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Dissent and Research: The Supreme Stimulants

About 5 million years ago, more or less, it would seem that the great apes living in Central Africa—the hominoids—split into three distinct species. This was not an unusual event. Speciation, the processes by which living organisms suddenly branch and divide into new and ever more complex or specialized forms, had been flourishing at a frenetic pace ever since the so-called Cambrian Explosion some 500 million years before the time modern animals began to evolve. The causes of speciation are unknown, but climate, temperature, and atmospheric composition are clearly important. As life continued to expand into every available ecological cranny, that moment came when the hominoids split into the species we now call gorillas, chimpanzees, and the hominids—the earliest forms of humans. On the face of it, the hominids were just another addition to the teeming profusion of life, a late arrival to an already crowded arena. The apocryphal, all-seeing extraterrestrial may not have noticed anything unusual, as hominids at first must have looked and behaved much like many other animals. But they proved to be very different, and an apparently innocu-

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Text Box 1: Nature

I use the word Nature throughout this book as if it were the name of some sort of being. I am not trying to make a religious or mystical point. I use it as shorthand for the universe and every aspect of everything in it. We have made great progress, but our understanding of that system is still in its infancy. However, no understanding is denied to us. My affectionate anthropomorphism is used out of respect for a system that commands the attention of every scientist.

ous event turned out to be the birth of the species that would dominate this planet. What was it that made us so special? The competition was enormous. What gave us the vital edge? As far as I know, there are no generally accepted answers to these questions. My suggestion here is that our overwhelming advantage stems from a source that hitherto has not been generally recognized—our innate capacity for dissent. However, another condition has also to be satisfied. While a capacity for this strange intellectual ability is imbued in every one of us, our dissenting trait should normally be dormant. That is, Nature would have to arrange things so that our species has just the right quota of full-blooded dissenters—no more and no less—to liberate us from a brutish existence and to progress in a hostile world. See Text Box 1.

Some of my friends have suggested that dissent is too negative a quality with which to characterize the human race. Its negative components cannot be ignored. When our dissenting spark is transiently activated, it can lead to such disruptive behavior as violence in the classroom, the playing field, or the pub. But those responsible are rarely working to an agenda. They are merely lashing out at some aspect of their parochial surroundings. Such dissatisfaction usually has no firm foundation, and like a sandcastle on the seashore, its memory is soon washed away. The class of dissenters also includes cranks and fanatics—people with a lifelong obsession with an issue and whose success is usually measured in terms of the mayhem or annoyance they create. Their ideas cannot always be dismissed as irrelevant. Many a pioneer has had to endure the slings and arrows of being outrageously cast among the lunatic fringes. And, of course, dissenters can turn out to be despots and dictators.

The form of dissent honored here, however, is the noblest of all. It is neither transient nor petulant but is usually based on an individual's overwhelming conviction that some aspect of life has become unbearable. It is the coinage of visionaries and, ultimately, the creator of hope. If

dissent and the changes it brings are efficiently suppressed, all hope dies, as it did during the Dark Ages, for example, and more recently for many millions in the former Soviet Union and elsewhere. Nevertheless, even in more tolerant societies, dissent, noble or otherwise, is usually resisted or ridiculed before its spin-off might be accepted and allowed to take its place in our social or technological infrastructures. One might say, therefore, that dissent is neither positive nor negative. Warts and all, it is a neutral fact of life. It is the trait that propels us and has made us what we are. Indeed, one might say that the cumulative consequences of humanity's dissent over the last few thousand millennia define civilization.

One might expect, therefore, that with such wonderful achievements to its credit, our defining trait would be celebrated and protected. That is not the case, nor is it necessary that it should be. Indeed, despite the fact that we owe it everything, our crucial characteristic has always had a relentless and implacable enemy—bureaucracy. Bureaucracy's roots, under whatever name, can be traced back to pre-Roman times, but pioneers have learned to live with it. However, in recent years, its power has grown enormously. Aided by modern electronics and communications and festooned with regulations that are correspondingly easy to enforce, it is almost invincible. Nobody seems to like it, but its power grows anyway. Ironically, the most important problems arise in the scientific world when the bureaucrats holding the purse strings strive to be fair to all-comers. This counterintuitive conclusion arises because even-handedness is often a policy for ducking the tough decisions. Fair shares for everyone or moving forward by general agreement are easily defendable policies. In some fields of human endeavor, they may even offer the best options, but science and technology are not among them. The discoveries that have transformed our lives often came from scientists who defied consensus. The goals they set themselves were not always reasonable. They often challenged what was thought to be possible. Until recently, there was just enough slack in the system to allow such pioneers to flourish. That is *exactly* how it should be. Nowadays, the bureaucrats have closed these loopholes on the spurious grounds of efficiency, and pioneering projects will probably be set aside as a risk too far, especially when funds are short.

