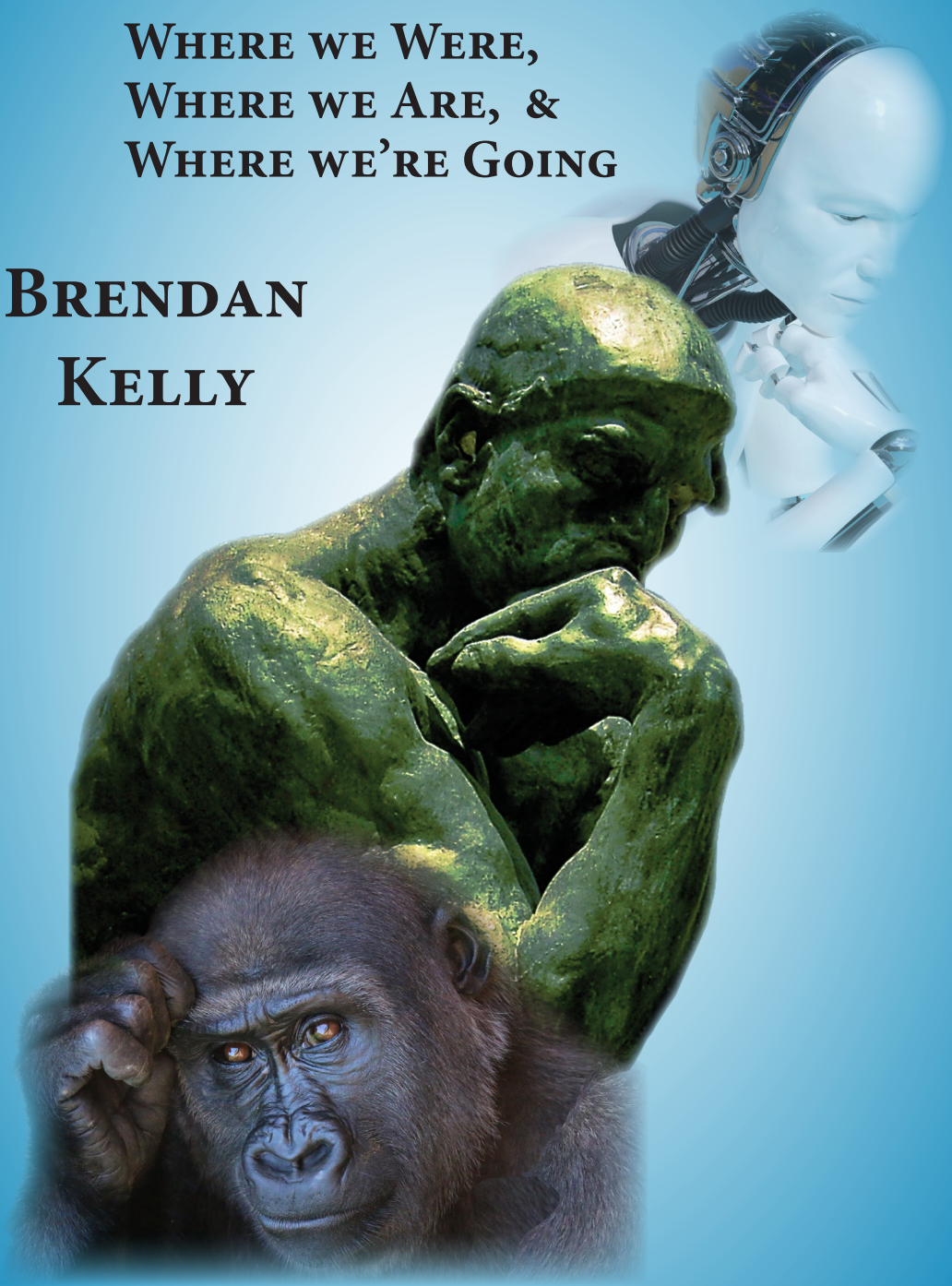
Intelligence

Where we Were, Where we Are, & Where we're Going

Brendan Kelly



Chapter 1

Profiles of Intelligence

Great spirits have always encountered violent opposition from mediocre minds.
– Albert Einstein, physicist

The Arbor Room: October 1962

Our story begins in the Arbor Room[1], where four math nerds met weekly to try to make sense of their changing world. Located in Hart House, in the University of Toronto, the Arbor Room was our sanctuary from the outside world–a kind of gentleman's club whose charter excluded females from entry before 2:00 p.m. It was an era, seemingly frozen in time, when the prevailing social structure appeared immutable. For us, it was an all-male world–it was neither good nor bad–it just *was*.

