Chapter 34

Society's Most Precious Resource

When you assemble the human résumé, only a few thousand people stand apart from the rest. Among them, the people who are indispensable to the story of human accomplishment number in the hundreds. Among those hundreds, a handful stand conspicuously above everyone else.

–Charles Murray, Political Scientist at the American Enterprise Institute

When I was a child, our annual summer holiday was a visit to my mother's family for two weeks in Keyport, New Jersey. This was a magical place where people spoke in what we called the "Joisey dialect." I played "bicebowl" [baseball] with my friends and went to the "seashowa" [seashore] with my family. In that delightful dialect resided the memories of good times in a carefree world, playing baseball in the park and visiting the Jersey shores in Asbury Park, Ocean Grove, and Monmouth Beach. I remember the men in white shoes, walking on the beach while officials checked our passes to ensure that we were dues-paying members. During these visits to the ocean, my siblings and I would ride the waves that would gather on the horizon, move toward us, and then flash a white underbelly just before crashing down and releasing an invisible energy that spilled onto the shore in a froth of bubbles. Correct timing would yield an exhilarating ride to shore, but a misjudgment, would catapult my corpus onto shore sending gravel between my swimsuit and my skin. The challenging part of this contest was in identifying the waves that would reach full maturity and deliver the enchanting ride. Some swelled early offering great promise, only to fizzle out with the failing expectation. Others, showing no hint of power, suddenly built to a crescendo with a thrilling release of unexpected energy. That's the way it was with the waves: some matured early and never materialized, some matured late with major impact, and yet others matured early and delivered impact beyond expectation. Capturing the energy in the ocean required identifying the waves with the greatest promise and riding them ashore. Years later, when studying human abilities, I discovered that the gifted, like waves, transmit an energy that "taken at the swell"[1] delivers precious rewards. A society must value, identify, and nurture this rich resource if it wishes to reach the highest levels of excellence.

On a steamy hot day in July 1988, about 30 years after these "Joisey" beach experiences, my wife, Teri, and I motored south along Interstate I-75 en route to our newly purchased condo in Florida. Our two young

children in the back seat inquired every few minutes whether we were there yet. Packing for a one-month vacation had delayed our departure from Burlington, Ontario leaving us just outside Toledo, Ohio as the sun touched down in the southwest corner of flatland farms.

An hour later, we were seated in the modest dining area of a very modest motel. A television mounted above the restaurant bar was broadcasting the news, reporting various world-wide events, when through a cacophony of sound bites, I heard the word "mathematics." The news item described a young Canadian student from a school in Toronto, who had achieved something remarkable in a mathematics competition–he stood first in the *American* Mathematical Olympiad in his final year of high school. Although I didn't catch his name, nor many of the details in the report, it was a pleasant surprise that the public respected such an intellectual achievement enough to feature it on the news. Never imagining that our world lines would intersect, I returned to our dinner table conversation and our children's pleas to visit Disney World.

A Strange Serendipity

In 1993 while attending a trustee meeting of the Sam Beatty Memorial Fund–an endowment to the U of T Mathematical Sciences Departments–I met Ravi Vakil, our recently appointed trustee. He was the rising mathematical star whom I had seen 5 years earlier on that television news clip. Ravi was now in his second year of postgraduate study at Harvard, having won virtually every high school mathematics competition that existed. He won a Silver Medal in 1986 at the International Mathematical Olympiad (IMO) in Warsaw, a Gold Medal at the IMO in Havana in 1987, and another in Canberra in 1988. As if dominating mathematics wasn't enough, he also won first prize in the Canadian Association of Physics Competition and led his high school computer team to three Ontario championships. During his undergraduate years, he placed among the top 5 competitors in the prestigious William Lowell Putnam Mathematical Competition, (chapters 9 and 10) earning him the top award of "Putnam Fellow" in *each* year. Since its inception in 1938, only 8 competitors have been able to achieve this amazing feat. His stellar performance prompted the *San Francisco Chronicle* to describe him as "a legend in the world of math competitions."

photo by Jewel Randolf

Ravi Vakil 1992 at 22 years of age

At the meeting, Ravi exuded the qualities common among people of exceptional intellect. His eyes darted back and forth as he absorbed with intensity the comments made by the other trustees. When he spoke, his

words often spilled over one another in a scramble to finish one idea to make room for the next–tailgating on its predecessor. He exuded the humility characteristic of those who are sufficiently confident in their personal prowess to acknowledge the attributes of others. In short, Ravi was personable and gregarious.

In 1990, I had incorporated *Brendan Kelly Publishing* to provide mathematics resources for teachers, and during the meeting, it occurred to me that no one was better qualified to author a book on problem solving than one who had triumphed in mathematics competitions.