It has only recently been formally recognized that science and technology drive economic growth (see Chapter 6). Nevertheless, the metaphorical engines that drive the processes of growth are still rather mysterious. Economists would rather concentrate on fiscal issues because they are thought to be well understood and the impact of fiscal changes can be almost immediate. Unfortunately, tough problems have a habit of biting back if they are ignored or misunderstood, and everyone can be affected.

On the wider scene, the threats from such diseases as AIDS or cancer or the problems of population growth or global warming are obvious examples. In these cases, the problems seem intractable, but scientifically at least we are doing what we can. However, it has now become fashionable to tinker with the engines of growth even though they have been working well for more than a century. In the mundane world, most drivers are smart enough to abide by the if-it-works-don't-fix-it rule when it comes to real engines. Economists and those who take their advice should take note.

Unfortunately, such a let-it-be policy is not consistent with current fashions. Everyone knows that scientific advances come from inspired scientists and engineers—from rare and wondrous geese that lay golden eggs. In the past, they were allowed to roam freely and create as the mood took them. Their success reached its peak during the 1950s, 1960s, and early 1970s—a period economists have called the Golden Age because global economic growth was so high. Nowadays, however, it seems to have been forgotten that unless highly creative people are given total freedom, they will probably not realize their full potential. Indeed, the central theme of this book is that humanity will continue to prosper only if we allow pioneers to be no less free than they have been throughout history.

I am optimistic that we will overcome, but optimism comes in many shades. At one end of the spectrum, those people who are disposed to the blind variety do not care what fates await them. They *know* that they personally, or the people in whom they put their trust, will overcome. Then somewhere in the middle there are those who declare that they are slightly, somewhat, or rather optimistic, and one waits for the conditional "but" that will give voice to their pessimism. At the other end, a small number of what I will call professional optimists will be found. These Panglossian characters have their eyes wide open and plan their positive strategies no matter how appalling the dangers that might lie ahead. Most people seem to be confident that humanity's boundless ingenuity will somehow find a way forward through the apparently intractable problems that face us. Professional optimists, however, are not idle philosophers—they are prepared to take the actions implied by the specific grounds for their optimism and to pursue them to the limit of their resources. This book has been written by one who strives to be such a professional.

Judging by the catalogue* of awfulness that lies ahead, optimism seems to be essential to survival. The inexorable rise in population seems

*A thorough review and a compendious bibliography may be found in Paul Kennedy's (1993) *Preparing for the Twenty-First Century*.

to be one of our most important problems. In this respect, humanity's turbulent progression is entering a new phase. For many centuries, our imaginary extraterrestrials looking down on us might have thought that our numbers were largely predetermined. Long-term fertility rates barely overcame the natural ravages of famine and disease, and the unnatural tolls of war. Consequently, between about 8000 B.C. and the beginning of the eighteenth century, global population hardly increased* throughout a healthy human lifespan. For men and women struggling for existence, the local ebb and flow of life-threatening forces would often have been overwhelming. This is still the case in the poorest parts of the world, but even the supposedly well-managed rich countries can now feel the pressures arising from their modestly increasing populations.

Optimism will not be enough, of course. We must recognize that the quest for ever-higher levels of efficiency also has its downside. The more efficient we make our institutions, the less flexible they become. There is no process in Nature that is 100% efficient, and the closer we try to encroach on that unachievable limit, the more obstinate Nature becomes. For human enterprise, maximum efficiency usually means pulling together, which is fine if everyone agrees on what we should be pulling toward. Hopefully, that will be the case for most of the time. We humans are very gregarious. The dangerous problems arise when we push the envelope of efficiency too hard. We humans did not get where we are by moving unquestionably together like the common herd.

But I am getting ahead of my story. In this and the next few chapters, I would like to say something about how our present precarious state came about before turning later on to what we should be doing about it. Research—the quest for new sciences and new ways of doing things—has been the instrument of humanity's outstanding success. But before amplifying on the essential role played by dissent, we should be clear about what research is. In everyday life, criminals believe that laws are made to be broken. Weakness in the law or in its enforcement should be exploited for the maximum personal advantage. If crime rises, legislators will normally respond with more enforcement or more law. If the changes prove to be effective, the law abiding can usually be persuaded to offset the additional restrictions against the better security of person or property. But laws curtail personal freedom, and few are happy with the law's increasing scope.

*The average trend of global population increase throughout the centuries leading to the Industrial Revolution was about 0.04% per annum (pa)—i.e., some 4% a century.

Scientific laws, however, work quite differently. If a new law or a fixable weakness in an accepted law is discovered, the results will probably be beneficial. We reap this reward because scientific laws are statements on how we believe Nature works. The more we understand, the more we will be able to persuade Nature to help us on our way. Since Nature's complexity seems boundless, the hungry scientist should never lack for motivation or employment. However, researchers should be realists. While they may take pleasure in exposing flaws in established scientific foundations and putting them right, they must recognize that it will only be a matter of time before their reinforcements are found wanting by smarter searchers after truth. These restless pursuits have no downside, however. We all gain because replacing ignorance with understanding is very rarely a bad thing.