The walls of the Arbor Room were animated with caricatures of male barristers, passionately pleading their cases before stern male judges in long curly wigs. Debaters, expounding ideas were depicted next to young men adorned in mortarboard and gown, receiving their sheepskins at graduation. The murals presented an all-pervasive promise of exciting careers for those who successfully navigated the hallowed halls of academe.

During his visit to Hart House on November 14, 1957, John F. Kennedy had boldly asserted[2], "I personally rather approve of keeping women out of these places … It's a pleasure to be in a country where women cannot mix in everywhere." As one of the last bastions of male primacy, the Arbor Room was an environment where men shared lofty ideas and laughed unabashedly about their primal needs. I mention the gender discrimination, neither to celebrate nor condemn it, but merely to elucidate the era in which our journey began. However, in this "bank and shoal of time," the winds of change were beginning to blow in a direction that would profoundly alter the destinies of us all.

MPC–Mathematics, Physics & Chemistry

On May 25, 1961, in a joint session of Congress, Kennedy had announced his intention to surpass the Soviet Union (USSR) in the space race:[3]

> *…I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth.*

Aware that the successful Soviet launch of Sputnik in 1957 had damaged the prestige of the United States in the midst of the Cold War, Kennedy had

resolved to recapture the world-wide perception of the US as first in technology. A new era was emerging in which the cognitive tools of technology–mathematics and science–would become a major national focus. By 1962, this American initiative had spread north into the major Canadian universities. The stage was set for the ascendancy of the nerd to a status of respectability.

All of us were first-year undergraduates enrolled in a program called MPC[4], the acronym for Mathematics, Physics, & Chemistry. MPC was generally regarded as the most prestigious course at the University (especially by those in the program) because it followed the practice of failing half of the students in each of the first two years. The professors referred to this practice as "separating the wheat from the chaff." This declaration was based on the widely accepted assumption that intelligence, measurable by IQ tests, is a characteristic that is distributed unequally throughout the population. Separating the wheat from the chaff was seen as a process for identifying those at the upper end of the intelligence spectrum and moving them forward.

MPC was, indeed, a magnet that drew many of the "best and brightest" to the University of Toronto during those "Camelot" years for mathematical studies. While university undergraduate programs traditionally involved a broad education in the humanities, the demands of the Cold War had shifted the focus, for this special group of students, to a more intense study of the so-called "hard sciences." We were all about to be graded on the "wheat-from-chaff" scale.

The Arbor Room on Tuesday, October 16, 1962

It was one of those mornings when everything goes wrong. I missed the Jane bus that constituted the first segment of my trip to the University, and then one of the Bloor streetcars came off its trolley–sending me off mine. In short, I missed my first class that morning. Arriving at the Arbor Room, I saw that my fellow nerds were already seated around the perimeter of a circular table that would become our forum. This was the location where conversations spanned the spectrum from high cerebral content to low-level gossip.

"Hey Brendan, you're late," said David. "Did you make it to physics class this morning?"

"No," I responded. "What did I miss?"

"Professor Hallett gave us the full 'look-to-your-left-look-to-your-right' routine."

"You mean, 'look to the person on your left–one of you won't make it to second year–look to the person on your right–one of you won't make it to third year'?" I inquired.

"You got it!" interjected Eldon. "Only this time the professor upped the ante by asking, 'How many of you are here on some form of scholarship?' A sea of hands rose from the multitude in the lecture hall. Hallett seemed pleased that he had made his point."

"That's right!" added David. "Everyone suffered a sphincter contraction."

"Not everyone," interjected Eldon. Eldon knew he would never be chaff, and he never felt the need to display false humility. He was the alpha male in nerd country and on a few occasions, he had impressed the professors with sophisticated answers to difficult questions. By the end of the first four weeks of classes, Eldon had earned the respect of his classmates in MPC.