During the dinner that followed the meeting, Ravi and I discussed the need for a problem-oriented book designed for bright high school and university students. This book would speak directly to the student in a light, informal way, capturing the aesthetics, paradoxes, and challenges of interesting problems and patterns in mathematics. Instead of presenting the traditional collection of puzzles, this book would develop "big ideas," and communicate how mathematicians *really* think about problems, and why mathematics is a unique field in which advances are measured by depth and beauty.

By the end of dinner, Ravi and I had agreed to collaborate in the publishing of a book that would meet our shared vision. He would be the author, and I would be the publisher, offering ideas concerning content. A few weeks afterwards, we met for coffee at a restaurant on Bloor Street to map out the content of the book. Our discussion was both exhilarating and exhausting. As ideas poured from Ravi's brain, our mutual excitement about the content of our book grew unabated, with Ravi speaking in the staccato style that I had observed at the trustee meeting. The pace of the conversation was swift, and punctuated with brief "ah ha" moments, resembling an intense tennis match when the ball stays in perpetual motion, interrupted only by an occasional pause.

Together, we had come upon the idea of providing role models for aspiring young people with an interest in puzzles and problem solving. Ravi's extensive work with international mathematics competitions had put him in touch with many of the top medalists world-wide. We agreed he would contact these people and solicit information and photos that would form a basis for short biographies. This special feature would add a dimension of human interest to the grand sport of mathematical problem solving. What we didn't anticipate until the creation of the second edition, 10 years later, was that this feature would yield some interesting insights into giftedness in mathematics.

Shortly after our meeting, Ravi started writing the book that he eventually titled, *A Mathematical Mosaic: Patterns & Problem Solving*.[2] We communicated throughout 1994, Ravi sending me drafts of chapters, and I commenting and attempting to add something where possible. By April 1995, in spite of the intense postgraduate work he had undertaken at Har-

vard, Ravi informed me that he had completed the first draft of the *entire* manuscript. I was presenting at the Annual NCTM Conference in Boston, so I met him at Harvard, and he handed me what was to become a seminal publication in the recreational mathematics genre.

After 8 months of revisions, rewrites, and scrupulous efforts to create and polish the mathematical gems, *Mosaic* was print-ready. Ravi's meticulous attention to detail included his request, out of respect for Hungarian readers, that we search for a font that would print the name Erdős, using the proper accent over the "o". When *Mosaic* was published in early 1996, it received wide acclaim. A review in *The Mathematics Teacher* asserted, "Without a doubt, this book is a must for any library, teacher's reference or student's amusement."[3] This was followed by a review in the *American Mathematical Monthly* stating:[4]

> *[A Mathematical Mosaic] speaks in an interesting and understandable way about number theory, combinatorics, game theory, geometry, and calculus, to say nothing about magic tricks, puzzles and other digressions. What is most important is that whenever Vakil starts to discuss something, he never leaves the reader without a piece of exact, rigorous knowledge.*

Mosaic became a favorite of university summer programs for bright students graduating from high school as well as for high school math clubs and math olympic teams.

In the decade that followed, Ravi completed his doctorate at Harvard in algebraic geometry, taught at Princeton and MIT, and ultimately took a position in the Mathematics Department at Stanford. When it came time to reprint *Mosaic*, we discussed the idea of updating the profiles of the superstars we had featured in the first edition, so that the reader could see where the winners of math olympiads were 10 years after their victories. Of the 7 people profiled in the first edition, Ravi was able to track down all but one, Eugenia Malinnikova of Russia. To this list, he added profiles of 5 more superstars, two of whom would be awarded a Fields medal in 2014!

Profiles of Giftedness

These twelve mathematically gifted high school students who distinguished themselves in mathematics competitions went on to excel at the most prestigious universities and, almost all, graduated with a Ph.D. in mathematics. En route, they had persevered through the pressure-cooker existence of the mathematics researcher and built the skills and knowledge they would need to make a substantial contribution to society. Table 34–1 summarizes the education and the career path of these remarkable individuals.

