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Consilience

THE UNITY OF KNOWLEDGE

EDWARD O. WILSON

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CHAPTER 1

The Ionian Enchantment

I REMEMBER very well the time I was captured by the dream of unified learning. It was in the early fall of 1947, when at eighteen I came up from Mobile to Tuscaloosa to enter my sophomore year at the University of Alabama. A beginning biologist, fired by adolescent enthusiasm but short on theory and vision, I had schooled myself in natural history with field guides carried in a satchel during solitary excursions into the woodlands and along the freshwater streams of my native state. I saw science, by which I meant (and in my heart I still mean) the study of ants, frogs, and snakes, as a wonderful way to stay outdoors.

My intellectual world was framed by Linnaeus, the eighteenth-century Swedish naturalist who invented modern biological classification. The Linnaean system is deceptively easy. You start by separating specimens of plants and animals into species. Then you sort species resembling one another into groups, the genera. Examples of such groups are all the crows and all the oaks. Next you label each species with a two-part Latinized name, such as *Corvus ossifragus* for the fish crow, where *Corvus* stands for the genus—all the species of crows—and *ossifragus* for the fish crow in particular. Then on to higher classification, where similar genera are grouped

into families, families into orders, and so on up to phyla and finally, at the very summit, the six kingdoms—plants, animals, fungi, protists, monerans, and archaea. It is like the army: men (plus women, nowadays) into squads, squads into platoons, platoons into companies, and in the final aggregate, the armed services headed by the joint chiefs of staff. It is, in other words, a conceptual world made for the mind of an eighteen-year-old.

I had reached the level of the Carolus Linnaeus of 1735 or, more accurately (since at that time I knew little of the Swedish master), the Roger Tory Peterson of 1934, when the great naturalist published the first edition of *A Field Guide to the Birds*. My Linnaean period was nonetheless a good start for a scientific career. The first step to wisdom, as the Chinese say, is getting things by their right names.

Then I discovered evolution. Suddenly—that is not too strong a word—I saw the world in a wholly new way. This epiphany I owed to my mentor Ralph Chermock, an intense, chain-smoking young assistant professor newly arrived in the provinces with a Ph.D. in entomology from Cornell University. After listening to me natter for a while about my lofty goal of classifying all the ants of Alabama, he handed me a copy of Ernst Mayr's 1942 *Systematics and the Origin of Species*. Read it, he said, if you want to become a real biologist.

The thin volume in the plain blue cover was one of the New Synthesis works, uniting the nineteenth-century Darwinian theory of evolution and modern genetics. By giving a theoretical structure to natural history, it vastly expanded the Linnaean enterprise. A tumbler fell somewhere in my mind, and a door opened to a new world. I was enthralled, couldn't stop thinking about the implications evolution has for classification and for the rest of biology.

And for philosophy. And for just about everything. Static pattern slid into fluid process. My thoughts, embryonically those of a modern biologist, traveled along a chain of causal events, from mutations that alter genes to evolution that multiplies species, to species that assemble into faunas and floras. Scale expanded, and turned continuous. By inwardly manipulating time and space, I found I could climb the steps in biological organization from microscopic particles in cells to the forests that clothe mountain slopes. A new enthusiasm surged through me. The animals and plants I loved so dearly reentered the stage as lead players in a grand drama. Natural history was validated as a real science.

I had experienced the Ionian Enchantment. That recently coined expression I borrow from the physicist and historian Gerald Holton. It means a belief in the unity of the sciences—a conviction, far deeper than a mere working proposition, that the world is orderly and can be explained by a small number of natural laws. Its roots go back to Thales of Miletus, in Ionia, in the sixth century B.C. The legendary philosopher was considered by Aristotle two centuries later to be the founder of the physical sciences. He is of course remembered more concretely for his belief that all matter consists ultimately of water. Although the notion is often cited as an example of how far astray early Greek speculation could wander, its real significance is the metaphysics it expressed about the material basis of the world and the unity of nature.

The Enchantment, growing steadily more sophisticated, has dominated scientific thought ever since. In modern physics its focus has been the unification of all the forces of nature—electroweak, strong, and gravitation—the hoped-for consolidation of theory so tight as to turn the science into a "perfect" system of thought, which by sheer weight of

evidence and logic is made resistant to revision. But the spell of the Enchantment extends to other fields of science as well, and in the minds of a few it reaches beyond into the social sciences, and still further, as I will explain later, to touch the humanities. The idea of the unity of science is not idle. It has been tested in acid baths of experiment and logic and enjoyed repeated vindication. It has suffered no decisive defeats. At least not yet, even though at its center, by the very nature of the scientific method, it must be thought always vulnerable. On this weakness I will also expand in due course.

Einstein, the architect of grand unification in physics, was Ionian to the core. That vision was perhaps his greatest strength. In an early letter to his friend Marcel Grossmann he said, "It is a wonderful feeling to recognize the unity of a complex of phenomena that to direct observation appear to be quite separate things." He was referring to his successful alignment of the microscopic physics of capillaries with the macroscopic, universe-wide physics of gravity. In later life he aimed to weld everything else into a single parsimonious system, space with time and motion, gravity with electromagnetism and cosmology. He approached but never captured that grail. All scientists, Einstein not excepted, are children of Tantalus, frustrated by the failure to grasp that which seems within reach. They are typified by those thermodynamicists who for decades have drawn ever closer to the temperature of absolute zero, when atoms cease all motion. In 1995, pushing down to within a few billionths of a degree above absolute zero, they created a Bose-Einstein condensate, a fundamental form of matter beyond the familiar gases, liquids, and solids, in which many atoms act as a single atom in one quantum state. As temperature drops and pressure is increased, a gas condenses into a liquid, then

a solid; then appears the Bose-Einstein condensate. But absolute, entirely absolute zero, a temperature that exists in imagination, has still not been attained.

On a far more modest scale, I found it a wonderful feeling not just to taste the unification metaphysics but also to be released from the confinement of fundamentalist religion. I had been raised a Southern Baptist, laid backward under the water on the sturdy arm of a pastor, been born again. I knew the healing power of redemption. Faith, hope, and charity were in my bones, and with millions of others I knew that my savior Jesus Christ would grant me eternal life. More pious than the average teenager, I read the Bible cover to cover, twice. But now at college, steroid-driven into moods of adolescent rebellion, I chose to doubt. I found it hard to accept that our deepest beliefs were set in stone by agricultural societies of the eastern Mediterranean more than two thousand years ago. I suffered cognitive dissonance between the cheerfully reported genocidal wars of these people and Christian civilization in 1940s Alabama. It seemed to me that the Book of Revelation might be black magic hallucinated by an ancient primitive. And I thought, surely a loving personal God, if He is paying attention, will not abandon those who reject the literal interpretation of the biblical cosmology. It is only fair to award points for intellectual courage. Better damned with Plato and Bacon, Shelley said, than go to heaven with Paley and Malthus. But most of all, Baptist theology made no provision for *evolution.* The biblical authors had missed the most important revelation of all! Could it be that they were not really privy to the thoughts of God? Might the pastors of my childhood, good and loving men though they were, be mistaken? It was all too much, and freedom was ever so sweet. I drifted away from the church, not definitively agnostic or atheistic, just

Baptist no more.

Still, I had no desire to purge religious feelings. They were bred in me; they suffused the wellsprings of my creative life. I also retained a small measure of common sense. To wit, people must belong to a tribe; they yearn to have a purpose larger than themselves. We are obliged by the deepest drives of the human spirit to make ourselves more than animated dust, and we must have a story to tell about where we came from, and why we are here. Could Holy Writ be just the first literate attempt to explain the universe and make ourselves significant within it? Perhaps science is a continuation on new and better-tested ground to attain the same end. If so, then in that sense science is religion liberated and writ large.

Such, I believe, is the source of the Ionian Enchantment: Preferring a search for objective reality over revelation is another way of satisfying religious hunger. It is an endeavor almost as old as civilization and intertwined with traditional religion, but it follows a very different course—a stoic's creed, an acquired taste, a guidebook to adventure plotted across rough terrain. It aims to save the spirit, not by surrender but by liberation of the human mind. Its central tenet, as Einstein knew, is the unification of knowledge. When we have unified enough certain knowledge, we will understand who we are and why we are here.

If those committed to the quest fail, they will be forgiven. When lost, they will find another way. The moral imperative of humanism is the endeavor alone, whether successful or not, provided the effort is honorable and failure memorable. The ancient Greeks expressed the idea in a myth of vaulting ambition. Daedalus escapes from Crete with his son Icarus on wings he has fashioned from feathers and wax. Ignoring the warnings of his father, Icarus flies toward the sun, whereupon his wings come apart and he falls into the sea.

That is the end of Icarus in the myth. But we are left to wonder: Was he just a foolish boy? Did he pay the price for hubris, for pride in sight of the gods? I like to think that on the contrary his daring represents a saving human grace. And so the great astrophysicist Subrahmanyan Chandrasekhar could pay tribute to the spirit of his mentor, Sir Arthur Eddington, by saying: Let us see how high we can fly before the sun melts the wax in our wings.

