PROUST and the SQUID

The STORY and SCIENCE of the READING BRAIN

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HARPER PERENNIAL

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I dedicate this book to all the members of my family...past, present, and still to come
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I have lived my life in the service of words: finding where they hide in the convoluted recesses of the brain, studying their layers of meaning and form, and teaching their secrets to the young. In these pages I invite you to ponder the profoundly creative quality at the heart of reading words. Nothing in our intellectual development should be less taken for granted at this moment in history, as the transition to a digital culture accelerates its pace.

This is particularly so because there has also never been a time when the complex beauty of the reading process stood more revealed, when the magnitude of its contributions was more clearly understood by science, or when these contributions seemed more in danger of being replaced by new forms of communication. Examining what we have and reflecting on what we want to preserve are the leitmotifs of these pages.

To truly understand what we do when we read would be, as the fin de siècle scholar Sir Edmund Huey memorably wrote long ago, "the acme of a psychologist's achievements, for it would be to describe very many of the most intricate workings of the human mind, as well as to unravel the tangled story of the most remarkable specific performance that civilization has learned in all
its history." Informed by areas of study as varied as evolutionary history and cognitive neuroscience, our contemporary knowledge about the reading brain would have dazzled Huey. We know that each new type of writing system was developed through millennia of human history, and required different adaptations of the human brain; we know that the multifaceted development of reading extends from infancy to ever-deepening levels of expertise; and we know that the curious mix of challenge and gift to be found in dyslexia— in which the brain struggles to learn to read—contains insights that are transforming our understanding of reading. Together, these areas of knowledge illuminate the brain’s nearly miraculous capacity to rearrange itself to learn to read, and in the process to form new thoughts.

In this book I hope to push you gently toward reconsidering things you might long have taken for granted—such as how natural it is for a child to learn to read. In the evolution of our brain’s capacity to learn, the act of reading is not natural, with consequences both marvelous and tragic for many people, particularly children.

To narrate this book demands a set of perspectives that have taken me many years to prepare for. I am a teacher of child development and cognitive neuroscience; a researcher of language, reading, and dyslexia; a parent of children you will learn about; and an apostle for written language. I direct a research center, the Center for Reading and Language Research, in the Eliot-Pearson Department of Child Development at Tufts University in Boston, where my colleagues and I conduct research on readers of all ages, particularly those with dyslexia. Together, we study what it means to be dyslexic in languages around the world, from languages that share roots with English—like German, Spanish, Greek, and Dutch—to less related languages like Hebrew, Japanese, and Chinese. We know the toll that not learning to read takes on children regardless of their native language, whether in struggling Filipino communities, on Native American reservations, or in affluent Boston suburbs. Many of our efforts explore the design of new interventions and the effects of these interventions on behaviors in the classroom and in the brain. Thanks to imaging technology, we can actually “see” how the brain reads before and after our work is done.

The sum of these experiences, the amount of research available, and the recognition of society’s shift into new modes of communication compelled me to write my first book for the general public. I am, it must be said, still becoming accustomed to a style where there is no immediate reference to the many scholars whose research underlies so much of this book. I earnestly hope the reader will take advantage of the extensive notes and references that accompany each chapter.

The book begins by celebrating the beauty, variety, and transformative capacities of the origins of writing; proceeds to the dramatic new landscapes of the development of the reading brain and its various pathways to acquisition; and ends with difficult questions about the virtues and dangers in what lies ahead.

Oddly enough, a preface often presents the author’s final thoughts to the reader on finishing the book. This book is no exception. But rather than end with my own words, I wish to use those from the gentle curator of Marilynne Robinson’s *Gilead*, as he gave his best writings to his young son: “I wrote almost all of it in the deepest hope and conviction. Sifting my thoughts and choosing my words. Trying to say what was true. And I’ll tell you frankly, that was wonderful.”
Chapter 1

READING LESSONS FROM PROUST AND THE SQUID

I believe that reading, in its original essence, is that fruitful miracle of communication in the midst of solitude.
— MARCEL PROUST

Learning involves the nurturing of nature.
— JOSEPH LEDOUX

We were never born to read. Human beings invented reading only a few thousand years ago. And with this invention, we rearranged the very organization of our brain, which in turn expanded the ways we were able to think, which altered the intellectual evolution of our species. Reading is one of the single most remarkable inventions in history; the ability to record history is one of its consequences. Our ancestors’ invention could come about only because of the human brain’s extraordinary ability to make new connections among its existing structures, a process made possible by the brain’s ability to be shaped by experience. This plasticity at the heart of the brain’s design forms the basis for much of who we are, and who we might become.

This book tells the story of the reading brain, in the context of
our unfolding intellectual evolution. That story is changing before our eyes and under the tips of our fingers. The next few decades will witness transformations in our ability to communicate, as we recruit new connections in the brain that will propel our intellectual development in new and different ways. Knowing what reading demands of our brain and knowing how it contributes to our capacity to think, to feel, to infer, and to understand other human beings is especially important today as we make the transition from a reading brain to an increasingly digital one. By coming to understand how reading evolved historically, how it is acquired by a child, and how it restructured its biological underpinnings in the brain, we can shed new light on our wondrous complexity as a literate species. This places in sharp relief what may happen next in the evolution of human intelligence, and the choices we might face in shaping that future.

This book consists of three areas of knowledge: the early history of how our species learned to read, from the time of the Sumerians to Socrates; the developmental life cycle of humans as they learn to read in ever more sophisticated ways over time; and the story and science of what happens when the brain can’t learn to read. Taken together, this cumulative knowledge about reading both celebrates the vastness of our accomplishment as the species that reads, records, and goes beyond what went before, and directs our attention to what is important to preserve.

There is something less obvious that this historical and evolutionary view of the reading brain gives us. It provides a very old and very new approach to how we teach the most essential aspects of the reading process—both for those whose brains are poised to acquire it and for those whose brains have systems that may be organized differently, as in the reading disability known as dyslexia. Understanding these unique hardwired systems—which are preprogrammed generation after generation by instructions from our genes—advances our knowledge in unexpected ways that have implications we are only beginning to explore.

Interwoven through the book’s three parts is a particular view of how the brain learns anything new. There are few more powerful mirrors of the human brain’s astonishing ability to rearrange itself to learn a new intellectual function than the act of reading. Underlying the brain’s ability to learn reading lies its protean capacity to make new connections among structures and circuits originally devoted to other more basic brain processes that have enjoyed a longer existence in human evolution, such as vision and spoken language. We now know that groups of neurons create new connections and pathways among themselves every time we acquire a new skill. Computer scientists use the term “open architecture” to describe a system that is versatile enough to change—or rearrange—to accommodate the varying demands on it. Within the constraints of our genetic legacy, our brain presents a beautiful example of open architecture. Thanks to this design, we come into the world programmed with the capacity to change what is given to us by nature, so that we can go beyond it.

We are, it would seem from the start, genetically poised for breakthroughs.

Thus the reading brain is part of highly successful two-way dynamics. Reading can be learned only because of the brain’s plastic design, and when reading takes place, that individual brain is forever changed, both physiologically and intellectually. For example, at the neuronal level, a person who learns to read in Chinese uses a very particular set of neuronal connections that differ in significant ways from the pathways used in reading English. When Chinese readers first try to read in English, their brains attempt to use Chinese-based neuronal pathways. The act of learning to read Chinese characters has literally shaped the Chinese reading brain. Similarly, much of how we think and what we think about is based on insights and associations generated from what we read. As the author Joseph Epstein put it, “A biography of any literary person ought to deal at length with what he read and when, for in some sense, we are what we read.”