A Glimpse of the Mathematically Gifted

Table 34–1

Name	Education	10 Years Later
J. P. Grossman	Ph.D. in engineering at MIT–focus on massively parallel computing.	Co-invented the computer game *Clobber.* Research in computer software design at D. E. Shaw.
Catriona Maclean	Ph.D. in mathematics in Paris	Maître de Conférences at the Université Joseph Fourier–Grenoble, France.
Ka-Ping Yee	Ph.D. at Berkeley in human-computer interaction.	Software engineer for movies, including *Star Wars Episode I: The Phantom Menace.*
Richard Rusczyk	From Princeton to Stanford for graduate work in mathematics.	Left job as Senior Vice President at D. E. Shaw to found the website *Art of Problem Solving.*
Jordan Ellenberg	M.A. in Creative Writing at Johns Hopkins University. Ph.D. in number theory at Harvard.	Professor at U. of Wisconsin. His 2014 book, *How Not to be Wrong: The Power of Mathematical Thinking* became a bestseller.
Manjul Bhargava	Ph.D. in number theory at Princeton, followed by a year at the Institute for Advanced Study.	Full professorship at Princeton at age 28. In 2014, was awarded a **Fields Medal**, the highest honor in mathematics.
Vin de Silva	Ph.D. at Oxford in symplectic topology.	Working in machine learning, cognitive science, and applied algebraic topology.
Melanie Matchett Wood	The first female Putnam Fellow. Ph.D. in number theory at Princeton.	Mathematics Professor at the University of Wisconsin.
Eric Wepsic	Graduated from Harvard. Left Ph.D. studies at Harvard to join D. E. Shaw	Became a "quant" and eventually a Managing Director and member of the Executive Committee at D. E. Shaw
Maryam Mirzakhani	Maryam was gold medalist at the IMO in 1994 and 1995. Ph.D. from Harvard–offered a Professorship at Princeton.	Mathematics Professor at Stanford. In 2014 became the first female to be awarded a **Fields Medal**. Tragically, at age 40, succumbed to breast cancer on July 14, 2017.
Noam Elkies	Attended Julliard School of Music and graduated from Harvard with a Ph.D. in mathematics.	Proved an outstanding conjecture in number theory. At 26, became the youngest person to receive tenure at Harvard.

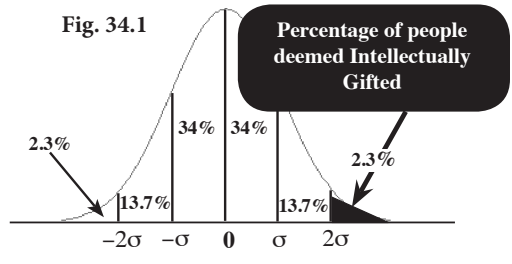
Table 34–1 reveals that high intelligence spans a wide spectrum of ethnicities and cultures, and is manifest in both genders. In fact, Eugenia Mallinikova, whom Ravi had profiled in the first edition of *A Mathematical Mosaic*, re-surfaced after a period of absence from mathematical research, to win the prestigious Clay Research Award in 2017 for her groundbreaking work in properties of solutions to elliptic eigenvalue problems. Ravi's detailed profiles of this mathematically gifted pantheon affirm that each of them has made substantial contributions in the decades following their formal education. Challenging the myth that the mathematically gifted are narrowly-focused linear thinkers, their biographies show that their collective contributions span areas as diverse as music, drama, literature, politics, and movie-making. Ravi, himself, explained in his profile in 1998:[5]

> *Until recently, it's been unclear that I'd be a mathematician, … , I planned on doing math so long as I could keep doing fun things. I also studied physics, but my first love was politics: I studied international relations and political theory, and took my LSATs in preparation to apply to law schools. My last year of university was spent mostly in extra-curricular and political philosophy courses.*

The fact that those who display mathematical giftedness also exhibit giftedness in other cognitive areas suggests that exceptional mathematical talent may be a good indicator of general intellectual brilliance.

What Proportion of Significant Contributions come from the Gifted?

In chapter 10, we saw several more examples of previous contest winners who went on to become Nobel laureates or Fields medal recipients. In addition to those identified through mathematics competitions, there are many gifted people who do not enter competitions, but who also make brilliant discoveries or create great works of art. In assessing the value of the gifted to our society, we are prompted to ask what proportion of significant contributions come from that elite sector endowed with cognitive or creative talent.



In psychology and education, the intellectually gifted are typically defined to be those with IQ at least two standard deviations above the mean, i.e., IQ ≥ 130. Furthermore, if accomplishment is strongly correlated to intellectual giftedness, we might expect that accomplishments in a modern industrialized society (where virtually ev-

eryone has access to education) might also be distributed in accordance with the normal distribution.

In *Human Accomplishment*, Charles Murray presents data to identify the sources of human achievement in the arts and sciences from the beginning of recorded history to 1950. While Murray accepts that human intelligence is distributed according to the normal distribution, he provides data to support the claim that *achievement* throughout the human population is represented by the Lotka (chapter 31) rather than the normal distribution. In fact, he asserts that the overwhelming number of world-changing discoveries, inventions, and creative works come from a remarkable few whom he designates as the "giants" in those domains:[6]

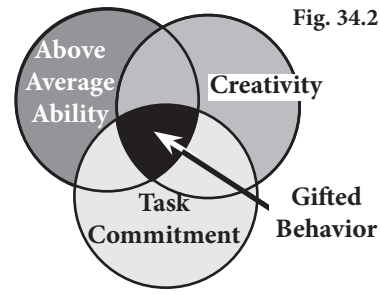
> *When you assemble the human résumé, only a few thousand people stand apart from the rest. Among them, the people who are indispensable to the story of human accomplishment number in the hundreds. Among those hundreds, a handful stand conspicuously above everyone else.*

