
THE
FIRST
MODERNS
William R. Everdell

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PROFILES IN
THE ORIGINS OF
TWENTIETH-CENTURY
THOUGHT

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For Ellie and Bill
Barbara and Chris
Lynn and Josh
and Ellen

◆

This all happened
before you were born.

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1 INTRODUCTION

WHAT MODERNISM IS AND WHAT IT PROBABLY ISN'T

The century is ending. The Western world is in what might be called a *fin-de-siècle* mood. What sense can we make of this long era? What legacy has it left? Every day we hear more talk about how the century began, with the simultaneous invention of movies, automobiles, skyscrapers, and abstract art. The high culture we have called Modernism has now been with us for most of this century and part of the previous one, longer than any other cultural *-ism* since the French began naming them back in the eighteenth century. This book is an attempt to tie down Modernism's beginnings and to begin to write its history.

The result you have before you is a narrative history of ideas, a thing that has become rare. Narrative, some now say, is obsolete, to which accusation the many have replied by building our time's demand for meaningful story—indeed, for any kind of story—to something like a fever pitch.[1] History too is now accused of obsolescence, and "theory" contends it is impossible to adopt a point of view and interpret the past from it. But it is extraordinarily hard to avoid doing that, and there are many reasons why one ought not to try. Some accuse ideas themselves of being obsolete, since all ideas are artifacts of subjectivity and cannot be passed on without intersubjectivity. This book, then, takes an old-fashioned position—that individuals can think new thoughts and communicate them. In fact, it is the collective history of a small group of people who did just that.

They are all of them individuals, and all of them are, in their way, geniuses. A genius I take to be a person who does something no one else can do until enough time has passed for a lot of other people to learn how to do it too. One can be a genius without being a hero; Valeriano Weyler in chapter 8 was, at least in my view, a classic villain. All are presented here, in a nod to a form of history as old as Plutarch, as profiles

in genius, notables of their intellectual specialties, from mathematics to painting. On the other hand, they ought not to be thought of as acting alone, like the mythic American frontiersman. Some, indeed, are women. They learned from each other, something that is harder to do in the more advanced state of intellectual specialization typical of our own times. The intellectual and cultural environment in which the first Moderns found themselves as the twentieth century began was rich and complicated, composed of every sort of social relationship in Western culture, including academic disciplines, family, nation, class, and language, habitual cafés and cabarets in particular cities, and of course circles of correspondents, blessed by the historian because they leave such good evidence behind. Ideas may well occur to people who have no relationships, but they are not ideas history can find out about.

Writing about Niels Bohr, the genius who came up with Modernism's epistemology of science, a historian asserted:

> The creative individual is, in a sense, complementary to the society in which he lives, rather as a soloist in a concerto. Both the basic ideas of science and the key inventions of mankind have generally been conceived in the minds of individuals, while the effort to gain the data on which the ideas and inventions have been based, and the subsequent effort to turn them to good account, have required the contributions of many besides the inventor and originator of ideas. So the individual and the community are necessary to one another. . . .[2]

For these individuals the necessary community, in many cases, was the entire Western world, at least insofar as it communicated with itself in the major Western languages. The great cities of 1900 where the first Modernists found themselves were already very populous, and usually multicultural. The nineteenth century had accomplished that. Communication was extremely swift, whether by postal correspondence (five deliveries a day in Munich), by publication (one month plus one week from contract to presentation copy for Kafka's first book of fiction), or by telephone and telegraph. It was possible for the poet Jules Laforgue to be born in Uruguay, educated at one of the best provincial secondary schools in France, employed as a reader by the Dowager Empress of Germany, and commissioned to translate the American works of Walt Whitman. James Joyce could write a novel meticulously set in the Dublin of 1904 while he was teaching English to Italians in the main seaport of the Austro-Hungarian Empire. In this sort of world an aristocratic Russian like Igor Stravinsky could change the course of Western music with a ballet score written in Switzerland and performed in Paris. Niels Bohr could write his classic paper on the atom in English while teaching in his native Denmark, publishing it in the journal of the British Royal Society under the guidance of a New Zealander who had made his scientific repu-

tation in Ontario, Canada, by extending the work of a Polish woman living in Paris. This kind of "hopscotching the world," as early film newsreels called it, suggests an absence of system, certainly to those who prized nineteenth-century distinctions based on ethnicity and language. But the system was there, and it was itself transnational. In fact, the insistence on a supra-ethnic community of thought and of art is one of the positions now often defined as Modernism.[3]