The facial features of this superhero in the MPC microcosm were as sharp as his insights, foreshadowing the emergence of Star Trek's Spock in the mid 1960s. His large forehead was underlined with thin eyebrows that bordered his narrow, piercing blue eyes. Sharp cheekbones and gaunt sunken cheeks, gave him the "lean and hungry look" of a Cassius[5], that hinted of an inner cerebral tenacity. Indeed, his face was a portrait of intensity.

"O.K., so you're a smart ass; but the rest of us are going to need to work hard to survive," said David.

"It's not work, if you love it," he responded. "Besides," he continued, "the 'look-to-your-left' metaphor is inconsistent with the assertion that half the students are going to fail in each of the first two years."

"How so?" responded David

"Well, not everyone has someone to his left or right."

"Geeeez," exclaimed David, exhibiting a mild form of frustration.

At this point, Sean, our resident sports enthusiast, jumped in, "Who's everyone picking to win the World Series?"

"That's right," someone interjected, "Today is the seventh game between the Yankees and the San Francisco Giants–a titanic east-west struggle."

(We did not know that, a few hours earlier, President Kennedy had been informed that there were Soviet missiles in Cuba, launching an east-west confrontation of epic proportions–for us, it was an *unknown unknown*.)

"Actually, it's not really an east-west struggle; it's really New York vs. New York," asserted Eldon.

"What do you mean?" asked Sean.

"Well five years ago, the San Francisco Giants were the New York Giants, so we really have two New York teams in the World Series. It's just a name change," observed Eldon. "The contest is only masquerading as east vs. west."

"Why is that important?" challenged Sean.

"Because it reveals our tribal instincts–our primitive need to divide our fellow humans into a "we-vs.-they" adversarial posture, even when the distinction is arbitrary."

"But, I think that's the great thing about sports; they channel natural aggression into a relatively harmless arena," rejoined Sean.

"Tell that to the victims of the soccer riots in Europe," retorted Eldon.

Coming to Sean's aid, David interjected, "Eldon, you have a way of taking the fun out of everything."

"How do you think I get my fun?" responded Eldon with a little self-satisfied smile that curled the corners of his mouth.

This was an early exchange among three compatriots who would become my life-long friends. It was not always clear to me whether Eldon believed in the positions he took or whether he merely enjoyed the parry and thrust of intellectual debate. However, I came to understand the depth of some of his insights only as time unfolded and the future became the present.

In the pages that follow, we will trace the journey of shared experiences and Arbor Room discussions that led these three talented young men to their lofty positions in society. It's a journey that I hope will provide some insights into a path that leads from thinking at an everyday functional level to thinking at the highest levels of intellectual sophistication.

Three Examples of "Wheat" on the "Wheat-from-chaff" Scale

On January 28, 1986, school children watched in horror as their teacher, Mrs. Christa McAuliffe, and six astronauts were instantly vaporized 73 seconds after the launch of the space Shuttle *Challenger.* The cause of the disaster was unclear, but until it was resolved, future NASA projects would be on hold. A mind-boggling list of potential causes confronted the *Presidential Commission on the Space Shuttle Challenger Accident* whose mission was to determine the cause of the disaster. Nobel laureate Richard Feynman, whom you will meet again in chapter 10, was one of the appointees to that Commission. Known for his eccentric genius and his ground-breaking contributions to physics, Feynman had distinguished himself for his unique ability to draw an insightful inference from clouds of complex information.

After traveling across America, interviewing engineers, and discussing various details about spacecraft, Feynman had an insight into the cause of the *Challenger* disaster. Feeling that Feynman's revelation might prove embarrassing to NASA, the Presidential Commission attempted to stifle his conclusion. Ever the renegade, Feynman insisted that his conclusions be published as a minority report, but the Commission decided to bury it in an appendix to the "official" report of the Commission. Not to be denied, he waited until the press conference at which the Commission's conclusions would be announced. When it was his turn to speak, Feynman extracted pliers and a clamp from his pocket. Holding a rubber O-ring in the clamp, he used the pliers to tear the O-ring away from its housing. Then

he dipped the O-ring in the pitcher of ice-water on the table, submerging it long enough to allow its temperature to reach the freezing point. Next he extracted the O-ring, distorted its shape with the pliers, and observed its lack of resilience at 0˚C. Then he said, "For a few seconds at least, … there is no resilience in this particular material when it's at 0˚C. I believe this has some significance for our problem."[6] He had shown, in dramatic fashion, the inability of the O-ring to snap back to its original shape at this temperature. It was this loss of elasticity in the O-rings on that cold January morning that allowed fuel to escape from the chamber and ignite. In the final statement of his report to the *Space Shuttle Challenger Inquiry,* Feynman observed, "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled."[7]

In his unrelenting quest for truth against all the political resistance, and his willingness to stand alone against the prevailing tide, Feynman exuded a defining characteristic of the world's most intelligent people. This formidable intellect had been identified as metaphorical wheat during the sorting process at the Far Rockaway High School in New York City in 1933.