This "handful" of giants in each field have contributed more than all the rest. This idea has been expressed quantitatively in a variety of forms. We recall from chapter 31 that Lotka's law asserts that the number of scholars who publish *exactly n* papers is approximately C/n^a where C is a constant specific to a given discipline and a is a constant close to 2. Heuristically speaking, this is like an inverse square law: the number of authors who have published n papers drops off as $1/n^2$. Related to this is Price's law, which asserts that half of all contributions to a given field are produced by the square root of the number of contributors.[7] For example, of 100 researchers in any field, the 10 most prolific would account for half of the total output. If the output is measured in terms of the number of papers published, each of the 10 most prolific people would contribute, on average, 9 times as many papers as each member of the other group.

These heuristically established "laws" indicate that the elite class of the "accomplishment gifted" is a relatively small subset of the intellectually gifted. Why is it that only a fraction of gifted people are making the great intellectual breakthroughs, inventions, and creative works that qualify them as the "giants" in their domain?

Renzulli Model of Gifted Behavior

Fig. 34.2



In 1978, Joseph Renzulli introduced what is known as his "three-ring" definition of giftedness.[8] He argued that "gifted behaviors" consist of 3 components: ability, task commitment, and creativity. Gifted behavior, as the intersection of the three components

flourishes when all three factors are simultaneously in play. That is, for someone to display gifted behavior, he or she must have above average ability, exceptional creativity, and extraordinary task commitment. If we assume that these three behaviors are independent and normally distributed throughout the population, then we can make a crude estimate of the percentage of people in the general population who will display gifted behavior as follows.

If we define "above average ability" to be one standard deviation above the mean, then we know from figure 34.1 that about 16% of the population satisfies this criterion for activities that strongly correlate with IQ. Similarly, let's also consider that about 16% of the population satisfies each of the criteria for creativity and task commitment. Our contestable assumption that these three components are independent enables us to estimate the proportion of people who may exhibit gifted behavior to be about $0.16 \times 0.16 \times 0.16 \approx 0.004$ or 0.4% of the population. This is substantially smaller than the 2.3% who are 2 standard deviations above the mean in intelligence or in any normally distributed characteristic. If there are more than 3 components (as suggested by Nobel laureate William Shockley[9]) required for gifted behavior, this would skew even more, the distribution of creative achievements throughout the human population.

In *Empowerment*, psychologist Gene Landrum notes that the greatest athletes have exceptional physical skills, but argues that it's their emotional and mental dispositions that catapult them from exceptional to eminent status:[10]

> *The truly eminent have physical skills that locate them on the right tail of the normal curve, but emotional and mental dispositions are the factors that combine to move the eminent to the extreme right tail of a Lotka curve, way ahead of the pack.*

Indeed, exceptional physicality embedded in the DNA is a necessary condition for an athlete to participate in the Olympics but, as in the case of mathematical performance, additional qualities of personality are required to win the gold. Vital to the development of those qualities is an environment in which world-class performance is valued and nurtured. A society that recognizes the importance of giftedness, especially mathematical giftedness, and celebrates intellectual achievement stands to reap substantial rewards. Later in this chapter, we will attempt to make the case to support the following hypothesis.

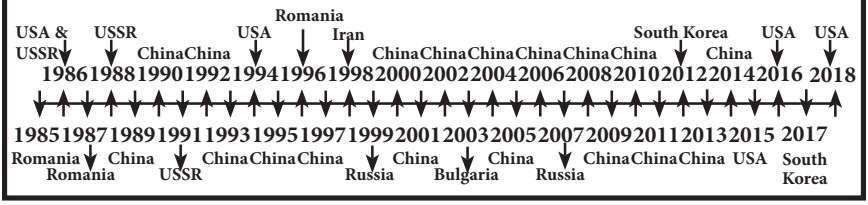
Hypothesis 34.1

The most precious resource in any society is the collective output of those who demonstrate gifted behaviors in the extreme. A society that cultivates and nurtures creative endeavor, ensures its survival and elevates the standard of cultural richness for all *of its members.*

How Prevalent is Cognitive Giftedness Across Cultures?

Just as Olympic games provide us with a rough assessment of athletic proclivities across cultures, so too mathematics olympiads can be used to survey cognitive giftedness across countries. Since the international mathematics competitions include a wide representation of nations, their test results can shed light on the global distribution of mathematically fertile cultures. Figure 34.3 displays the nation whose team stood first in the IMO Competition each year between 1985 and 2018.

