response "activates the body's alert systems to a greater degree as a result of a more severe or longer-lasting threat," and with the presence of buffering relationships likely does not have long-term effects on development. A toxic stress response can occur when stress is frequent, prolonged,

and unbuffered. Toxic stress "can disrupt the development of brain architecture and other developing organs" if not buffered by supportive, responsive relationships (Center on the Developing Child at Harvard University, 2016, p. 12).

During the stress response, hormonal and neurochemical systems are activated in the body. The HPA system produces cortisol and the sympathetic-adrenomedullary (SAM) system produces adrenaline, both of which help the body prepare for stress (National Scientific Council on the Developing Child, 2005/2014). Stress hormones increase our heart rate, blood pressure, inflammatory reactivity, and blood sugar levels (Center on the Developing Child at Harvard University, 2016). To prepare our minds and our bodies to meet a threat, this "fight or flight" response triggers increased vigilance and alertness and reduces non-essential functions such as complex thinking. These responses can be life-saving in the face of an acute threat but damaging when activated for long periods of time—particularly on the developing limbic system and immune systems of the body (Center on the Developing Child at Harvard University, 2016).

Exposure to chronic, unbuffered stress is associated with changes in brain architecture, including the smaller volume of the prefrontal cortex and hippocampus, larger volume in the amygdala, altered brain chemistry, and inflammation associated with higher risk of chronic diseases such as obesity, asthma, hypertension, heart disease, and diabetes (e.g., Bucci et al., 2016). A dysregulated stress response system is one of the few systems of the body that can affect the development of all four structures—brainstem, diencephalon, limbic system, cortex—in the brain and, in particular, the integration of these structures (e.g., Siegel, 2012). Indeed, research on the consequences of developmental trauma has found that the major neural impact on the brain is the impairment in the growth of the integrative structures. (e.g., Teicher, Samson, Anderson, & Ohashi, 2016). These studies show, for example, impairments in the growth of the

corpus callosum, the hippocampus, and the prefrontal cortex—regions that link differentiated areas to each other.

Learning to cope with stress and adversity is an important part of healthy child development, and when the stress response is activated within the context of strong, supportive, buffering relationships, it can be brought to baseline quickly and long-term physiological effects prevented entirely. When stress is unbuffered, children's development and coping can become overwhelmed. Under these circumstances, children's stress responses move rapidly to fear, defense, and self-protection (Center on the Developing Child at Harvard University, 2016).

Increasing and cumulative stress, as is experienced by children who face a build-up of "adverse childhood experiences" (ACEs), can be "toxic" to development, health, and learning. The common definition of ACEs involves stressful or traumatic events experienced before age 18 that fall into three broad domains: abuse, neglect, and household dysfunction (Burke Harris & Renschler, 2015). The traditional ACE are physical, emotional, and sexual abuse; physical and emotional neglect; divorce or separation; mother treated violently; substance abuse; parental mental illness; and incarceration of a relative (Bucci et al., 2016). In recent related work, experts have expanded these categories to include ecological risk factors that include community stressors; personal victimization; economic hardship; hunger; disturbances in family functioning; loss of a parent; challenging peer relationships; discrimination; poor health; overemphasis on achievement; and stressful experiences at school, with the child welfare system, and with juvenile justice (e.g., Wade, Shea, Rubin, & Wood, 2014); these risk factors are related to macrosystem factors such as poverty and institutionalized racism (e.g., Spencer, 2007).

ACEs cut across socioeconomic lines, though the original empirical work on ACEs used a largely middle class sample (Felitti et al., 1998). Later research employed a more diverse

sample (Giovanelli, Reynolds, Mondi, & Ou, 2016). Poverty places individuals at greater levels of risk for ACEs due to the myriad related adversities (e.g., Giovanelli, et al., 2016), but ecological risk factors that include and extend beyond poverty affect how children experience and respond to ACEs.

Impact of Adversity on Health

There is a strong and graded link between childhood adversity and long-term health outcomes, including several major categories of chronic disease, lung cancer, diabetes, various autoimmune diseases, depression and other mental illnesses and elevated rates of high-risk behavior (Felitti et al., 1998). These associations, which stem from a dysregulated stress response and inflammatory hormones such as cortisol and cytokines, can reshape brain structure and function and immune system efficiency (Walker, 2016). The most sobering statistic is premature mortality where individuals with six or more ACEs had a life span that was shorter by an average of 20 years (Felitti et al., 1998).

There is also evidence of a compounding effect of trauma that increases the risk of health, social, and emotional problems associated with a toxic stress response (Felitti et al., 1998). Among the pathways implicated in this finding is damage to the ventral tegmental area (VTA) of the brain, which is a dopamine pathway involved in motivation and reward, which produces "numbing" of sensitization to risk, contributing to dramatic increases in risk-taking behaviors like substance abuse and suicidal behavior (e.g., Brenhouse, Lukkes, & Andersen, 2013). Chronic stress is also shown to have an impact on unhealthy self-modulation such as smoking and substance abuse across economic groups. (e.g., Luthar, Barkin, & Crossman, 2013)

Impact of Adversity on Learning

The structure and function of brain centers affected by chronic stress, in particular the limbic system, are modulated by the activities of the HPA axis, and are involved in key learning systems, including self-regulation, executive functions, attention, memory, stress reactivity, and language (e.g., Essex et al., 2011). Chronic stress is associated with impairments in the functioning of these systems even before children start school. The combination of lower cognitive stimulation in the home and absence of early childhood education can significantly affect children's school and learning readiness (e.g., Center on the Developing Child at Harvard University, 2016).

As children get older, previous developmental challenges can accumulate and set off a cascade of challenges to learning, both directly and through transactions with others at school (Blair & Diamond, 2008). This results in a continuum that ranges from reactive or impulsive behavior at one end to proactive or goal-directed behavior at the other (e.g., Center on the Developing Child at Harvard University, 2016).

Chronic stress is associated with chronic mental health conditions, such as mood syndromes, PTSD, and ADHD, which have replaced chronic physical illness in the top five most significant pediatric health issues affecting learning (e.g., Granger, & Riis, 2013). Children's responses to chronic stress, such as hypervigilance, defiance, and a compromised ability to regulate behavior, can affect how peers and teachers interact with them, further affecting learning readiness and cognitive engagement. For example, young children who lack self-regulation are less likely to develop supportive relationships, engage in school, and pay attention in class, and they are more likely to withdraw and to develop antisocial behavior as they grow older (e.g., Cole, Eisner, Gregory, & Ristuccia, 2013). Absent supportive relationships, new traumatic experiences may re-traumatize children and result in school disengagement and failure (Bethell et al., 2014).

Overcoming the effects of adversity on learning requires attention to both reducing sources of stress and strengthening capabilities in children and the adults caring for them. Resilience can be socially constructed (e.g., Kendziora & Osher, 2004) and developed (Masten, 2014), and practices that follow theories of interpersonal neurobiology, such as mindfulness practices, create opportunities to reorient patterns of neural connectivity and adaptation well into adulthood (Siegel, 2013). Classrooms and schools designed to be rich in interpersonal connection and to promote individual developmental skills and mindsets can change the trajectory of children's learning and their lives.

The Science of Resilience

Resilience is shaped by multi-level dynamics—interactions across levels of analysis, including interactions between the gene and its environment, the individual and his or her relationships, and the individual and the broader ecological contexts in which he or she is embedded (Ungar, 2013). Resilience is best understood as a bio-psychosocial-ecological process wherein promotive internal and external systems facilitate the potential for positive outcomes (e.g., Masten & Obradović 2006). Resilience is a common phenomenon—there is an "ordinariness of resilience" (e.g., Bethell, Newacheck, Hawes, & Halfon, 2014). Whether of a person, group, or larger system, resilience involves the use of internal and external resources as positive adaptation mechanisms when confronted with significant internal or environmental adversity (e.g., Ungar, 2013).

Resilience is characterized by equifinality, differential impact, and contextual and cultural moderation (Ungar et al., 2013). Diverse proximal processes lead to different, but equally viable, development and well-being—equifinality. Resilience is defined locally and is culturally, socially, and historically embedded (Masten, 2011). Though exposure to risk is

endemic to the human species, the nature of risk and the resources available to respond vary among cultural and ecological contexts (Lee, 2009).