These two dimensions of the reading brain’s development and evolution—the personal-intellectual and the biological—are rarely described together, but there are critical and wonderful lessons to be discovered in doing just that. In this book I use the celebrated French novelist Marcel Proust as metaphor and the largely underappreciated squid as analogy for two very different
aspects of reading. Proust saw reading as a kind of intellectual “sanctuary,” where human beings have access to thousands of different realities they might never encounter or understand otherwise. Each of these new realities is capable of transforming readers’ intellectual lives without ever requiring them to leave the comfort of their armchairs.

Scientists in the 1950s used the long central axon of the shy but cunning squid to understand how neurons fire and transmit to each other, and in some cases to see how neurons repair and compensate when something goes awry. At a different level of study, cognitive neuroscientists today investigate how various cognitive (or mental) processes work in the brain. Within this research, the reading process offers an example par excellence of a recently acquired cultural invention that requires something new from existing structures in the brain. The study of what the human brain has to do to read, and of its clever ways of adapting when things go wrong, is analogous to the study of the squid in earlier neuroscience.

Proust’s sanctuary and the scientist’s squid represent complementary ways of understanding different dimensions in the reading process. Let me introduce you more concretely to the approach of this book by having you read two of Proust’s breath-defying sentences from his book On Reading, as fast as you can.

There are perhaps no days of our childhood we lived so fully as those... we spent with a favorite book. Everything that filled them for others, so it seemed, and that we dismissed as a vulgar obstacle to a délicieuse pleasure: the game for which a friend would come to fetch us at the most interesting passage; the troublesome bee or sun ray that forced us to lift our eyes from the page or to change position; the provisions for the afternoon snack that we had been made to take along and that we left beside us on the bench without touching, while above our head the sun was diminishing in force in the blue sky; the dinner we had to return home for, and during which we thought only of going up immediately afterward to finish the interrupted chapter, all those things with which reading should have kept us from feeling anything but annoyance, on the contrary they have engraved in us so sweet a memory (so much more precious to our present judgment than what we read then with such love), that if we still happen today to leaf through those books of another time, it is for no other reason than that they are the only calendars we have kept of days that have vanished, and we hope to see reflected on their pages the dwellings and the ponds which no longer exist.

Consider first what you were thinking while reading this passage, and then try to analyze exactly what you did as you read it, including how you began to connect Proust to other thoughts. If you are like me, Proust conjured up your own long-stored memories of books: the secret places you found to read away from the intrusions of siblings and friends; the thrilling sensations elicited by Jane Austen, Charlotte Brontë, and Mark Twain; the muffled beam of the flashlight you hoped your parent wouldn’t notice beneath the sheets. This is Proust’s reading sanctuary, and it is ours. It is where we first learned to roam without abandon through Middle Earth, Lilliput, and Narnia. It is the place we first tried on the experiences of those we would never meet: princes and paupers, dragons and damsels, Kung warriors, and a German-Jewish girl hiding in a Dutch attic from Nazi soldiers.

It is said that Machiavelli would sometimes prepare to read by dressing up in the period of the writer he was reading and then setting a table for the two of them. This was his sign of respect for the author’s gift, and perhaps of Machiavelli’s tacit understanding of the sense of encounter that Proust described. While reading, we can leave our own consciousness, and pass over into the consciousness of another person, another age, another culture. “Passing over,” a term used by the theologian John Dunne, describes the process through which reading enables us to try on, identify with, and ultimately enter for a brief time the wholly different perspective of another person’s consciousness. When we pass over into how a knight thinks, how a slave feels, how a hero-
ine behaves, and how an evildoer can regret or deny wrongdoing, we never come back quite the same; sometimes we’re inspired, sometimes saddened, but we are always enriched. Through this exposure we learn both the commonality and the uniqueness of our own thoughts—that we are individuals, but not alone.

The moment this happens, we are no longer limited by the confines of our own thinking. Wherever they were set, our original boundaries are challenged, teased, and gradually placed somewhere new. An expanding sense of “other” changes who we are, and, most importantly for children, what we imagine we can be.

Let’s go back to what you did when I asked you to switch your attention from this book to Proust’s passage and to read as fast as you could without losing Proust’s meaning. In response to this request, you engaged an array of mental or cognitive processes: attention; memory; and visual, auditory, and linguistic processes. Promptly, your brain’s attentional and executive systems began to plan how to read Proust speedily and still understand it. Next, your visual system raced into action, swooping quickly across the page, forwarding its gleanings about letter shapes, word forms, and common phrases to linguistic systems waiting the information. These systems rapidly connected subtly differentiated visual symbols with essential information about the sounds contained in words. Without a single moment of conscious awareness, you applied highly automatic rules about the sounds of letters in the English writing system, and used a great many linguistic processes to do so. This is the essence of what is called the alphabetic principle, and it depends on your brain’s uncanny ability to learn to connect and integrate at rapid-fire speed what it sees and what it hears to what it knows.

As you applied all these rules to the print before you, you activated a battery of relevant language and comprehension processes with a rapidity that still astounds researchers. To take one example from the language domain, when you read the 233 words in Proust’s passage, your word meaning, or semantic, systems contributed every possible meaning of each word you read and incorporated the exact correct meaning for each word in its context. This is a far more complex and intriguing process than one might think. Years ago, the cognitive scientist David Swinney helped uncover the fact that when we read a simple word like “bug,” we activate not only the more common meaning (a crawling, six-legged creature), but also the bug’s less frequent associations—spies, Volkswagens, and glitches in software. Swinney discovered that the brain doesn’t find just one simple meaning for a word; instead it stimulates a veritable trove of knowledge about that word and the many words related to it. The richness of this semantic dimension of reading depends on the riches we have already stored, a fact with important and sometimes devastating developmental implications for our children. Children with a rich repertoire of words and their associations will experience any text or any conversation in ways that are substantively different from children who do not have the same stored words and concepts.

Think about the implications of Swinney’s finding for texts as simple as Dr. Seuss’s Oh, The Places You’ll Go! or as semantically complex as James Joyce’s Ulysses. Children who have never left the narrow boundaries of their neighborhood, either figuratively or literally, may understand this book in entirely different ways from other children. We bring our entire store of meanings to whatever we read—or not. If we apply this finding to the passage from Proust that you just read, it means that your executive planning system directed a great many activities to ensure that you comprehended what was there, and retrieved all your personal associations to the text. Your grammatical system had to work overtime to avoid stumbling over Proust’s unfamiliar sentence constructions, like his use of long clauses strung together by many commas and semicolons before the predicate. To accomplish all this without forgetting what you already read fifty words back, your semantic and grammatical systems had to function closely with your working memory. (Think of this type of memory as a kind of “cognitive blackboard,” which temporarily stores information for you to use in the near term.) Proust’s unusually sequenced grammatical information had to be connected to the meanings of individual words without losing track of the overall propositions and context of the passage.
As you linked all this linguistic and conceptual information, you generated your own inferences and hypotheses based on your own background knowledge and engagement. If this cumulative information failed to make sense, you might have reread some parts to ensure that they fit within the given context. Then, after you integrated all this visual, conceptual, and linguistic information with your background knowledge and inferences, you arrived at an understanding of what Proust was describing: a glorious day in childhood made timeless through the "divine pleasure" that is reading!

