**Excerpt : Chapter One**

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# Chapter 1 : Lessons From The Petri Dish: In Praise of Smart Cells and Smart Students

## Trouble in Paradise

On my second day in the Caribbean, as I stood in front of over a hundred visibly on-edge medical students, I suddenly realized that not everyone viewed the island as a laid-back refuge. For these nervous students, Montserrat was not a peaceful escape but a last-ditch chance to realize their dreams of becoming doctors.

My class was geographically homogenous, mostly American students from the East Coast, but there were all races and ages, including a 67-year-old retiree who was anxious to do more with his life. Their backgrounds were equally varied-former elementary school teachers, accountants, musicians, a nun and even a drug smuggler.

Despite all the differences, the students shared two characteristics. One, they had failed to succeed in the highly competitive selection process that filled the limited number of positions in American medical schools. Two, they were ‘strivers’ intent on becoming doctors,they were not about to be denied the opportunity to prove their qualifications. Most had spent their life savings or indentured themselves to cover the tuition and extra costs of living out of the country. Many found themselves completely alone for the first time in their lives, having left their families and friends and loved ones behind. They put up with the most intolerable living conditions on that campus. Yet with all the drawbacks and the odds stacked against them, they were never deterred from their quest for a medical degree.

Well, at least that was true up to the time of our first class together. Prior to my arrival, the students had had three different histology/cell biology professors. The first lecturer left the students in the lurch when he responded to some personal issue by bolting from the island three weeks into the semester. In short order, the school found a suitable replacement who tried to pick up the pieces; unfortunately he bailed three weeks later because he got sick. For the preceding two weeks a faculty member, responsible for another field of study, had been reading chapters out of a textbook to the class. This obviously bored the students to death, but the school was fulfilling a directive to provide a specified number of lecture hours for the course. Academic prerequisites set by American medical examiners have to be met in order for the school’s graduates to practice in the States.

For the fourth time that semester, the weary students listened to a new professor. I briefed them on my background and my expectations for the course. I made it clear that even though we were in a foreign country, I was not going to expect any less from them than what was expected from my Wisconsin students. Nor should they want me to, because to be certified, all doctors have to pass the same Medical Boards, no matter where they go to medical school. Then I pulled a sheaf of exams out of my briefcase and told the students that I was giving them a self-assessment quiz. The middle of the semester had just passed and I expected them to be familiar with half of the required course material. The test I handed out on that first day of the course consisted of 20 questions taken directly from the University of Wisconsin histology midterm exam.

The classroom was deadly silent for the first ten minutes of the testing period. Then nervous fidgeting felled the students one by one, faster than the spread of the deadly Ebola virus. By the time the twenty minutes allotted for the quiz were over, wide-eyed panic had gripped the class. When I said, “Stop”, the pent-up nervous anxiety erupted into the din of a hundred excited conversations. I quieted the class down and began to read them the answers. The first five or six answers were met with subdued sighs. After I reached the tenth question, each subsequent answer was followed by agonizing groans. The highest score in the class was ten correct answers, followed by several students who answered seven correctly; with guesswork, most of the rest scored at least one or two correct answers.

When I looked up at the class, I was greeted with frozen, shell-shocked faces. The ‘strivers’ found themselves behind the big eight ball. With more than half a semester behind them, they had to start the course all over again. A dark gloom overcame the students, most of whom were already treading water in their other, very demanding medical school courses. Within moments, their gloom had turned into quiet despair. In profound silence, I looked out over the students and they looked back at me. I experienced an internal ache-the class collectively resembled one of those Greenpeace pictures of wide-eyed baby seals just before heartless fur traders club them to death.

My heart welled. Perhaps the salt air and sweet scents had already made me more magnanimous. In any case, unexpectedly, I found myself announcing that I would make it my personal commitment to see that every student was fully prepared for the final exam, if they would commit to providing matching efforts. When they realized I was truly committed to their success, I could see the lights flash on in their previously panicked eyes.