CHAPTER 2

The Great Branches of Learning

YOU WILL SEE at once why I believe that the Enlightenment thinkers of the seventeenth and eighteenth centuries got it mostly right the first time. The assumptions they made of a lawful material world, the intrinsic unity of knowledge, and the potential of indefinite human progress are the ones we still take most readily into our hearts, suffer without, and find maximally rewarding through intellectual advance. The greatest enterprise of the mind has always been and always will be the attempted linkage of the sciences and humanities. The ongoing fragmentation of knowledge and resulting chaos in philosophy are not reflections of the real world but artifacts of scholarship. The propositions of the original Enlightenment are increasingly favored by objective evidence, especially from the natural sciences.

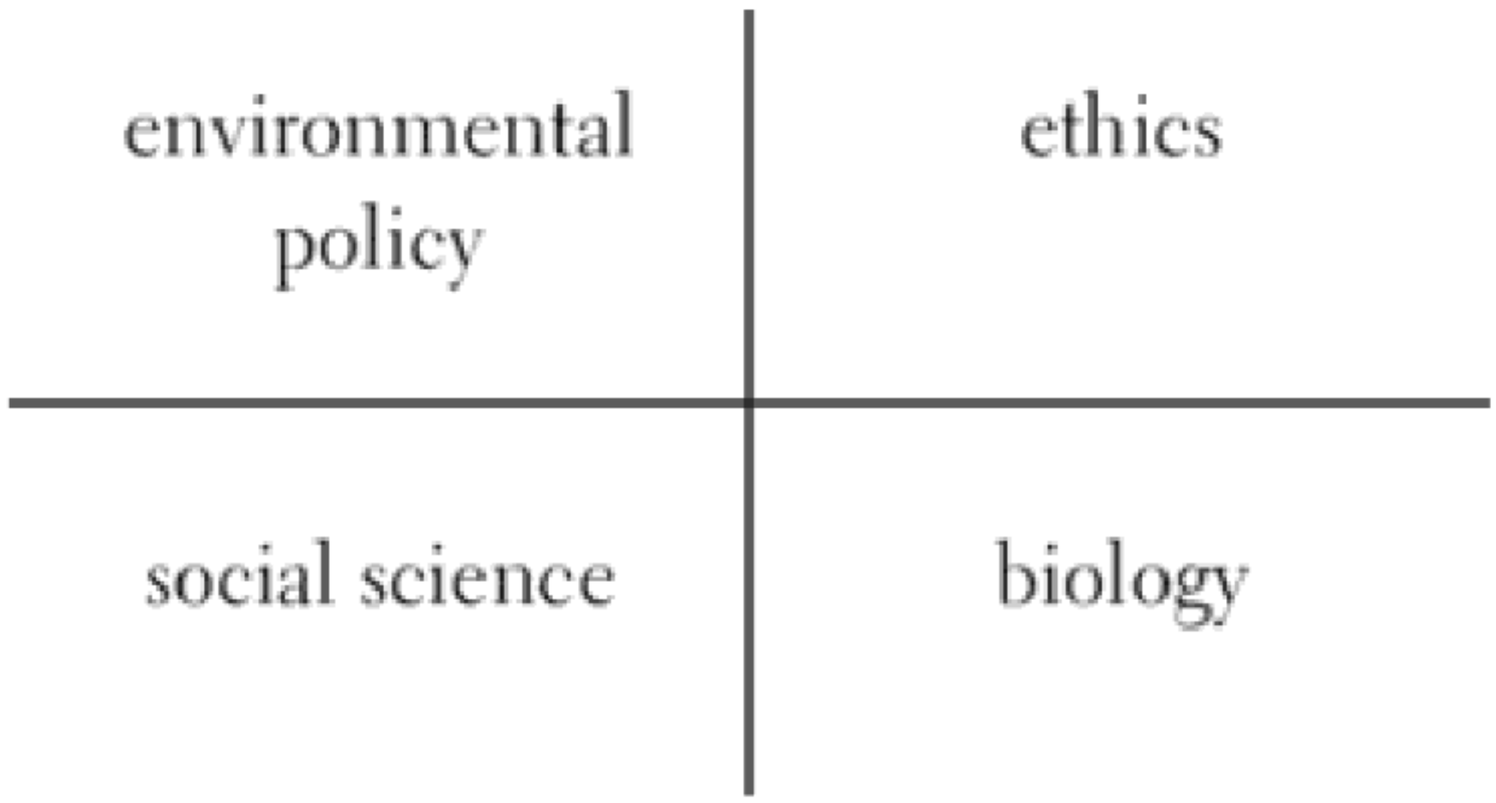
Consilience is the key to unification. I prefer this word over "coherence" because its rarity has preserved its precision, whereas coherence has several possible meanings, only one of which is consilience. William Whewell, in his 1840 synthesis *The Philosophy of the Inductive Sciences*, was the first to speak of consilience, literally a "jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of

explanation. He said, "The Consilience of Inductions takes place when an Induction, obtained from one class of facts, coincides with an Induction, obtained from another different class. This Consilience is a test of the truth of the Theory in which it occurs."

The only way either to establish or to refute consilience is by methods developed in the natural sciences—not, I hasten to add, an effort led by scientists, or frozen in mathematical abstraction, but rather one allegiant to the habits of thought that have worked so well in exploring the material universe.

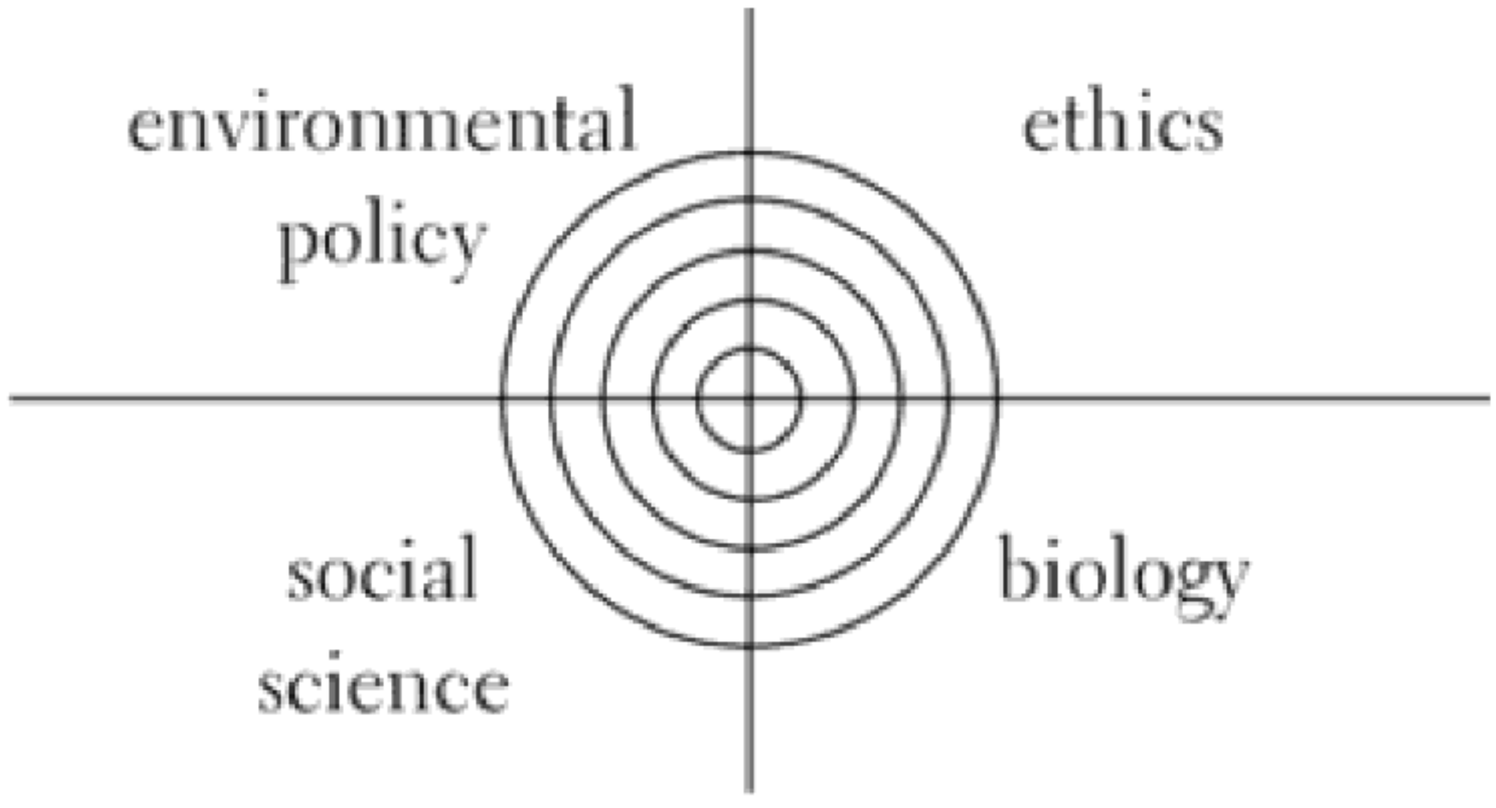
The belief in the possibility of consilience beyond science and across the great branches of learning is not yet science. It is a metaphysical world view, and a minority one at that, shared by only a few scientists and philosophers. It cannot be proved with logic from first principles or grounded in any definitive set of empirical tests, at least not by any yet conceived. Its best support is no more than an extrapolation of the consistent past success of the natural sciences. Its surest test will be its effectiveness in the social sciences and humanities. The strongest appeal of consilience is in the prospect of intellectual adventure and, given even modest success, the value of understanding the human condition with a higher degree of certainty.