Nation with the Highest Team Score by Year **Fig. 34.3**



We see that in this 34-year period, the Chinese team came first 18 times, Russia (including the USSR) 5 times, the USA 5 times, Romania 3 times, South Korea twice, and Bulgaria and Iran once each. (The total number of wins is 35, because the USA and USSR tied for first in 1986.) In 2018, more than 100 countries entered teams into the IMO, yet we see that China has dominated, while Russia, and the United States are strong, and Romania and South Korea are close behind. The Chinese domination might be explained by sheer population numbers, i.e., a royal flush of cognitive capabilities is more likely to occur at least once in a population of 1 billion than in a population of 1 million.[11] It might also be explained by the existence of a culture that values and nurtures mathematical achievement. For example, on the 2018 US team, James Lin scored a perfect paper, while Andrew Gu, Vincent Huang, Michael Ren and Mihir Anand Singhal all won gold medals and Adam Ardeishar won a silver–most of the team composed of second or third-generation immigrants from cultures that value mathematics.[12]The coach of the US team was Professor Po-Shen Loh who is the son of immigrant parents from Singapore.

Arbor Room Meeting at CERN: November 6 – 20, 2018

After many years of talking about meeting at the CERN, it was finally about to happen. Sean had arranged for a visit to the Large Hadron Collider (LHC) where the Higgs boson was discovered in 2011-2012 and confirmed in 2013. Our visit to the CERN would be followed 4 days later by a short drive to the celebrated Chamonix Resort, where Sean had rented a

chalet. Since our flights were to arrive at different times, we had agreed to meet for cocktails and dinner at 6:00 p.m. in the lobby of the Hotel Bristol.

Weary from the long overnight flight from Toronto, I booked into the Hotel, and took a brief power nap–refreshing me enough to finish the work on my laptop that had engaged me during my travel. Then, I shaved, showered, and descended the elevator to the lobby, where three distinguished-looking gentlemen were involved in conversation.

"Brendan, you made it just in time to weigh in on our discussion," said Eldon. "But first, let's find the bar."

Since we had met less than a year ago, we had dispensed with the usual pleasantries, and after finding a table in the bar launched right into the discussion that had begun before my arrival.

"We were just discussing the conference at CERN a month or so ago," said Sean. "It was the *High Energy Theory and Gender Conference*, where Alessandro Strumia of the University of Pisa, gave a talk in which he argued that women are not as good at physics as men, yet they are being given special funding and unwarranted promotions in the interest of equality."

"Wow! The timing is ironic, wasn't Donna Strickland from your post-graduate alma mater recently awarded the Nobel Prize in physics?" I asked.

"Yes, Waterloo University is under pressure to make her a full professor."

"What happened to Professor Strumia after his presentation?" I asked.

"CERN disavowed his opinions, charging that his talk was 'highly offensive,' and removed all his slides from the Conference website."

"How did Strumia respond?" asked David.

"He said that he was merely speaking the truth and that his slides provided the truth."

"I don't know specifically what he said, but in this political climate, truth is perceived differently depending on your ideology. Look at what happened in America over the Judge Kavanaugh appointment," I commented.

"Quite right," interjected Eldon. "In my senior years, I'm becoming more cynical and increasingly convinced that we humans operate mostly in the visceral and seldom in cerebral mode."

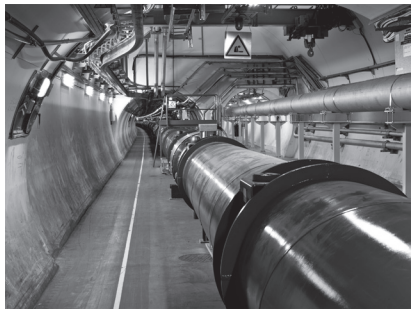
"But surely at the CERN," protested David, "aren't the people predominantly rational?"

"Yes, when they're doing physics. But when it comes to receiving acknowledgement for their work or looking for advancement, the primate need for intra-tribal status comes to the fore. It's ironic that evolution has developed in us a neocortex that enables us to engage in highly productive cerebral activity; yet, when a critical mass of people form a visceral tribe, the individuals collapse like the wave function into visceral mode. The tribal IQ is always significantly lower than the individual IQs. That's

why groupthink fails."

I had never before seen this side of Eldon. It seemed as if he had become disillusioned with life and had given up on the human species. His insights were as prescient as ever but later, throughout dinner, he evoked a tone of passive resignation to the irrational behavior of humans. He seemed to have lost some of the fire of his earlier days.

The next day, Eldon took us on a tour of the LHC. This giant torus of diameter 8.6 km is not only a monument to science, but is also a tribute to human curiosity–the unrelenting quest to convert known unknowns to known knowns. Sean, David and I had not seen Eldon in his home environment, but were overwhelmed by the celebrity status he enjoyed at CERN. No matter where we went, someone would stop to pay him homage with an enthusiastic handshake or a shared vignette. The deference in the body language of his colleagues displayed the elevated status that he had earned. To us, he was just "Eldon," but within his tribe, he was a demi-god.



reprinted by courtesy of CERN

After the awe-inspiring tour of the LHC, someone announced that it was lunch time, so we made a soft landing in a cafeteria that the inmates called *R1*–an abbreviation for the creative name, "Restaurant #1."