And so the restless quest for new knowledge has gone on since fully fledged humans made their appearance on the global stage more than 50,000 years ago. There were no laws of any kind in those days, except perhaps that of the survival of the fittest. Hundreds of thousands of species have made their appearance on the planetary stage over the geological times since life first emerged. It seems that every possible ecological niche that will support life, from the poles to the ocean depths, eventually came to be occupied. However, each species tacitly agreed, anthropomorphically speaking, to make the best of whatever they could get from the flora and fauna that Nature provided. There could be no complaints, and they would prosper or perish according to their ability to adapt. But then humans suddenly arrived, and we took a very different line. At some crucial moment in the distant past, the creatures that became our ancient ancestors became seriously dissatisfied with the pact that their fellow species had always accepted. This was not a passing phase. It did not fade away when such problems as hunger or homelessness had been solved, as it does for other animals. Our defining moment seems to have created a determination not merely to succeed—all animals have that—but to enhance and extend the ranges of success. Such determination had not been seen before. It led to us becoming the dominant species.

I have focused on dissent because otherwise we do not seem to have much going for us. Many animals are better than we are in some way that could make an important contribution to eventual dominance. We are not the strongest or the heaviest and most certainly not the largest (see Figure 1). The old one-liner—Where does a 10-ton gorilla sit? Anywhere it wants.—applies only in a joke world, apparently. Cheetahs, among many others, are faster; horses have more stamina; eagles better eyes;

Figure 1
Size is clearly not important when it comes to determining the capacity for lasting world dominance. The skull of *Carcharodontosaurus saharicus*, the largest of the predator dinosaurs, was discovered in 1995 by Paul Sereno and co-workers in the Sahara in Northern Africa (*Science*, May 17, 1996, p. 986). Dated to 90 million years before present, its brain size is only about one-fifteenth that of an average human today. It is shown here with a modern human skull on the same scale. But, of course, humans and *C. saharicus* were never in competition as the dinosaurs became extinct some 65 million years ago. (Image reproduced by permission of Paul C. Sereno, University of Chicago.)

bats better hearing; dogs a better sense of smell. We are relatively poor swimmers. We have no natural weapons such as horns, fangs, or claws. Other animals can coordinate their movements at least as well as humans. They can also cooperate—hunting in packs, for example. Humans can communicate, but we are not alone in that, and it would seem that primitive human vocal chords were poorly developed so our communication skills would not have given us much of an advantage to start with. Nevertheless, we became the undisputed number 1. Why?

The all-important edge could have stemmed from intelligence. But intelligence is not spread evenly among a population. Its natural variation—sometimes popularly referred to as the bell curve—means that a tiny proportion of humans can be exceptionally brilliant while a similar pro-

portion may have severe learning difficulties. Animals are also thought to be intelligent, and since the spread of intelligence among members of each species will have its own natural variation, it is possible that some exceptionally gifted individual animals will be more intelligent than some disadvantaged humans, however uncomfortable that prospect may be. Those especially gifted animals would be generally more successful. As even slight advantages can accumulate to yield enormous benefits over many generations, evolutionary pressures should have increased the average intelligence of that species with time. If it has, it does not seem to have changed ways of life. As far as we know, animal behavior—humans excepted—has been unchanged for millions of years.

Intelligence, however, is not easy to define or to measure. The conventional measure—the intelligence quotient (IQ)—usually selects for abstract reasoning ability, but people with very high IQs can sometimes be hopelessly impractical—too clever by half. Since, in addition, intelligent animals do not seem to have progressed, it is not easy to see how intelligence alone could determine the triumph of a species. In any case, primitive human brains seem to have been much smaller than those of modern humans. They may not have been especially intelligent therefore. Intellectual capabilities seem to be very broad, however, and they include another ingredient that seems to have been vital to our success—the capacity for dissent.

Many of our animal functions are automatic. We do not have to remember to breathe, to blink, to digest what we eat, or to activate our reflex actions. Functions like these are preprogrammed, as they are for animals in general. A natural inclination to dissent, however, seems to be confined to humans. "Oh no its not," some might say. Of course, animals fight, as we do over food, mates, territory, or anything else that might affect our immediate future. However, what I am concerned with here is not anger or stubbornness but the dissent that leads to principled, determined, and sustained action. This type of dissent seems to be related to the scope for individuality. The cartoonist Gary Larson seems to have expanded on that idea in some of his *Far Side* cartoons. They are funny because he often places animals in preposterous situations. Replace Larson's mischievous animals by people, and the humor would disappear. Animals do show individuality, but it is limited. Animals that live communally are generally content once the pecking order has been established. Their leaders come and go, but pack or herd dominance is their sole objective. Once leaders have made it, they never try to change the way their followers live or how they behave.