Bear with me while I cite an example to illustrate the claim just made. Think of two intersecting lines forming a cross, and picture the four quadrants thus created. Label one quadrant environmental policy, the next ethics, the next biology, and the final one social science.



We already intuitively think of these four domains as closely connected, so that rational inquiry in one informs reasoning in the other three. Yet undeniably each stands apart in the contemporary academic mind. Each has its own practitioners, language, modes of analysis, and standards of validation. The result is confusion, and confusion was correctly identified by Francis Bacon four centuries ago as the most fatal of errors, which "occurs wherever argument or inference passes from one world of experience to another."

Next draw a series of concentric circles around the point of intersection.



As we cross the circles inward toward the point at which the quadrants meet, we find ourselves in an increasingly unstable and disorienting region. The ring closest to the intersection, where most real-world problems exist, is the one in which fundamental analysis is most needed. Yet virtually no maps exist. Few concepts and words serve to guide us. Only in imagination can we travel clockwise from the recognition of environmental problems and the need for soundly based policy; to the selection of solutions based on moral reasoning; to the biological foundations of that reasoning; to a grasp of social institutions as the products of biology, environment, and history. And thence back to environmental policy.

Consider this example. Governments everywhere are at a loss as to the best policy for regulating the dwindling forest reserves of the world. There are few established ethical guidelines from which agreement might be reached, and those are based on an insufficient knowledge of ecology. Even if adequate scientific knowledge were available, there would still be little basis for the long-term valuation of forests. The economics of sustainable yield is still a primitive art, and the psychological benefits of natural ecosystems are almost wholly unexplored.

The time has come to achieve the tour in reality. This is not an idle exercise for the delectation of intellectuals. How wisely policy is chosen will depend on the ease with which the educated public, not just intellectuals and political leaders, can think around these and similar circuits, starting at any point and moving in any direction.

To ask if consilience can be gained in the innermost domains of the circles, such that sound judgment will flow easily from one discipline to another, is equivalent to asking whether, in the gathering of disciplines, specialists can ever reach agreement on a common body of abstract principles

and evidentiary proof. I think they can. Trust in consilience is the foundation of the natural sciences. For the material world at least, the momentum is overwhelmingly toward conceptual unity. Disciplinary boundaries within the natural sciences are disappearing, to be replaced by shifting hybrid domains in which consilience is implicit. These domains reach across many levels of complexity, from chemical physics and physical chemistry to molecular genetics, chemical ecology, and ecological genetics. None of the new specialties is considered more than a focus of research. Each is an industry of fresh ideas and advancing technology.

Given that human action comprises events of physical causation, why should the social sciences and humanities be impervious to consilience with the natural sciences? And how can they fail to benefit from that alliance? It is not enough to say that human action is historical, and that history is an unfolding of unique events. Nothing fundamental separates the course of human history from the course of physical history, whether in the stars or in organic diversity. Astronomy, geology, and evolutionary biology are examples of primarily historical disciplines linked by consilience to the rest of the natural sciences. History is today a fundamental branch of learning in its own right, down to the finest detail. But if ten thousand humanoid histories could be traced on ten thousand Earthlike planets, and from a comparative study of those histories empirical tests and principles evolved, historiography—the explanation of historical trends—would already be a natural science.

The unification agenda does not sit well with a few professional philosophers. The subject I address they consider their own, to be expressed in their language, their framework of formal thought. They will draw this indictment: *conflation, simplism, ontological reductionism, scientism*, and other sins

made official by the hissing suffix. To which I plead guilty, guilty, guilty. Now let us move on, thus. Philosophy plays a vital role in intellectual synthesis, and it keeps us alive to the power and continuity of thought through the centuries. It also peers into the future to give shape to the unknown—and that has always been its vocation of choice. One of its most distinguished practitioners, Alexander Rosenberg, has recently argued that philosophy in fact addresses just two issues: the questions that the sciences—physical, biological, and social—cannot answer, and the reasons for that incapacity. "Now of course," he concludes, "there may not be any questions that the sciences cannot answer eventually, in the long run, when all the facts are in, but certainly there are questions that the sciences cannot answer *yet*." This assessment is admirably clear and honest and convincing. It neglects, however, the obvious fact that scientists are equally qualified to judge what remains to be discovered, and why. There has never been a better time for collaboration between scientists and philosophers, especially where they meet in the borderlands between biology, the social sciences, and the humanities. We are approaching a new age of synthesis, when the testing of consilience is the greatest of all intellectual challenges. Philosophy, the contemplation of the unknown, is a shrinking dominion. We have the common goal of turning as much philosophy as possible into science.

IF THE WORLD really works in a way so as to encourage the consilience of knowledge, I believe the enterprises of culture will eventually fall out into science, by which I mean the natural sciences, and the humanities, particularly the creative arts. These domains will be the two great branches of learning in the twenty-first century. The social sciences will continue to split within each of its disciplines, a process

already rancorously begun, with one part folding into or becoming continuous with biology, the other fusing with the humanities. Its disciplines will continue to exist but in radically altered form. In the process the humanities, ranging from philosophy and history to moral reasoning, comparative religion, and interpretation of the arts, will draw closer to the sciences and partly fuse with them. Of these several subjects I will say more in later chapters.

I admit that the confidence of natural scientists often seems overweening. Science offers the boldest metaphysics of the age. It is a thoroughly human construct, driven by the faith that if we dream, press to discover, explain, and dream again, thereby plunging repeatedly into new terrain, the world will somehow come clearer and we will grasp the true strangeness of the universe. And the strangeness will all prove to be connected and make sense.

In his 1941 classic *Man on His Nature*, the British neurobiologist Charles Sherrington spoke of the brain as an enchanted loom, perpetually weaving a picture of the external world, tearing down and reweaving, inventing other worlds, creating a miniature universe. The communal mind of literate societies—world culture—is an immensely larger loom. Through science it has gained the power to map external reality far beyond the reach of a single mind, and through the arts the means to construct narratives, images, and rhythms immeasurably more diverse than the products of any solitary genius. The loom is the same for both enterprises, for science and for the arts, and there is a general explanation of its origin and nature and thence of the human condition, proceeding from the deep history of genetic evolution to modern culture. Consilience of causal explanation is the means by which the single mind can travel most swiftly and surely from one part of the communal mind

to the other.

In education the search for consilience is the way to renew the crumbling structure of the liberal arts. During the past thirty years the ideal of the unity of learning, which the Renaissance and Enlightenment bequeathed us, has been largely abandoned. With rare exceptions American universities and colleges have dissolved their curriculum into a slurry of minor disciplines and specialized courses. While the average number of undergraduate courses per institution doubled, the percentage of mandatory courses in general education dropped by more than half. Science was sequestered in the same period; as I write, in 1997, only a third of universities and colleges require students to take at least one course in the natural sciences. The trend cannot be reversed by force-feeding students with some-of-this and some-of-that across the branches of learning. Win or lose, true reform will aim at the consilience of science with the social sciences and humanities in scholarship and teaching. Every college student should be able to answer the following question: What is the relation between science and the humanities, and how is it important for human welfare?

Every public intellectual and political leader should be able to answer that question as well. Already half the legislation coming before the United States Congress contains important scientific and technological components. Most of the issues that vex humanity daily—ethnic conflict, arms escalation, overpopulation, abortion, environment, endemic poverty, to cite several most persistently before us—cannot be solved without integrating knowledge from the natural sciences with that of the social sciences and humanities. Only fluency across the boundaries will provide a clear view of the world as it really is, not as seen through the lens of ideologies and religious dogmas or commanded by myopic response to

immediate need. Yet the vast majority of our political leaders are trained exclusively in the social sciences and humanities, and have little or no knowledge of the natural sciences. The same is true of the public intellectuals, the columnists, the media interrogators, and think-tank gurus. The best of their analyses are careful and responsible, and sometimes correct, but the substantive base of their wisdom is fragmented and lopsided.

A balanced perspective cannot be acquired by studying disciplines in pieces but through pursuit of the consilience among them. Such unification will come hard. But I think it is inevitable. Intellectually it rings true, and it gratifies impulses that rise from the admirable side of human nature. To the extent that the gaps between the great branches of learning can be narrowed, diversity and depth of knowledge will increase. They will do so because of, not despite, the underlying cohesion achieved. The enterprise is important for yet another reason: It gives ultimate purpose to intellect. It promises that order, not chaos, lies beyond the horizon. I think it inevitable that we will accept the adventure, go there, and find out.

CHAPTER 3

The Enlightenment

THE DREAM OF INTELLECTUAL UNITY first came to full flower in the original Enlightenment, an Icarian flight of the mind that spanned the seventeenth and eighteenth centuries. A vision of secular knowledge in the service of human rights and human progress, it was the West's greatest contribution to civilization. It launched the modern era for the whole world; we are all its legatees. Then it failed.