Then, some of you paused at the end of Proust’s passage and went somewhere beyond what the text provided. But before tackling this more philosophical point, let’s turn back to the biological dimension and look immediately below the surface of the behavioral act of reading. All human behaviors rest on layers of teeming, underlying activity. I asked the neuroscientist and artist Catherine Stoddley of Oxford to draw a pyramid to illustrate how these various levels operate together when we read a single word (Figure 1-1). In the top layer of this pyramid, reading the word “bear” is the surface behavior; below it is the cognitive level, which consists of all those basic attentional, perceptual, conceptual, linguistic, and motor processes you just used to read. These cognitive processes, which many psychologists spend their entire lives studying, rest on tangible neurological structures that are made up of neurons built up and then guided by the interaction between genes and the environment. In other words, all human behaviors are based on multiple cognitive processes, which are based on the rapid integration of information from very specific neurological structures, which rely on billions of neurons capable of trillions of possible connections, which are programmed in large part by genes. In order to learn to work together to perform our most basic human functions, neurons need instructions from genes about how to form efficient circuits or pathways among the neurological structures.

This pyramid functions like a three-dimensional map for understanding how any genetically programmed behavior, such as vision, happens. It does not explain, however, how it can be applied to a reading circuit, because there are no genes specific only to reading in the bottom layer. Unlike its component parts such as vision and speech, which are genetically organized, reading has no direct genetic program passing it on to future generations. Thus the next four layers involved must learn how to form the necessary pathways anew every time reading is acquired by an individual brain. This is part of what makes reading—and any cultural invention—different from other processes, and why it does not come as naturally to our children as vision or spoken language, which are preprogrammed.

How, then, did the first time ever occur? The French neuroscientist Stanislas Dehaene tells us that the first humans who invented writing and numeracy were able to do this by what he calls “neuronal recycling.” For example, in his work with primates,
Dehaene shows that if you put two plates of bananas in front of a monkey—one with two bananas and one with four—an area in the monkey’s posterior cortex will activate just before he grasps the more bountiful plate. This same general area is one of the regions of the brain we humans now use for some mathematical operations. Similarly, Dehaene and his colleagues argue that our ability to recognize words in reading uses the species’ evolutionarily older circuitry that is specialized for object recognition. Furthermore, just as our ancestors’ capacity to distinguish between predator and prey at a glance drew on an innate capacity for visual specialization, our ability to recognize letters and words may involve an even further in-built capacity that allows “specialization within a specialization.”

If one were to expand Dehaene’s view somewhat, it would seem more than likely that the reading brain exploited older neuronal pathways originally designed not only for vision but for connecting vision to conceptual and linguistic functions: for example, connecting the quick recognition of a shape with the rapid inference that this footprint can signal danger; connecting a recognized tool, predator, or enemy with the retrieval of a word. When confronted, therefore, with the task of inventing functions like literacy and numeracy, our brain had at its disposal three ingenious design principles: the capacity to make new connections among older structures; the capacity to form areas of exquisitely precise specialization for recognizing patterns in information; and the ability to learn to recruit and connect information from these areas automatically. In one way or another, these three principles of brain organization are the foundation for all of reading’s evolution, development, and failure.

The elegant properties of the visual system provide an excellent example of how recycling existing visual circuits made the development of reading possible. Visual cells possess the capacity to become highly specialized and highly specific, and to make new circuits among preexisting structures. This allows babies to come into the world with eyes that are almost ready to fire and that are exceptional examples of design and precision. Soon after birth, each neuron in the eye’s retina begins to correspond to a specific set of cells in the occipital lobes. Because of this design feature in our visual system, called retinotopic organization, every line, diagonal, circle, or arc seen by the retina in the eye activates a specific, specialized location in the occipital lobes in a split second (Figure 1-2).

This quality of the visual system is somewhat different from why our Cro-Magnon ancestors could identify animals on the distant horizon, why many of us can identify the model of a car a quarter-mile away, and why bird-watchers can identify a tern other people may not even see. Dehaene suggests that the visual areas in our ancestors’ brains responsible for object recognition

![Figure 1-2: Visual Systems](image)
were used to decipher the first symbols and letters of written language by adapting their built-in system for recognition. Critically, the combination of several innate capacities—for adaptation, for specialization, and for making new connections—allowed our brain to make new pathways between visual areas and those areas serving the cognitive and linguistic processes that are essential to written language.

The third principle exploited by reading—the capacity of the neuronal circuits to become virtually automatic—incorporates the other two. This is what allowed you to fly across Proust’s passage and understand what you read. Becoming virtually automatic does not happen overnight and is not a characteristic of either a novice bird-watcher or a young novice reader. These circuits and pathways are created through hundreds or, in the case of some children with reading disabilities like dyslexia, thousands of exposures to letters and words. The neuronal pathways for recognizing letters, letter patterns, and words become automatic thanks to retinotopic organization, object recognition capacities, and to one other extremely important dimension of brain organization: our ability to represent highly learned patterns of information in our specialized regions. For example, as the networks of cells responsible for recognizing letters and letter patterns learn to “fire together,” they create representations of their visual information that are far more rapidly retrieved.

Fascinatingly, networks of cells that have learned to work together over a long time produce representations of visual information, even when this information isn’t in front of us. In an illuminating experiment by Harvard cognitive scientist Stephen Kosslyn, adult readers in a brain scanner were asked to close their eyes and imagine certain letters. When they were asked about capital letters, discrete regions responsible for one part of the visual field in the visual cortex responded; lowercase letters triggered other discrete areas. Thus merely imagining letters results in activation of particular neurons in our visual cortex. For the expert reading brain, as information enters through the retina, all the physical properties of the letters are processed by an array of specialized neurons that feed their information automatically deeper and deeper into other visual processing areas. They are part and parcel of the virtual automaticity of the reading brain, in which all its representations and indeed all its individual processes—not just visual ones—become rapid-fire and effortless.

What happens between our first exposure to letters and expert reading is very important to scientists because it offers a unique opportunity to watch the orderly development of a cognitive process. The various features that characterize the visual system—enlisting older genetically programmed structures, recognizing patterns, creating discrete working groups of specialized neurons for particular representations, making circuit connections with great versatility, and achieving fluency through practice—are similar in all the other major cognitive and linguistic systems involved in reading. I will elaborate on this later, but first I want to highlight a marvelous (and hardly coincidental) analogue between what happens in the brain and what happens in the internal thoughts of every reader.

In much the way reading reflects the brain’s capacity for going beyond the original design of its structures, it also reflects the reader’s capacity to go beyond what is given by the text and the author. As your brain’s systems integrated all the visual, auditory, semantic, syntactic, and inferential information from Proust’s passage about a single day in childhood with a beloved book, you, the reader, automatically began to connect what Proust wrote with your own thinking and personal insights.

I cannot, of course, describe where your thoughts went, but I can describe mine. Because I had just visited an exhibit at the Boston Museum of Fine Arts on Monet and impressionism, I found myself connecting how Proust wrote about a single day in his childhood with how Monet painted *Impression: Sunrise*. Both Proust and Monet used pieces of information to render a composite that made a more vivid impression than if they had created a perfect reproduction. In so doing, both artist and novelist are examples of Emily Dickinson’s enigmatic charge to “tell all the Truth, but tell it slant—/Success in Circuit lies.”

Emily Dickinson never envisioned neuronal circuits when she wrote those lines, but it turns out that she was as astute physio-
logically as she was poetically. By using indirect approaches, Proust and Monet force their readers and viewers to contribute actively to the constructions themselves, and in the process to experience them more directly. Reading is a neurally and intellectually circuitous act, enriched as much by the unpredictable directions of a reader’s inferences and thoughts, as by the direct message to the eye from the text.