"Well Sean," said Eldon, "I know you love donuts. Was the LHC big enough for you?" [Everyone laughed, as they recalled Sean's favorite Arbor Room confectionery.]

"Eldon," I asked, "what was it that prompted Peter Higgs to conjecture the existence of the boson?"

"Actually, he was attempting to explain how elementary particles can obtain a rest mass while preserving gauge invariance. Elementary particle physics seeks patterns in equations to construct models that form a basis for our conjectures. Then we test the conjectures by observing what happens when we accelerate elementary particles in the LHC. It's usually "theory-first-observation-second," though sometimes we observe something that prompts a new theory."

"It seems that in the microcosm our intuition must rely on symmetries in mathematical representations," suggested David.

"That's true whenever we're outside our direct sensory realm," Eldon responded.

During our tours of the LHC, I was at a loss to describe its impressive combination of architecture and engineering, except to say that it may

qualify as one of the Modern Wonders of the World. It has enabled humans to view the microcosm at its most fundamental level and investigate the mechanisms that generate mass–the stuff of which the universe is built. The LHC also showcased what can be achieved when a large number of humans cooperate in a shared project–a quality that brought us to the top of the top of the food chain in the animal kingdom (chapter 28).

The CERN is an intellectual ant colony consisting of components united in a common purpose. It was clear that the scientists were immersed in their work and little concerned with the trappings of affluence. Their offices resembled rabbit hutches carved out of a concrete slab, and the attire of the inmates revealed that the only dress code was the prohibition of smart casual. Their haste to consume lunch quickly and return to work revealed the intensity of their engagement, enabling them to ignore questions about life's purpose and live from moment to moment; this was how they found their meaning in life.

After our tour of the CERN, we spent several days exploring Geneva and traveling to the nearby towns in France and Switzerland, culminating in a drive to Chamonix Resort. There we imbibed in a week of skiing, schussed down long runs adorned with spectacular vistas in the French Alps, and made soft landings in our chalet for après-ski. The outer glow of cold air against the face, followed by the inner glow of a brandy by the warm fireplace, provided an ideal stimulus for many relaxed reflections on the well-being of the inner man.

During our final après-ski, the night before our departure, we finished dinner and convened in the parlor of the chalet, from which we could see the lights reflecting off the snow in a crystalline sparkle. In the afterglow of Bordeaux wine, I shared my impressions of what I had observed at CERN, noting the total engagement that the physicists seemed to exude. "Imagine," I asserted with great enthusiasm, "what these people could achieve if their longevity were extended to 200 years!"

Eldon hesitated, "Total engagement is how we find purpose in life, in the face of no alternative. We humans have evolved to fear and avoid death; it's in our DNA. But during our evolution, we've developed a neocortex enabling us to understand that our lives have no purpose. Our visceral aversion to death is in continuous conflict with our cerebral awareness that life has no purpose. This is the cosmic joke: we are hardwired to pursue purpose in a purposeless universe. Tolstoy, observing this quandary, said something to this effect in his *Confession*."

[After our Arbor Room meeting, I tracked down Tolstoy's comments]:[13]

> *According to rational knowledge, it follows that life is evil, and people know it. They do not have to live, yet they have lived and they do live,*

just as I myself have lived, even though I have known for a long time that life is meaningless and evil.

Responding to Eldon's uncharacteristically negative tone, David challenged, "Eldon, you sound weary of life, but that doesn't match your behavior on the slopes a few hours ago. You appeared exhilarated!"

Eldon paused before responding, "Yes, I was living in the moment on the ski runs. But the long run is different. We humans live our lives from day to day, pursuing one goal after another. Eventually, we tire of the relentless pursuit of goals and we lose interest in life. I call this *psychological longevity*. It's that time span between our birth and the day we suddenly realize that we've been on a treadmill, and want to exit the exercise wheel."

"I agree that our existence is purposeless," said David, "but there are at least three ways to resolve the anomie of nihilism. You can decide to ignore it and live a hedonistic life, or get on with life, dedicating yourself to some project to reinstitute a sense of purpose, or you can commit suicide like Turing and the others. I have chosen the second option by savoring family relationships and pursuing pet projects."

"Most of the people we saw at CERN seemed also to have chosen the second option," remarked Sean, "and I've also made that choice."

"Yes," acknowledged Eldon with a nod, "it seems the second option may be the most popular. Yet, some of the greatest thinkers have chosen the third option when they reached their psychological longevity. Turing reached his at 41, Hardy at 70, Ramanujan at 37, Boltzmann at 62, Taniyama at 31, and Ehrenfest at 53."