Are we in the wrong intellectual climate for a narrative history of Modernism? For a while now we have been in what is called the postmodern era. Restless academics and other employees of the culture factory who launched "Structuralism" in the 1960s tried out a new term in the 1970s, "Post-Modernism," hoping to apply it to the last fifty years or so of Western culture (with a nod or two further back at Nietzsche). Debate has been fierce about what postmodernism might mean, and before the word even lost its hyphen there were nay-sayers claiming there was no such thing. The word "Post-Modern," with hyphens and capitals, has been around at least since Irving Howe and Harry Levin used it in the 1950s, but it was Robert Venturi's 1972 *Learning from Las Vegas,* an architect's manifesto, that became postmodernism's charter in the United States.[4] By 1977, only five years later, Venturi's colleague Charles Jencks was writing that Modern architecture had "expired finally and completely."[5] There ensued something of a rush among intellectuals to be the first with a general definition of postmodernism.[6]

Historian of literature Charles Newman and historian of science Stephen Toulmin dubbed literature and science "postmodern." Dance, critics archly assumed, was also postmodern, though not so often.[7] According to Andrew Ross, who taught "Postmodernism: Theory and Practice" in the Princeton English department, postmodernism was an "emerging concept . . . a contemporary response to the modernist division of high culture from mass culture." Not so, countered Claude Rawson, whose field is eighteenth-century studies:

> the massive works of what are called postmodern novelists are . . . in their difficulty, allusive density, and simpering air of in-group donnishness . . . in their bulky appearance and learned showmanship, reminiscent of dissertations. . . . The trend was already potential in an earlier modernism, with its delight in esoteric allusion and its self-conscious (part satirical, part participatory) obsession with pedantry.[8]

Ada Louise Huxtable didn't like postmodernism either, but hers was different. It was "the renunciation and devaluation of everything the modernists believed in and built," and embodied "something somewhat nastier—a parvenu, old-tie, anti-liberal snobbism of the new, and young, far Right."[9] (Huxtable had probably been reading *The New Criterion,* which had become, under Hilton Kramer's editorship, the U. S. voice of

those whose only quarrel with Modernism was that it had been too utopian or too austere, not to mention anticapitalist, and never too democratic.)

According to Mark Stephens in 1985, "One of the great achievements of modernism was to stress the value of art as art, free from its encumbering baggage,—the overstuffed rooms, the money, the snobbery." On the other hand, a "concern with glitter, opulence and spectacle . . . ersatz theatricality and devotion to stylishness . . . eclectic taste and reverence for the past are all typical of postmodernism."[10] If he was right, we might seem to be going backwards.

What are these good people talking about? Bruce Handy at *Spy* magazine wondered too, and must have begun filling a file on postmodernism at about the same time I did. His 1988 article noted, among other loony delights, *Elle* magazine's "The Postmodern parka? Après-ski gone party with semiprecious metallic parkas for p.m." from 1986, and the *Village Voice*'s "Postmod Sex" from 1987.[11] By 1992 the abbreviation "pomo" had appeared in print in a magazine addressed to struggling humanities scholars.[12] As Margaret Atwood summed up the situation, "post this, post that. Everything is post these days, as if we're all just a footnote to something earlier that was real enough to have a name of its own."[13] Perhaps in reaction to this sort of glitz, Kirk Varnedoe of MOMA read the word out of his vocabulary in 1990. "I don't believe that there is such a thing as Postmodernism," Varnedoe said flatly. Instead he saw "a continuity of what began as a revolution from around 1880 to 1920. It opened up a new set of languages and questions and options. I don't believe those options are over. There has been no comparable watershed since."[14] This was five years after Paul Goldberger, on page 1 of the Arts and Leisure section of the *New York Times,* had invented postmodernism's successor, "Neo-modernism."[15] So far, it doesn't seem to have caught on.