Astonishingly—it failed. When does such a historical period come to an end? It dies when, for whatever reason, usually in the aftermath of war and revolution, its ideas no longer dominate. It is of surpassing importance, therefore, to understand the essential nature of the Enlightenment and the weaknesses that brought it down. Both can be said to be wrapped up in the life of the Marquis de Condorcet. In particular, no single event better marks the end of the Enlightenment than his death on March 29, 1794. The circumstances were exquisitely ironic. Condorcet has been called the prophet of the Laws of Progress. By virtue of his towering intellect and visionary political leadership, he seemed destined to emerge from the Revolution as the Jefferson of France. But in late 1793 and early 1794, as he was composing the ultimate Enlightenment blueprint, *Sketch*

for a Historical Picture of the Progress of the Human Mind, he was instead a fugitive from the law, liable to sentence of death by representatives of the cause he had so faithfully served. His crime was political: He was perceived to be a Girondist, a member of a faction found too moderate—too reasonable—by the radical Jacobins. Worse, he had criticized the constitution drawn up by the Jacobin-dominated National Convention. He died on the floor of a cell in the jail at Bourg-la-Reine, after being mauled by villagers who had captured him on the run. They would certainly have turned him over to the Paris authorities for trial. The cause of death is unknown. Suicide was ruled out at the time. Poison, which he carried with him, is nevertheless possible; so are trauma and heart attack. At least he was spared the guillotine.

The French Revolution drew its intellectual strength from men and women like Condorcet. It was readied by the growth of educational opportunity and then fired by the idea of the universal rights of man. Yet as the Enlightenment seemed about to achieve by this means political fruition in Europe, something went terribly wrong. What seemed at first to be minor inconsistencies widened into catastrophic failures. Jean-Jacques Rousseau, in *The Social Contract* thirty years earlier, had introduced the idea that was later to inspire the rallying slogan "Liberty, Equality, Fraternity." But he had also invented the deadly abstraction of the "general will" to achieve these goals. The general will, he said, is the rule of justice agreed upon by assemblies of free people whose interest is only to serve the welfare of the society and of each person in it. When achieved, it forms a sovereign contract that is "always constant, unalterable, and pure.... Each of us puts his person and all his power in common under the supreme direction of the general will, and in our corporate capacity, we receive each member as an indivisible

part of the whole." Those who do not conform to the general will, Rousseau continued, are deviants subject to necessary force by the assembly. There is no other way to achieve a truly egalitarian democracy and thus to break humanity out of the chains that everywhere bind it.

Robespierre, leader of the Reign of Terror that overtook the Revolution in 1793, grasped this logic all too well. He and his fellow Jacobins across France implemented Rousseau's necessary force to include summary condemnations and executions for all those who opposed the new order. Some 300,000 nobles, priests, political dissidents, and other troublemakers were imprisoned, and 17,000 died within the year. In Robespierre's universe, the goals of the Jacobins were noble and pure. They were, as he serenely wrote in February 1794 (shortly before he himself was guillotined), "the peaceful enjoyment of liberty and equality, the rule of that eternal justice whose laws have been engraved … upon the hearts of men, even upon the heart of the slave who knows them not and of the tyrant who denies them."

Thus took form the easy cohabitation of egalitarian ideology and savage coercion that was to plague the next two centuries. Better to exile from the tribe, the reasoning follows, those unwilling to make the commitment to the perfect society than to risk the infection of dissent. The demagogue asks only for unity of purpose on behalf of virtue: "My fellow citizens (comrades, brothers and sisters, Volk), eggs must be broken to make an omelette. To achieve that noble end, it may be necessary to wage a war." After the Revolution subsided, the principle was administered by Napoleon and the soldiers of the Revolution, who, having metamorphosed into the *grande armée*, were determined to spread the Enlightenment by conquest. Instead, they gave

Europe additional cause to doubt the sovereignty of reason.

In fact, reason had never been sovereign. The decline of the Enlightenment was hastened not just by tyrants who used it for justification but by rising and often valid intellectual opposition. Its dream of a world made orderly and fulfilling by free intellect had seemed at first indestructible, the instinctive goal of all men. Its creators, among the greatest scholars since Plato and Aristotle, showed what the human mind can accomplish. Isaiah Berlin, one of their most perceptive historians, praised them justly as follows: "The intellectual power, honesty, lucidity, courage, and disinterested love of the truth of the most gifted thinkers of the eighteenth century remain to this day without parallel. Their age is one of the best and most hopeful episodes in the life of mankind." But they reached too far, and their best efforts were not enough to create the sustained effort their vision foretold.

THEIR SPIRIT WAS compressed into the life of the ill-fated Marie-Jean-Antoine-Nicolas Caritat, Marquis de Condorcet. He was the last of the French *philosophes*, the eighteenth-century public philosophers who immersed themselves in the political and social issues of their times. Voltaire, Montesquieu, d'Alembert, Diderot, Helvétius, and Condorcet's mentor, the economist and statesman Anne-Robert-Jacques Turgot, Baron de l'Aulne—all that remarkable assemblage was gone by 1789. Condorcet was the only one in their ranks who lived to see the Revolution. He embraced it totally and labored in vain to control its demonic force.

Condorcet was born in 1743 in Picardy, one of the most northerly provinces of old France, a member of an ancient noble family that originated in Dauphiné, the southeastern

province from which the dauphin, eldest son of the king, took his title. The Caritats were hereditary members of the *noblesse d'épée*, order of the sword, traditionally devoted to military service, and of higher social status than the *noblesse de robe*, or high civil officials.

To the disappointment of his family, Condorcet chose not to be a soldier like his father but a mathematician. At the age of sixteen, while still a student at the Navarre College in Paris, he publicly read his first paper on the subject. But having entered the one scientific profession where talent can be confidently sorted into levels by the age of twenty, Condorcet turned out not to be a mathematician of the first rank, and certainly nowhere near the equal of his great contemporaries Leonhard Euler and Pierre Simon de Laplace. Still, he achieved enough to be elected, at the exceptionally young age of twenty-five, to the Académie des Sciences, and at thirty-two became its permanent secretary. In 1780, at age thirty-eight, he was accepted into the august Académie Française, arbiter of the literary language and pinnacle of intellectual recognition in his country.

Condorcet's principal scientific accomplishment was to pioneer the application of mathematics to the social sciences, an achievement he shared with Laplace. He was inspired by the idea, central to the Enlightenment agenda, that what had been accomplished in mathematics and physics can be extended to the collective actions of men. His 1785 *Essay on the Application of Analysis to the Probability of Majority Decisions* is a distant forerunner of present-day decision theory. As pure science, however, it is not impressive. While Laplace developed the calculus of probabilities and applied it brilliantly to physics, Condorcet made minor advances in mathematics and used the techniques he invented with little effect in the study of political behavior. Still, the concept that

social action might be quantitatively analyzed and even predicted was original to Condorcet. It influenced the later development of the social sciences, especially the work of the early sociologists Auguste Comte and Adolphe Quételet in the 1800s.

Condorcet has been called the "noble philosopher," referring not just to his social rank but to his character and demeanor. Without irony his friends dubbed him "Le Bon Condorcet," Condorcet the Good. Julie de Lespinasse, who presided over his favorite salon on the rue de Belle Chasse, described him thus in a letter to a friend: "His physiognomy is sweet and calm; simplicity and negligence mark his bearing," reflecting the "absolute quality of his soul."

He was unfailingly kind and generous to others, including even the virulently jealous Jean-Paul Marat, whose own ambitions in science were unrewarded and who would gladly have seen him dead. He was passionately committed to the ideal of social justice and the welfare of others, both individually and collectively. He opposed, at considerable political risk, the colonial policies of France. With Lafayette and Mirabeau he founded the antislavery organization Society of the Friends of the Blacks. Even after he had gone into hiding during the Terror, his arguments contributed to the abolition of slavery by the National Convention.

Liberal to the bone, a follower of the English philosopher John Locke, Condorcet believed in the natural rights of men, and, like his contemporary Immanuel Kant, he sought moral imperatives that lead rather than follow the passions. He joined Tom Paine to create *Le Républicain*, a Revolutionary journal that promoted the idea of a progressive, egalitarian state. "The time will come," he later wrote, "when the sun will shine only on free men who know no other master than their reason."

Condorcet was a polymath with a near-photographic memory, for whom knowledge was a treasure to be acquired relentlessly and shared freely. Julie de Lespinasse, infatuated, praised these qualities in particular: "Converse with him, read what he has written; talk to him of philosophy, belles lettres, science, the arts, government, jurisprudence, and when you have heard him, you will tell yourself a hundred times a day that this is the most astonishing man you have ever heard; he is ignorant of nothing, not even the things most alien to his tastes and occupations; he will know … the genealogies of the courtiers, the details of the police and the names of the hats in fashion; in fact, nothing is beneath his attention, and his memory is so prodigious that he has never forgotten anything."

Condorcet's combination of talent and personality propelled him quickly to the highest levels of pre-Revolutionary Parisian society and established his reputation as the youngest of the *philosophes.* His taste for synthesis led him to fit into a coherent whole the principal ideas representing, if any such collection can legitimately be said to do so, the position of the late Enlightenment. On human nature he was a nurturist: He believed that the mind is molded wholly by its environment, so that humans are free to make themselves and society as they please. He was consequently a perfectibilist: The quality of human life, he insisted, can be improved indefinitely. He was politically a complete revolutionary, both anticlerical and republican, departing from Voltaire and others who would "destroy the altar but preserve the throne." In social science Condorcet was a historicist, believing that history can be read to understand the present and predict the future. As an ethicist, he was committed to the idea of the unity of the human race. And while egalitarian, he was not a multiculturalist in the

present-day sense, but rather thought all societies would eventually evolve toward the high civilization of Europe. Above all, he was a humanitarian who saw politics as less a source of power than a means of implementing lofty moral principles.