"Geez, you're depressing me!" protested Sean.

"Well, I'm approaching my own psychological longevity," observed Eldon in a phlegmatic tone, "yet I don't lament its arrival. When Planck said that science advances one funeral at a time, he was acknowledging that we all have a period when we make our contribution.[14] After that we become less open to new ideas and we should yield to younger members whose new insights can pollinate the flowers of human knowledge."

Jumping into the fray, David observed, "Friedrich Schiller captured this idea in asserting, 'the lamp of genius burns quicker than the lamp of life,' "[15]

"Amen," said Eldon. "That's why I think that Calico's quest for eternal life is a pipe-dream; it fails to recognize that even if we can get the body to live indefinitely, we would have to change our brains to prevent psychological fatigue."

At that point, I saw two attractive young women pass our table, but none of the heads at our table turned: it seemed that the passions of youth had, indeed, departed with the passion for life–which departure came first, remained an unknown unknown.

Sean reflected, "I think Shakespeare expressed his recognition of our purposeless existence through the character of Macbeth in his soliloquy following the death of Lady Macbeth. We all have a brief hour on the stage and then exit into oblivion; Macbeth was reaching the limits of his psychological longevity."

> — To-morrow, and to-morrow, and to-morrow,
> Creeps in this petty pace from day to day,
> To the last syllable of recorded time;
> And all our yesterdays have lighted fools
> The way to dusty death. Out, out, brief candle!
> Life's but a walking shadow, a poor player
> That struts and frets his hour upon the stage
> And then is heard no more. It is a tale
> Told by an idiot, full of sound and fury
> Signifying nothing.
>
> — Macbeth (Act 5, Scene 5, lines 17-28)

Attempting to lighten the tone, I commented, "Actually, knowing I'm going to die, has enhanced my enjoyment of life. Why worry about anything if life will be over soon? You do your best to look after your loved ones by leaving them some assets and a host of good memories, but each of us will ultimately return to where we were a century ago–nonexistence."

"Brendan, I think you've chosen option 1," responded Eldon. [everyone laughed in the way that people respond to gallows humor.] Then he paused for a moment of deep reflection and said, "Actually, Shakespeare may have been contemplating suicide *before* he wrote *Macbeth*. In Hamlet's famous soliloquy he says, 'To be or not to be, that is the question,' and then, in a later scene, he goes on to say 'If it be now, 'tis not to come; if it be not to come, it will be now; if it be not now, yet it will come—the readiness is all.' "

"How soon after he wrote *Macbeth* did Shakespeare die, and how did he die?" I asked.

Eldon paused, took a sip of wine and then responded. "He died about a decade later, at the age of 52, but we're not sure of the cause. Apparently the vicar of Stratford had written in his notebook that Shakespeare and fellow playwrights Ben Jonson and Michael Drayton went on a drinking binge from which Shakespeare contracted a fever and subsequently died."

"What a shame," lamented Sean. "He was probably one of the most gifted people to walk the earth, and he died taking his gift to the grave."

"Actually," responded Eldon, "he left his gift behind, bequeathing its yield to the generations that were to follow. The only thing that could destroy his legacy would be a human population too stupid to understand its value."

Through the picture window, I could see light puffy snow falling gently, reminding me of the winters back home when nature covered the dead leaves of autumn with a bright pristine layer of white snow. As seniors in the winter of our years, we were four men waiting for Godot, each in his own way, accepting the futility of life with passive resignation. As we departed the next day, it hadn't occurred to me that our foursome would never be together again.

Afterword

Three days after my return to Canada, I received an email from Sean who told me that Eldon had committed suicide. Characteristically enslaved to dotting all the i's and crossing all the t's of every undertaking, Eldon had sought closure by writing a formal letter of departure to us all.

Gentlemen,

It is with great pleasure that I announce my departure from the cosmos as I return to the state of inexistence that was terminated 76 years ago when an egg and sperm collided in a moment of random passion. Reflecting on life, Disraeli said, "Youth is a blunder; manhood a struggle; and old age a regret." I am fortunate to be able to say that my blunders in youth were few, my manhood involved strong discipline, but little struggle, and I've had no regrets in my senior years–a combination of good luck and good judgment.

Our friendship and our sharing of ideas were for me a joyful indulgence of my primate need for an occasional oasis in the desert of my isolation. I have no family and no close friends other than you, leaving me free to take this action without psychological encumbrance. Pascal said that the end point of rationality is to demonstrate the limits of rationality. I am inclined to amend this by saying that the end point of rationality is to realize that we are hardwired to seek purpose in a universe that is without purpose. It's the great cosmic joke, and I'm laughing because my immersion in physics has enabled me to distract myself from this cruel irony. I wish you all well during your wait for the deferred gratification of inexistence. Thank you for making my existence more pleasant.