"Post-Modernism" may still have a future; after all, we have been calling ourselves "modern" in the West at least since the sixteenth century. In a more than graceful gesture to our own past, we began a hundred years ago to term "modern" everything that had happened to us since the fourteenth century. By extension we later began to call "modern" everything that happened to any other culture after it had built its first railroad or printed an edition of Marx. With a capital letter, Modern, like postmodern, becomes a term applying mostly to high, or intellectual, culture; but whatever postmodernism may mean—a furious eclecticism, "decentering" of "discourse," abandonment of self and "other," or "high" and "low," confusion of periods, bricolage, formalism, a brittle insistence on the decomposability of a work of art, or the replacement of the Chevrolet Impala by the Apple Macintosh—it seems, at the very least, that we should be cagy about calling our culture "postmodern" until we

know what "Modernism" means. If John Barth was right in 1980 that discussions of postmodernism must "either presume that modernism . . . needs no definition . . . or else must attempt after all to define [it]," then Maurice Beebe was wrong to assert in 1974 that "we can now define Modernism with confidence."[16] Perhaps we could, but we haven't. Isn't it about time? After all, it has been at least fifty years since Modernism became known as a settled phenomenon.[17]

The educated reader uses the term "Modernism" all the time, possessed of certain spreadeagled definitions learned, perhaps, in courses in art history or twentieth-century fiction and reinforced by daily trips through the glass canyons of downtown; but in fact we know less about it than we do about any other -ism—very little indeed. Communism or liberalism, even classicism or romanticism, would be less of a problem for us, if only because they are not so general. Unlike Modernism, none of these others requires us to understand a bit of everything and to indulge in the wholesale crossing of what we have come, in the twentieth century, to call "disciplinary barriers."

There is classical music, classic art, and classical physics, to be sure, and there may even be classical mathematics, but the disciplines have charge of them and they do not all belong to the same period. Were we to define a Classical period, extending from about 1620 to 1780, and call it, as historians do, the Ages of Reason and Enlightenment, we would still confront fewer creators working in fewer and far less well-marked-off "disciplines." With some ease we could put them together, as we put Locke, Newton, Voltaire, and Bach together, on the basis of style, attitude, or preconceptions. By contrast, Modernism requires uncomfortable leaps. What kind of biology, for example, is Modernist (if any)? What kind of problems does a Modern mathematician solve? Is there a Modern style in sociology—or is it simply Modern to be a sociologist? And Immodern to be a ballet dancer? Most important, do the biologists and the ballet dancers ever affect each other, and in what sense may they be said to be contributors to a common culture?

If Modernism may be too broad a term to be meaningful, it may also be too long. What is the duration of an -ism? The first to name itself was romanticism (classicism is retroactively applied), and it lasted little more than a generation, though much later and even now, thinkers will be called "romantic" if the old ingredients are there.[18] Realism in the later nineteenth century has the same sort of history, though it seemed to last longer. By the 1880s -isms had begun to succeed each other at roughly five-year intervals. Five years, in the age before international telephoning, was barely enough time for bright members of a generation to find each other. Now, with postmodernism we have -isms that cover more than a generation and have little coherence. Perhaps because the bright young people in a generation don't cohere, or because there are too many of

them, or because we are now in the habit of -ism-ing and can't find an alternative, critics and commentators have taken over, and instead of making terms that refer to new ideas and those who come up with them, they make terms that refer to themselves.

So what is Modernism? One premise of this book is that we had better define Modernism soon or we will lose the use of the term as soon as the last generation of Modernists follows the first to its centenary, putting an end to what may be the longest-lived cultural movement our civilization has ever experienced. It has been a long time since the first Moderns.[19] James Joyce was born in 1883 when Freud and Strindberg were twenty-four; Anton Webern and Niels Bohr were born in 1885 when Bertrand Russell was thirteen and Kandinsky going on twenty. Isadora Duncan, Ludwig Boltzmann, Georg Cantor, and Stéphane Mallarmé all died before their work could be fully understood. Stravinsky and Picasso lived long, but not forever. Oskar Kokoschka was still alive when this book was planned, but he did not reach one hundred. The last of the quantum physicists, Paul Dirac, died in 1985 at eighty. Martha Graham survived until 1991, but modern dance is older than her company.

Another premise of this book is that history can still be written: history being defined in that rudimentarily whiggish way as the story of how we got the things we value, the things that are currently important to us. But how is that value decided? Because of what Modernism has achieved we can no longer be blithe in defining or deciding the importance of things. Nevertheless, impossible though it may be to back it up philosophically, it is still possible to make such a claim and to hope for the best. And why not be bold? What we value may well be the discovery of new truth and new beauty. This book, at any rate, is a collection of such discoveries. If it must therefore read as an elegy for Modernism, there is no one to blame except perhaps Minerva's famous owl of wisdom who, according to one downcast historian, took flight only at dusk when the day's chaos was over and understanding could at last begin.