This unique aspect of reading has begun to trouble me considerably as I consider the Google universe of my children. Will the constructive component at the heart of reading begin to change and potentially atrophy as we shift to computer-presented text, in which massive amounts of information appear instantaneously? In other words, when seemingly complete visual information is given almost simultaneously, as it is in many digital presentations, is there either sufficient time or sufficient motivation to process the information more inferentially, analytically, and critically? Is the act of reading dramatically different in such contexts? The basic visual and linguistic processes might be identical, but would the more time-demanding, probative, analytical, and creative aspects of comprehension be foreshortened? Or does the potential added information from hyperlinked text contribute to the development of children’s thinking? Can we preserve the constructive dimension of reading in our children alongside their growing abilities to perform multiple tasks and to integrate ever-expanding amounts of information? Should we begin to provide explicit instruction for reading multiple modalities of text presentation to ensure that our children learn multiple ways of processing information?

I stray with these questions. But indeed we stray often when we read. Far from being negative, this associative dimension is part of the generative quality at the heart of reading. One hundred fifty years ago Charles Darwin saw in creation a similar principle, whereby “endless” forms evolve from finite principles: “From so simple a beginning, endless forms most beautiful and most wonderful have been, and are being evolved.” So it is with written language. Biologically and intellectually, reading allows the species to go “beyond the information given” to create endless thoughts most beautiful and wonderful. We must not lose this essential quality in our present moment of historical transition to new ways of acquiring, processing, and comprehending information.

To be sure, the relationship between readers and text differs across cultures and across history. Thousands of lives have been altered or lost depending on whether a sacred text like the Bible is read in a concrete, literal way or in a generative, interpretative way. Martin Luther’s act of translating the Latin Bible into the German language, which permitted ordinary people to read and interpret it for themselves, significantly influenced the history of religion. Indeed, as some historians observe, the changing relationship of readers to text over time can be seen as one index of the history of thought.

The thrust of this book, however, will be more biological and cognitive than cultural-historical. Within that context, the generative capacity of reading parallels the fundamental plasticity in the circuit wiring of our brains: both permit us to go beyond the particulars of the given. The rich associations, inferences, and insights emerging from this capacity allow, and indeed invite, us to reach beyond the specific content of what we read to form new thoughts. In this sense reading both reflects and reenacts the brain’s capacity for cognitive breakthroughs.

Proust said most of this, if more obliquely, in a powerful description of the ability of reading to elicit our own thinking.

We feel quite truly that our wisdom begins where that of the author ends, and we would like to have him give us answers, while all he can do is give us desires. And these desires he can arouse in us only by making us contemplate the supreme beauty which the last effort of his art has permitted him to reach. But by . . . a law which perhaps signifies that we can receive the truth from nobody, and that we must create it ourselves, that which is the end of their wisdom appears to us as but the beginning of ours.

Proust’s understanding of the generative nature of reading contains a paradox: the goal of reading is to go beyond the author’s
ideas to thoughts that are increasingly autonomous, transformative, and ultimately independent of the written text. From the child’s first, halting attempts to decipher letters, the experience of reading is not so much an end in itself as it is our best vehicle to a transformed mind, and, literally and figuratively, to a changed brain.

Ultimately, the biological and intellectual transformations brought about by reading provide a remarkable petri dish for examining how we think. Such an examination requires multiple perspectives—ancient and modern linguistics, archaeology, history, literature, education, psychology, and neuroscience. The goal of this book is to integrate these disciplines to present new perspectives on three aspects of written language: the evolution of the reading brain (how the human brain learned to read); its development (how the young brain learns to read and how reading changes us); and its variations (when the brain can’t learn to read).

How the Brain Learned to Read

We will begin in Sumer, Egypt, and Crete, where the still mysterious beginnings of written language can be found among Sumerian cuneiform, Egyptian hieroglyphs, and some recently discovered proto-alphabetic scripts. Each major type of writing invented by our ancestors demanded something a little different from the brain, and this may explain why more than 2,000 years elapsed between these earliest known writing systems and the remarkable, almost perfect alphabet developed by the ancient Greeks. At its root the alphabetic principle represents the profound insight that each word in spoken language consists of a finite group of individual sounds that can be represented by a finite group of individual letters. This seemingly innocent-sounding principle was totally revolutionary when it emerged over time, for it created the capacity for every spoken word in every language to be translated into writing.

Why Socrates directed all his legendary rhetorical skills against the Greek alphabet and the acquisition of literacy is one of the great, largely untold stories in the history of reading. In words unerringly prescient today, Socrates described what would be lost to human beings in the transition from oral to written culture. Socrates’ protests—and the silent rebellion of Plato as he recorded every word—are notably relevant today as we and our children negotiate our own transition from a written culture to one that is increasingly driven by visual images and massive streams of digital information.

How the Young Brain Learns to Read and How We Are Changed over the Life Span

Several thought-provoking links connect the history of writing in the species to the development of reading in the child. The first is the fact that although it took our species roughly 2,000 years to make the cognitive breakthroughs necessary to learn to read with an alphabet, today our children have to reach those same insights about print in roughly 2,000 days. The second concerns the evolutionary and educational implications of having a “rearranged” brain for learning to read. If there are no genes specific only to reading, and if our brain has to connect older structures for vision and language to learn this new skill, every child in every generation has to do a lot of work. As the cognitive scientist Steven Pinker eloquently remarked, “Children are wired for sound, but print is an optional accessory that must be painstakingly bolted on.” To acquire this unnatural process, children need instructional environments that support all the circuit parts that need bolting for the brain to read. Such a perspective departs from current teaching methods that focus largely on only one or two major components of reading.

Understanding the period in development stretching from infancy to young adulthood necessitates an understanding of the full range of circuit parts in the reading brain and their development. It also involves a tale of two children, both of whom must acquire hundreds upon hundreds of words, thousands of concepts, and tens of thousands of auditory and visual perceptions. These are
the raw materials for developing the major components of reading. Owing largely to their environments, however, one child will acquire these essentials, and the other will not. Through no fault of their own, the needs of thousands of children go unmet every day.

Learning to read begins the first time an infant is held and read a story. How often this happens, or fails to happen, in the first five years of childhood turns out to be one of the best predictors of later reading. A little-discussed class system invisibly divides our society, with those families that provide their children environments rich in oral and written language opportunities gradually set apart from those who do not, or cannot. A prominent study found that by kindergarten, a gap of 32 million words already separates some children in linguistically impoverished homes from their more stimulated peers. In other words, in some environments the average young middle-class child hears 32 million more spoken words than the young underprivileged child by age five.

Children who begin kindergarten having heard and used thousands of words, whose meanings are already understood, classified, and stored away in their young brains, have the advantage on the playing field of education. Children who never have a story read to them, who never hear words that rhyme, who never imagine fighting with dragons or marrying a prince, have the odds overwhelmingly against them.

Knowledge about the precursors of reading can help change that situation. Thanks to remarkable new technologies, we can now see what happens if all goes right in the acquisition of reading, as a child moves from decoding a word like “cat” to the fluent, seemingly effortless comprehension of “a feline creature named Mephistopheles.” We find a series of predictable phases that a human passes through across the life span, illustrating just how different the circuits and requirements of a new reader’s brain are from those of an expert reader, who navigates the tangled worlds of Moby-Dick, War and Peace, and texts on economics. Our growing knowledge about how the brain learns to read over time can help predict, ameliorate, and prevent some forms of unnecessary reading failure. Today, we possess sufficient knowl-

edge about the components of reading to be able not only to diagnose almost every child in kindergarten at risk of a learning difficulty, but also to teach most children to read. This same knowledge underscores what we do not wish to lose in the achievement of the reading brain, just as the digital epoch begins to make new and different demands on that brain.