With the outbreak of the Revolution in 1789, Condorcet abruptly turned from scholarship and threw himself into politics. He served two years as an elected member of the Commune of Paris, and when the Legislative Assembly was formed in 1791, he became a deputy for Paris. Immensely popular among his fellow revolutionaries, he was appointed one of the Assembly secretaries, then elected vice-president and finally president. When the Assembly was succeeded in September 1792 by the National Convention, and the Republic established, Condorcet was elected as representative for the Department of the Aisne, part of his native province of Picardy.

Throughout his brief public career, Condorcet tried to stay aloof from partisan politics. He had friends among both the moderate Girondists and the leftist Montagnards (the latter so named because their deputies sat on the higher benches, or "Mountain," of the assembly). He was identified with the Girondists nonetheless, and the more so when the Montagnards fell under the spell of the radical wing of the Jacobin Club of Paris. After the overthrow of the Girondists during the popular insurrections of 1793, the Montagnards controlled the Convention and then the Committee of Public Safety, which ruled France during the year-long Terror. It was during this spasm of official murder that Condorcet fell from hero to criminal suspect, and his arrest was ordered by the National Convention.

When he learned of the warrant, Condorcet fled to the boardinghouse of Madame Vernet, on the rue Servandoni of

old Paris, where he remained in hiding for eight months. In April 1794 the refuge was discovered, and friends warned him that his arrest was imminent. He escaped once again, and for several days wandered about homeless until detected and thrown into the prison at Bourg-la-Reine.

During his stay on the rue Servandoni, Condorcet wrote his masterwork, *Sketch for a Historical Picture of the Progress of the Human Mind.* It was a remarkable achievement of both mind and will. Desperately insecure, with no books, relying only on his prodigious memory, he composed an intellectual and social history of humanity. The text, relentlessly optimistic in tone, contains little mention of the Revolution and none of his enemies in the streets of Paris. Condorcet wrote as though social progress is inevitable, and wars and revolutions were just Europe's way of sorting itself out.

His serene assurance arose from the conviction that culture is governed by laws as exact as those of physics. We need only understand them, he wrote, to keep humanity on its predestined course to a more perfect social order ruled by science and secular philosophy. These laws, he added, can be adduced from a study of past history.

Condorcet, however mistaken in details and hopelessly trusting of human nature, made a major contribution to thought through his insistence that history is an evolving material process. "The sole foundation for belief in the natural sciences," he declared, "is the idea that the general laws directing the phenomena of the universe, known or unknown, are necessary and constant. Why should this principle be any less true for the development of the intellectual and moral faculties of man than for other operations of nature?"

The idea was already in the air when those words were penned. Pascal had compared the human race to a man who

never dies, always gaining knowledge, while Leibniz spoke of the Present big with the Future. Turgot, Condorcet's friend and sponsor, had written forty years before Condorcet's *Sketch* that "all epochs are fastened together by a sequence of causes and effects, linking the condition of the world to all the conditions which have gone before it." In consequence, "the human race, observed from its first beginning, seems in the eyes of the philosopher to be one vast whole, which, like each individual in it, has its own infancy and its own conditions of growth." Kant, in 1784, expressed the germ of the same concept, observing in particular that man's rational dispositions are destined to express themselves in the species as a whole, not in the individual.

Inevitable progress is an idea that has survived Condorcet and the Enlightenment. It has exerted, at different times and variously for good and evil, a powerful influence to the present day. In the final chapter of the *Sketch*, "The Tenth Stage: The Future Progress of the Human Mind," Condorcet becomes giddily optimistic about its prospect. He assures the reader that the glorious process is underway: All will be well. His vision for human progress makes little concession to the stubbornly negative qualities of human nature. When all humanity has attained a higher level of civilization, we are told, nations will be equal, and within each nation citizens will also be equal. Science will flourish and lead the way. Art will be freed to grow in power and beauty. Crime, poverty, racism, and sexual discrimination will decline. The human life span, through scientifically based medicine, will lengthen indefinitely. With the shadow of the Terror deepening without, Le Bon Condorcet concluded:

> How consoling for the philosopher who laments the errors, the crimes, the injustices which still pollute the earth and of which

he is often the victim is this view of the human race, emancipated from its shackles, released from the empire of fate and from that of the enemies of its progress, advancing with a firm and sure step along the path of truth, virtue, and happiness! It is the contemplation of this prospect that rewards him for all his efforts to assist the progress of reason and the defense of liberty.

THE ENLIGHTENMENT GAVE RISE to the modern intellectual tradition of the West and much of its culture. Yet, while reason was supposedly the defining trait of the human species and needed only a little more cultivation to flower universally, it fell short. Humanity was not paying attention. Humanity thought otherwise. The causes of the Enlightenment's decline, which persist to the present day, illuminate the labyrinthine wellsprings of human motivation. It is worth asking, particularly in the present winter of our cultural discontent, whether the original spirit of the Enlightenment—confidence, optimism, eyes to the horizon—can be regained. And to ask in honest opposition, *should* it be regained, or did it possess in its first conception, as some have suggested, a dark-angelic flaw? Might its idealism have contributed to the Terror, which foreshadowed the horrendous dream of the totalitarian state? If knowledge can be consolidated, so might the "perfect" society be designed—one culture, one science—whether fascist, communist, or theocratic.

The Enlightenment itself, however, was never a unified movement. It was less a determined swift river than a lacework of deltaic streams working their way along twisted channels. By the time of the French Revolution it was very old. It emerged from the Scientific Revolution during the early seventeenth century and attained its greatest influence

in the European academy during the eighteenth century. Its originators often clashed over fundamental issues. Most engaged from time to time in absurd digressions and speculations, such as looking for hidden codes in the Bible or for the anatomical seat of the soul. The overlap of their opinion was nevertheless extensive and clear and well reasoned enough to bear this simple characterization: They shared a passion to demystify the world and free the mind from the impersonal forces that imprison it.

They were driven by the thrill of discovery. They agreed on the power of science to reveal an orderly, understandable universe and thereby lay an enduring base for free rational discourse. They thought that the perfection of the celestial bodies discovered by astronomy and physics could serve as a model for human society. They believed in the unity of all knowledge, individual human rights, natural law, and indefinite human progress. They tried to avoid metaphysics even while the flaws and incompleteness of their explanations forced them to practice it. They resisted organized religion. They despised revelation and dogma. They endorsed, or at least tolerated, the state as a contrivance required for civil order. They believed that education and right reason would enormously benefit humanity. A few, like Condorcet, thought human beings perfectible and capable of achieving a political utopia.

We have not forgotten them. In their front rank were a disproportionate number of the tiny group of scientists and philosophers recognizable by a single name: Bacon, Hobbes, Hume, Locke, and Newton in England; Descartes and the eighteenth-century *philosophes* around Voltaire in France; Kant and Leibniz in Germany; Grotius in Holland; Galileo in Italy.

It has become fashionable to speak of the Enlightenment as

an idiosyncratic construction by European males in a bygone era, one way of thinking among many different constructions generated across time by a legion of other minds in other cultures, each of which deserves careful and respectful attention. To which the only decent response is yes, of course —to a point. Creative thought is forever precious, and all knowledge has value. But what counts most in the long haul of history is seminality, not sentiment. If we ask whose ideas were the seeds of the dominant ethic and shared hopes of contemporary humanity, whose resulted in the most material advancement in history, whose were the first of their kind and today enjoy the most emulation, then in that sense the Enlightenment, despite the erosion of its original vision and despite the shakiness of some of its premises, has been the principal inspiration not just of Western high culture but, increasingly, of the entire world.

SCIENCE WAS the engine of the Enlightenment. The more scientifically disposed of the Enlightenment authors agreed that the cosmos is an orderly material existence governed by exact laws. It can be broken down into entities that can be measured and arranged in hierarchies, such as societies, which are made up of persons, whose brains consist of nerves, which in turn are composed of atoms. In principle at least, the atoms can be reassembled into nerves, the nerves into brains, and the persons into societies, with the whole understood as a system of mechanisms and forces. If you still insist on a divine intervention, continued the Enlightenment philosophers, think of the world as God's machine. The conceptual constraints that cloud our vision of the physical world can be eased for the betterment of humanity in every sphere. Thus Condorcet, in an era still unburdened by complicating fact, called for the illumination of the moral

and political sciences by the "torch of analysis."

The grand architect of this dream was not Condorcet, or any of the other *philosophes* who expressed it so well, but Francis Bacon. Among the Enlightenment founders, his spirit is the one that most endures. It informs us across four centuries that we must understand nature, both around us and within ourselves, in order to set humanity on the course of self-improvement. We must do it knowing that destiny is in our hands and that denial of the dream leads back to barbarism. In his scholarship Bacon questioned the solidity of classical "delicate" learning, those medieval forms based on ancient texts and logical expatiation. He spurned reliance on ordinary scholastic philosophy, calling for a study of nature and the human condition on their own terms, without artifice. Drawing on his extraordinary insights into mental processes, he observed that because "the mind, hastily and without choice, imbibes and treasures up the first notices of things, from whence all the rest proceed, errors must forever prevail, and remain uncorrected." Thus knowledge is not well constructed but "resembles a magnificent structure that has no foundation."