In consequence, yet another premise of this book is that we really can define Modernism, and that in fact we can define it a good deal less loosely than we can something like liberalism. To make that definition, we will have to cut Modernism loose from a populous entourage. Modernism is not, to take a few examples: industrialism, capitalism, Marxism, or the Enlightenment. All but one of those is from the nineteenth century (one is from the eighteenth), and they all make hash of the painstaking task of periodization. What Cyril Black and the economic historians have called "modernization" is not the same as Modernism, and their use of "modern," almost the equivalent of "industrialized," refers to the results of a process that began in England at the end of the eighteenth century.[20] It is a usage closely related to the phrase "Modern History,"

the historian's term of art for what begins with the rebirth of cities in the fourteenth century and continues today. Many German culture critics, following Jürgen Habermas, insist on a "modern" era that begins with the Age of Enlightenment, but this too is a confusing retronym that probably better represents the stumbling blocks of German historiography than a stage in Western culture.

Some time after her bones were found in the cave of Cro-Magnon in 1879, *Homo sapiens sapiens* came to be called "Modern Man," but this is yet another meaning of the word. Cro-Magnon is the type specimen for us only because our species has shown no biologically definable change since the Upper Paleolithic. Embedded in this usage is the idea that the word "modern" must never refer to things that are no longer with us. The tendency to insist on this meaning is what makes the term "postmodern" so jokily contentious. Similarly, the use of the word "Modernism" to refer to an episode in cultural history implies the assumption of up-to-dateness. In fact, it should not have to. If the changes in the way we think and in the ways we make science, philosophies, and art should come to be seen as fundamental, we should be ready to name a new -ism and relegate Modernism, as some already have, to a dead and superseded past.

For such an enterprise we need our history, for how can we assess any change as fundamental without comparisons? What then does Modernism mean in this century and in cultural terms? Why does "Modernism" not mean, for example, the movement in the Catholic Church condemned by Pope Pius X in 1907? Because that "Modernism" attempted to revise theology with nineteenth-century science. Why does "Modernism" not mean a school of Spanish poets and critics called "Modernismo" in the 1880s, or one that German and Scandinavian speakers called "Modernismus" only slightly later? The reason must be that the international "Modernism," when it appeared, had a considerably different content. The "Modernismo" of José Martí, Rubén Darío, and their group would have been called by the French "Parnassian," a decidedly pre-Modernist style, or "symbolist," which chronologically just precedes Modernism and is often opposed to it. The most Modernist thing about "Modernismo" may be the fact that it originated not in Spain but in the Americas, and that Martí, a Cuban, and Darío, a Nicaraguan, had both learned some prosody from Walt Whitman.[21] The "Modernisme" popular among writers in Spain's step-province of Catalonia from about 1890 to 1910 was also under some influence from Whitman, though it took most of its cues from Wagnerites and francophone symbolists.[22] The German term "Modernismus," on the other hand, was first applied in the 1880s mainly to plays, the prose "problem" plays of Ibsen and of successors like August Strindberg, Gerhart Hauptmann, Léon Hennique, and Frank Wedekind.[23] Here modernism meant roughly the same thing as

"naturalism"—that is, theatrical or slice-of-life realism, rough surfaces, sexual indiscretion, and true crime. As an aesthetic in theater and fiction it fit in well with the nineteenth century's new allegiance to science and technology, and it certainly fits with the economist's "modernization," but this puts it in the old century rather than this one.[24] Symbolism better accords with the Modernism we have come to mean, for symbolism was characterized by an idealist reaction against naturalism and a parallel reaction against science. The reaction was so strong in France that the first name applied to the group was *Décadence.*

Symbolism is also a more useful term than most for the cultural historian, since it was adopted not only by playwrights and novelists but also by poets and painters; but it is fundamentally an aesthetic, too narrow to provide a core for Modernism. Unless it is stretched to include some Freudian psychologists, it describes no scientists at all. Such deepening divisions between the "disciplines"have made it difficult for academics in one of them to feel competent to write about others; as a result, a full history of Modernism, including all the arts and sciences, has never before been written.[25] Successors of Louis Untermeyer's old biographical dictionary exist, but they all use the order we call alphabetical.[26] What seems to be needed is a set of centrally located ideas, informing more than one discipline, that can together be termed Modernist retroactively if necessary but without serious anachronism.