When the Brain Can’t Learn to Read

Knowledge about reading failure provides a different angle on this knowledge base, with some surprises for anyone who looks there. From the viewpoint of science, dyslexia is a bit like studying a young squid that can’t swim very fast. This squid’s different wiring can teach us both about what is necessary for swimming and about the unique gifts this squid must have to be able to survive and flourish without swimming like every other squid. My colleagues and I use a variety of tools, from naming letters to brain imaging, to understand why so many children with dyslexia, including my own firstborn son, have difficulty not only with reading but also with seemingly simple linguistic behaviors like discriminating individual sounds or phonemes within words, or quickly retrieving the name of a color. By tracking activity in the brain as it performs these various behaviors in normal development and in dyslexia, we are constructing living maps of the neuronal landscape.

The surprises on this landscape increase daily. Recent advances in neuroimaging research begin to paint a different picture of the brain of a person with dyslexia that may have enormous implications for future research, and particularly for intervention. Understanding these advances can make the difference between having a huge number of our future citizens poised to contribute to society and having a huge number who cannot contribute what they could otherwise. Connecting what we know about the typical child’s development to what we know about impediments in reading can help us reclaim the lost potential of millions of children, many of whom have strengths that could light up our lives.
For we are also in the exciting early stages of understanding the little-studied benefits that accompany the brain development of some persons with dyslexia. It is no longer reducible to coincidence that so many inventors, artists, architects, computer designers, radiologists, and financiers have a childhood history of dyslexia. The inventors Thomas Edison and Alexander Graham Bell, the business entrepreneurs Charles Schwab and David Neeleman, the artists Leonardo da Vinci and Auguste Rodin, and the Nobel prize-winning scientist Baruj Benacerraf are all extraordinarily successful individuals with a history of dyslexia or related reading disorders. What is it about the dyslexic brain that seems linked in some people to unparalleled creativity in their professions, which often involve design, spatial skills, and the recognition of patterns? Was the differently organized brain of a person with dyslexia better suited for the demands of the preliterate past, with its emphasis on building and exploring? Will individuals with dyslexia be even better suited to the visual, technology-dominated future? Is the most current imaging and genetic research giving us the outlines of a very unusual brain organization in some persons with dyslexia that may ultimately explain both their known weaknesses and our steadily growing understanding of their strengths?

Questions about the brain of a person with dyslexia lead us to look both backward to our evolutionary past and forward to the future of our symbolic development. What is being lost and what is being gained for so many young people who have largely replaced books with the multidimenionsed “continuous partial attention” culture of the Internet? What are the implications of seemingly limitless information for the evolution of the reading brain and for us as a species? Does the rapid, almost instantaneous presentation of expansive information threaten the more time-demanding formation of in-depth knowledge? Recently, Edward Tenner, who writes about technology, asked whether Google promotes a form of information illiteracy and whether there may be unintended negative consequences of such a mode of learning: “It would be a shame if brilliant technology were to end up threatening the kind of intellect that produced it.”

Reflecting on such questions underscores the value of intellectual skills facilitated through literacy that we don’t wish to lose, just when we appear potentially poised to replace them with other skills. This book is two parts science, one part personal observation, and as much truth as I can find to tell about how fiercely we must work as a society to preserve the development of particular aspects of reading, both for this generation and for generations to come. I will argue that unlike Plato, who with deep ambivalence straddled oral language and literacy, we do not need to choose between two modes of communication; rather, we must be vigilant not to lose the profound generativity of the reading brain, as we add new dimensions to our intellectual repertoire.

Like Proust, however, I can lead the viewer only so far in the realm of established or given knowledge. My final chapter goes beyond the information that we know, into areas where we have only intuition and extrapolation to guide us. By the end of this exploration of the reading brain, what we know of the profound cognitive miracle that takes place every time a human being learns to read will be the reader’s to preserve and to go beyond.
CONCLUSIONS: FROM THE READING BRAIN TO “WHAT COMES NEXT”

Each torpid turn of the world has such disinherited children to whom neither what’s been nor what is to come, belongs. For what comes next is too large and remote for humankind.

—Rainer Maria Rilke

Reading is an act of interiority, pure and simple. Its object is not the mere consumption of information. . . . Rather, reading is the occasion of the encounter with the self. . . . The book is the best thing human beings have done yet.

—James Carroll

In the clash between the conventions of the book and the protocols of the screen, the screen will prevail. On this screen, now visible to one billion people on earth, the technology of search will transform isolated books into the universal library of all human knowledge.

—Kevin Kelly

Every society worries over the future of its young and the challenges they will face. No one describes the accelerating pace of those challenges at this moment in human evolution more compellingly than the futurist and inventor Ray Kurzweil. His visionary work depicts the staggering shifts that may occur as the 100 trillion neural connections in our brains extend exponentially through the technological, nonbiological intelligence we have invented:

We can have confidence that we will have the data-gathering and computational tools needed by the 2020s to model and simulate the entire brain, which will make it possible to combine the principles of operation of human intelligence with the forms of intelligent information processing. We will also benefit from the inherent strength of machines in storing, retrieving, and quickly sharing massive amounts of information. We will then be in a position to implement these powerful hybrid systems on computational platforms that greatly exceed the capabilities of the human brain’s relatively fixed architecture.

How can we, limited by our current brain’s capacity for $10^16$ to $10^19$ calculations per second, even begin to imagine what our future civilization in 2099—with brains capable of $10^{60}$ calculations per second—will be capable of thinking and doing?

One thing we can imagine is that our capacities for good and for destruction will also be exponentially increased. If we are to prepare for such a future, our ability to make profound choices must be honed with a rigor rarely practiced by learners in past generations. If the species is to progress in the fullest sense, such preparations require singular capacities for attention and decision making that incorporate a desire for the common good. In other words, to prepare for what comes next demands the absolute best of what we possess in the present adaptation of the reading brain, as it already begins to undergo its next generation of changes.

I differ with Kurzweil’s implicit assumption that an exponential acceleration of thought processes is altogether positive. In music, in poetry, and in life, the rest, the pause, the slow movements are essential to comprehending the whole. Indeed, in our
brain there are “delay neurons” whose sole function is to slow neuronal transmission by other neurons for mere milliseconds. These are the inestimable milliseconds that allow sequence and order in our apprehension of reality, and that enable us to plan and synchronize soccer moves and symphonic movements.

The assumption that “more” and “faster” are necessarily better requires vigorous questioning, especially since this assumption already increasingly influences everything in American society, including how we eat and how we learn, with doubtful benefits. For example, will the accelerated rate of change already experienced by our children have consequences that radically affect the quality of attention that can transform a word into a thought and a thought into a world of unimagined possibility? Will this next generation’s capacity to find insights, pleasures, pain, and wisdom in oral and written language be dramatically altered? Will their relationship to language be fundamentally changed? Will the present generation become so accustomed to immediate access to on-screen information that the range of attentional, inferential, and reflective capacities in the present reading brain will become less developed? And what of future generations? Are Socrates’ concerns about unguided access to information more warranted today than they were in ancient Greece?

Or will the demands of our new information technologies—to multitask, and to integrate and prioritize vast amounts of information—help to develop equally if not more valuable new skills that will increase our human intellectual capacities, our quality of life, and our collective wisdom as a species? Could the acceleration of such intelligence allow us more time for reflection and for the pursuit of the good for humanity? If so, will this next set of intellectual skills produce a new disenfranchised group of differently wired children equivalent to the dyslexic readers of the present? Or will we now be more prepared to view children’s learning differences in terms of different patterns of brain organization, with genetic variations that bestow both strengths and weaknesses?