Feeling like an embattled coach revving up the team for the Big Game, I told them I thought they were every bit as intelligent as the students I taught in the States. I told them I believed their State-side peers were simply more proficient at rote memorization, the quality that enabled them to score better in the medical college admissions tests. I also tried very hard to convince them that histology and cell biology are not intellectually difficult courses. I explained that in all of its elegance, nature employs very simple operating principles. Rather than just memorizing facts and figures, I promised they were going to gain an understanding of cells because I would present simple principles on top of simple principles. I offered to provide additional night lectures, which would tax their stamina after their already long lecture and lab-packed days. The students were pumped up after my ten-minute pep talk. When the period ended they bolted from that classroom snorting fire, determined they would not be beaten by the system.

After the students left, the enormity of the commitment I had made sank in. I started having doubts. I knew that a significant number of the students were truly unqualified to be attending medical school. Many others were capable students whose backgrounds had not prepared them for the challenge. I was afraid that my island idyll would degenerate into a frenetic, time-consuming academic scrimmage that would end in failure for my students and for me as their teacher. I started thinking about my job at Wisconsin, and suddenly it was beginning to look easy. At Wisconsin, I gave only eight lectures out of the approximately 50 that made up the histology/cell biology course. There were five members of the Anatomy Department who shared the lecturing load. Of course I was responsible for the material in all of the lectures because I was involved in their accompanying laboratory sessions. I was supposed to be available to answer all course-related questions asked by the students. But knowing the material and presenting lectures on the material are not the same thing!

I had a three-day weekend to wrestle with the situation I had created for myself. Had I faced a crisis such as this back home, my type A personality would have had me swinging from the proverbial chandeliers. Interestingly, as I sat by the pool, watching the sun set into the Caribbean, the potential angst simply morphed into an exciting adventure. I began to get excited about the fact that for the first

time in my teaching career, I was solely responsible for this major course and free from having to conform to the style and content restrictions of team-taught programs.

**Cells As Miniature Humans**

As it turned out, that histology course was the most exhilarating and intellectually profound period of my academic career. Free to teach the course the way I wanted to teach it, I ventured into a new way of covering the material, an approach that had been roiling in my brain for several years. I had been fascinated by the idea that considering cells as 'miniature humans' would make it easier to understand their physiology and behavior. As I contemplated a new structure for the course, I got excited. The idea of overlapping cell and human biology rekindled the inspiration for science I had felt as a child. I still experienced that enthusiasm in my research laboratory, though not when I was mired in the administrative details of being a tenured faculty member, including endless meetings and what for me were tortuous faculty parties.

I was prone to thinking of cells as human-like because, after years behind a microscope, I had become humbled by the complexity and power of what at first appear to be anatomically simple, moving blobs in a Petri dish. In school you may learned the basic components of a cell: the nucleus that contains genetic material, the energy-producing mitochondria, the protective membrane at the outside rim, and the cytoplasm in between. But within these anatomically simple-looking cells is a complex world; these smart cells employ technologies that scientists have yet to fully fathom.

The notion of cells as miniature humans that I was mulling over would be considered heresy by most biologists. Trying to explain the nature of anything not human by relating it to human behavior is called anthropomorphism. 'True' scientists consider anthropomorphism to be something of a mortal sin and ostracize scientists who knowingly employ it in their work.

However, I believed though that I was breaking out of orthodoxy for a good reason. Biologists try to gain scientific understanding by observing nature and conjuring up a hypothesis of how things work. Then they design experiments to test their ideas. By necessity, deriving the hypothesis and designing the experiments require the scientist to "think" how a cell or another living organism carries out its life. Applying these 'human' solutions, i.e. a human view of resolving biology's mysteries, automatically makes these scientists guilty of anthropomorphizing. No matter how you cut it, biological science is based to some degree on humanizing the subject matter.

Actually, I believe that the unwritten ban on anthropomorphism is an outmoded remnant of the Dark Ages when religious authorities denied any direct relationship existed between humans and any of God's other creations. While I can see the value of the concept when people try to anthropomorphize a light bulb, a radio or a pocketknife, I do not see it as a valid criticism when it is applied to living organisms. Human beings are multicellular organisms,we must inherently share basic behavioral patterns with our own cells.