Ideas like this are usually philosophical, and indeed, in the history of culture it is philosophy that is usually first to arrive in new intellectual worlds. Historians of philosophy, however, have not yet agreed on what is Modernist, nor do they seem at all anxious to do so. In general, Pragmatism, Phenomenology, and Logical Positivism are all Modern, but Monism, Materialism, and Idealism are not. Positivism may be, depending on whether we believe its early nineteenth-century inventor, Auguste Comte, or its last great practitioners, Ernst Mach and his disciples.

For similar reasons, other terms fail to satisfy the requirements of comprehensiveness. Because Modernism has been so long-lasting it makes no sense to identify it with the *fin-de-siècle.* Because it has been international, it makes no sense to identify it with what are in essence reactions to it, like Ezra Pound's fascism. Because it has been so multidisciplinary, calling it *Jugendstil* or art nouveau or Bauhaus is merely identifying a part with the whole.

Modernism is, moreover, not merely what the architects say it is, pointing to the likes of Louis Sullivan, Mies van der Rohe, and the International Style. If primacy of function over decoration (or worse, the prevalence of reinforced concrete) is to be its essence, then we can do nothing with the word in literature or even painting. The literary equivalent of unadorned functionalism would have to be "naturalism," but naturalism's unadorned description, based on purely empirical theories of

knowledge, disappeared from literature with Zola and Conrad long before the Bauhaus came to our house, and even before it came to Dessau.

Architectural Modernism has been defined, almost from the first, by its relation to the industrial modernization of materials and the economic modernization of production. This is not confusing to begin with, because so much in the word "modern" has its origins in the heroic materialism of the late nineteenth century. Modernism, however, is something different. Except in architecture, Modernists got started precisely by rejecting that heroic materialism of the nineteenth century and much more, including positivism, scientific determinism, the idea of progress, and the moral faith that went with it. From an aesthetic (as opposed to a historical) point of view, modern architecture may have just begun.[27]

History, however, must deal with temporal coincidence, even if it makes other things a little messy. The influence of structural steel on Sullivan, like that of standard time on Joyce, of the telephone on Proust, of the bicycle on Boccioni, or of electric streetlights on Delaunay, is real and not to be denied. The powered safety elevator, first presented to the public at the New York Crystal Palace Exhibition in 1854, suggested the thought experiment that led Einstein to rewrite Newton's laws. It is hard to explain how Einstein could have imagined the equivalence of gravity and inertia in 1907 and come up with the general theory of relativity without an elevator to imagine himself in. As for the special theory of relativity, it was an answer to a question raised by the creation of standard time in the 1880s, and by the wireless telegraph of 1900. The telephone, a gadget first shown off at the 1876 Philadelphia Centennial, changed the idea of dialogue for Twain and Strindberg, and possibly for Joyce. Generalized "modernity" is not the subject of this book. In fact there is good reason to wonder if "modernity" means anything at all beyond a change in the pace of change. But there can be no question that there are changes in the way people think and in the way their cultures work that can be considered one by one, that many of the changes depend on each other, and that many of them together can be called "Modernism."

Where Modernism began may have more to do, as we shall see, with a couple of mathematicians in Germany and a cabaret in Paris than with novels and buildings. Its intellectual origins lie in an often profound rethinking of the whole mind set of the nineteenth century, the world view that originally gave rise to speed, industry, world markets, and the newly aggressive tone of the word "modern." The nineteenth century's collection of assumptions fit so smoothly together that even now there are many who cannot see how to insert a blade between them.