Dyslexia is our best, most visible evidence that the brain was never wired to read. I look at dyslexia as a daily evolutionary reminder that very different organizations of the brain are possible. Some organizations may not work well for reading, yet are critical for the creation of buildings and art and the recognition of patterns—whether on ancient battlefields or in biopsy slides. Some of these variations of the brain’s organization may lend themselves to the requirements of modes of communication just on the horizon.

In the twenty-first century we are poised to change significantly and rapidly in ways that most of us can barely predict or fully comprehend. It is within this pronounced sense of transition that I locate this book’s central themes about the evolution, development, and different organizations of the reading brain. The evolution of writing and the development of the reading brain give us a remarkable lens on ourselves as a species, as the creators of many oral and written language cultures and as individual learners with different and expanding forms of intelligence.

In this final chapter I use the lens of reading to look back over several major insights, and then to venture “beyond the text.” There, in that uncharted territory, I want to consider the implications of this information for the present generation of children and for the next. And by the end, I want to reflect on what we should strive with all our power to preserve in the reading brain, before the transition to its next rearrangement is complete.

**Reflections on Reading’s Evolution**

My overarching reaction to the evolution of the reading brain is surprise. How could a tiny set of token symbols flower in such a relatively short time into a full-blown writing system? How could a single cultural invention less than 6,000 years old change the ways the brain is connected within itself and the intellectual possibilities of our species? And then there’s a deeper surprise: how miraculous it is that the brain can go beyond itself, enlarging both its functions and our intellectual capacities in the process. Reading illuminates how the brain learns new skills and adds to its
intelligence: it rearranges the circuits and connections among older structures; it capitalizes on the ability to commit areas to specialization, particularly pattern recognition; and it illustrates how new circuits can become so automatic that more cortical time and space can be allocated to other, more complex, thought processes. In other words, reading displays how the most basic design principles in the brain's organization underlie and shape our continuously evolving cognitive development.

The brain's design made reading possible, and reading's design changed the brain in multiple, critical, still-evolving ways. The reciprocal dynamics shine through the birth of writing in the species and through the acquisition of reading in the child. Learning to read released the species from many of the former limitations of human memory. Suddenly our ancestors could access knowledge that would no longer need to be repeated over and over again, and that could expand greatly as a result. Literacy made it unnecessary to reinvent the wheel and thus made possible the more sophisticated inventions that would follow, like a machine that can read to those who can't, invented by Ray Kurzweil.

Simultaneously, the capacity of literacy for rapid-fire performance released the individual reader not only from the restrictions of memory but from those of time. By its ability to become virtually automatic, literacy allowed the individual reader to give less time to initial decoding processes and to allocate more cognitive time and ultimately more cortical space to the deeper analysis of recorded thought. Developmental differences in the circuit systems between a beginning, decoding brain and a fully automatic, comprehending brain span the length and breadth of the brain's two hemispheres. A system that can become streamlined through specialization and automaticity has more time to think. This is the miraculous gift of the reading brain.

Few inventions ever did more to prepare the brain and poised the species for its own advancement. As literacy became widespread in a culture, the act of reading silently invited each reader to go beyond the text; in so doing, it further propelled the intellectual development of the individual reader and the culture. This is the biologically given, intellectually learned generativity of reading that is the immeasurable yield of the brain's gift of time. The biological evidence for this view begins with the realization that structurally there is little to differentiate our brain today from that of nonliterate humans 40,000 years ago. We share our brain structures with our Sumerian and Egyptian ancestors. How we use and connect these structures, however, creates a distinction, as the comparative reading of different writing systems like hieroglyphs and alphabets illustrates. The pioneering work of Charles Perfetti, Li-Hai Tan, and their group demonstrates that each writing system—ancient or new—uses many similar and some unique structural connections. A brain wired to read Egyptian hieroglyphs or Chinese characters activates some areas never used to read the Greek or English alphabet, and vice versa. The variety of these adaptations is fresh evidence of the brain's innate potential for rearranging itself to perform new functions.

With the birth of writing systems, changes occurred in more than just the brain's circuitry. As the classicist Eric Havelock asserts, the Greek alphabet represents a psychological and pedagogical revolution in human history: the process of writing released an unprecedented ability to achieve novel thoughts. Some of our finest cognitive neuroscientists study the neurological basis for this new ability in all comprehensive writing systems, not only alphabets. They describe how the reordering of the brain's basic computations that occurs during the acquisition of reading becomes the neuronal basis for new thoughts. In other words, the new circuits and pathways that the brain fashions in order to read become the foundation for being able to think in different, innovative ways.

The reading revolution, therefore, was both neuronally and culturally based, and it began with the emergence of the first comprehensive writing systems, not the first alphabet. The increased efficiency of writing and the memory it freed contributed to new forms of thought, and so did the neuronal systems set up to read. New thought came more readily to a brain that had already learned how to rearrange itself to read; the increasingly so-
These ancient works became timeless witnesses to the emergence of what we often think of as modern consciousness.

Few scholars are more eloquent about the contributions of literacy to the emergence of consciousness in the ancient world than the Jesuit cultural historian Walter Ong. In his lifelong study of the relationship between the spoken word and literacy, Ong reframed the question of the unique contributions of reading in a way that may help us understand our own current transition to more digital modes of communicating. Two decades ago, Ong asserted that the real issue in human intellectual evolution is not the set of skills advanced by one cultural mode of communication versus another, but the transformative changes bestowed on humans steeped in both. In a prescient passage, Ong wrote:

The interaction between the orality that all human beings are born into and the technology of writing, which no one is born into, touches the depths of the psyche. It is the oral word that first illuminates consciousness with articulate language, that first divides subject and predicate and then relates them to one another, and that ties human beings to one another in society. Writing introduces division and alienation, but a higher unity as well. It intensifies the sense of self and fosters more conscious interaction between persons. Writing is consciousness-raising.

To Ong, new understandings of human consciousness were the real changes rendered when oral and written language converged: reading changed how human beings could think about thinking. From Levin’s disclosures in Anna Karenina to a spider’s predicament in Charlotte’s Web, the ability to see another’s thoughts makes us doubly aware—of the other’s consciousness and of our own. Through our ability to study people’s thought processes across 3,000 years, we are able to internalize the consciousness of human beings we could never otherwise imagine, including that of the greatest apologist of oral traditions, Socrates. It is only because we can read the product of Plato’s ambivalence that we
can come to understand Socrates and the universal nature of his concerns.

When all is said and done, of course, Socrates' worries were not so much about literacy as about what might happen to knowledge if the young had unguided, uncritical access to information. For Socrates, the search for real knowledge did not revolve around information. Rather, it was about finding the essence and purpose of life. Such a search required a lifelong commitment to developing the deepest critical and analytical skills, and to internalizing personal knowledge through the prodigious use of memory, and long effort. Only these conditions assured Socrates that a student was capable of moving from exploring knowledge in dialogue with a teacher to a path of principles that lead to action, virtue, and ultimately to a “friendship with his god.” Socrates saw knowledge as a force for the higher good; anything—such as literacy—that might endanger it was anathema.