But humans do. Leadership is not enough. Following our somewhat miraculous event, whatever may have been its cause, we began to do new

things. We created such artifacts as tools, weapons, clothing, and shelter. Some animals do some of these things, of course. Primates use sticks and stones. Birds build nests. Ants and termites go in for elaborate structures. And so on. But humans had an extraordinary capacity for individuality. There always seemed to be someone who would be very unhappy with some aspect of our lot. These dissidents did not stop there. They were not merely whingers—they had to change something, to leave their mark. They might not have known quite what to do, and there would probably have been a great deal of thrashing about. It would be presumptuous to call it research at that early stage in our progression, but there was trial and error, not only with material things but with our social structures too. Some of them stuck. Step by tiny step, therefore, foundations were laid down that would lead to a radically new way of life, foundations that could be built on inexorably, generation after generation. Our behavior gradually changed. Eventually, when modern humans finally did emerge, we were so different that it would be possible to believe that we were not really animals at all. We became people.

There is no general agreement on the causes of this miraculous transition. Perhaps it was because we had extended the processes of evolution further into the intellectual domain than any other animal species had done previously. Hitherto, animals had progressed or perished dependent on their fitness for purpose determined mainly on the relationship of their physical abilities with the environment. Each species had its specialist niche, but its prosperity was also determined by its ability to cope with change. Thus, polar bears thrive in the Arctic but would not survive a tropical climate. Dolphins would not survive on land. Our species shared many of the physical advantages of the primates from which we evolved, and these abilities must have played an essential role in the early days of our separation. But those abilities also included the scope for intellectual expansion, and we moved so far into this intellectual domain that we found we had no competitors there.* We had found virgin "territory," so to speak. We could rule the roost without challenge.

The potential of our precious discovery would seem to be almost limitless. Our new type of fitness can be used to allow us to survive anywhere—even outside our planetary home if we so choose. Problems that might be fatal to the survival of other species can be solved. We can quite literally move mountains. But there is a snag. We must continually

*One might offer the tongue-in-cheek but nevertheless terrifying conjecture that our future excursions into such areas as supercomputation and artificial intelligence may eventually create intellects more powerful than our own!

do our best to maintain the conditions that allow the dissenting few to have their say. They do not need encouragement, but neither should they be actively suppressed as they were in the Dark Ages, for example. Today, we have a new problem in that we have become obliged to believe that dissent is synonymous with inefficiency, however miniscule the dose. But I must not get too far ahead.

Our separation from the primates* did not happen overnight. Indeed, it was a very protracted affair. It took ages because the very concept of purposive change had to be developed and accepted. As far as we know, that concept does not exist for other species. They are driven by the need to survive, of course, but other species do not seem able to respond to say radical changes in the environment or the food supply if they exceed certain limits. Humanity progressively and purposefully extended those limits, but we had to learn how to do it. As we know today, most people usually resist change. Routine and the status quo can offer comfortable ways of life. Things usually have to get worse before they can get better. When they become unbearable, we tend to be receptive to the idea that something must be done, thereby creating fertile ground for the persuasive dissident.

It is probable, therefore, that even such important inventions as the wheel and the bow and arrow would have been adopted only when everyone agreed that they offered overwhelming advantages. Thus, it would seem that the fomentation of enduring change needs a well-defined launching pad. If our ancestors had listened to everyone who tried to change our ways, we would soon have sunk into chaos and instability. As if by magic, therefore, Nature's evolutionary forces seem to have endowed humanity with just enough of the spark of our special type of dissent to ensure that we separated from the animal kingdom and prospered. The changes it led to would have to be significant to create a new species. On the other hand, their effects must also be slow and subtle. According to current understanding, some 5 million years of their evolutionary pressure was required to forge from the hominids the beings we can now clearly recognize as primitive versions of ourselves.

I do not mean to imply, however, that evolution is smooth and orderly.† On the contrary, it seems to go in fits and starts. Change is often succeeded by long periods when nothing much happens. *It is as if* there were indeed evolutionary forces that work in close collaboration with

*Strictly speaking, our species is of course included within the primate order. We are still part of it.

†This subject is still very controversial. For an elegant and short overview, see the book reviews in *Nature* by Michael A. Goldman (2001, p. 252).

similarly magical forces managing the land, sea, and air environments. These forces seem to take care to consolidate each change and to check that it has produced a fitter product before starting the next round. And so on. The nature and distribution of our dissent too had to be regulated. Without our dissenting spark, we would not have escaped from the tooth-and-claw existence that other animals must still endure. On the other hand, if the spark had been distributed too freely, social cohesion could not have developed. Progress would then be impossible as there would never have been sufficient numbers to agree on what should be done or to consolidate a new status quo. Chiefs need Indians.

I must not get carried away. Evolution is not preplanned, and there is no such thing as destiny. The famous American physicist Murray Gell-Mann once said that Nature is a purely totalitarian state. Everything that is not forbidden is compulsory. That is, everything that can happen will happen.* The ''forces of evolution'' are not needed, therefore. But it does no harm to anthropomorphize on the reasons why we might have emerged. Such simplification might even help us to stimulate an interest in how we might survive in the future.