Smoothness, in fact, was one of the ruling metaphors of the age. Nineteenth-century minds disagreed about almost everything except how much they disliked hard edges. Between one thing and another, whether

on the canvas of an academic painter or in the natural and social worlds, there was always a *sfumato,* a transition. Marx, Hegel, and Darwin agreed that change was, if not regular, at least smooth. The tidal wave of dialectic, the *Aufhebung* (elevation) of Being, the evolutionary origin of a species, was a spectacular show, but it was neither catastrophic nor unpredictable. It was more like the forbiddingly complex but entirely harmonic development of a Brahms symphony. And its tempo, like that of a classical ballet, was *legato.* The reader of novels, mimicking the omniscient narrator, could assess something called "development of character" over hundreds of pages that mimicked real time. Even in physics it began to seem, especially after the full influence of James Clerk Maxwell was felt toward the end of the century, that there were no particles in the world, only waves and fields, that everything shaded into everything else. An observer, that "objective observer" with whom so many nineteenth-century thinkers were so intimately acquainted, could watch such phenomena unfold, with an Olympian assurance that they would not overwhelm him.

This set of assumptions about continuous change was unaffected by politics or religion. It was neither right nor left, neither French nor German, neither Christian nor unchristian. It said nothing about what changes might occur—only about the shape of the transition. It legitimized a vocabulary used by nearly every thinker, comprising words like "stasis," "development," "*Auf-* and *Erhebung,*" "transition," "*Entwicklung,*" "evolution" (suitably less staccato than "revolution"), "*Untergang,*" and decay. The assumption of continuity was what philosophers call ontological, a decision about the nature of being that goes beyond (or below) any particular thing. And ontological continuity was so strikingly characteristic of the thought of the nineteenth century in the West that even now it is hard to find an exception. As Charles Sanders Peirce, one of the true founders of Modernist thought, noticed in 1894, "If we survey the work of the nineteenth century, it is surprising to find to what extent its successes have been due to the recognition of the idea of Continuity, and its failures to the want of such recognition."[28]

We shall begin with the few areas in the thought of the nineteenth century where the recognition of continuity was wanting, and show how they began to relate to each other in the later and newer corners of the late nineteenth-century intellectual world. The earliest atoms in common thought were the atoms of the chemical elements, proposed by John Dalton in 1808 to help explain why the weights of substances in chemical combination tended to be in simple whole-number ratios. We shall see, first, how the atomism of chemistry came to find echoes in other sciences, in the arts, and in philosophy. We shall see how the atomic assumption in mechanics drove first scientists and then all sorts of thinkers to the conclusion that statistical and probabilistic descriptions of reality were

truer than the old deterministic dynamics. We shall see how, beginning not in science but in literature and painting, Modern thought gave up the stubborn old belief that things could be seen "steadily and whole" from some privileged viewpoint at a particular moment—or, in other words, why it is that Cézanne painted Mont Sainte-Victoire from nearly every available perspective except its summit. We shall see also how, at the same time, the belief in objectivity crumbled so that phenomenology and solipsism began to take over not only philosophy, but literature, politics, psychology, and at last even physics. Finally, we shall see, I hope, how looking at oneself not only produces the sensation of consciousness, but sets an axe to the roots of formal logic and ends by making it impossible to know even the simplest things that the nineteenth century took for granted. Each of these—statistics, multiple perspective, subjectivity, and self-reference—alone and together can be shown to have devolved from the collapse of ontological continuity.[29] Severally, they lead to the nonlogical, nonobjective, and essentially causeless mental universe in which (with the exception of a few historians) we all now live.

One might expect an academic to do things of that sort on a high level of abstraction, but my academy is a secondary school. The reader will recognize no sense of obligation here to narrow the field of research or to restrict what is written about Modernists to things that have never been published before. The usual academic taboos against supplying a lay reader with a general history are not in effect, and this book uses biographical and chronicle forms, rather than those ritually adopted for launching a new salvo in one or another specialists' debate. These biographical profiles of the great first Modernists are focused on their most ground-breaking works, linked and arranged so that those works appear in chronological order. In this way there can always be one or more stories to tell: the story of how a particular poem or theorem was made, the story of one individual life or another, and the story of early Modernism as a whole.