However, I know that it takes a shift in perception to acknowledge that parallel. Historically, our Judeo-Christian beliefs have led us to think that we are the intelligent creatures who were created in a separate and distinct process from all other plants and animals. This view has us looking down our noses at lesser creatures as non-intelligent life forms, especially those organisms on the lower evolutionary rungs of life.

Nothing could be farther from the truth. When we observe other humans as individual entities or see ourselves in the mirror as an individual organism, in one sense, we are correct, at least from the perspective of our level of observation. However, if I brought you down to the size of an individual cell so you could see your body from that perspective, it would offer a whole new view of the world. When

you looked back at yourself from that perspective you would not see yourself as a single entity. You would see yourself as a bustling community of more than 50 trillion individual cells.

As I toyed with these ideas for my Histology class, the picture that kept recurring in my mind was a chart from an encyclopedia I had used as a child. Under the section on humans, there was an illustration with seven transparent plastic pages, each printed with an identical, overlapping outline of the human body. On the first page the outline was filled in with an image of a naked man. Turning the first page was like peeling off his skin and revealing his musculature, the image within the outline on the second page. When I turned the second page, the overlapping images of the remaining pages revealed a vivid dissection of the body. Flipping through the pages I could see in turn, the skeleton, the brain and nerves, blood vessels and organ systems.

For my Caribbean course, I mentally updated those transparencies with several additional, overlapping pages, each illustrated with cellular structures. Most of the cell's structures are referred to as organelles, which are its 'miniature organs' suspended within a jelly-like cytoplasm. Organelles are the functional equivalents of the tissues and organs of our own bodies. They include the nucleus, which is the largest organelle, the mitochondria, the Golgi body and vacuoles. The traditional way of teaching the course is to deal first with these cellular structures, then move on to the tissues and organs of the human body. Instead, I integrated the two parts of the course to reflect the overlapping nature of humans and cells.

I taught my students that the biochemical mechanisms employed by cellular organelle systems are essentially the same mechanisms employed by our human organ systems. Even though humans are made up of trillions of cells, I stressed that there is not one 'new' function in our bodies that is not already expressed in the single cell. Each eukaryote (nucleus-containing cell) possesses the functional equivalent of our nervous system, digestive system, respiratory system, excretory system, endocrine system, muscle and skeletal systems, circulatory system, integument (skin), reproductive system and even a primitive immune system, which utilizes a family of antibody-like 'ubiquitin' proteins.

I also made it clear to my students that each cell is an intelligent being that can survive on its own, as scientists demonstrate when they remove individual cells from the body and grow them in a culture. As I knew intuitively when I was a child, these smart cells are imbued with intent and purpose; they actively seek environments that support their survival while simultaneously avoiding toxic or hostile ones. Like humans, single cells analyze thousands of stimuli from the microenvironment they inhabit. Through the analysis of this data, cells select appropriate behavioral responses to ensure their survival.

Single cells are also capable of learning through these environmental experiences and are able to create cellular memories, which they pass on to their offspring. For example, when a measles virus infects a child, an immature immune cell is called in to create a protective protein antibody against that virus. In the process, the cell must create a new gene to serve as a blueprint in manufacturing the measles antibody protein.

The first step in generating a specific measles antibody gene occurs in the nuclei of immature immune cells. Among their genes are a very large number of DNA segments that encode uniquely shaped snippets of proteins. By randomly assembling and recombining these DNA segments, immune cells create a vast array of different genes, each one providing for a uniquely shaped antibody protein. When an immature immune cell produces an antibody protein that is a 'close' physical complement to the invading measles virus, that cell will be activated.