Limiting the dissenting trait to a light sprinkling would mean that the trait would normally be dormant for most of us. This parsimony led to a remarkable consequence. Turning for a moment to less abstract considerations, we can take comfort from Nature's success in creating immune systems that generally protect us from such alien bodies as bacteria, viruses, and toxins and keep our bodies healthy most of the time. It would seem, however, that our intellects have also evolved a form of protection for acquired knowledge, whatever its quality. Thus, what we *know* becomes a part of us—a possession that must be kept safe from all challenges. We have all met those infuriating stick-in-the-muds who doggedly refuse to change their ways even though the case for change can be overwhelming. Some of us might even admit to similar obstinacy ourselves. But immunity from doubt could have played a vital role in human evolution. Humanity needs its dogged determined narrow-minded dinosaurs to defend their ways of life. Pioneers *should* be made to fight for what they believe in. Our ancient ancestors would not have wasted their time arguing about such questions as who had the best techniques for lighting fires, skinning animals, or simply staying alive. These skills would be passed down the generations and defined the status quo. In contrast with the rest of the animal kingdom, however, our light dusting of dissidents

*The ancient Greek philosopher Democritus is credited with a similar remark: ''Everything existing in the universe is the fruit of chance and necessity.''

could sow the seeds of permanent change. It was a very slow process, but we gradually ratcheted ourselves away from the animals as we moved further and further into the intellectual domain. The animals remained wild, of course, but we grew increasingly confident about our collective abilities. It turned out to be a tender trap. Humanity became the first of the tamed tellurians—*the first animals on this planet to domesticate themselves*.*

The recipe for creating the human race seems to have been simple. Take a suitable species, particularly one with a capacity for intellectual development. Give it a temperament prepared to accept the idea of purposive change. However, let that species be superbly confident and generally untroubled by self-doubt. Then, spice it with a pinch of creative and determined dissidents. Let it simmer slowly for about 5 million years. If the species is generally complacent, it will mean that anyone who tries to change the status quo will meet with stubborn or hostile resistance. But those rare and troubled individuals in whom the dissenting spark has been fully ignited will not easily be deterred—the instigation of change is their consuming passion. Many might fail, but others will follow. Eventually, the recipe ensures that the species passes through the doors of domestication without protest. The species will have become civilized. The human race will also be ready for anything.

Those who would bring about lasting change will usually need to understand the issues involved. The concept of research should therefore be intrinsically attractive because it provides the means by which our dissent can be made more effective. Research, however, involves a great deal more than mere idle curiosity. Many animals, particularly when young, engage in playful exploration and experiment, but any sense of wonder is fleeting, it never becomes a consuming interest, and it does not lead to permanent changes in their way of life. It is surprising, therefore, that when the time came to give a scientific name to our species, Carl Linnaeus (1707–1778), a Swedish botanist, chose the Latin *Homo sapiens*. It means ''wise man,'' and it was not a good choice. Wisdom is too passive a trait to explain how we came to our present dominance. We are certainly not born with it. Wisdom must be acquired—usually painfully, if at all. In the young of other animal life forms—lions, gorillas, birds, or fish—it is possible to see the signs of their major characteristics soon after they are born. Children, on the other hand, have many wonderful ways, but being wise is not one of them. Passionate and raucous dissent seems

*Many types of insects—ants, bees, etc.—lived in social harmony long before we did. However, their behavior seems to be programmed and unchanging. As far as we know, they live today as they lived millions of years ago.

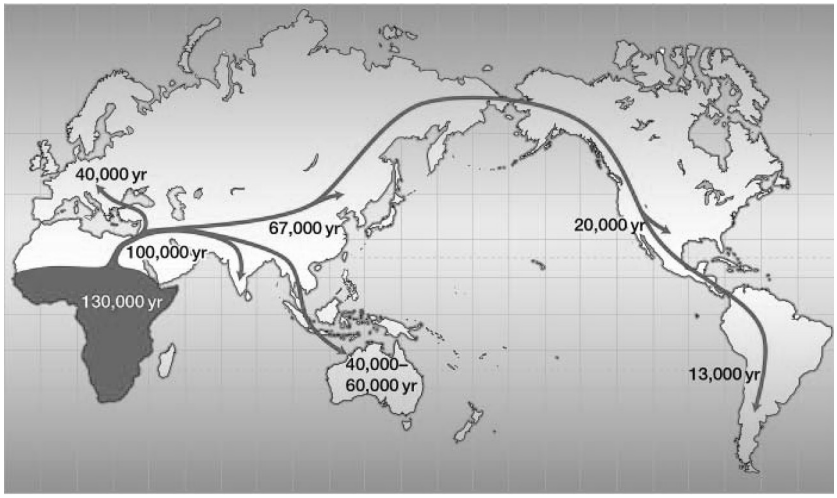

Figure 2
The origin and dispersal of modern humans as estimated from mitochondrial DNA samples by S. Blair Hedges of Pennsylvania State University. Our time of arrival as a distinct species is not well known, but Blair Hedges estimates that it was in the range 130,000–465,000 years ago. (Reprinted by permission from *Nature 408*, 653 (2000). Copyright 2000 by Macmillan Publishers Ltd.)

to come naturally to us all at first; it is only later that most us become tamed for most of the time.