Sometimes the sorting of the wheat from the chaff occurs even before high school. As a precocious toddler of 3, Jeff insisted that he should have a bed instead of a crib, but his mother, Jackie, denied his request. A short time later, his mother discovered him with screwdriver in hand, dismantling his crib and transforming it into a real bed. Jeff attended a Montessori pre-school where he became so engrossed in each project that he had to be picked up–chair and all–and moved to the next activity.

His elementary teachers in Houston, Texas, recognized immediately that Jeff was an exceptional child. At age 8, he was enrolled in the pilot program for gifted students at River Oaks Elementary School. In one of his more ingenious moments, he and some fellow students used a modem to connect a teletype machine to a mainframe computer and used it to play a Star Trek game. On another occasion, he created a makeshift buzzer for his bedroom door to sound an alarm when his younger siblings trespassed on his territory.

Jeff became one of the prized exemplars for the gifted program at River Oaks. In 1977, his intelligence prompted author Julie Ray to feature Jeff as the subject of a chapter in a book she was writing, titled *Turning on Bright Minds: A Parent Looks at Gifted Education in Texas*. In it she described him as a bright student of "general intellectual excellence." However, his elementary teachers assessed him as "not particularly gifted in leadership." (As noted by Gene Landrum in *Entrepreneurial Genius*,[8] "Teachers of the exceptional tend to admire the intellect and creativity of their gifted students, but typically find them to be difficult because of their intolerance of conformity and their need to push against limits.")

Having won awards as the best math and science student, and standing at the top of a class of 680 students in his graduation from Palmetto High, Jeff knew he was a commodity. He applied only to Princeton, because that was where Albert Einstein had been a professor, and Jeff wanted to study theoretical physics. That he would be accepted was never in doubt, but something he never anticipated–an unknown unknown–emerged. Could it be that Jeff might not be the most gifted student in the class? A career-changing moment in Jeff's life is described by biographer Mark Leibovich:[9]

> *One night during his freshman year, [Jeff] was struggling over a partial differential equation he had to complete for a quantum mechanics class. After a few hours of frustration, he and his study partner visited the dorm room of a classmate, who glanced at the equation and said, "Cosine."*
>
> *"After we expressed some incredulousness," [Jeff] says, "he proceeded to draw three pages of equations that flowed through and showed that it was cosine." It led to a realization: There were people whose brains were wired to process abstract concepts in a very graceful way, and he [Jeff] was not one of those people. "It was initially devastating," he says, "very, very, troubling."*

This epiphany prompted Jeff to re-direct his focus. He changed his major to electrical engineering and computer science. Once again, he excelled in the cognitive courses buttressed by abnormal intensity, competitiveness and a strong work ethic. He graduated summa cum laude in 1986 with a B.S.E. degree in electrical engineering and computer science and was subsequently elected to Phi Beta Kappa.

In 1994, while Vice-President at D. E. Shaw, a global investment company based in New York, Jeff observed the emergence of the internet and saw the potential for a bookstore in cyberspace. On February 9, 1995, Jeff Bezos dipped into his savings to incorporate this virtual bookstore. Within a decade, his fledgling company had expanded into the behemoth that eventually became America's leading online retailer–known today as Amazon.com. Jeff's brilliance resides in his ability to identify opportunities in a changing world. He is a prime example of wheat that was identified at an early stage.

Sometimes the sorting of the wheat from the chaff goes horribly wrong, resulting in top-grade wheat finding itself on the chaff pile. On February 12, 1809, the very day that Abe was born to a poor family in a one-room log cabin in Hardin County, Kentucky, a child named Charlie, was born to a wealthy and socially prominent family in Shrewsbury, England. Abe would eventually become the 16th President of the United States and a champion of abolition. Charlie, the grandson of two famous abolitionists would also become an abolitionist–but of a different kind.