The neural and psychobiological roots of resilience and resilience-promoting relationships represent an emergent area of research (Khanlou & Wray, 2014). Adaptive neurobiological systems that contribute to resilience include the learning systems of the brain, the mastery motivation system, the stress response systems, and the self-regulatory systems, as well as the integration of these systems (Masten & Obradović, 2006). By compelling individuals to gain proficiency in tasks and skills and to seek out others to help them do so, the mastery motivation system is thought to drive resilience from an early age (e.g., Masten, 2014).

Early biological and contextual supports contribute to early patterns of adaptation, which provide a foundation for—and thus predict—later, more complex patterns (Yates, Egeland, & Sroufe, 2003). Adaptation is not a fixed process, and resilience is not immutable (e.g., Cicchetti, 2013). Throughout the lifespan, and particularly during periods of transition, internal and external factors present new opportunities for adaptation or maladaptation (e.g., Ungar, 2013).

Researchers have documented substantial heterogeneity in resilience (e.g., Bethell et al., 2014) and its dependency on social support and context (e.g., Masten, 2011). Children's long-term responses to adversities vary as a function of individual dispositions, socialization practices, the type, timing, and intensity of the adversity, and the countervailing buffering supports available to them (e.g., Spencer, 2007). While multiple systems contribute to the development of resilience, no two individuals draw from the same combination and experience of these systems (Masten, 2014). Such heterogeneity has important implications for the intentional development of resilience.

Internal assets (Benson, Scales, & Syvertsen, 2011) that contribute to adaptation include social and emotional competencies, self-regulation, growth mindsets, cognitive functioning, ego control, self-efficacy, agency, internal perceptions of control, perceptions of whether a stressor is stressful, and the ability to develop healthy relationships with individuals who can provide support (e.g., Masten & Obradović, 2008).

External assets are located in a child's microsystem (Lee, 2009). Adaptive external systems include a child's attachments (i.e., consistent and supportive adult relationships inside and outside the home), the family (e.g., expectations), the school (e.g., school culture, cultural sensitivity, staff attunement to students' needs, teaching practices that involve scaffolding, reflection, and healthy peer interaction), peer relations (e.g., reciprocal friendships), community (e.g., cohesiveness, support in the face of individual- and community-level adversities), cultural resources (e.g., spiritual connections), and societal systems (e.g., media-based resources) (e.g., Cicchetti, 2013). Research has repeatedly found that children who do well in the face of adversity have at least one stable and responsive relationship with a parent, caregiver, or other adult (Center on the Developing Child at Harvard University, 2016). This finding has led resilience researchers to recommend policies and programs to better support the adults in children's lives (Luthar, 2015).

Conclusion

Taken together, the theories of human development presented in this paper—including the sciences of attachment, self-regulation, individuality, learning, stress and adversity, and resilience—demonstrate a vital foundational principle: Children's growth is characterized by complex, dynamic transactions between nature, nurture, how these are interpreted and internalized, and variations across time, place, and among individuals. Throughout this entire

process, genes are chemical "followers" – their expression at the biological level is determined by contextual influences. The leading role of context gives rise to the core principles of malleability and plasticity in human development. Human development is not predetermined, fixed, or linear; rather, it is unique to each and every individual, highly responsive to environments and relationships, and subject to change across the lifespan. The ability of contextual influences to encourage adaptive epigenetic signatures and to buffer factors that contribute to maladaptive epigenetic signatures represents one of our most powerful levers to unleash children's genetic potential.

This susceptibility to context and experience has both positive and risky dimensions. Negative, unbuffered stress and the neurobiological mechanisms that are triggered can render children vulnerable to the impact of negative external influences, including adversity, on learning, behavior and health. It is well established that stable, responsive relationships with adults buffer children from the developmental disruption caused by stress, help to build key capabilities, and enable children to manage stress and thrive in the future. But the power of positive context goes beyond its role as an antidote to stress. Relational integration supports ongoing neural integration, which drives increasing interconnections between different parts of the brain. This interconnectivity and synaptic strength is associated with the development of higher order cortical functions. Students learn most deeply when they are in environments that are relationship-rich, promote the integration of emotional, social, cognitive and affective development and are correctly attuned to students' zones of proximal development.

That interpersonal, micro- and macro-contextual influences impact children's development on a cellular level is a molecular gift. Neural malleability and plasticity, the dynamics of resilience and the interconnectedness of individuals with their social and physical

contexts gives rise to an important opportunity to facilitate conditions and experiences that are interpersonally rich, predictable, patterned and attuned to children's individual capacities, needs and potential. Alignment between individual strengths of children and youth and resources for positive growth in their families, schools, and communities have the power to increase the brain's functional capacities, integration, and connectivity, as well as its resilience to stress. As such, the personalization of context is perhaps our single most powerful means to promote the realization of the potential – neurobiological, physiological, psychosocial, and cognitive – in all children.

While this paper synthesizes foundational knowledge about human development, and the effects of context (both positive and negative) on that development, there is not sufficient space to delve into a discussion of such contexts. The second half of this paper will provide a robust discussion of context – including relational and environmental diversity, the brain's inherent malleability to context across space and time, the intersections between interpersonal, micro-, and macro-systemic influences, and the nature of individual-contextual relations across phases of development. In order to leverage the power of context on behalf of all children, a deep investigation into the many ecological contexts and their effects on development is warranted.

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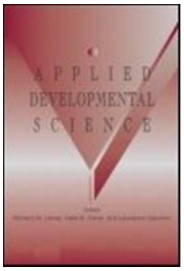
Table 1. *Overarching Themes Fromn Key Findings*

Overarching Themes
• The ongoing, reciprocal relations between individuals' biology, their relationships, and the ecologies and contextual influences in which they are embedded determine the expression of their genetic endowment and ultimately their development as individuals.
• Genes are chemical "followers"; their expression is determined by contextual influences at the biological level.
• Epigenetic adaptation determines the expression of our genetic makeup and is part of a system of ongoing two-way exchanges between human beings and the physical and social world that create qualitative changes over time.
• Malleability and neural plasticity are the core principles of human development.
• Each child's development as a learner is nonlinear, has its own unique pacing, and is highly responsive to context.
• The development of children's skills is progressive and does not occur in isolation; it requires the integration and layering of prerequisite skills.
• Neural integration and interconnectivity of children's cognitive, social, and emotional development is essential for well-being—both anatomically and functionally.
• Contextual influences and ecology cannot be ignored.
• Adversity can affect development, mental and physical health, and learning.
• Resilience and thriving in the face of adversity is possible and is a product of children's internal assets and supports from individuals within a child's social environment.
• Adults' buffering of stress plays a central role in healthy child development; therefore, building and supporting adult capacity are critically important tasks.
• Schools and other child-serving systems are potentially powerful contexts through which stress can be buffered, neural integration and connectivity supported, and individual development nurtured.
• Culture, cultural responsiveness, and cultural competence are critical components of context and are profoundly important in shaping the experiences through which children grow.



Drivers of Human Development: How Relationships and Context Shape Learning and Development

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Keywords:	stress and adversity, ecological contexts, human development, multidisciplinary synthesis
Abstract:	The paper synthesizes foundational knowledge on the role of relationships and context in supporting and/or undermining the healthy development of children and youth. A companion paper focuses on how the human brain develops, the major constructs that define human development, and the opportunities for resilience. Relationships between and among children and adults are a primary process through which the biological and the contextual influence and mutually reinforce each other. Micro- and macro-ecologies can be risks and assets for healthy learning and development—with mechanisms and effects that can be observed at neurobiological, chemical, physiological, phenomenological, behavioral, and social levels. The influence of ecologies on development can be seen across generations. The accumulated knowledge on these influences can inform child-serving systems that support positive adaptations, resilience, learning, health, and well-being.