> And whilst men agree to admire and magnify the false powers of the mind, and neglect or destroy those that might be rendered true, there is no other course left but with better assistance to begin the work anew, and raise or rebuild the sciences, arts, and all human knowledge from a firm and solid basis.

By reflecting on all possible methods of investigation available to his imagination, he concluded that the best among them is induction, which is the gathering of large numbers of facts and the detection of patterns. In order to

changes since Sir Nicholas Bacon's time."

He had been all that, and more. He was released in three days. Shorn at last of the burden of public ambition, he spent his last days totally immersed in contented scholarship. His death in the early spring of 1626 was symbolically condign, the result of an impromptu experiment to test one of his favorite ideas. "As he was taking the air in a coach with Dr. Witherborne towards High-gate," John Aubrey reported at the time, "snow lay on the ground, and it came into my Lord's thoughts, why flesh might not be preserved in snow, as in salt. They were resolved they would try the experiment presently. They alighted out of the coach and went into a poor woman's house at the bottom of High-gate hill, and bought a hen, and made the woman exenterate it, and then stuffed the body with snow, and my Lord did help to do it himself. The snow so chilled him that he immediately fell so extremely ill, that he could not return to his lodgings…." He was taken instead to the Earl of Arundel's house close by. His condition remained grave, and he died on April 9, most likely of pneumonia.

The ache of disgrace had been subdued by the return to his true calling of visionary scholar. As he wrote in one of his oft-quoted adages, "He that dies in an earnest pursuit is like one that is wounded in hot blood, who for the time scarce feels the hurt." He saw his life as a contest between two great ambitions, and toward the end he regretted having invested so much effort in public service with an equivalent loss of scholarship. "My soul," he mused, "hath been a stranger in life's pilgrimage."

His genius, while of a different kind, matched that of Shakespeare. Some have believed, erroneously, that he *was* Shakespeare. He melded great literary gifts, so evident in *The Advancement of Learning*, with a passion for synthesis, two

qualities most needed at the dawn of the Enlightenment. His great contribution to knowledge was that of learned futurist. He proposed a shift in scholarship away from rote learning and deductive reasoning from classical texts and toward engagement with the world. In science, he proclaimed, is civilization's future.

Bacon defined science broadly and differently from today's ordinary conception to include a foreshadowing of the social sciences and parts of the humanities. The repeated testing of knowledge by experiment, he insisted, is the cutting edge of learning. But to him experiment meant not just controlled manipulations in the manner of modern science. It was all the ways humanity brings change into the world through information, agriculture, and industry. He thought the great branches of learning to be open-ended and constantly evolving ("I do not promise you anything"), but he nonetheless focused eloquently on his belief in the underlying unity of knowledge. He rejected the sharp divisions among the disciplines prevailing since Aristotle. And fortunately, he was reticent in this enterprise when needed: He refrained from forecasting how the great branches of learning would ultimately fall out.

Bacon elaborated on but did not invent the method of induction as a counterpoint to classical and medieval deduction. Still, he deserves the title Father of Induction, on which much of his fame rested in later centuries. The procedure he favored was much more than mere factual generalizations, such as—to use a modern example—"ninety percent of plant species have flowers that are yellow, red, or white, and are visited by insects." Rather, he said, start with such an unbiased description of phenomena. Collect their common traits into an intermediate level of generality. Then proceed to higher levels of generality, such as: "Flowers have

evolved colors and anatomy designed to attract certain kinds of insects, and these are the creatures that exclusively pollinate them." Bacon's reasoning was an improvement over the traditional methods of description and classification prevailing in the Renaissance, but it anticipated little of the methods of concept formation, competing hypotheses, and theory that form the core of modern science.

It was in psychology, and particularly the nature of creativity, that Bacon cast his vision farthest ahead. Although he did not use the word—it was not coined until 1653—he understood the critical importance of psychology in scientific research and all other forms of scholarship. He had a deep intuitive feel for the mental processes of discovery. He understood the means by which the processes are best systematized and most persuasively transmitted. "The human understanding," he wrote, "is no dry light, but receives an infusion from the will and affections; whence proceed sciences which may be called 'sciences as one would.' " He did not mean by this to distort perception of the real world by interposing a prism of emotion. Reality is still to be embraced directly and reported without flinching. But it is also best delivered the same way it was discovered, retaining a comparable vividness and play of the emotions. Nature and her secrets must be as stimulating to the imagination as are poetry and fables. To that end, Bacon advised us to use aphorisms, illustrations, stories, fables, analogies—anything that conveys truth from the discoverer to his readers as clearly as a picture. The mind, he argued, "is not like a wax tablet. On a tablet you cannot write the new till you rub out the old; on the mind you cannot rub out the old except by writing in the new."

Through light shed on the mental process, Bacon wished to reform reasoning across all the branches of learning. Beware,

he said, of the *idols of the mind*, the fallacies into which undisciplined thinkers most easily fall. They are the real distorting prisms of human nature. Among them, idols of the *tribe* assume more order than exists in chaotic nature; those of the imprisoning *cave*, the idiosyncrasies of individual belief and passion; of the *marketplace*, the power of mere words to induce belief in nonexistent things; and of the *theater*, unquestioning acceptance of philosophical beliefs and misleading demonstrations. Stay clear of these idols, he urged, observe the world around you as it truly is, and reflect on the best means of transmitting reality as you have experienced it; put into it every fiber of your being.

I do not wish by ranking Francis Bacon so highly in this respect to portray him as a thoroughly modern man. He was far from that. His younger friend William Harvey, a physician and a real scientist who made a fundamental discovery, the circulation of the blood, noted drily that Bacon wrote philosophy like a Lord Chancellor. His phrases make splendid marble inscriptions and commencement flourishes. The unity of knowledge he conceived was remote from the present-day concept of consilience, far from the deliberate, systematic linkage of cause and effect across the disciplines. His stress lay instead upon the common means of inductive inquiry that might optimally serve all the branches of learning. He searched for the techniques that best convey the knowledge gained, and to that end he argued for the full employment of the humanities, including art and fiction, as the best means for developing and expressing science. Science, as he broadly defined it, should be poetry, and poetry science. That, at least, has a pleasingly modern ring.

Bacon envisioned a disciplined and unified learning as the key to improvement of the human condition. Much of the veritable library that accumulated beneath his pen still

makes interesting reading, from his often quoted essays and maxims to *Advancement of Learning* (1605), *Novum Organum* (The New Logic, 1620), and *New Atlantis* (1627), the latter a utopian fable about a science-based society. Most of his philosophical and fictional writing was planned to implement the scheme of the unification of knowledge, which he called *Instauratio Magna*, literally the Great Instauration, or the New Beginning.

His philosophy raised the sights of a small but influential public. It helped to prime the scientific revolution that was to blossom spectacularly in the decades ahead. To this day his vision remains the heart of the scientific-technological ethic. He was a magnificent figure standing alone by necessity of circumstance, who achieved that affecting combination of humility and innocent arrogance present only in the greatest scholars. Beneath the title of *Novum Organum* he had the publisher print these lines:

FRANCIS OF VERULAM
REASONED THUS WITH HIMSELF
and judged it to be for the interest of the present and future generations that they should be made acquainted with his thoughts.

ALL HISTORIES THAT live in our hearts are peopled by archetypes in mythic narratives, and such I believe is part of Francis Bacon's appeal and why his fame endures. In the tableau of the Enlightenment, Bacon is the herald of adventure. There is a new world waiting, he announced; let us begin the long and difficult march into its unmapped terrain. René Descartes, the founder of algebraic geometry and modern philosophy and France's preeminent scholar of all time, is the mentor in the narrative. Like Bacon before

in many great experiments of science, this one is simple; anyone can quickly repeat it. With a prism bend a beam of sunlight so that its different wavelengths fall out into the colors of the visible spectrum. Now bend the colors back together again to create the beam of sunlight. Newton applied his findings in the construction of the first reflecting telescope, a superior instrument perfected a century later by the British astronomer William Herschel.

In 1684 Newton formulated the mass and distance laws of gravity, and in 1687 the three laws of motion. With these mathematical formulations he achieved the first great breakthrough in modern science. He showed that the planetary orbits postulated by Copernicus and proved elliptical by Kepler can be predicted from the first principles of mechanics. His laws were exact and equally applicable to all inanimate matter, from the solar system down to grains of sand, and of course to the falling apple that had triggered his thinking on the subject twenty years previously—apparently a true story. The universe, he said, is not just orderly but also intelligible. At least part of God's grand design could be written with a few lines on a piece of paper. His triumph enshrined Cartesian reductionism in the conduct of science.

Because Newton established order where magic and chaos had reigned before, his impact on the Enlightenment was enormous. Alexander Pope celebrated him with a famous couplet:

> Nature and Nature's laws lay hid in night:
> God said, *"Let Newton be!"* and all was light.