When Charlie was 8 years old, his mother died and he was boarded at the local Anglican school for boys. His father Robert, a prominent physician, wanted Charlie to follow in his footsteps, so when Charlie reached the tender age of 16, he was entered into the prestigious Edinburgh School of Medicine. However, Charlie wasn't interested in practising medicine, so his disappointed father enrolled him at Christ's College, Cambridge where he would pursue an *ordinary* Bachelor of Arts degree to qualify as an Anglican parson. This lower-level program disqualified Charlie from writing the prestigious tripos examination at Cambridge, but this didn't matter because Charlie had little interest in academic study. He preferred riding, hunting, and beetle collecting to the dull and inert taxonomies that characterized his natural history studies. Ironically, his interest in the different varieties of beetles connected him to zoologist, John Steven Henslow, who subsequently sponsored him to serve an apprenticeship as a "gentleman scientist" on a two-year voyage to chart the coast of South America.

On December 27, 1831, at the age of 22, this apparently aimless young man set sail on the HMS Beagle on a voyage of discovery that would eventually lay the foundations of biology as a science. In 1859, Charlie, known to the world now as Charles Robert Darwin, wrote his *On the Origin of Species* that some regard as the most important scientific document of all time–establishing the *principle of natural selection* that explains how the environment determines which of nature's creatures will survive. As the mechanism underpinning evolution, natural selection showed that humans and the other primates share a common ancestor–abolishing forever the belief that humans are separate from the animal kingdom. Simultaneously, his birthmate and fellow abolitionist, Abraham Lincoln, was engaged in a campaign that would bring him into the White House the following year. Though Darwin and Lincoln would be identified today as metaphorical wheat, the former was originally relegated to the pile of chaff, while the latter reached the top of the wheat-from-chaff scale by natural selection.

What is Intelligence?

Implicit in the wheat-from-chaff scale is the assumption that there is a mental quality called "intelligence" that differs from one human to another and pervades all cognitive activity such as, decision making, the capacity for abstraction, and pattern recognition. In the early 20th century, Charles Spearman and others asserted that there is a general intelligence, called a *g factor*, that pervades all cognitive activity of an individual. Hence, humans could be compared on an intelligence scale of the wheat-from-chaff variety. A person with a higher ranking on the IQ scale would be expected to outperform, on most cognitive tasks, a person of lower ranking.

In the late 20th century, some social scientists challenged this idea, suggesting that each human has a set of proclivities for a variety of cognitive processes. Hence, an individual's cognitive strength could be measured by a set of "scores" on specific cognitive tasks–a vector rather than a single number. For example, one person might have a higher propensity than another for language acquisition, but a lower propensity for mathematical reasoning. Hence the intelligence of a person could not be characterized by a single score. The transferability from one proclivity to another was restricted, so ordering intelligence on a linear scale would not be possible. While both points of view have merit, there has been a natural tendency among humans–at least since the time of Homer in 600 BC–to attribute high intelligence to some individuals and not to others, based on observed behaviors. Teachers observe that some children seem to learn more quickly than others and understand concepts at a deeper level. Among our acquaintances and relatives, we observe those who seem to have high intelligence and those who do not. Since it's difficult to characterize how we make these judgments, we will take a "Wittgensteinian" approach. That is, we will define intelligence in a general sense as "the ability to perceive information, and to retain it as knowledge to be applied towards adaptive behaviors within a particular environment." Then we will use examples of high levels of cognition to define intelligence more precisely through context.

The foregoing examples of metaphorical wheat remind us that high intelligence is difficult to identify because it manifests at different stages in a person's lifetime and often masquerades in different disguises. Sometimes it is masked by anti-social behaviors and sometimes it lies dormant until ignited by some previously undiscovered passion. Albert Einstein was so slow in learning to talk that his parents consulted a doctor. His sister Maja reported, "He had such difficulty with language that those around him feared he would never learn [to speak]."[10] In fact, one of his schoolmasters predicted that he would never amount to much. Mozart, on the other hand, was identified as a prodigy early in life, creating compositions at age 5 and composing his first symphony at age 8, (though psychologist Michael Howe argues that Mozart's quality pieces were written after Mozart was 20 years of age.)[11]