Drivers of Human Development: How Relationships and Context Shape Learning and Development

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Abstract

The paper synthesizes foundational knowledge on the role of relationships and context in supporting and/or undermining the healthy development of children and youth. A companion paper focuses on how the human brain develops, the major constructs that define human development, and the opportunities for resilience. Relationships between and among children and adults are a primary process through which the biological and the contextual influence and mutually reinforce each other. Micro- and macro-ecologies can be risks and assets for healthy learning and development—with mechanisms and effects that can be observed at neurobiological, chemical, physiological, phenomenological, behavioral, and social levels. The influence of ecologies on development can be seen across generations. The accumulated knowledge on these influences can inform child-serving systems that support positive adaptations, resilience, learning, health, and well-being.

Drivers of Human Development: How Relationships and Context Shape Learning and Development[1]

This article compliments the companion article entitled "Malleability, Plasticity, and Individuality: How Children Learn and Develop in Context," which synthesizes convergent bodies of knowledge across diverse scientific disciplines that show that child development is neither genetically predetermined nor governed by a "nature vs. nurture" dichotomy. Rather, it is shaped by ongoing, reciprocal interactions between children's biology and their contextual surroundings, with the latter playing a leading role, and with the quality of relationships within those surroundings driving effects. From the expression of genes at the cellular level through the secretion of chemical hormones, expression of behaviors, and processing of experience, children's development is responsive to context; hence the fundamental principles of malleability and plasticity in development along with the power of relational and environmental influences to positively impact the trajectories of children's lives.

A powerful through line exists between a child's relational and neural integration, neuroendocrinology, emotions, and his or her development of higher-order cognitive, social, and affective skills throughout childhood and adolescence. Micro- and macro-ecologies can be risks and assets for healthy learning and development—with mechanisms and effects that can be observed at neurobiological, chemical, physiological, phenomenological, behavioral, and social levels. Whether in the home, in schools, or in other child-serving settings, relationships characterized by sensitivity, attunement, consistency, trustworthiness, cognitive stimulation, and

[1] The authors limited the citations in this version of the paper due to space constraints. Only one citation was kept in the cases where more than one citation was originally listed. A set of decision rules was used to narrow the list of references. The rules and order in which they were applied are as follows: 1. Preference was given to references that were cited more than once. 2. No more than two references by the same first author were kept. 3. For each list of multiple citations, the most recent reference was kept. The full list of references will be available online.

appropriately scaffolded learning enable children to develop secure attachments and mature in progressively complex ways (Center on the Developing Child at Harvard University, 2016). Children's foundational patterns of development remain responsive to relationships and context throughout childhood and adolescence, offering opportunities to buffer and overcome the effects of risk factors throughout development.

Ecological contexts encompass an array of environments and societal structures. Structural and social features of ecological contexts can advance development and buffer the effects of poverty and other adversities when they provide culturally responsive and developmentally appropriate relationships and intentionally promote self-regulation, executive function, social and behavioral skills. The adaptations that young people make to one context carry over to other contexts. Supportive contexts help children and youth develop the capacity to adapt skills to new contexts, therein enabling them to succeed in environments that pose new and differing challenges. Meanwhile, developmentally unsuitable and culturally incongruent contexts can exacerbate stress and hinder the development of foundational competencies, as can insufficient support for adults and peers who interact with the developing child. If a negative context is recurring and continuous, the brain ceases to recognize it as abnormal.

Individual children and youth learn and develop in different ways; they benefit from both personalization and multiple opportunities to succeed. Sensitive periods for rapid change exist, but developmental growth and malleability occur throughout childhood and into adulthood and can have multigenerational effects. In this paper, we synthesize broad literature on the key relationships in young people's lives that drive human development. We describe why and how key contexts that range from the home and school to cultural and structural factors interact with individual factors to shape development. We then describe how these interactions differ across

development and are transmitted across generations. The paper concludes with a call for a robust translational R&D agenda that integrates this scientific knowledge and applies it to practice.

Relationships as Drivers of Human Development: Positive Supportive Contexts

Relationships between and among children and adults are a primary process through which the biological and the contextual influence and mutually reinforce each other (e.g., Bronfenbrenner & Morris, 2006). Secure and responsive relationships with adults, along with high-quality, positive learning interactions (and environments), are foundational to healthy development (NRC, 2015). Attachment, social synchrony, and attunement allow caregivers to care for the physical and emotional needs of infants and children. Attuned, compassionate communication with the caregiver also aids in relational integration. The caregiver's perceptions of and responses to the child's mental state are important for building shared experiences and emotions (Siegel, 2012). The ability to use mental-state language and to sense the child's mental state is related to attachment patterns and to the child's metacognitive monitoring capacity necessary for the development of self-regulation (e.g., Main, 1991).

These processes start with early attachment relationships but continue as children become increasingly self-sufficient, inter-dependent, and independent. As children get older, early organizational patterns of social behaviors in the attachment relationship build on previous patterns of interactions with caregivers, and extend to behavioral patterns with peers and teachers. Children continue to benefit from readily available relationships with peers and other adults (e.g., teachers) to the degree that the relationships continue to be sensitive and attuned to their emotional needs, consistent, trustworthy, and cognitively stimulating (Bergin & Bergin, 2009). Early and ongoing interactions at home and at school that involve support, coaching, co-regulation, scaffolding, and modeling promote balance between self-regulatory systems and

contribute to the child's capacity to regulate emotions, behavior, and cognition; to feel connected to other people; and to establish an autobiographical narrative (e.g., Murray et al., 2015).

Parents

The parent–child dyad and the family (which includes all primary caregivers) play a foundational role in the development of children's social, emotional, and cognitive skills (National Academies of Sciences, Engineering, & Medicine, 2016). Parents are both structurally and psychologically important. Structurally, they have rights (unless terminated), can direct and allocate the resources they control, and can structure and manage the environment around children (Grusec & Davidov, 2016). Psychologically, parents play a key role in five relational domains, each of which has its own developmental course and set of regulatory mechanisms: protection, mutual reciprocity, control, guided learning, and group participation. Each domain is activated under different conditions, involves a different parent-child relationship, requires different parenting responses, and is associated with different outcomes (Grusec & Davidov, 2016). Six parenting practices are particularly important: 1) contingent responsiveness: adult behavior that occurs immediately after a child's behavior and is related to the child's focus of attention; 2) showing warmth and sensitivity; 3) routines and reduced household chaos; 4) shared book reading and talking to children; 5) practices that promote children's health and safety; 6) use of appropriate (less harsh) discipline (IOM & NRC, 2015).

There are some universally harmful practices, which include harsh punishment, lack of psychological support, and, as children mature, lack of autonomy. Parents affect, are affected by, and respond to their children. Children are also selective in what they hear, see, and do. Parental inputs are effective when children feel that their parents consistently care for them, are sensitive to their needs, understand them, and have their best interests at heart (Grusec & Davidov, 2016).

The role of parents continues to be important through adolescence and young adulthood, though the range and depth of parental control change as the child extends more complex engagement in social fields that include school, peers, and work. For many adolescents, the opinions of peers become more important than those of family (e.g., Blakemore & Mills, 2014). Parents can still affect their development and life course trajectories through attachment-based support and monitoring of their children's behavior as well as by creating and supporting access to healthy social environments (e.g., Blakemore & Mills, 2014). Doing this well requires skill and, in some cases, support. Adolescents want and strive for autonomy, differentiated identity, and an increased role in family decisions (Beveridge & Berg, 2007). Since parents and children may perceive risk and their children's competence differently (Holmbeck & O'Donnell, 1991), parents who are more accurate in their ability to understand their adolescents' thought processes are likely to experience better outcomes in conflicts (Hastings & Grusec, 1998). Parents who have better relationships with their children also realize better results from monitoring their children (e.g., Abar, Jackson, & Wood, 2014).

Structural factors affect the outcomes of parental behavior. Poverty is a key structural factor that affects parents' levels of monitoring and control. Still, many parents who struggle with poverty provide their children with effective care and supervision, leveraging both their skills and social capital (e.g., Smith, Brooks-Gunn, & Klebanov, 1997). However, limited financial resources affect access to social, cultural, and liquid financial assets that middle class parents can more easily leverage to improve learning and health outcomes for their children (e.g., Osher & Chasin, 2016). Parents may need additional support, whether due to stress, motivational issues, skills, or resources (e.g., Semke, Garbacz, Kwon, Sheridan, & Woods, 2010).