Well—not all, not yet. But the laws of gravity and motion were a powerful beginning. And they started Enlightenment scholars thinking: Why not a Newtonian solution to the

affairs of men? The idea grew into one of the mainstays of the Enlightenment agenda. As late as 1835, Adolphe Quételet was proposing "social physics" as the basis of the discipline soon to be named sociology. Auguste Comte, his contemporary, believed a true social science to be inevitable. "Men," he said, echoing Condorcet, "are not allowed to think freely about chemistry and biology, so why should they be allowed to think freely about political philosophy?" People, after all, are just extremely complicated machines. Why shouldn't their behavior and social institutions conform to certain still-undefined natural laws?

Reductionism, given its unbroken string of successes during the next three centuries, may seem today the obvious best way to have constructed knowledge of the physical world, but it was not so easy to grasp at the dawn of science. Chinese scholars never achieved it. They possessed the same intellectual ability as Western scientists, as evidenced by the fact that, even though far more isolated, they acquired scientific information as rapidly as did the Arabs, who had all of Greek knowledge as a launching ramp. Between the first and thirteenth centuries they led Europe by a wide margin. But according to Joseph Needham, the principal Western chronicler of Chinese scientific endeavors, their focus stayed on holistic properties and on the harmonious, hierarchical relationships of entities, from stars down to mountains and flowers and sand. In this world view the entities of Nature are inseparable and perpetually changing, not discrete and constant as perceived by the Enlightenment thinkers. As a result the Chinese never hit upon the entry point of abstraction and break-apart analytic research attained by European science in the seventeenth century.

Why no Descartes or Newton under the Heavenly Mandate? The reasons were historical and religious. The

Chinese had a distaste for abstract codified law, stemming from their unhappy experience with the Legalists, rigid quantifiers of the law who ruled during the transition from feudalism to bureaucracy in the Ch'in dynasty (221–206 B.C.). Legalism was based on the belief that people are fundamentally antisocial and must be bent to laws that place the security of the state above their personal desires. Of probably even greater importance, Chinese scholars abandoned the idea of a supreme being with personal and creative properties. No rational Author of Nature existed in their universe; consequently the objects they meticulously described did not follow universal principles, but instead operated within particular rules followed by those entities in the cosmic order. In the absence of a compelling need for the notion of general laws—thoughts in the mind of God, so to speak—little or no search was made for them.

Western science took the lead largely because it cultivated reductionism and physical law to expand the understanding of space and time beyond that attainable by the unaided senses. The advance, however, carried humanity's self-image ever further from its perception of the remainder of the universe, and as a consequence the full reality of the universe seemed to grow progressively more alien. The ruling talismans of twentieth-century science, relativity and quantum mechanics, have become the ultimate in strangeness to the human mind. They were conceived by Albert Einstein, Max Planck, and other pioneers of theoretical physics during a search for quantifiable truths that would be known to extraterrestrials as well as to our species, and hence certifiably independent of the human mind. The physicists succeeded magnificently, but in so doing they revealed the limitations of intuition unaided by mathematics; an understanding of Nature, they discovered, comes very

hard. Theoretical physics and molecular biology are acquired tastes. The cost of scientific advance is the humbling recognition that reality was not constructed to be easily grasped by the human mind. This is the cardinal tenet of scientific understanding: Our species and its ways of thinking are a product of evolution, not the purpose of evolution.

WE NOW PASS to the final archetype of the epic tableau, the keepers of the innermost room. The more radical Enlightenment writers, alert to the implications of scientific materialism, moved to reassess God Himself. They invented a Creator obedient to His own natural laws, the belief known as deism. They disputed the theism of Judaeo-Christianity, whose divinity is both omnipotent and personally interested in human beings, and they rejected the nonmaterial world of heaven and hell. At the same time, few dared go the whole route and embrace atheism, which seemed to imply cosmic meaninglessness and risked outraging the pious. So by and large they took a middle position. God the Creator exists, they conceded, but He is allowed only the entities and processes manifest in His own handiwork.

Deistic belief, by persisting in attenuated form to the present day, has given scientists a license to search for God. More precisely, it has prompted a small number to make a partial sketch of Him (Her? It? Them?) from their professional meditations. He is material in another plane but not personal. He is, perhaps, the manager of alternative universes popping out of black holes, Who adjusts physical laws and parameters in order to observe the outcome. Maybe we see a faint trace of Him in the pattern of ripples in cosmic background radiation, dating back to the first moments of our own universe. Alternatively, we may be predestined to reach Him billions of years in the future at an omega point of

evolution—total unity, total knowledge—toward which the human species and extraterrestrial life forms are converging. I must say that I have read many such schemes, and even though they are composed by scientists, I find them depressingly non-Enlightenment. That the Creator lives outside this universe and will somehow be revealed at its end is what the theologians have been telling us all along.

Few scientists and philosophers, however, let alone religious thinkers, take the playful maunderings of scientific theology very seriously. A more coherent and interesting approach, possibly within the reach of theoretical physics, is to try to answer the following question: Is a universe of discrete material particles possible only with one specific set of natural laws and parameter values? In other words, does human imagination, which can conceive of other laws and values, thereby exceed possible existence? Any act of Creation may be only a subset of the universes we can imagine. To this point Einstein is reported to have remarked to his assistant Ernst Straus, in a moment of neo-deistic reflection, "What really interests me is whether God had any choice in the creation of the world." That line of reasoning can be extended rather mystically to formulate the "anthropic principle," which notes that the laws of nature, in *our* universe at least, had to be set a certain precise way so as to allow the creation of beings able to ask about the laws of nature. Did Someone decide to do it that way?

The dispute between Enlightenment deism and theology can be summarized as follows. The traditional theism of Christianity is rooted in both reason and revelation, the two conceivable sources of knowledge. According to this view, reason and revelation cannot be in conflict, because in areas of opposition, revelation is given the higher role—as the Inquisition reminded Galileo in Rome when they offered him

And there is another concern: that a science-driven society risks upsetting the natural order of the world set in place by God or, if you prefer, by billions of years of evolution. Science given too much authority risks conversion into a self-destroying impiety. The godless creations of science and technology are in fact powerful and arresting images of modern culture. Frankenstein's monster and Hollywood's Terminator, the latter an all-metal and microchip-guided Frankenstein's monster, wreak destruction on their creators, including the naive geniuses in lab coats who arrogantly forecast a new age ruled by science. Storms rage, hostile mutants spread, life dies. Nations menace one another with world-destroying technology. Even Winston Churchill, whose country was saved by radar, worried after the atom bombing of Japan that the stone age might return "on the gleaming wings of Science."

FOR THOSE WHO for so long thus feared science as Faustian rather than Promethean, the Enlightenment program posed a grave threat to spiritual freedom, even to life itself. What is the answer to such a threat? Revolt! Return to natural man, reassert the primacy of individual imagination and confidence in immortality. Find an escape to a higher realm through art, promote a Romantic Revolution. In 1807 William Wordsworth, in words typical of the movement then spreading over Europe, evoked the aura of a more primal and serene existence beyond Reason's grasp:

> Our Souls have sight of that immortal sea
> Which brought us hither,
> Can in a moment travel thither,
> And see the Children sport upon the shore,
> And hear the mighty waters rolling evermore.

With Wordsworth's "breathings for incommunicable powers," the eyes close, the mind soars, the inverse square distance law of gravity falls away. The spirit enters another reality beyond the reach of weight and measure. If the constraining universe of matter and energy cannot be denied, at least it can be ignored with splendid contempt. There is no question that Wordsworth and his fellow English Romantic poets of the first half of the nineteenth century conjured works of great beauty. They spoke truths in another tongue, and guided the arts still further from the sciences.

Romanticism also flowered in philosophy, where it placed a premium on rebellion, spontaneity, intense emotion, and heroic vision. Searching for aspirations available only to the heart, its practitioners dreamed of man as part of boundless nature. Rousseau, while often listed as an Enlightenment *philosophe*, was really instead the founder and most extreme visionary of the Romantic philosophical movement. For him learning and social order are the enemies of humanity. In works from 1749 (*Discourse on the Sciences and the Arts*) to 1762 (*Émile*), he extolled the "sleep of reason." His utopia is a minimalist state in which people abandon books and other accouterments of intellect in order to cultivate enjoyment of the senses and good health. Humanity, Rousseau claimed, was originally a race of noble savages in a peaceful state of nature, who were later corrupted by civilization—and by scholarship. Religion, marriage, law, and government are deceptions created by the powerful for their own selfish ends. The price paid by the common man for this high-level chicanery is vice and unhappiness.

Where Rousseau invented a stunningly inaccurate form of anthropology, the German Romantics, led by Goethe, Hegel, Herder, and Schelling, set out to reinsert metaphysics into science and philosophy. The product, *Naturphilosophie*, was a

hybrid of sentiment, mysticism, and quasi-scientific hypothesis. Johann Wolfgang von Goethe, preeminent among its expositors, wanted most of all to be a great scientist. He placed that ambition above literature, where in fact he became an immortal contributor. His respect for science as an idea, an approach to tangible reality, was unreserved, and he understood its basic tenets. Analysis and synthesis, he liked to say, should be alternated as naturally as breathing in and breathing out. At the same time he was critical of the mathematical abstractions of Newtonian science, thinking physics far too ambitious in its goal of explaining the universe. He was also often contemptuous of the "technical tricks" employed by experimental scientists. In fact, he tried to repeat Newton's optical experiments but with poor results.