Activated cells employ an amazing mechanism called affinity maturation that enables the cell to perfectly 'adjust' the final shape of its antibody protein, so that it will become a perfect complement to the invading measles virus. [Li, et al, 2003; Adams, et al, 2003] Using a process called somatic hypermutation, activated immune cells makes hundreds of copies of their original antibody gene. However, each new version of the gene is slightly mutated so that it will encode a slightly different shaped antibody protein. The cell selects the variant gene that makes the best fitting antibody. This selected version of the gene also goes through repeated rounds of somatic hypermutation to further sculpt the shape of the antibody to become a 'perfect' physical complement of the measles virus. [Wu, et al, 2003; Blanden and Steele 1998; Diaz and Casali 2002; Gearhart 2002]

When the sculptured antibody locks on to the virus, it inactivates the invader and marks it for destruction, thus protecting the child from the ravages of measles. The cells retain the genetic 'memory' of this antibody, so that in the future if the individual is again exposed to measles, the cells can immediately launch a protective immune response. The new antibody gene can also be passed on to all the cell's progeny when it divides. In this process, not only did the cell 'learn' about the measles virus, it also created a 'memory' that will be inherited and propagated by its daughter cells. This amazing feat of genetic engineering is profoundly important because it represents an inherent intelligence mechanism by which cells evolve. [Steele, et al, 1998]

**The Origins of Life: Smart Cells Get Smarter**

It shouldn't be surprising that cells are so smart. Single-celled organisms were the first life forms on this planet. Fossil evidence reveals they were here within 600 million years after the Earth was first formed. For the next 2.75 billion years of the Earth's history, only free-living, single-celled organisms bacteria, algae and amoeba-like protozoans, populated the world.

Around 750 million years ago, these smart cells figured out how to get smarter when the first multicellular organisms (plants and animals) appeared. Multicellular life forms were initially loose communities or 'colonies', of single-celled organisms. At first, cellular communities consisted of tens and hundreds of cells. But the evolutionary advantage of living in a community soon led to organizations comprised of millions, billions and even trillions of socially interactive single cells. Though each individual cell is of microscopic dimensions, the size of multicellular communities may range from the barely visible to the monolithic. Biologists have classified these organized communities based on their structure as observed by the human eye. While the cellular communities appear as single entities to the naked eye, a mouse, a dog, a human, they are, in fact, highly organized associations of millions and trillions of cells.

The evolutionary push for ever-bigger communities is simply a reflection of the biological imperative to survive. The more awareness an organism has of its environment, the better its chances for survival. When cells band together they increase their awareness exponentially. If each cell were to be arbitrarily assigned an awareness value of X, then each colonial organism would collectively have a potential awareness value of at least X times the number of cells in the colony.

In order to survive at such high densities, the cells created structured environments. These sophisticated communities subdivided the workload with more precision and effectiveness than the ever-changing organizational charts that are a fact of life in big corporations. It proved more efficient for the community to have individual cells assigned to specialized tasks. In the development of animals and plants, cells begin to acquire these specialized functions in the embryo. A process of cytological specialization enables the cells to form the specific tissues and organs of the body. Over time, this pattern of differentiation, i.e. the distribution of the workload among the members of the community, became embedded in the genes of every cell in the community, significantly increasing the organism's efficiency and its ability to survive.

In larger organisms, for example, only a small percentage of cells are concerned with reading and responding to environmental stimuli. That is the role of groups of specialized cells that form the tissues and organs of the nervous system. The function of the nervous system is to perceive the environment and coordinate the behavior of all the other cells in the vast cellular community.

Division of labor among the cells in the community offered an additional survival advantage. The efficiency it offered enabled more cells to live on less. Consider the old adage, 'Two can live as cheaply as one.' Or consider the construction costs of building a two-bedroom, single home versus the cost of building a two-bedroom apartment in a hundred-apartment complex. To survive, each cell is required to expend a certain amount of energy. The amount of energy conserved by individuals living in a community contributes to both an increased survival advantage and a better quality of life.

In American capitalism, Henry Ford saw the tactical advantage in the differentiated form of communal effort and employed it in creating his assembly line system of manufacturing cars. Before Ford, a small team of multi-skilled workers would require a week or two to build a single automobile. Ford organized his shop so that every worker was responsible for only one specialized job. He stationed a large number of these differentiated workers along a single row, the assembly line, and passed the developing car from one specialist to the next. The efficiency of job specialization enabled Ford to produce a new automobile in 90 minutes rather than weeks.