Teachers

A substantial body of research converges on the benefits to students of having strong positive relationships with teachers. Relationships with teachers that can help children modulate stress reactivity can also provide working models for students about the process of learning and about teachers as reliable and trustworthy sources and for teachers about students as effective learners (e.g., Mayer, 2014). Students who have close relationships with teachers are more confident and positive in their approaches to learning (IOM & NRC, 2015). Positive student–teacher relationships can help students achieve, engage, regulate their emotions, build social competence, and take on academic challenges. A high-quality relationship may also (with other teacher strategies) reduce stereotype threat (Steele, 2010), protect students who are at higher levels of risk for poor outcomes (e.g., Roorda, Koomen, Spilt, & Oort, 2011), and buffer the effects of victimization and other adversity (e.g., Norwalk, Hamm, Farmer, & Barnes, 2016).

Effective teaching depends upon teacher capacity, which is a product of teacher skills and the support provided to teachers. Teacher effects on student outcomes appear to be driven by the extent to which they create opportunities to learn (including time on task), emotional security, student concepts of themselves as learners, motivation, and positive peer interactions (e.g., Gregory & Korth, 2016). Teacher capacity includes the technical, pedagogical, social, and emotional skills to teach content, manage classrooms, and develop supportive and culturally responsive relationships (e.g., Osher, Bear, Sprague, & Doyle, 2010).

Teacher stress matters, and is affected by the teacher's ecology, which includes the level of principal support, job press, and teacher ability to manage student feelings and behaviors (e.g., Johnson, Kraft, & Papay, 2012). Findings from evaluations of school-based interventions, including ones that monitor student and teacher cortisol levels, suggest that teacher stress affects

their interaction with students, student stress levels, teacher behavior, and student academic outcomes (e.g., Flook, Goldberg, Pinger, Bonus, & Davidson, 2013). Reducing teacher stress through interventions such as mindfulness interventions can reduce student stress biomarkers (e.g., Oberle & Schonert-Reichl, 2016).

Peers

Peers are important socializing agents, both directly and indirectly though their effects on teachers and other adults. Adults intentionally and unintentionally structure peer relationships, which can be more or less promotive of healthy peer interactions depending on their ability to attune to students (e.g., Hamm, Farmer, Dadisman, Gravelle, & Murray, 2011). Peers socialize each other directly through social learning, reference group effects, and peer pressure at the peer group, classroom, school, and community levels (e.g., Snyder, Schrepferman, Bullard, McEachern, & Patterson, 2012). Peer interactions provide opportunities to practice and refine self-regulation, executive function, interpersonal and communication skills in ways that adult interactions may not. In young children, scaffolded peer interactions (e.g., social dramatic play) can be important for the development of executive function skills (e.g., Center on the Developing Child at Harvard University, 2016).

As children mature, peer relationships become more central and complex, and serve as venues to acquire prosocial norms, perspective taking, social communication, and concepts of self in relationships (e.g., Rubin, Coplan, Chen, Buskirk, & Wojslawowicz, 2005). Peer relationships help children and adolescents understand themselves and their values, which is important for identity development (Parker, Rubin, Price, & DeRosier, 1995).

Peer interactions also include victimization and rejection, which affect and are affected by dysregulation of the stress response, and can have long-term consequences on physical and

mental health (Vaillancourt, Hymel, & McDougall, 2013). Early peer acceptance or rejection may lead to behavioral disorders later in childhood and adolescence. Peer friendship during the early childhood stage can protect young children from both later rejection and a tendency toward aggression (Hay et al., 2004). Young children who exhibit aggressive behaviors and are rejected by peers are at greater risk for later antisocial behavior than children who exhibit aggression and are not rejected (Coie, Terry, Lenox, Lochman, & Hyman, 1995). Peer interactions can also reinforce risk-taking and antisocial behaviors through modeling and reinforcement, particularly when in groups unaccompanied by adults (e.g, Silva, Chein, & Steinberg, 2016).

Ecological Contexts of Development: Illustrative Examples

Human behavior and development take place in nested ecological systems, which affect development directly and indirectly (e.g., Bronfenbrenner & Morris, 2006). Ecological contexts encompass an array of environments and societal structures (e.g., Holman, Garfin, & Silver, 2014). Such contexts and the individuals embedded in them are characterized by continual interactions within and across levels and by great variation of internal as well as external risk and protective factors. In Margaret Beale Spencer's language: "Risks and protective factors may take a variety of forms given variations in race/ethnicity, gender, faith community, body type, immigration status, skin color, privilege, health quality or disability status, cultural traditions, social class, and temperament. All are linked to the character of the context and the individual's history of experiences and even the group's history in the nation" (Spencer, 2007, p. 840). For each individual there is a net level of stress experienced that is the effect of the stresses experienced and the supports available to deal with those stresses (Spencer, 2007).

A range of literatures have accumulated knowledge on the importance of ecological contexts. Research on epigenetic adaptation illuminates the effects of microsystems (i.e., contexts where children directly interact with others) (e.g., Cole, 2014). Sociological studies show how contexts (e.g., exosystem contexts that affect microsystems such as neighborhood stressors and cultural and structural macrosystem factors such as racism) relate to parental behavior (e.g., Perkins & Sampson, 2015). Prevention science provides empirical evidence of the importance of contextual factors by showing that intervention-related changes in contexts are related to intervention-related changes in outcomes, as well as how local contexts can shape the successful implementation of interventions (e.g., Dymnicki et al., in press).

Developmentally rich settings provide enriching opportunities and healthy relationships with adults, practice and reinforcement of foundational competencies, and opportunities to take on leadership roles and participate in collaborative and productive peer interactions. Structural and social features of schools and early childhood educational settings can heighten human development potential and buffer the effects of poverty-related stress and other adversity on development through positive relationships and by direct targeting of self-regulation, executive functions, and social and behavioral skills (e.g., Jones & Bouffard, 2012). Developmentally unsuitable contexts exacerbate stress; hinder the reinforcement of foundational competencies; and impel maladaptive behaviors by failing to foster healthy relationships with adults, lacking developmental fit, limiting enrichment and stimulating experiences, and reducing the chances of interacting with peers who are positive influences (e.g., Farmer, Dawes, Alexander, & Brooks, 2016). If a negative context is recurring and continuous, the brain ceases to recognize it as abnormal and habituates to it (Siegel, 1999).

Children and youth cope with stress and adversity in ways that may be adaptive or maladaptive. Adaptations in one context carry over to other contexts. The result will depend on alignment between contexts, as well as the capacity of adults to understand the origin of the behavior and to provide the child with attuned, developmentally appropriate, and culturally competent support (e.g., Spencer, 2007). This support can help children and youth develop a capacity to code switch, which can help them adapt to environments that have differing behavioral expectations and pose differing challenges (e.g., Jakonen, 2016).

Microsystem Contexts

Bronfenbrenner (1994) defined a microsystem as "a pattern of activities, social roles, and interpersonal relations … that invite, permit, or inhibit engagement in sustained, progressively more complex interaction with, and activity in, the immediate environment" (p. 39). Microsystems include families, early care and learning settings, schools, peers, religious institutions and faith communities, youth development programs, drop-in centers, cultural institutions and settings, gangs, and juvenile justice institutions. Each provides opportunities for social learning and can affect social, emotional, and cognitive development through the quality of relationships and the extent to which children and youth experience safety, connectedness, engagement, challenge, and opportunities to develop competencies and access supports—both positively (e.g., enrichment and social and emotional learning) and negatively (e.g., bullying and engagement in high-risk behaviors). We focus on three key settings: families, early care and childhood settings, and schools.

Families. Family structures vary. In 2014, 26 percent of children younger than age 18 lived with a single parent (Pew Research Center, 2015). Parents are monoracial or interracial, same-sex or different-sex, and adoptive, biological, or a mixture of both (Powell, Hamilton, Manago, & Cheng, 2016). Parents vary in terms of age and culture. Children's residences vary, and include foster care or custodial care.

Family resources, social supports, emotional climate, stability, and the quality of caregiver-child interactions and relationships are the prerequisites for families to provide the bonding, connection, and safety necessary for healthy development (e.g., Patterson & Hastings, 2007). Insufficient space or privacy, environmental toxins, and housing insecurity are examples of resource-related factors that can affect the quality of social, emotional, and cognitive developmental context insecurity (e.g., Diette & Ribar, 2015), and can contribute to increases in student mobility, stress and self-regulation challenges (e.g., Herbers, Reynolds, & Chen, 2013).