Goethe can be easily forgiven. After all, he had a noble purpose, no less than the coupling of the soul of the humanities to the engine of science. He would have grieved had he foreseen history's verdict: great poet, poor scientist. He failed in his synthesis through lack of what is today called the scientist's instinct. Not to mention the necessary technical skills. Calculus baffled him, and it is said he could not tell a lark from a sparrow. But he loved Nature in a profoundly spiritual sense. One must cultivate a close, deep feeling for her, he proclaimed. "She loves illusion. She shrouds man in mist, and she spurs him toward the light. Those who will not partake of her illusions she punishes as a tyrant would punish. Those who accept her illusions she presses to her heart. To love her is the only way to approach her." In the philosophers' empyrean I imagine Bacon has long since lectured Goethe on the idols of the mind. Newton will have lost patience immediately.

Friedrich Schelling, leading philosopher of the German Romantics, attempted to bind the scientific Prometheus to

immobility not with poetry but with reason. He proposed a cosmic unity of all things, beyond the understanding of man. Facts by themselves can never be more than partial truths. Those we perceive are only fragments of the universal flux. Nature is alive, Schelling concluded; she is a creative spirit that unites knower and known, progressing through greater and greater understanding and feeling toward an eventual state of complete self-realization.

In America, German philosophical Romanticism was mirrored in New England transcendentalism, whose most celebrated proponents were Ralph Waldo Emerson and Henry David Thoreau. The transcendentalists were radical individualists who rejected the overwhelming commercialism that came to prevail in American society during the Jacksonian era. They envisioned a spiritual universe built entirely within their personal ethos. They nevertheless found science more congenial than did their European counterparts —witness the many accurate natural history observations in *Faith in a Seed* and other writings by Thoreau. Their ranks even included one full-fledged scientist: Louis Agassiz, director of the Museum of Comparative Zoology at Harvard University, founding member of the National Academy of Science, geologist, zoologist, and supremely gifted lecturer. This great man, in a metaphysical excursion paralleling that of Schelling, conceived the universe as a vision in the mind of God. The deities of science in his universe were essentially the same as those of theology. In 1859, at the height of his career, Agassiz was scandalized by the appearance of Darwin's *Origin of Species*, which advanced the theory of evolution by natural selection and saw the diversity of life as self-assembling. Surely, he argued before rapt audiences in cities along the Atlantic seaboard, God would not create the living world by random variation and survival of the fittest.

Our view of life must not be allowed to descend from cosmic grandeur to the grubby details of ponds and woodlots. Even to think of the human condition in such a manner, he argued, is intolerable.

NATURAL SCIENTISTS, chastened by such robust objections to the Enlightenment agenda, mostly abandoned the examination of human mental life, yielding to philosophers and poets another century of free play. In fact, the concession turned out to be a healthy decision for the profession of science, because it steered researchers away from the pitfalls of metaphysics. Throughout the nineteenth century, knowledge in the physical and biological sciences grew at an exponential rate. At the same time the social sciences—sociology, anthropology, economics, and political theory—newly risen like upstart duchies and earldoms, vied for territory in the space created between the hard sciences and the humanities. The great branches of learning emerged in their present form—natural sciences, social sciences, and the humanities—out of the unified Enlightenment vision generated during the seventeenth and eighteenth centuries.

The Enlightenment, defiantly secular in orientation while indebted and attentive to theology, had brought the Western mind to the threshold of a new freedom. It waved aside everything, every form of religious and civil authority, every imaginable fear, to give precedence to the ethic of free inquiry. It pictured a universe in which humanity plays the role of perpetual adventurer. For two centuries God seemed to speak in a new voice to humankind. That voice had been foreshadowed in 1486 by Giovanni Pico della Mirandola, Renaissance forerunner of the Enlightenment thinkers, in this benediction:

sciences and humanities. The faculties of higher education around the world are a congeries of experts. To be an original scholar is to be a highly specialized world authority in a polyglot Calcutta of similarly focused world authorities. In 1797, when Jefferson took the president's chair at the American Philosophical Society, all American scientists of professional caliber and their colleagues in the humanities could be seated comfortably in the lecture room of Philosophical Hall. Most could discourse reasonably well on the entire world of learning, which was still small enough to be seen whole. Their successors today, including 450,000 holders of the doctorate in science and engineering alone, would overcrowd Philadelphia. Professional scholars in general have little choice but to dice up research expertise and research agendas among themselves. To be a successful scholar means spending a career on membrane biophysics, the Romantic poets, early American history, or some other such constricted area of formal study.

Fragmentation of expertise was further mirrored in the twentieth century by modernism in the arts, including architecture. The work of the masters—Braque, Picasso, Stravinsky, Eliot, Joyce, Martha Graham, Gropius, Frank Lloyd Wright, and their peers—was so novel and discursive as to thwart generic classification, except perhaps for this: The modernists tried to achieve the new and provocative at any cost. They identified the constraining bonds of tradition and self-consciously broke them. Many rejected realism in expression in order to explore the unconscious. Freud, as much a literary stylist as a scientist, inspired them and can be justifiably included in their ranks. Psychoanalysis was a force that shifted the attention of modernist intellectuals and artists from the social and political to the private and psychological. Subjecting every topic within their domain to

the "ruthless centrifuge of change," in Carl Schorske's phrase, they meant to proudly assert the independence of twentieth-century high culture from the past. They were not nihilists; rather, they sought to create a new level of order and meaning. They were complete experimentalists who wished to participate in a century of radical technological and political change and to fashion part of it entirely on their own terms.

Thus the free flight bequeathed by the Enlightenment, which disengaged the humanities during the Romantic era, had by the middle of the twentieth century all but erased hope for the unification of knowledge with the aid of science. The two cultures described by C. P. Snow in his 1959 Rede Lecture, the literary and the scientific, were no longer on speaking terms.

ALL MOVEMENTS TEND to extremes, which is approximately where we are today. The exuberant self-realization that ran from romanticism to modernism has given rise now to philosophical postmodernism (often called poststructuralism, especially in its more political and sociological expressions). Postmodernism is the ultimate polar antithesis of the Enlightenment. The difference between the two extremes can be expressed roughly as follows: Enlightenment thinkers believe we can know everything, and radical postmodernists believe we can know nothing.

The philosophical postmodernists, a rebel crew milling beneath the black flag of anarchy, challenge the very foundations of science and traditional philosophy. Reality, they propose, is a state constructed by the mind, not perceived by it. In the most extravagant version of this constructivism, there is no "real" reality, no objective truths external to mental activity, only prevailing versions

disseminated by ruling social groups. Nor can ethics be firmly grounded, given that each society creates its own codes for the benefit of the same oppressive forces.

If these premises are correct, it follows that one culture is as good as any other in the expression of truth and morality, each in its own special way. Political multiculturalism is justified; each ethnic group and sexual preference in the community has equal validity. And, more than mere tolerance, it deserves communal support and mandated representation in educational agendas, not because it has general importance to the society but because it exists. That is—again—if the premises are correct. And they must be correct, say their promoters, because to suggest otherwise is bigotry, which is a cardinal sin. Cardinal, that is, if we agree to waive in this one instance the postmodernist prohibition against universal truth, and all agree to agree for the common good. Thus, Rousseau redivivus.

Postmodernism is expressed more explicitly still in deconstruction, a technique of literary criticism. Each author's meaning is unique to himself, goes the underlying premise; nothing of his true intention or anything else connected to objective reality can be reliably assigned to it. His text is therefore open to fresh analysis and commentary issuing from the equally solipsistic world in the head of the reviewer. But then the reviewer is in turn subject to deconstruction, as well as the reviewer of the reviewer, and so on in infinite regress. That is what Jacques Derrida, the creator of deconstruction, meant when he stated the formula *Il n'y a pas de hors-texte* (There is nothing outside the text). At least, that is what I think he meant, after reading him, his defenders, and his critics with some care. If the radical postmodernist premise is correct, we can never be sure that is what he meant. Conversely, if that *is* what he meant, it is not

certain we are obliged to consider his arguments further. This puzzle, which I am inclined to set aside as the "Derrida paradox," is similar to the Cretan paradox (a Cretan says "all Cretans are liars"). It awaits solution, though one need not feel any great sense of urgency in the matter.

Nor is it certain from Derrida's ornately obscurantist prose that he himself knows what he means. Some observers think his writing is meant as a *jeu d'esprit*, a kind of joke. His new "science" of grammatology is the opposite of science, rendered in fragments with the incoherence of a dream, at once banal and fantastical. It is innocent of the science of mind and language developed elsewhere in the civilized world, rather like the pronouncements of a faith healer unaware of the location of the pancreas. He seems, in the end, to be conscious of this omission, but contents himself with the stance of Rousseau, self-professed enemy of books and writing, whose work *Émile* he quotes: "… the dreams of a bad night are given to us as philosophy. You will say I too am a dreamer; I admit it, but I do what others fail to do, I give my dreams as dreams, and leave the reader to discover whether there is anything in them which may prove useful to those who are awake."

Scientists, awake and held responsible for what they say while awake, have not found postmodernism useful. The postmodernist posture toward science in return is one of subversion. There appears to be a provisional acceptance of gravity, the periodic table, astrophysics, and similar stanchions of the external world, but in general the scientific culture is viewed as just another way of knowing, and, moreover, contrived mostly by European and American white males.

It is tempting to relegate postmodernism to history's curiosity cabinet alongside theosophy and transcendental