Socrates' concerns might have been partly addressed through a more nuanced understanding of how inextricably related knowledge and literacy are, and how important they are to the development of the young. Ironically, today's hypertext and online text provide a dimension of virtual dialogue to reading in computer-based presentations. The contemporary scholar John McEneaney argues that the “dynamic agency of on-line literacy challenges the traditional roles of reader and author, as well as the authority of text.” Such reading requires new cognitive skills that neither Socrates nor modern educators totally understand. We are only at the beginning of analyzing the cognitive implications of using, for instance, the browser “back” button, URL syntax, “cookies,” and “pedagogical tags” for enhancing comprehension and memory. These tools have extremely promising implications for the intellectual development of the users, particularly users with discrete areas of weakness that applied learning technologies can address directly and well. As the applied technology expert David Rose and his group persuasively demonstrate, digital texts can offer choice to teacher and learner: “choice in appearance, in level of support, in type of support, in method of response, in content...all key to engagement.” And the engagement of our learners is as important today as it was in the Athenian courtyards.

There are deeper meanings in these Socratic concerns, however. Throughout the story of humankind, from the Garden of Eden to the universal access provided by the Internet, questions of who should know what, when, and how remain unresolved. At a time when over a billion people have access to the most extensive expansion of information ever compiled, we need to turn our analytical skills to questions about a society's responsibility for the transmission of knowledge. Ultimately, the questions Socrates raised for Athenian youth apply equally to our own. Will unguided information lead to an illusion of knowledge, and thus curtail the more difficult, time-consuming, critical thought processes that lead to knowledge itself? Will the split-second immediacy of information gained from a search engine and the sheer volume of what is available delay the slower, more deliberate processes that deepen our understanding of complex concepts, of another's inner thought processes, and of our own consciousness?

At the start of this book I quoted the technology expert Edward Tenner, who asked whether our new information technology would “threaten the very intellect that created it.” This book's questions are not quixotic efforts to prevent the spread of technology—whose indisputable worth transforms all our lives. Tenner's concerns are the technological analogue both of Socrates' concerns and of the issues discussed below about what the reading brain contributes to the intellectual formation of the species and the child. The question that emerges, therefore, is this: what would be lost to us if we replaced the skills honed by the reading brain with those now being formed in our new generation of “digital natives,” who sit and read transfixed before a screen?

The evolution of writing provided the cognitive platform for the emergence of tremendously important skills that make up the first chapters of our intellectual history: documentation, codification, classification, organization, interiorization of language, consciousness of self and others, and consciousness of consciousness itself. It is not that reading directly caused all these skills to flourish, but the secret gift of time to think that lies at the core of
the reading brain's design was an unprecedented impetus for their growth. Examining the development of these skills through the “natural history of reading” shows in slow motion how far our species has come in the 6,000 years since literacy emerged, as well as what it stands to lose.

Reflections on the “Natural History” of Reading

Each brain of each ancestral reader had to learn to connect multiple regions in order to read symbolic characters. Each child today must do the same. Young novice readers around the globe must learn how to link up all the perceptual, cognitive, linguistic, and motor systems necessary to read. These systems, in turn, depend on utilizing older brain structures, whose specialized regions need to be adapted, pressed into service, and practiced until they are automatic.

For this to happen in the absence of any genetic transmission specific to reading requires explicit learning and explicit teaching, all in a relatively brief time. Despite the fact that it took our ancestors about 2,000 years to develop an alphabetic code, children are regularly expected to crack this code in about 2,000 days (that is, by six or seven years of age), or they will run afoul of the whole educational structure—teachers, principals, family, and peers. If reading is not acquired on society’s schedule, these suddenly disinherit children will never feel the same about themselves. They will have learned they are different, and no one ever tells them that, evolutionarily, this might be for good reason.

As we recognize the neuronal high-wire act that the young brain has to accomplish to acquire reading, we as a society can begin to teach individual children. Some children need more help than others with one or more of the parts of reading. The more we learn about those parts, the better able we will be to teach all children. Within such a perspective there can be no one-size-fits-all instruction. Our expanding knowledge about the development of reading has the potential to contribute to two all-important goals: understanding the magnitude of the reading brain’s accomplishments, and improving the opportunities for every individual child in the next generation to learn to read.

The developmental transformations that mark the way to reading expertise begin in infancy, not in school. The amount of time the child spends listening to parents and other loved ones read continues to be one of the best predictors of later reading. As they listen to stories of Babar, Toad, and Curious George and say “good night moon” every evening, children gradually learn that the mysterious notations on the page make words, words make stories, stories teach us all manner of things that make up the known universe.

Their world of stories, words, and magic letters is a microcosm of the thousands of words, concepts, and perceptions that go into the development of the young brain reading itself to read. The more young children are engaged in conversation, the more they will acquire words and concepts. The more young children are read to, the more they will understand the language of books and increase their vocabulary, their knowledge of grammar, and their awareness of the tiny but very important sounds inside words. The full sum of this tacit knowledge—the similar sounds in “hickory, dickory, dock”; the multiple meanings of “bear”; the fearful thoughts of Wilbur the pig—prepares the young child’s brain to connect visual symbols to all that stored knowledge.

The development of reading, therefore, has two parts. First, the ideal acquisition of reading is based on the development of an amazing panoply of phonological, semantic, syntactic, morphological, pragmatic, conceptual, social, affective, articular, and motor systems, and the ability of these systems to become integrated and synchronized into increasingly fluent comprehension. Second, as reading develops, each of these abilities is facilitated further by this development. Knowing “what’s in a word” helps you read it better; reading a word deepens your understanding of its place in the continuum of knowledge.

This is the dynamic relationship between the brain’s contribution to reading and reading’s contribution to the brain’s cognitive
capacities. Children's phonological systems help them to develop an awareness of the sounds inside a word; this awareness helps them learn letter-sound rules; those rules help them learn to read more easily. Then, as children begin to read more and more, they become exquisitely attuned to the phonemic aspects in words, which makes reading easier. Similarly, children whose semantic systems are well developed know the meanings of more words, so that they are able to decode already known words faster. This adds to their repertoire of written words, which fosters their oral vocabulary, which prepares them to read even more sophisticated stories—which increases their knowledge of grammar, morphology, and relationships among words. "The rich get richer and the poor poorer." These developmental-environmental dynamics form the basis for making the great transition from "learning to read" to real reading, or not.

Fluent, silent comprehension in the later phases of reading development would have symbolized for Socrates the most dangerous moment in literacy, because it makes the reader autonomous. It gives each new reader time to make predictions, to form new thoughts, to go beyond the text, and to become an independent learner. Imaging studies confirm that the fluent reading brain activates newly expanded cortical regions across frontal, parietal, and temporal lobes of both hemispheres during comprehension processes such as inference, analysis, and critical evaluation. These are some of the very intellectual skills Socrates feared would be lost if literacy was allowed to spread.

Other concerns of Socrates are less resolved during the developmental transition to "expert reading." First, do most young readers, in fact, really learn to use their imagination fully, or to use their independent, probing, analytical processes? Or are these more time-demanding skills increasingly derailed by the seemingly limitless information children now receive on-screen? Do young readers who spend a disproportionate amount of their reading time on-screen, as opposed to in the pages of a book, develop differently in their ability to identify with Jane Eyre, Atticus Finch, and Celie?

I do not question the extraordinary ways the digital world brings to life the realities and the perspectives of other people and cultures. I do wonder whether typical young readers view the analysis of text and the search for deeper levels of meaning as more and more anachronistic because they are so accustomed to the immediacy and seeming comprehensiveness of the on-screen information—all of which is available without critical effort, and without any apparent need to go beyond the information provided. I ask, therefore, whether our children are learning the heart of the reading process: going beyond the text.