Grandparents, siblings, and other kin play key roles. In 2010, 7 percent of children lived in households headed by a grandparent and seventeen percent of children living with grandparents were being raised in homes with no biological or adoptive parent present (U.S. Census Bureau, 2010). Some are children of incarcerated parents and face particular social, emotional, and academic challenges (e.g., Eddy et al., 2014). Research on grandparents is limited. The preponderance of available research on the effects of grandparents suggests that they can be important support systems for and positive influences on their grandchildren (Powell, Hamilton et al., 2016). Siblings also matter. Siblings may spend more time with one another than with their parents (Lucey, 2010).). Sibling effects, like peer effects, can be positive or negative, can be direct or indirect (through effects on parents and teachers), and may affect social, emotional, and cognitive development (e.g., McHale, Updegraff, & Whiteman 2012). Kin who

do not live in the household may support effects on family capacity and extend the family's resources by providing social, cultural, and financial capital (Stack, 1974).

Early care and childhood settings. Early care and education settings are, next to the family, the most important social contexts in which early development unfolds. Child care and other early child settings affect development during a highly sensitive period of brain development. Children tend to enter early care within the first few months of life and spend approximately 36 hours a week there. Experiencing quality ECE is a function of access and economic status, and research suggests that the magnitude and sometimes the direction of child-care effects on development may be markedly different for children from higher risk contexts (Berry et al., 2014).

ECE quality varies around an average that is mediocre with regard to the capacity to promote positive developmental outcomes (e.g., IOM & NRC, 2015). One factor that affects (and reflects) quality is the high rates of suspensions and expulsions from ECE programs (U.S. Department of Education, Office of Civil Rights, 2014): Expulsion rates are 13 times higher in federally funded child care centers than in K–12 classrooms (Gilliam & Shahar, 2006). African-American children are 3.6 times more likely to receive one or more suspensions than white preschoolers. Boys are 3 times as likely to be suspended as girls. These disparities appear to be due to implicit bias (e.g., NAEYC, 2016).

Effective child-care settings have high adult–child ratios, small group sizes, developmentally appropriate curriculum, safe physical environments to support positive interactions and effective instruction (Center on the Developing Child at Harvard University, 2016) and staff who are well-trained, supported, and well-compensated (National Scientific Council on the Developing Child, 2007). These settings provide ample opportunities for

frequent, warm, and responsive interactions with adults through language- and relationship-rich environments (e.g., Center on the Developing Child at Harvard University, 2016). This often includes experiential learning, which enables children to incorporate and use knowledge (Blair & Raver, 2014). Pretend play, when combined with child-centered classrooms and playful learning, is an important context for learning and development in early childhood (e.g., Snow, 2016).

Child care settings that have a clear focus on social and emotional learning and on developing self-regulatory skills (including executive functions) can build greater school readiness, and these efforts can be enhanced by more intensive, targeted social interventions and social and cognitive skills training (e.g., Flook, Goldberg, Pinger, & Davidson, 2015). Practices that encourage self-regulatory skills improve executive functions, attention, and stress-response physiology, as well as academic ability, particularly among kindergartners attending high-poverty schools (Blair & Raver, 2014).

Schools. Schools create positive conditions for learning when students experience emotional, intellectual, and physical safety; connectedness; support; challenge; engagement; respect; agency; learner-centered instruction; and learner-friendly classrooms and facilities (e.g., Berkowitz, Moore, Astor, & Benbenishty, 2016). Schools can address the specific needs of the most vulnerable children to improve and leverage their strengths, while simultaneously creating conditions and opportunities that support the engagement and learning of all children.

Emotionally close, trustful relationships with nurturing adults and high teacher responsiveness foster positive development and learning (e.g., Jones & Bouffard, 2012). Teachers' explicit expression of high expectations and belief in students' capabilities correlate with successful achievement (e.g., Steele, 2010). Positive relationships with teachers promote self-regulation, which supports children's classroom behavior, and in turn contributes to positive

classroom climates. Positive climates are associated with student skills and dispositions such as greater cognitive and academic competence, self-esteem, school satisfaction and engagement, higher attendance, and less acting out (Hamre & Pianta, 2005). Positive relationships with other school staff that occur outside the classroom can benefit students in similar ways.

Classroom management and instructional strategies that use language and positive interactions as a way to increase engagement and maintain appropriate levels of arousal (and intentional teaching and practice with social and emotional competencies), support the development of emotion regulation, executive functions, and academic skills (e.g., Zelazo et al., 2016) and contribute to positive self-representations and more positive responses from others (e.g., Murray et al., 2015). For example, reflective reprocessing of information prior to responding is thought to be necessary for the development of executive functions, and can be encouraged through instructional practices (Zelazo, 2015). Research suggests that executive function skills can be developed through meditation, problem-solving tasks, and video gaming which induce changes in brain structure and function (including neural activation patterns, resting state functional connectivity, and neurochemistry), in behavior, and in the likelihood that executive function skills will be activated in the future (e.g., Galinsky et al., in press).

Strong relationships with adults, effective instructional strategies, and positive classroom climates can counter the effects of chronic stress. Conversely, negative interpersonal transactions that include infrequent positive teacher support and attention during academic learning, lack of teacher praise, and limited opportunities to respond (e.g., Sutherland & Oswald, 2005), as well as teacher stereotype priming (Steele, 2010), can increase stress. Heightened stress and anxiety can reduce working memory and lead to trouble paying attention in class, completing work, and inhibiting behavior, especially for students with repeated difficulty regulating behavior in social

situations in school and at home. These social and classroom behaviors lead to negative perceptions and expectations on the part of both the student and the teacher regarding the student being poorly regulated and unable to learn. This can contribute to negative reinforcement, negative student self-identities, student learned helplessness, and a teachers' sense of inefficacy (e.g., Mayer, Davis, & Schoorman, 1995). Psychological distress or appraisals of events as stressful or challenging are, in turn, associated with impairments in self-regulation (e.g., Duckworth, Kim, & Tsukayama, 2013).

Classroom climates characterized by conflict aggravate this feedback loop and are associated with poor peer relations, more aggression, and poorer academic focus (e.g., Jones & Bouffard, 2012). Over time, negative experiences in school can lead children to withdraw and become less motivated, leading to greater gaps in school performance and achievement (e.g., Ursache, Blair, & Raver, 2012). This disengagement can contribute to poor attendance and grades in core classes, repeating grades, and discipline problems, including suspension, that can, in turn, lead to dropout and school failure (Kendziora et al., 2014).

The use of exclusionary discipline contributes to student disengagement, grade retention, dropout, and arrests (e.g., Mallett, 2015). Exclusionary discipline can negatively affect the learning, engagement, and sense of safety of students who are not suspended (e.g., Perry & Morris, 2014). Even one suspension increases the risk of repeating grades, school dropout, and incarceration, and reduces the likelihood of postsecondary success (Arcia, 2006).

Many staff in schools and other child serving systems are challenged by adult stress; lack of capacity, cultural and linguistic competence, attunement to the development needs of children; and an inability to respond to the impacts of trauma on children and adults (Baird & Kracen, 2006). Adults, in schools and other agencies, need effective preparation, training, and support.

They, too, benefit from respectful and supportive leadership, and strategies that address stress provide guidance on managing classroom and other setting dynamics (e.g., Farmer et al., 2016).

Macrosystem Factors

Research often neglects the impact of macro-level factors at the microsystem and exosystem levels (Spencer, 2007). Children and adults experience macrosystem factors regularly and directly. Macrosystem factors are institutionalized and operationalized through rituals, policies, protocols, routinized practices, and opportunity structures. Macrosystem factors affect and are experienced directly through attitudes, behaviors, and routines that affect how children experience and react to environments; and indirectly through social stigma and exposure to contexts where opportunities for enrichment and choice are limited (e.g., Oyserman & Lewis, 2017). Macrosystem factors are also structural, as in the case of labor market segmentation, and cultural, as in the case of victim-blaming approaches to understanding social problems (e.g., Ryan, 1972). Structural and cultural systems tend to ignore or deemphasize the impacts of history and context on family resources and child outcomes (Lee, 2010).