Unfortunately, we conveniently 'forgot' about the cooperation necessary for evolution when Charles Darwin emphasized a radically different theory about the emergence of life. He concluded 150 years ago that living organisms are perpetually embroiled in a 'struggle for existence.' For Darwin, struggle and violence are not only a part of animal (human) nature, but the principal forces behind evolutionary advancement. In the final chapter of The Origin of Species: By Means of Natural Selection, Or, The Preservation Of Favoured Races In The Struggle For Life. Darwin wrote of an inevitable 'struggle for life' and that evolution was driven by *the war of nature, from famine and death.* Couple that with Darwin's notion that evolution is random and you have a world, as poetically described by Tennyson that can be characterized as 'red in tooth and claw,' a series of meaningless, bloody battles for survival.

**Evolution Without the Bloody Claws**

Though Darwin is by far the most famous evolutionist, the first scientist to establish evolution as a scientific fact was the distinguished French biologist Jean-Baptiste de Lamarck. [Lamarck 1809, 1914, 1963] Even Ernst Mayr, the leading architect of neo Darwinism, a modernization of Darwin's theory that incorporates twentieth-century molecular genetics, concedes that Lamarck was the pioneer. In his classic 1970 book Evolution and the Diversity of Life, [Mayer 1976, page 227] Mayr wrote: It seems to me Lamarck has a much better claim to be designated the founder of the theory of evolution, as indeed he has by several French historians he was the first author to devote an entire book primarily to the presentation of a theory of organic evolution. He was the first to present the entire system of animals as a product of evolution.

Not only did Lamarck present his theory fifty years before Darwin, he offered a much less harsh theory of the mechanisms of evolution. Lamarck's theory suggested that evolution was based on an 'instructive,' cooperative interaction among organisms and their environment that enables life forms to survive and evolve in a dynamic world. His notion was that organisms acquire and pass on adaptations necessary for their survival in a changing environment. Interestingly, Lamarck's hypothesis about the mechanisms of evolution conform to modern cell biologists' understanding of how immune systems adapt to their environment as described above.

Lamarck's theory was an early target of the Church. The notion that humans evolved from lower life forms was denounced as heresy. Lamarck was also scorned by his fellow scientists, who, as creationists, ridiculed his theories. A German developmental biologist, August Weismann, helped propel Lamarck into obscurity when he tried to test Lamarck's theory that organisms pass on survival-oriented traits acquired through their interaction with the environment. In one of Weismann's experiments, he cut off the tails of male and female mice and mated them. Weismann argued that if Lamarck's theory were correct, the parents should pass on their tail-less state to future generations. The first generation of mice was born with tails. Weismann repeated the experiment for 21 more generations, but not one tail-less mouse was born, leading Weismann to conclude that Lamarck's notion of inheritance was wrong.

But Weismann's experiment was not a true test of Lamarck's theory. Lamarck suggested that such evolutionary changes could take immense periods of time, according to biographer L. J. Jordanova. In 1984, Jordanova wrote that Lamarck's theory 'rested on' a number of 'propositions' including: the laws governing living things have produced increasingly complex forms over immense periods of time.' [Jordanova 1984, page 71] Weismann's five-year experiment was clearly not long enough to test the theory. An even more fundamental flaw in his experiment is that Lamarck never argued that every change an organism experienced would take hold. Lamarck said organisms hang on to traits (like tails) when they need them to survive. Although Weismann didn't think the mice needed their tails, no one asked the mice if they thought their tails were necessary for survival!

Despite its obvious flaws, the study of the tail-less mice helped destroy Lamarck's reputation. In fact, Lamarck has been mostly ignored or vilified. Cornell University evolutionist C.H. Waddington, wrote in The Evolution of An Evolutionist [Waddington 1975, page 38]: Lamarck is the only major figure in the history of biology whose name has become to all intents and purposes, a term of abuse. Most scientists contributions are fated to be outgrown, but very few authors have written works, which, two centuries later, are still rejected with indignation so intense that the skeptic may suspect something akin to an uneasy conscience. In point of fact, Lamarck has, I think, been somewhat unfairly judged.