Recently I read an essay in the Wall Street Journal, headed "How Low Can They Go?" It was about the current decline in verbal SAT scores. The writer described recent changes in the SAT test that resulted in more emphasis on reading skills than on vocabulary, thereby rewarding students with more refined analytical skills and penalizing those less prepared to discern and evaluate the underlying meaning of a text. He observed that students of forty years ago probably would do better in this test format than today's students, who appear far less capable of reading critically. For this he blamed the schools, not the test.

Blame is rarely well distributed. The author of this essay may well be correct, but there are many reasons for a decline: some sociological, some political, and some cognitive. Many students who have cut their teeth on relatively effortless Internet access may not yet know how to think for themselves. Their sights are narrowed to what they see and hear quickly and easily, and they have too little reason to think outside our newest, most sophisticated boxes. These students are not illiterate, but they may never become true expert readers. During the phase in their reading development when critical skills are guided, modeled, practiced, and honed, they may have not been challenged to exploit the acme of the fully developed, reading brain: time to think for themselves.

Everyone involved in the education of the young—parents, teachers, scholars, policy makers—needs to ensure that each component of the reading process is sensibly, carefully, explicitly prepared for or taught from birth until full adulthood. Nothing, from knowledge about the word's smallest sounds in preschool to the
ability to interpret T. S. Eliot’s most subtle inferences in “Little Gidding,” should be taken for granted along the way. And within children’s particularly vulnerable transition to the level of fluent, comprehending reader we must exert our greatest efforts to ensure that immersion in digital resources does not stunt our children’s capacity to evaluate, analyze, prioritize, and probe what lies beneath any form of information. We must teach our children to be “bitextual,” or “multitextual,” able to read and analyze texts flexibly in different ways, with more deliberate instruction at every stage of development on the inferential, demanding aspects of any text. Teaching children to uncover the invisible world that resides in written words needs to be both explicit and part of a dialogue between learner and teacher, if we are to promote the processes that lead to fully formed expert reading in our citizenry.

My major conclusion from an examination of the developing reader is a cautionary one. I fear that many of our children are in danger of becoming just what Socrates warned us against—a society of decoders of information, whose false sense of knowing distracts them from a deeper development of their intellectual potential. It does not need to be so, if we teach them well, a charge that is equally applicable to our children with dyslexia.

Reflections on Dyslexia and Thinking Outside the Box

In a book devoted to the reading brain it would be easy enough to skip over the contributions of a brain ill-suited to reading. But the squid who doesn’t swim quickly has a lot to teach about how it learns to compensate. This is an imperfect analogy, to be sure, because the squid’s ability to swim is genetic and a squid who can’t swim quickly would very likely die. But if a poor-swimming squid not only didn’t die, but went on to beget 5 to 10 percent of the squid population, one would have to ask what in the world that squid had going for itself that made it so successful despite the missing capacity. Reading isn’t laid down genetically, and the child who can’t learn to read doesn’t die. More significantly, the genes associated with dyslexia have survived robustly.

The list of gifted figures with dyslexia—people such as Rodin and Charles Schwab—may be one reason why. Another reason is bound up in our human diversity. As Norman Geschwind often asserted, the diversity of our genetically endowed strengths and weaknesses allows us to form a society capable of meeting all our varied needs. Dyslexia, with its seemingly untidy mix of genetic talents and cultural weaknesses, exemplifies human diversity—with all the important gifts this diversity bestows on human culture. Picasso’s Guernica, Rodin’s Thinker, Gaudi’s La Pedrera, and Leonardo’s Last Supper are icons as real and as expressive of our intellectual evolution as any written text. That all these were created by individuals who more than likely were dyslexic is not coincidental.

The real tragedy of dyslexia is that no one tells this to the children who year after year publicly, humiliatingly, cannot learn to read, despite all their intelligence and despite the critical importance of just their type of intelligence for the species. Also, no one tells the children’s peers. This view does not minimize the difficulties every child with dyslexia confronts in learning. On the contrary, it tells these children just how important they are to us all, and that it is up to us to find better ways of teaching this differently organized brain to learn to read.

One of the most hopeful applications of neuroscience concerns just that. The more we know about the development of the reading brain and the dyslexic brain, the better we are able, in our interventions, to target more specifically the particular parts or connections that are not developing in some children. Intervention in dyslexia—just as in reading that is developing typically—must explicitly address every component system of reading intensively and imaginatively, until some level of automaticity and comprehension is attained. This is a far more difficult and demanding task for a brain that is wired less efficiently for many written language processes, and that may well represent a different adaptation of the brain for reading.
It is in the highest interests of our society to protect the potential contributions our children with dyslexia. As described in the work of Harvard scholar Gil Noam, there is a necessity that we help them endure what is difficult and foster their resilience, so that they are prepared to invent the next lightbulb when they are ready. I do not want to dwell on the waste that has been caused by years of ignorance about dyslexia and many other forms of learning disabilities. It is a sad chapter in the larger story that began when some of us learned to read, while others among us continued to build, create wondrous things, and think differently from the rest. Fortunately, the stories of the reading brain and the dyslexic brain are emerging as twinned tales in the larger saga of the great human family.

An appreciation of the genetic diversity that drives all these differences in our intellectual traits and skills is especially important during our transition to the near future. Not unlike Plato’s ambivalence, this book is written from two perspectives—that of a passionate apologist for the reading brain’s contributions to our intellectual repertoire, and that of a contributing participant in and vigilant observer of the technological changes which will help shape the next rearranged brains. Humans today do not need to be binary thinkers, and future generations certainly don’t. As an apt Viennese expression puts it, “If two choices appear before you, there’s usually a third.”

In the transmission of knowledge the children and teachers of the future should not be faced with a choice between books and screens, between newspapers and capsuled versions of the news on the Internet, or between print and other media. Our transition generation has an opportunity, if we seize it, to pause and use our most reflective capacities, to use everything at our disposal to prepare for the formation of what will come next. The analytical, inferential, perspective-taking, reading brain with all its capacity for human consciousness, and the nimble, multifunctional, multimodal, information-integrative capacities of a digital mind-set do not need to inhabit exclusive realms. Many of our children learn to code-switch between two or more oral languages, and we can teach them also to switch between different presentations of written language and different modes of analysis. Perhaps, like the memorable image captured in 600 BCE of a Sumerian scribe patiently transcribing cuneiform beside an Akkadian scribe, we will be able to preserve the capacities of two systems and appreciate why both are precious.

... . . .

In sum, the natural history of reading development presents an exceedingly hopeful, but also cautionary tale about reaching the highest and deepest levels of reading. It’s a magnificent, sometimes poignant, often humbling story that began thousands of years ago, in cultures that are known to us only because some human ancestors had the daring and the neuronal adaptability to preserve their debts and their yearnings on tablets of clay and rolls of papyrus.

Equally courageous, Socrates feared above all else that the “semblance of truth,” conveyed by the seeming permanence of this written language, would lead to the end of the search for true knowledge, and that this loss would mean the death of human virtue as we know it. Socrates never knew the secret at the heart of reading: the time it frees for the brain to have thoughts deeper than those that came before. Proust knew this secret, and we do. The mysterious, invisible gift of time to think beyond is the reading brain’s greatest achievement; these built-in milliseconds form the basis of our ability to propel knowledge, to ponder virtue, and to articulate what was once inexpressible—which, when expressed, builds the next platform from which we dive below or soar above.

To the Reader: A Final Thought

A book about how our species learned to leap beyond the text shouldn’t have a last sentence. Gentle readers, it is all yours. . . .