Linnaeus was one of the most perceptive scientists of the eighteenth century. To understand the thinking that led to his remarkable choice, we have to go back to the time of the first disciplined scientists—the ancient Greeks. Aristotle, who lived from 384 to 322 B.C., was perhaps the most influential of them all. He believed that all living things could be classified into two distinct kingdoms—plants and animals—and each had its place in a hierarchy. In the plant kingdom, he placed the algae and the ferns at the bottom, and the more prestigious levels were given to the higher plants, including those with flowers, seeds, and fruits. In the animal kingdom, the possession of a backbone was the determining factor, and not surprisingly, since a member of our species was awarding the grades, he placed humanity at the highest level.

One cannot make progress in scientific research without making assumptions. They are analogous to the use of pitons, karabiners, or ropes in a difficult mountaineering climb, and one's progress will depend on

Figure 3
Isaac Newton's birthplace—the manor house of Woolsthorpe, near Grantham in Lincolnshire. Newton (1642–1727) was the son of a farmer. (Photograph by the author)

their strength and durability. The convention in research is that any assumptions should be clearly stated alongside one's discovery. Thus, one might claim, as Isaac Newton could have done to illustrate his law of gravity, that projectiles travel in a curve (a parabola) determined only by their initial velocity and Earth's gravity. Assuming air resistance can be neglected, the projectile's mass and shape would not be important.

Among the most perilous pitfalls in research, however, are the assumptions arising from subconscious prejudices. They might arise from an unquestioning acceptance of common sense—the generally accepted wisdom* of the time—but all too often, it is not sense at all. In Aristotle's case, he took as incontrovertible fact, as everyone did in his day, that the

*In his wonderful book *Tools for Thought*, C. H. Waddington (1977) introduces the concept of Conventional Wisdom of the Dominant Group. As he says, "If you would like to contract this lengthy phrase in the fashionable way, COWDUNG is memorable, appropriate, and accurate enough" (p. 16).

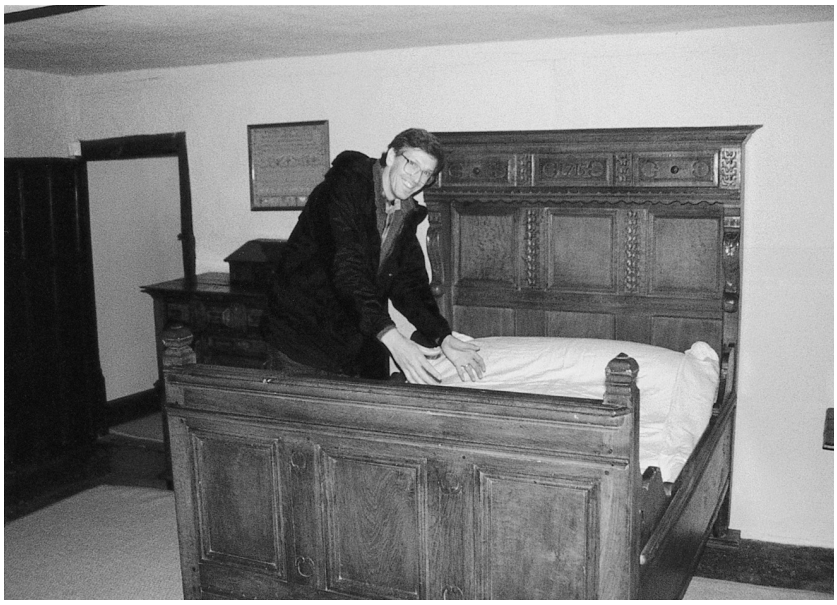

Figure 4
Jeff Kimble, a physicist from Caltech and a Venture Researcher (see Chapter 8), "delivering" Newton into the world from his very bed in the manor house. (Photograph by the author)

species inhabiting Earth were distinct and immutable. They were the same when Aristotle was alive as they always had been. They would never change because they were the product of divine creation.

Linnaeus was the son of a country curate, Nils Ingemarsson, but Swedish families in the eighteenth century did not always use family names. His father chose Linnaeus after a beautiful Linden tree in the family garden. He used the Latin form after the fashion of the time and because Latin was the language of the scholars his father hoped his son would soon join. Linnaeus began his training at the University of Lund in 1727, but with an eye on earning his future living, he initially chose medicine rather than his beloved botany, which had little more status among scholars of that time than a hobby. In the following year, he moved to the more prestigious University of Uppsala, where he must have been surprised to find that his botanical expertise was quickly appreciated. He won a commission from the Academy of Sciences to travel throughout Lapland, a journey that led him to develop his ideas for classifying plants. Such a system was urgently needed to bring some order to the profusion

of discoveries being made at the time. How could one claim to have found a new animal or plant if it cannot be described in a language that will be widely accepted and understood?