Waddington wrote those prescient words thirty years ago. Today Lamarck's theories are being reevaluated under the weight of a body of new science that suggests that the oft-denounced biologist was not entirely wrong and the oft-lauded Darwin not entirely correct. The title of an article in the prestigious journal Science in 2000 was one sign of glasnost: Was Lamarck Just a Little Bit Right? [Balter 2000]

One reason some scientists are taking another look at Lamarck is that evolutionists are reminding us of the invaluable role cooperation plays in sustaining life in the biosphere. Scientists have long noted symbiotic relationships in nature. In Darwin's Blind Spot [Ryan 2002, page 16], British physician Frank Ryan chronicles a number of such relationships, including a yellow shrimp that gathers food while its partner gobi fish protects it from predators, and a species of hermit crab that carries a pink anemone on top of its shell. Fish and octopuses like to feed on hermit crabs, but when they approach this species, the anemone shoots out its brilliantly colored tentacles, with their microscopic batteries of poisoned darts, and sting the potential predator, encouraging it to look elsewhere for its meal. The warrior anemone gets something out of the relationship as well because it eats the crab's leftover food.

But today's understanding of cooperation in nature goes much deeper than the easily observable ones. Biologists are becoming increasingly aware that animals have coevolved, and continue to coexist, with diverse assemblages of microorganisms that are required for normal health and development, according to a recent article in Science called We Get By With A Little Help From Our (Little) Friends. [Ruby et al, 2004] The study of these relationships is now a rapidly growing field called Systems Biology.

Ironically, in recent decades, we have been taught to wage war against microorganisms with everything from anti-bacterial soap to antibiotics. But that simplistic message ignores the fact that many bacteria are essential to our health. The classic example of how humans get help from microorganisms is the bacteria in our digestive system, which are essential to our survival. The bacteria in our stomach and intestinal tract help digest food and also enable the absorption of life-sustaining vitamins. This microbe-human cooperation is the reason that the rampant use of antibiotics is detrimental to our survival. Antibiotics are indiscriminate killers; they kill bacteria that are required for our survival as efficiently as they kill harmful bacteria.

Recent advances in genome science have revealed an additional mechanism of cooperation among species. Living organisms, it turns out, actually integrate their cellular communities by sharing their genes. It had been thought that genes are passed on only to the progeny of an individual organism through reproduction. Now scientists realize that genes are shared not only among the individual members of a species, but also among members of different species. The sharing of genetic information via gene transfer speeds up evolution since organisms can acquire learned experiences from other organisms. [Nitz et al, 2004; Pennisi 2004; Boucher et al, 2003; Dutta, et al, 2002; Gogarten 2003] Given this sharing of genes, organisms can no longer be seen as disconnected entities; there is no wall between species. Daniel Drell, manager of the Department of Energy's microbial genome program told Science in (2001 294:1634): we can no longer comfortably say what is a species anymore. [Pennisi 2001]

This sharing of information is not an accident. It is nature's method of enhancing the survival of the biosphere. As discussed earlier, genes are physical memories of an organism's learned experiences. The recently recognized exchange of genes among individuals disperses those memories, thereby influencing the survival of all organisms that make up the community of life. Now that we are aware of this inter- and intra-species gene transfer mechanism, the dangers of genetic engineering become apparent. For example, tinkering with the genes of a tomato may not stop at that tomato, but could alter the entire biosphere in ways that we cannot foresee. Already there is a study that shows that when humans digest genetically modified foods, the artificially created genes transfer into and alter the character of the beneficial bacteria in the intestine. [Heritage 2004; Netherwood, et al, 2004] Similarly, gene transfer among genetically engineered agricultural crops and surrounding native species has given rise to highly resistant species deemed superweeds. [Milius 2003; Haygood, et al, 2003; Desplanque, et al, 2002; Spencer and Snow 2000] Genetic engineers have never taken the reality of gene transfer into consideration when they have introduced genetically modified organisms into the environment. We are now beginning to experience the dire consequences of this oversight as their engineered genes are spreading among, and altering other organisms in the environment. [Watrud, et al, 2004]