Poverty and racism, both separately and together, make the experience of stress and adversity more likely for children and adults who must deal regularly with the consequences of poverty and racism in their daily lives. These effects may be visible in the moment (e.g., a racial slur) or they may be emergent and only visible upon analysis (e.g., racial disparities that are the product of multiple small and often subtle steps) (Osher, 2015). They can also be indirect, such as the impacts of housing segregation on resources available for schools under local funding formulas (Cutler & Glaeser, 1997).

Poverty. Poverty is an ecological risk factor that makes it less likely that children will benefit from appropriate experience and enrichment opportunities and makes it more likely that

they will experience stress-producing adversity and health challenges. Poverty is only a distal risk factor for multiple proximal drivers such as fewer opportunities for positive stimulation and more frequent exposure to negative stimulation at home, in child care, at school, and in the community (e.g., Blair & Raver, 2016). The stresses of poverty can contribute to lowered warmth and sensitivity among some parents who experience multiple stressors and lack access to support in dealing with these adversities. Poverty gets under the skin through the response to stress, and affects social, emotional, cognitive, and physical development (e.g., Blair & Raver, 2016). When children experience high levels of stress and that stress is not adequately buffered, neural and behavioral responses to stimulation can cause children to be reactive and defensive rather than reflective and approach-oriented (e.g., Lee, Siegle, Dahl, Hooley, & Silk, 2015). A lack of caregiver warmth and sensitivity can reduce opportunities to buffer stress, heighten the stress response in children, and undermine the development of foundational competencies such as self-regulation (Blair & Raver, 2016), as children adapt to harsh or inconsistent parenting, particularly in chaotic environments (e.g., Mills-Koonce et al., 2016). Poverty-related risk factors increase the odds that children will demonstrate more behavioral problems and less social and emotional competence (West, Denton & Reaney, 2001). The effects of poverty on the stress response are thought to underlie findings that show an association between poverty and diminished self-regulation including executive functions (Blair & Raver, 2016).

ECE settings and schools may amplify these effects, as economically disadvantaged children are more likely to be exposed to less access to robust academic opportunities (Gustafsson et al., 2014), a disproportionate number of underprepared teachers (U.S. Department of Education, Office of Civil Rights, 2014), and policies that run counter to how children learn and develop (e.g., Nance, 2013).

While poverty makes poor outcomes more likely, family assets and families' leveraging of other assets such as religious institutions can protect children from the negative consequences of poverty. Family assets include social networks (DiMaggio & Garip, 2012) and cultural resources that help families address the impacts of poverty. The seminal examination of parenting in Philadelphia by Furstenberg and colleagues (1999) identified the diversity of parenting strategies in high-need neighborhoods and how parents used their knowledge and social capital to protect their children and maximize their success.

Racism. Racism, which affects people of color in manifold ways, is both ubiquitous and omnipresent. It is operationalized across ecological systems (Lee et al., 2003) and experienced both directly and indirectly. Institutionalized racism drives (and has driven) structural inequalities that are related to poverty, inequality, and an absence of wealth accumulation (e.g., Reardon & Bischoff, 2011). Processes that lead to associations between racism and children's learning and development are historical, and occur at the individual level as well as in the microsystem, mesosystem, exosystem, and macrosystem (e.g., Dupree, Spencer, & Spencer, 2015). The stresses created by the experience of racial aggressions and microagressions can become embedded in a child. They can affect children and adolescents' perceptions of themselves and others, and how they deal with what they feel and experience. Many children and their families demonstrate instrumental and psychological resilience by building on individual, family, and cultural strengths (Spencer, 2007). However, research suggests that the physiological burden lasts (Chen, Miller, Body, & Lei, 2015). This can limit opportunities and has been associated with stress-related mental and physical illnesses across the lifespan (Center on the Developing Child at Harvard University, 2016).

Racism affects students directly through the identities they create, stereotype threat, and microaggressions, as well as through the adjustments they make in order to succeed and maintain a sense of dignity (e.g., Stevenson & Stevenson, 2013). Racism affects the microsystem through structural inequities in child-serving institutions. The Civil Rights Data Collection (U.S. Department of Education, Office of Civil Rights, 2014) data demonstrate the impacts of structural inequities in education, which include not only disparities in discipline but disparities in opportunities to learn and enrichment. Racism affects the education-related aspects of the mesosystem when there are problematic interactions between educators and families of color (e.g., Harry, Klinger, & Hart, 2005). It affects the exosystem through well-documented disparities in health care, mental health, housing, child welfare, educational resources, work opportunities, opportunities for civic participation, justice, and policing, (e.g., Fisher et al., 2012). It affects the macrosystem when policies and cultural forces sustain or legitimize racial privilege (Pager & Shepherd, 2008).

Institutionalized racism creates contextual factors that enhance the likelihood that children, adolescents, and young adults experience compounded deprivation, which Perkins and Sampson (2015) operationalize as the combination of individual deprivation (e.g., poverty) and social and emotional deprivation (e.g., low collective efficacy). Explicit biases, discrimination, and racial microaggressions also contribute to deprivation (Pager & Shepherd, 2008). These experiences can have durable effects on verbal abilities (Sampson, Sharkey, & Radenbush, 2008) when not effectively buffered by internal and external assets (Spencer, 2007), and individual and social identities, which can contribute both to positive and negative adaptations.

Individual–Context Relations Across Development

Child development progresses along a continuum and varies widely between individuals and developmental tasks. At the same time, some brain functions (e.g., executive functions in early childhood) predictably undergo rapid change in certain developmental periods (Davidson, Amso, Anderson, & Diamond, 2006). Similarly, some interactions between the individual and the context occur more prominently at certain points in development, which can trigger more rapid improvements in specific functions. The first three years of life, early childhood, middle childhood, and adolescence are culturally determined phases of the life span that involve both biological changes and differential participation in a variety of social fields that have their own behavioral demands (Kellam & Rebok, 1992).

The First Three Years

Infants and toddlers devote their time to forming attachment relationships (including developing trust of others), learning to function autonomously (including developing trust in themselves), and acquiring self-regulatory attributes that allow them to be flexible problem-solvers (Yates et al., 2003). In the early years the brain's plasticity is strongest; 700–1,000 new neural connections form every second, and the volume of gray matter increases rapidly (Center on the Developing Child at Harvard University, 2016). This early period of formation and pruning of neural circuits shapes the architecture of the developing brain before the circuits are fully mature and stabilized (e.g., Center on the Developing Child at Harvard University, 2016). Emotional development, including the ability to experience, express, and manage emotions and impulses, begins in this stage, in conjunction with motor control and cognition (e.g., Tarullo, Obradović, & Gunnar, 2009). The early years are also a sensitive period for the development of language and visual systems (Dawson Ashman, & Carver, 2000).

The first three years are an important time to build resilience within and across settings (e.g., Masten & Cicchetti, 2010). Parent responsiveness, proper nutrition, and early interventions to address cognitive, social, and academic concerns during this period are associated with long-term benefits; parental depression and maltreatment, social deprivation, and exposure to toxic substances are associated with long-term challenges (Dawson, et al., 2000). Early caregiver relationships are the most proximal and prominent contextual influences on development in these years, and can serve to promote optimal brain function and behavior. Attunement is associated with executive function, early language processing skills and vocabulary growth, and other immediate and long-term outcomes (Bindman, Pomerantz, & Roisman, 2015).

Early Childhood

Neurobiological, emotional, and behavioral foundations in very early childhood set the stage for the development of school readiness skills and for positive developmental outcomes over the life course (e.g., Schweinhart et al., 2005). With the proper supports, early childhood marks a period of dramatic increase in executive functions and cognition–emotion integration (e.g., Espinet, Anderson, & Zelazo, 2012). Cognitive, emotional, and behavioral integration at this stage helps children successfully navigate the social demands of preschool. As children begin preschool, they enter into relationships with teachers and peers that can mutually reinforce social behavior (e.g., Hay et al., 2004). The skills necessary to be accepted by peers—emotion regulation, executive functions, social understanding, and prosocial behaviors (such as helpfulness and sharing)—are the same skills that afford children opportunities to form positive relationships with teachers and to learn (e.g., Hay et al., 2004). Early experiences can set off a cascade of relationships, behaviors, self-perceptions, stress responses, and emotions that

mutually reinforce each other over time in sometimes adaptive or sometimes maladaptive ways (e.g., Nagaoka et al., 2015).