On his return, he met a fellow medical student, Petrus Artedi, who also had a passion for natural philosophy. They soon realized that their skills and temperaments were so perfectly matched that they might tackle something important. Neither lacked ambition, and while they were both still in their twenties, they made a pact that they would classify the known organisms in the entire living world, no less. Later in my story, I will relate how nowadays the ways by which research is administered and funded make it very difficult, to say the least, for such youthful exuberance to flourish—how the various research bureaucracies will insist on being persuaded that an impossible mountain in all but the eyes of dauntless youth is not only worth climbing but it can be proved that it *can* be climbed; that a more manageable peak in a more accessible range might not be a better choice; that the young pretenders are the best people available to make the attempt; that the cost cannot be reduced; that they have worked out a realistic route to their ambitious summit taking into account every possible hazard they might meet; and that they have devised a credible timetable for reaching each milestone along the way. All this red tape must be neatly tied up and approved by the bureaucrats before they would be allowed to take the first step.

Fortunately, their breathtaking audacity was matched by their energy and dedication. The only obstacles they had to overcome were those created by Nature herself, and she is never bureaucratic. They started by carving up the living world between them according to a simple formula. Linnaeus did not like fishes or reptiles, so Artedi took those: Linnaeus assumed responsibility for the rest. Their collaboration turned out to be very fruitful and survived their move to Holland, where Linnaeus took his formal medical examinations. Tragically, after they had been working together for only five years, Artedi drowned when he fell into an Amsterdam canal at night. Such was their meticulous attention to detail that they had agreed that if one of them died, the other would take over. Linnaeus therefore continued with the momentous task alone. He usually worked at a frenetic pace, but nevertheless it took him another 25 years.

For Linnaeus, species of organisms could be grouped into higher categories called *genera* (singular, *genus*) and further classified by a name for the *species* that expressed a characteristic. Aristotle had used a similar scheme, using the word genus for a group of similar organisms together with the *differentio specifica*—the specific difference of each type of organism. But there was no agreement on how genera should be grouped.

Groupings were often arbitrary, lumping, say, domestic or water animals together because they had a similar habitat. Linnaeus's innovation was the grouping of genera into higher *taxa* that were also based on shared similarities. In Linnaeus's original system, therefore, genera were grouped into orders, orders into classes, and classes into kingdoms. Thus, the kingdom Animalia contained the class Vertebrata, which contained the order Primates, which contained the genus *Homo* with the species *sapiens* expressing the characteristic wise.*

Linnaeus's scheme simplified naming considerably. He designated one Latin name to indicate the genus and another that could be used as a shorthand name for the species. The binomial system, as it came to be called, was first established for the plants and was published in its final form in 1753 in his *Species Plantarum*. It was followed five years later by the final edition of his *Systema Naturae* that covered the animal world. Hitherto, the animals and plants had been described by whatever features the observer thought might be important, but the resultant shambles made it difficult to recognize any order there might be among the many thousand types of plants and animals known even at that time. Linnaeus's succinct shorthand, on the other hand, was easy to use. It came to him, as he described, "like putting a clapper to the bell." The binomial system not only appealed to contemporary scientists but has also proved to be so powerful that it has continued in use to the present day (with modification). It also caught the public's imagination. Anyone could now name the plants and wild flowers they might come across and enjoy the satisfaction of placing them accurately in Linnaeus's great scheme.

Linnaeus was a devout Christian. Like Aristotle, he strongly believed that all living things had been created at some divine moment in the profusion that we see them today. In the somewhat pompous language of the time he saw organic Nature as an "endless cycle of life and death in which every plant and animal fulfils its destined task in the service of the whole." Although he came to modify these views slightly as a result of his work on plant hybrids (which of course as any gardener knows cannot be divine creations), the seeds of doubt did not take root. As I shall outline later, Aristotle's thinking exerted a virtually paralyzing effect on more than *50 generations* of philosophers and scientists and was still exerting its intellectual grip in Linnaeus's time. As might be expected, therefore, Linnaeus attributed such aberrations as hybrids that he had actually observed with his own eyes to "the work of Nature in a sportive mood." He

*Linnaeus originally gave humanity the name *Homo diurnis*, as opposed to *Homo nocturnus* for the orangutan.

remained a firm advocate of "the fixity of the species" until the end of his life in 1778, believing that he was a prophet called by God to promulgate "the only true dogma" and that any who disagreed were "heretics" and deserved to be persecuted.