Genetic evolutionists warn that if we fail to apply the lessons of our shared genetic destiny, which should be teaching us the importance of cooperation among all species, we threaten human existence. We need to move beyond Darwinian theory, which stresses the importance of individuals, to one that stresses the importance of the community. British scientist Timothy Lenton provides evidence that evolution is more dependent on the interaction among species than it is on the interaction of individuals within a species. Evolution becomes a matter of the survival of the fittest groups rather than the survival of the fittest individuals. In a 1998 article in Nature, Lenton wrote that rather than focusing on individuals and their role in evolution, We must consider the totality of organisms and their material environment to fully understand which traits come to persist and dominate. [Lenton 1998]

Lenton subscribes to James Lovelock's Gaia hypothesis that holds that the Earth and all of its species constitute one interactive, living organism. Those who endorse the hypothesis argue that tampering with the balance of that super-organism called Gaia, whether it be by destroying the

rainforest, depleting the ozone layer or altering organisms through genetic engineering, can threaten its survival and consequently ours.

Recent studies funded by Britain's Natural Environment Research Council provide support for those concerns. [Thomas, et al, 2004; Stevens, et al, 2004] While there have been five mass extinctions in the history of our planet, they are all presumed to have been caused by extraterrestrial events, such as a comet smashing to earth. One of the new studies concludes that the natural world is experiencing the sixth, major extinction event in its history. [Lovell 2004] This time though, the cause of the extinctions is not extra terrestrial. According to one of the study's authors, Jeremy Thomas: As far as we can tell this one is caused by one animal organism'man.'

**Walking the Talk of Cells**

In my years of teaching in medical school, I had come to realize that medical students in an academic setting are more competitive and backbiting than a truckload of lawyers. They live out the Darwinian struggle in their quest to be one of the 'fittest' who stagger to graduation after four grueling years in medical school. The single-minded pursuit of stellar medical school grades, without regard for the students surrounding you, no doubt follows a Darwinian model, but it always seemed to me an ironic pursuit for those who are striving to become compassionate healers.

But my stereotypes about medical students toppled during my stay on the island. After my call to arms, my class of misfits stopped acting like conventional medical students; they dropped their survival of the fittest mentality and amalgamated into a single force, a team that helped them survive the semester. The stronger students helped the weaker and in so doing, all became stronger. Their harmony was both surprising and beautiful to observe.

In the end, there was a bonus: a happy Hollywood ending. For their final exam, I gave my students exactly the same test the students in Wisconsin had to pass. There was virtually no difference in the performance of these 'rejects' and their 'elitist' counterparts in the States. Many students later reported that when they went home and met with their peers who attended American medical schools, they proudly found themselves more proficient in their understanding of the principles governing the life of cells and organisms.

I was of course thrilled that my students had pulled off an academic miracle. But it was years before I understood how they were able to do it. At the time, I thought the format of the course was key, and I still believe that overlapping human and cell biology is a better way to present the course material. But now that I've ventured into what I told you would be considered by some as wacky Dr. Dolittle territory, I think a good part of the reason for my students success was that they eschewed the behavior of their counterparts in the United States. Instead of mirroring smart American medical students, they mirrored the behavior of smart cells, banding together to become even smarter. I didn't tell my students to pattern their lives after the lives of the cells, because I was still steeped in traditional, scientific training. But I like to think that they went in that direction intuitively, after listening to my praise of cells ability to group together cooperatively to form more complex and highly successful organisms.

I didn't know it at the time, but I now believe that another reason for my students success was that I did not stop at praising cells. I praised the students as well. They needed to hear they were first-rate students in order to believe that they could perform as first-rate students. As I will detail in future chapters, so many of us are leading limited lives not because we have to, but because we THINK we have to. But I'm getting ahead of myself. Suffice it to say that after four months in paradise, teaching in a way that clarified my thinking about cells and the lessons they provide to humans, I was well on

my way to an understanding of the New Biology, which leaves in the dust the defeatism of genetic and parental programming as well as survival-of-the-fittest Darwinism.

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