Aggressiveness, impulsivity, and attention deficits, often associated with chronic stress, as well as affective responses (e.g., shyness) undermine opportunities to connect with others, thereby diminishing opportunities to learn and depreciating the child's and adult's perceptions of the child as a learner. For example, children who exhibit antisocial behavior in preschool participate in fewer classroom activities and teachers provide them with less instruction and less positive feedback, potentially setting off a cascade of less engagement, learning, and attention that can lead to poor academic performance and early dropout (Raver & Knitzer, 2002). As a result, emotional, social, and behavioral competence can be more important for early school success than cognitive competence or family background (Raver & Knitzer, 2002), and intentional efforts to promote these skills have been found to be successful (Menting, Orobio de Castro, & Matthys, 2013). An intentional focus on the development of self-regulation in young children can build brain functions involved in self-regulation and support the deepening of cognitive functions (Center on the Developing Child at Harvard University, 2016).

Middle Childhood

Middle childhood is marked by its own meaningful changes in brain development and social contexts: brain structures and functions, predominantly in the prefrontal cortex (which supports cognitive self-regulation and executive function), undergo rapid growth between ages 7 and 9 (Johnson et al., 2016). It is a time when children are experiencing increasing independence in new and challenging contexts and changes in the nature of their social interactions. In the United States, the typical key developmental tasks during middle childhood are self-regulation, acquiring skills and knowledge related to learning, and developing interpersonal skills (Nagaoka

et al., 2015). These tasks emerge out of the formation and development of friendships, increasing autonomy and behavioral expectations, and increasing academic demands. As children become self-regulated and the caregiver–child relationship becomes more collaborative, the nature of the attachment relationship changes from proximity to availability (Bosmans & Kerns, 2015). Attachment relationships also expand to other adults, especially teachers. These adults expect children to learn critical academic skills and to develop contextually appropriate behavioral and attention skills, including empathy, emotional expressiveness, interpersonal negotiation strategies, and cooperation with rules. These competencies facilitate relationships with adults and peers, afford increasingly diverse opportunities in the home, school, and other structured settings, and drive academic success (NRC & IOM, 2009). These competencies become more sophisticated as children develop social skills and knowledge through friendships, as well as social perspective-taking abilities (e.g., Goldstein et al., 2002).

Children who do not develop social, emotional, and cognitive competencies and representations of self as a successful learner are more likely to exhibit poor social skills, such as impulsivity, aggressive behaviors, poor social problem-solving skills, and school disengagement (IOM & NRC, 2009). Fortunately, an increasing body of research indicates that social and emotional learning strategies can help many elementary and middle school students develop these competencies (e.g., Osher, Kidron, Brackett et al., 2016).

Middle childhood is a time when mental health disorders and antisocial behaviors begin to emerge with consequences for later outcomes (NRC & IOM, 2009). Middle childhood marks the first symptoms of conduct and anxiety disorders, obsessive compulsive disorder, and depression (NRC & IOM, 2009). Feedback loops between maturational shifts in the child (e.g., social and cognitive abilities) and an expanding social environment that reinforces

representations of self and others, is more or less promotive of healthy development, which helps explain divergence in developmental trajectories during these years (e.g., Mah & Ford-Jones, 2012). For example, research on the iatrogenic effects of punitive, reactive, and segregating interventions suggests that poor long-term outcomes may in part be a product of developmentally inappropriate responses to troubling behavior (e.g., Petitclerc, Gatti, Vitaro, & Tremblay, 2013).

Adolescence

After early childhood, adolescence is the time of the brain's most dramatic growth spurt. Adolescence is marked by co-occurring changes in brain development, hormone levels, physical health, and contextual demands and opportunities that have implications for later physical and mental health and behavior. For many, adolescence is a time for risk taking, social reward seeking, and novelty seeking (e.g., Yeager, Fong, Lee, & Espelage, 2015); it is also a time of expanding processing and decision making skills, opportunity, creativity, exploration, and optimism about one's role in the world (Geisz & Nakashian, 2016).

During adolescence, intentional skill development is particularly important and effective. It is a period in which environments and relationships, particularly those outside the family in the school and community, play a uniquely important role in integration and development. One of the greatest misconceptions of this period is that adolescents do not need adults; adolescents crave relationship and connection to both peers and adults.

Adolescence is a highly sensitive period for the development of regions of the brain involved in social cognition and self-awareness (e.g. Nagaoka et al., 2015). The part of the brain associated with social and emotional functioning experiences a surge around puberty that creates changes in social motivation, including a focus on social status and social rewards (Crone & Dahl, 2012). The frontal lobe, which governs cognitive control, continues to mature and is still

developing in adolescence and early adulthood. A remodeling of the brain's dopaminergic system occurs around the time of puberty, in which amounts of dopamine fall sharply from levels in the early developmental phases (e.g., Sisk & Zehr, 2005). The dopaminergic system overlaps and interacts with the brain's social networks and the networks for processing affective and motivational stimuli (Nelson, Leibenluft, McClure, & Pine, 2005).

One way of viewing the adolescent period of brain remodeling is through the lens of neural integration. Research suggests that the brain has two fundamental processes: one of pruning in early adolescence, the other of myelin formation in middle to late adolescence (e.g., Sherman et al., 2014). Pruning enables regions of the brain to become more differentiated; myelin enables these remaining regions to become more linked. The implication of this research is that pruning and myelination lead to increases in differentiation and linkage. This adolescent brain remodeling and integration is thought to contribute to higher capacities for regulation and other higher order cortical functions (Stevens, Skudlarski, Pearlson, & Calhoun, 2009).

The various risks of adolescence include the onset of serious psychiatric disorders (Johnson, Kemp, Heard, Lennings, & Hickie, 2015). One view is that the pruning process may reveal underlying vulnerabilities in the neural connectivity of the individual. When stress arises from this diminished functioning, even more pruning may occur, as cortisol, the stress hormone released with prolonged stressors, can be neurotoxic. Shifts in the dopaminergic reward system may also be at play in the risk of developing addictive problems and other risk-taking behaviors during this period (Ross & Peselow, 2009). The functioning of these sub-systems in the brain and neural integration depend upon adolescents' developmental contexts.

Adolescence is a time of increasingly goal-oriented learning, identity formation, autonomy assertion, and a growing sense of values (e.g., Nagaoka et al., 2015).The specific tasks

of adolescence move many children from the dependencies of childhood to the emerging identities and responsibilities of adulthood. Brain and hormonal changes, along with contextual changes, allow many adolescents to more intentionally contribute to adaptive regulation with their context (e.g., selecting positive goals, using cognitive and behavioral skills to optimize potential, and compensating for challenges and failures) (e.g., Gestsdottir & Lerner, 2008). Adolescents are also flooded by emotion, whether driven by puberty, social anxiety, or memories. Many of the tasks of adolescence are about the balance between honing attributes like self-regulation, sense of purpose, and belonging (pre-frontal cortex) versus handling some of the overwhelming emotions that drive risk taking and impulsive behavior (amygdala).

Unfortunately, middle and high schools often are organized in ways that do not fit the developmental needs of adolescents (Eccles & Roeser, 2009). Although adolescents need more autonomy and connectedness, they often experience a loss of autonomy, as rules become harsher and connections to adults—who work with more students—become more difficult to maintain.

Providing enriching opportunities in schools and other contexts in which adolescents spend their time helps them fulfill their potential and experience increasing independence. All adolescents need positive and sustained relationships with competent and caring adults who can provide exposure to life-skill-building activities; opportunities to actively participate and take leadership in family, school, and community activities; and provide clear standards for behavior and norms (e.g., Geisz & Nakashian, 2016). Studies of young adults suggest that mindfulness training is one strategy for promoting increases in neural integration. These studies have found that mindfulness training is correlated with increased interconnectivity of the connectome, and growth of the corpus callosum, the hippocampus, and the prefrontal region (Cole, 2014).