More difficult than identifying high intelligence is the task of clarifying what is meant by intelligence. On what scale can we compare the genius of an Einstein and a Mozart? Thomas Edison, known for a variety of inventions, such as the light bulb, was regarded as the quintessential genius, yet when asked what he thought of Einstein's Theory of Relativity, he responded, "I don't think anything of Einstein's Theory of Relativity because I don't understand it."[12] Is intelligence a general cognitive aptitude that spans most

domains, or is it specific to restricted domains and not transferable across a wide spectrum? To gain insight into these questions, we will explore some recent research from a variety of fields including cognitive psychology, mathematics, neuroscience, and artificial intelligence. In the chapters that follow, we will examine in depth the various cognitive skills that define intelligence, such as:

- decision making
- visualization
- capacity for abstraction
- problem solving
- perceiving patterns and metaphorical connections
- drawing and testing inferences
- making predictions

These cognitive processes and the biases built into the human psyche by evolution are vital in understanding our own thought processes and in decreasing the gap between our perceptions and reality.

Is Intelligence Genetic and Immutable?

If we agree that there is a cognitive entity called "intelligence," we are confronted with the question about the degree to which intelligence is inherited and the extent to which it can be changed by environmental influences. If intelligence is determined solely by the genes, then the raison d'être for education evaporates. However, if it can be enhanced by environmental factors–the way athletic proclivities can be enhanced by training–then we must discover what kinds of experiences bring it to its maximum potential.

The nature vs. nurture discussion as it pertains to intelligence has precipitated a great deal of political debate since Sir Francis Galton, a 19th-century British scientist, proposed the idea of inherited intelligence in 1869. Some political scientists feared that if intelligence is inherited, it would justify the existence of an upper class consisting of the highly intelligent and their offspring. As the concept of IQ emerged in the early 20th century as a measure of general intelligence, the controversy expanded from class distinctions based on birth to class distinctions based on race. The emotionally-charged battles that erupted in 1994 with the publication of *The Bell Curve*[13] created a polarization in the community of social scientists. The so-called *hereditarians* asserted that intelligence is mostly genetic and environmental influences like training and education are limited in their effect. The *nurturists*, on the other hand, asserted that intelligence is quite malleable and subject to significant enhancement through intervention. The ensuing *Bell Curve Wars* evolved into a schism in the social

science community that split along the fault line of political ideology. This polarization was reminiscent of the antipathy that split the natural sciences when Copernicus challenged the geocentric model of the universe and when Darwin challenged the evolutionary separation of man and animal.

The controversies in the natural sciences were eventually resolved by the creation and testing of mathematical models through observation and measurement. However, the mathematical models in the social sciences have been less conclusive because concepts such as "intelligence" are less precisely defined and hence, less precisely measurable. Nevertheless, mathematical models together with observation remain our best cognitive tool in probing for answers in a labyrinth of complex information. It is the development of fluency in mathematics that is part of a newly evolving literacy that has been greatly amplified by the new technologies. We will investigate this new literacy in chapter 32.

What You've Got Left when You've Forgotten Everything You've Learned

During our freshman year, the Chairman of the Chemistry Department, Professor F. E. W. Wetmore, addressing us by our course acronym, asserted, "Mark you now MPC, education is what you've got left when you've forgotten everything you've learned." At that time, I sensed there was truth in his statement, though in the years that followed, I wondered *why* it was true. Eventually, I came to see how the educational experience, whether formal or informal, changes a person's perspective on issues enabling them to process information and make judgments so much more effectively than those who have never immersed themselves in some form of mental discipline. This higher form of cognition was seen to persist long after most of the facts and details of the learning experience had faded from memory. Somehow, in the process of reading, absorbing, reflecting, and analyzing, we develop the cognitive skills that expand our intellectual capacity. After we have forgotten the details in our study of the US Civil War, we have a better understanding of modern racial tensions in America. After we have forgotten the details of Darwin's observations in the Galapagos, we have a deeper insight into our origins and the roots of human behavior. After we have forgotten the specific techniques for solving differential equations or manipulating matrices, we can still read and interpret the equations we encounter in chemistry, physics, economics, psychology, and biology. I observed how the process of education somehow enhances our ability to access our cerebral capabilities and quiet the voices of instinct that came from our early beginnings as a species. Yet, neither I nor my MPC cohorts anticipated how these tribal instincts in our society would prevail in an all-out assault against the cerebral faculties as the future unfolded into the present.