Some 50 years later, when he was only 29, Charles Darwin (1809–1882) formulated his ideas on the origin and evolution of the species. However, Linnaeus's reputation as a brilliant observer weighed heavily on him. Many great discoveries often appear obvious with hindsight. Indeed, after reading Darwin's eventual publication, Thomas Huxley famously remarked, "How extremely stupid not to have thought of that." But Darwin had to ask himself why the great Linnaeus, who apparently missed nothing, had not thought of it. He also feared, quite rightly, that his ideas would be fiercely opposed by the scientific and religious establishments. He was also concerned that they might offend his devout close friends and family. Not surprisingly, therefore, he sat on them for 20 years. In 1858, however, he was shocked to receive an essay from an up-and-coming youngster—Alfred Wallace (1823–1913)—who had independently conceived similar ideas on evolution. Rather than rush into print to squeeze each other out, as the competitive climate would virtually enforce today, they showed a wonderful spirit of camaraderie in agreeing to publish jointly.* Ironically, they chose the *Journal of the Linnean Society*, set up in London† to honor the great man. Their momentous paper swept away much of the dogmatic thinking that Linnaeus and others had so passionately defended. It also created a furious controversy that lasted many years.‡ See Text Box 2. The study of biology subsequently grew explosively. It also stimulated growth in such other fields as geology, physics, and cosmology that might help us to understand the origin of life—"the mystery of mysteries"—as it was called in Darwin's time, a description that would not be out of place today.

The convention in biology is that once the holotype (the original

*They remained friends for the rest of Darwin's life. Wallace was a pallbearer at Darwin's funeral.

†When Linnaeus's son died without heirs, his wife and daughters sold Linnaeus's library, manuscripts, and natural history collections to the English natural historian Sir James Edward Smith, who founded the Linnean Society of London to take care of them.

‡Even politicians joined in. The Earl of Beaconsfield (1804–1881, i.e., Benjamin Disraeli) remarked that it seemed to be in dispute whether men were descended from apes or angels, and that for his part he was "on the side of the angels."

Text Box 2: Evolution and the Church

It was not until 1996 that Pope John Paul II acknowledged the existence of Darwin's concept of evolution. (Sadly, Wallace's contribution is rarely mentioned today. His first full-scale biography—*Alfred Russel Wallace: A Life* by P. Raby—was not published until 2001.) The Pope indicated that the Catholic Church was ready formally to accept scientific evidence that evolution is more than just a hypothesis, saying that it is acceptable to believe that "the human body originates from living matter which predates it." He went on to say, however, that Darwin's view that "the spirit is also a product of matter" was unacceptable, as it would lead to an irresolvable conflict between science and faith. The influential Creationists—particular in some states of the United States—resist Darwin and Wallace's ideas to the present day.

specimen from which the description of a new species is established) of an organism has been deposited in a national library or museum and its name has been accepted, it should not be changed. For plants, the holotype is usually a pressing of the dried plant. For animals, they might be stuffed or preserved in part or whole. For human beings, this treatment is not now possible, although Jeremy Bentham (see Figure 5) eccentrically opted for it in his will. However, it has been jokingly remarked that the holotype of our species was eventually deposited by Linnaeus's family in 1778 at a site 6 feet below the ground in Uppsala, Sweden.

As I have mentioned, however, the name he chose for us—*Homo sapiens*—leaves much to be desired. It was in Latin, of course, the language of scholars at the time. Today, the equivalent language is English (or American), and my choice for our species would focus on humanity's capacity for dissent. Thus, it would be *Dissentient man* or *Homo dissentiens* if Latin must be used. It is not likely to be accepted. However, I suggest it because it could play an important role in our future survival. It could provide a constant reminder that our species has reached its present ascendancy only because successive generations have always spawned a sprinkling of dissidents who would challenge the generally accepted wisdom. Indeed, we will survive only if we continue to change. *Homo sapiens*, on the other hand, encourages the idea that our privileged position is unassailable. Wisdom does not necessarily have to be refreshed and renewed. Once one has been accorded the status of being wise, one can sit back and enjoy it.

Figure 5
One of the most influential people in the founding of the university at which I am a visiting professor—University College London (UCL)—was Jeremy Bentham (1748–1832), one of the nineteenth century's most radical philosophers. Thanks to Bentham and others, UCL has a tradition of tolerating dissent and was indeed the first university in England to accept Catholics and other nonmembers of the Church of England. Bentham had his body preserved and installed in the main entrance to the college, where seated amiably in a glass case he could greet all comers. The cabinet contains Bentham's preserved skeleton dressed in his own clothes and surmounted by a wax head (his mummified head is kept in the college vault). His welcoming effigy marks a very convenient meeting place. (Photograph by the author)

In fact, our position is delicately balanced. As the last century turned, the euphoria helped hide the fact that we were facing an avalanche of serious problems. Our only hope for the future is that the complacency of the majority does not overwhelm the efforts of the dissenting few who can keep us one step ahead of the game.