Intergenerational Transmission of Adversity

Development is also intergenerational. The role of intergenerational transmission of both adaptive and maladaptive systems is rooted in biological and social processes that begin even before the child is born, when the neurons in the brain that build the foundation for synaptic connections are still developing (e.g., Halfon, Shulman, & Hochstein, 2001). These processes are related to changes in maternal brain structure and function, including elevated stress hormones and oxytocin levels (e.g., Kim, Strathearn, & Swain, 2016). These changes, in turn, influence the development of the fetus and the attachment relationship in infancy (Center on the Developing Child at Harvard University, 2016; Kim et al., 2016), which is dependent on sensitive responsiveness to the child's signals (e.g., Feldman, 2015). In the first year of life, the physical and behavioral interactions between caregiver and infant trigger a process of bio-behavioral synchrony (i.e., sensitivity to each other) that involves the release of oxytocin and physical contact. This process builds a child's capacity for social development and mediates socialization, stress management, emotion regulation, and well-being (Feldman, 2015).

Children can adapt to hostile environments in ways that can undermine learning and support their involvement in unhealthy or high-risk behaviors (Crick & Dodge, 1994). Some of the proximal contributors to chronic stress and the intergenerational transmission of adversity are the family, the neighborhood, and the school. For instance, neighborhood disadvantage is associated with a build-up of biological "wear and tear" (i.e., allostatic load) over the life course, especially in men (e.g., Gustafsson et al., 2014).

Early dysregulation in emotions, cognition, and behavior at school entry can contribute to unsupportive interactions that reinforce negative beliefs about belonging and intelligence and questions about the purpose of school itself. Absent appropriate intervention with both the child

and school staff, these factors can contribute to disciplinary problems, grade repetition, dropping out, incarceration, substance abuse, mental disorder, and long-term physical health problems (e.g., diabetes, lung cancer), which can place the next generation at risk (e.g., Chandler, 2016).

Research documents how parents leverage their social and cultural capital to promote adaptive behavior and prevent engagement in high-risk behavior (e.g., Furstenberg, 2004). However, this is not possible for all parents: ineffective parental behaviors and disruptive family management styles mediate the onset of health-compromising behaviors such as smoking and obesity (e.g., Park & Schepp, 2015). Examples are a lack of supervision of a child's nutrition and energy intake, harsh parenting, irritability, and lack of supervision.

Caregiver adversity can disrupt bio-behavioral synchrony by weakening the emotional response system of the brain and lowering the caregiver's sensitivity to the child's social cues (Kim & Watamura, 2015). Disruptions can be linked to social psychopathologies, including autism, social anxiety, depression, and schizophrenia (Feldman, 2015). As children grow, exposure to trauma and adversity in the home and in other settings continue to affect biology and behavior. Children who experience trauma and adversity show biomarker and brain structure and activation differences that increase their vulnerability to risk behaviors (e.g., being a perpetrator or victim of violence, suicide, drug addiction) later in life (e.g., Park & Schepp, 2015). Some children exposed to trauma such as parental mental illness or alcohol abuse, physical or emotional neglect, or violence, show cognitive impairments, attention problems, language deficits, academic difficulties, withdrawn behavior, externalizing problems, mental health problems, and difficulty with interpersonal relationships (Center on the Developing Child at Harvard University, 2016).

Caregiver challenges and impaired child development are related to macrosystem factors, which contribute to the intergenerational transmission of adversity. Education and health disparities, housing segregation, economic disadvantage and the lack of sufficient support for families contribute to the increased likelihood of caregivers' poor mental and physical health outcomes, intimate partner violence, malnutrition, and exposure to known toxins such as tobacco, alcohol, and mercury—during pregnancy, but even dating back to the mother's own childhood (e.g., Cutler & Glaeser, 1997). The disproportionately high level of arrests of African-American males (Chandler, 2016) creates adverse childhood experiences and affects children of incarcerated parents through such factors as the absence of supportive males in the household and male role models in the community, and the students who go to school with them (e.g., Foster & Hagan, 2015). Students who have incarcerated parents and students who attend schools with those children experience poorer behavioral and academic outcomes (e.g., Haskins, 2016).

Similarly, the disproportionate use of exclusionary and harsh discipline in schools can affect lifelong outcomes for black males, including beliefs about themselves, increased disengagement from school and dropping out, increased likelihood of fathering a child in adolescence, diminished likelihood of postsecondary school attainment and employment, and diminished ability to support a family emotionally and financially (e.g., Skiba et al., 2011). These factors, in turn, affect generations to come (e.g., Foster & Hagan, 2015).

Preventing the negative impacts of adversity on children and the adults who care for them can prevent the intergenerational transmission of adversity and its many risks to development. The societal cost and benefit are enormous and therefore requires intervention at the level of family, society, and policy, including culturally competent and family-driven approaches (e.g., Johnson et al., 2013). Evidence suggests that well-designed developmental contexts, with the

right intervention and prevention strategies, can provide the level of support, enrichment, and stimulation needed to buffer the effects of trauma and other ecological challenges on adults and children (e.g., Sawhill & Karpilow, 2014).

Conclusion

Taken together, theories of human development—including the sciences of attachment, self-regulation, individuality, learning, stress and adversity, and resilience—demonstrate a vital foundational principle: Children's growth is characterized by complex, dynamic transactions between nature, nurture, how these are interpreted and internalized, and how these vary across time, place, and among individuals. Throughout this entire process, genes are chemical "followers" – their expression at the biological level is determined by contextual influences. The leading role of context gives rise to the core principles of malleability and plasticity in human development. Human development is not predetermined, fixed, or linear; rather, it is unique to each and every individual, highly responsive to environments and relationships, and subject to change across the lifespan. The ability of contextual influences to encourage adaptive epigenetic signatures and to buffer factors that contribute to maladaptive epigenetic signatures represents one of our most powerful levers to unleash children's genetic potential.

This susceptibility to context and experience has both positive and negative dimensions. In fact, the role of context carries with it the potential of intergenerational transmission of both adaptive and maladaptive systems rooted in biological and social processes.

The future of our education and child-serving systems should build upon what we now know about the development of the brain and the power of context in that development, including the supports provided to adults. Both the education and child-serving systems were designed with too little attention to the foundational knowledge summarized in this and the

companion paper regarding the powerful role of context in development. This knowledge, when understood, translated and applied with an appreciation for the power of culture, can support positive adaptation, resilience, learning, health, and well-being.

Although much research still needs to be done, it is now possible to offer a scientifically grounded view of the mind as an emergent, self-organizing, embodied, and relational process that regulates the flow of energy and information (Siegel, 2013) in interaction with other minds at home, at school, and in the community. Looked at this way, it is possible to visualize a powerful role for culturally responsive early childhood settings, community-based centers, schools, and child-serving systems in modeling, shaping, modulating, and monitoring this developmental process collaboratively with children and their families.

Dramatic improvements in outcomes and equity depend on public and political will, sound policy in service to whole-child practices based on rigorous science, implemented with quality, measured with an understanding of formative progression, and adopted at scale with cultural competence and equitable outcomes as explicit goals. A cornerstone of this effort must include a robust translational R&D agenda that supports synthesis, integration and application of current scientific knowledge within and across disciplines, while addressing important gaps in knowledge, practice, methods, and measures.

To ensure that approaches to whole-child personalization are scaled successfully, we must develop a comprehensive set of strategies to drive demand for and adoption of successful tools, methods, and measures, which would include a common taxonomy of definitions and measures across the continuum of ages into young adulthood and support for effective implementation across diverse contexts.

Each person's development is unique. However, neural malleability and plasticity, the dynamics of resilience, and the interconnectedness of individuals with their social and physical contexts provide powerful opportunities to facilitate conditions where children can thrive. The personalization of context is perhaps the most powerful means at our disposal to promote the potential—neurobiological, physiological, social, emotional, and cognitive–-in all children. The effective use of practices designed with the knowledge of human development as a foundation can support a deeper personalization of learning and the learner experience, going well beyond the traditional definitions that have been applied to these terms. This personalization must build upon the assets that children, families, and communities have, must be interdisciplinary—mirroring the nature of development itself—and applied at the individual level.

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