Since Eldon's demise, Sean, David and I continue to meet on occasion, and we speak of Eldon without sadness, because he departed the planet in the same rational way that he navigated through life. None of us had ever met anyone who had so successfully transcended his primate beginnings. As the quintessential intellectual being, he strived relentlessly to understand the universe, never taking refuge in tribal associations or indulging in comfortable, but unfounded beliefs. Though he could be cordial and sometimes, even charming, he never put anyone's head above his own, always listening intently, but reaching verdicts in the court of his own quiet counsel. In sacrificing the deep joy that comes from intimate relationships and shared struggles, he somehow seemed to receive in exchange a clarity of insight in the face of which the rest of us could only stand in awe.

Epilog

The results of international competition in mathematics remind us that the "best and brightest" of the human species are spread throughout most, if not all, the nations of the world. For example, can you guess the second language spoken (after English) in Microsoft Offices throughout the world? Most people might conjecture Mandarin Chinese, based on the stellar performance of the Chinese in international competitions. However, you may recall, from figure 34.3, a country the size of Michigan that won the International Mathematics Olympiad almost as many times as the United States between 1985 and 2017. At the Regional Cyber Security Summit in May 2015 Bruce Andrews, US Deputy Secretary of Commerce, said:[16]

> *We want to create a much safer Internet cyberspace. … Romania became a leader on the informational technology market. And, when I say this, I will give you just one example: here we have Bitdefender, a Romanian company that launched a revolutionary solution in cybersecurity named* Box*, strictly designed for domestic users. We already know that Romanian is the second language spoken in the Microsoft offices around the world.*

As Steve Jobs observed (chapter 31) "A small team of A^+ players can run circles around a giant team of B and C players." So even relatively small groups of exceptional people can achieve world-class results.

As long as differing ideologies and conflicting national self-interest threaten international stability, each nation is well-advised to recruit its best and brightest citizens to prepare for the imminent future. History has taught us that national security involving cryptography, missile defense, and economic strength is vitally dependent on the caliber of its top mathematicians and scientists. Indeed, the cryptographers who protect our computers from cyberattacks will not be drawn from the ranks of those with mediocre cognitive skills. The outcome of a cyber war, should it occur, would be determined by the superstars of the belligerent nations. (Recall Simon Singh's comment in chapter 23). These are the "nerds" who have a passion for the STEM subjects. Just as the decryption of the Enigma code by Alan Turing and the development of the atomic bomb by America's most brilliant physicists were vital determinants of the outcome of World War II, so also would the outcome of future conflict hinge on the talents of a nation's best and brightest.

While national security and a strong economy are necessary prerequisites for a quality of life, they are not sufficient. Science must be engaged in the long-term fight to build a healthy environment, cure diseases, eliminate starvation, and *pursue research into areas of mathematics and science whose sole purpose is the acquisition of knowledge*. (Much, if not most of what we know today, has come from the investigation of questions posed

by curiosity rather than purpose.) These initiatives will require the "best-and-brightest" aided by an army of people who have a variety of skills and talents. Gaining support for such projects requires a government that understands the importance of research and scholarship, and this in turn requires an infoliterate (chapter 32) electorate that votes wisely.

History has shown (chapter 28) that the sciences thrive in environments that also foster a broad spectrum of creative activity. Indeed, not only does a nation need the cognitively gifted in the natural sciences, but also in the arts, as well as the social sciences to contribute knowledge and foster rational debates about social issues. The intellectually gifted are needed in the field of jurisprudence to interpret the laws and make logically consistent arguments avoiding the kinds of inferential mistakes we've noted in earlier chapters. Given a supportive environment, those with sufficient commitment and drive will make medical breakthroughs, create new technologies to protect our planet, and formulate the sound social and fiscal policies that will provide a better quality of life for the next generation. Indeed, virtually all the significant achievements in the coming decades of the 21st century will come from our exceptional youth. They are our most precious resource and it is in our self-interest and in the interest of our descendants that we provide the environment that fosters and encourages their creativity.

But how can a nation develop such an infoliterate population that values and nurtures its gifted citizens? As argued throughout this book, and particularly in the previous chapter, a major part of the answer lies in recruiting gifted teachers into an upgraded professional community known as "educators." Members of this new professional sector in the social strata would model intellectual behavior at a high level by their own passion for learning and broad range of personal interests. Through a judicious balance of encouragement, support, and pressure, they would help students overcome the inertia of the "lazy bum" brain (chapter 7) to reap the rewards that come with personal discipline and self-efficacy. In this "ideal world," we might enter a new Age of Enlightenment where homo sapiens, for the first time in its history, is able to subordinate the visceral component of its intelligence to the cerebral component when appropriate.