Telling stories is not only, I hope, the more appealing way of arguing a case, but also by far the most Modern. Philosophers of the most contemporary dash now argue that there is no theory by which to judge truth—only more or less plausible stories. Given a collage of remarkable events, chronologically arranged, the reader will hopefully not mind the narrator's occasional insistence on consequence and coincidence among them, his assumption of near-omniscience, or his observance of the tradition that there be always one damned thing after another.[30] The French critic Remy de Gourmont already understood this attitude a year before the twentieth century began, when he wrote that "ideas, like the atoms of Epicurus, hook up to each other as best they can, whatever the risk of confrontations, shocks and accidents."[31] The story of Modernism begins with German mathematicians and moves on to physicists in Vienna, Ber-

lin, Bern, and Copenhagen; a French painter; French and American poets; a histologist and a politician from Spain; a Viennese psychologist; a Dutch biologist; English, German, and Italian logicians; a New York filmmaker; a Parisian painter from Spain; a Swedish playwright; musicians from Vienna, New Orleans, and St. Petersburg (Russia); a novelist from Dublin; and a Muscovite painter in Munich. In addition to these central characters there were architects from Glasgow and Vienna, dancers from California and New Jersey, African nationalists from Georgia and the Caribbean, and writers of fiction from a dozen countries, including New Zealand and Norway. Finding each other was not hard for them, in the age of the telephone and the railroad and the heyday of the World's Fair. This book tries to bring them together by pausing occasionally for a sudden confluence of minds in Vienna, Paris, or St. Louis, Missouri. Sometimes, as at the Upton Inn in *Tom Jones,* everyone was in the same place without ever meeting each other at all, while the emerging professions and disciplines ignored their cross-talk and fervently organized and subdivided themselves. More often, however, these geniuses did meet, conveniently or incongruously, deliberately or by the remotest chance, in person or in the educated minds of our own late twentieth-century culture. As the French say, "les grands esprits se rencontrent"; but if great minds have met in this century, it is because they have had no choice.

2 THE CENTURY ENDS IN VIENNA

MODERNISM'S TIME LOST

1899

My watch is turned backward
Never is what's past over for me
And I stand differently in time.
Whatever future I may reach
And whatever I grasp for the first time
Becomes for me the past.

—Karl Kraus, "Turn Back in Time"

Time was on the move. People not yet born in those days will find it hard to believe, but even then time was racing along like a cavalry camel, just like today. But nobody knew where time was headed. And it was not always clear what was up or down, what was going forward or backward.

—Robert Musil, *The Man without Qualities*

In 1857, in Vienna, the headquarters city of the old world of Central Europe, the ancient walls that had kept out the Turks for so many centuries were ordered demolished and replaced by a great circular boulevard. Under the benign sponsorship of Franz Josef, who had been Emperor of Austria since 1848, feverish construction began that would in thirty-five years line the newly created Ringstrasse with a tiara of new public buildings flaunting every architectural style inherited from the glory days of Western civilization, from classical to Gothic to Flemish and Italian Renaissance. Nothing new of course, or Modern, for Vienna had never been the sort of city that looked to the future. In the 1890s it was the capital of the most Catholic country east of Spain, where once a year on Corpus Christi Day the Emperor appeared on foot leading the other classes, in order of rank, in procession to the cathedral. It was the capital of an empire of peasants where in some provinces thirty-three percent of the land might be owned by one or two percent of the population. It was the city of waltzes and whipped cream ("schlock," as they called it in dialect), where Metternich was still remembered fondly for having turned back the clock after Napoleon. When Baron Franz von Uchatius invented a motion picture projector in the 1850s, he used it to

teach ballistics and sold it to a local stage magician. When Siegfried Marcus drove Vienna's first automobile down the street in 1875, he got not a single order. When Viennese founded the world's first organized aviation institute in 1880, no one noticed; twenty years later, when Wilhelm Kress tried to fly a gasoline-powered airplane two years before Kitty Hawk, he crashed and was forgotten. Still later, Hermann Oberth's dissertation on space rockets was rejected by the city's university. As for Vienna's Emperor Franz Josef, he remained skeptical of telegraphs, telephones, typewriters, electric lights, and elevators well into the 1890s, and didn't ride in an automobile until England's Edward VII shamed him into it in 1908, his sixtieth year on the throne. Early in his reign, even railroads had been banned because they might bring on revolution, and his daughter-in-law Princess Stephanie had had to pay to have bathrooms constructed in his palace. The situation had not much changed for Austria since Napoleon had taken the title of Holy Roman Emperor away from Franz Josef's grandfather, prompting the latter to call his kingdom "a worm-eaten house. Take away part of it, and the rest might collapse."[1]

In such a city Modernism would find it impossible to thrive; but Vienna was indeed the kind of city where it could be born. Most of the preconditions were in place. Vienna was big, and getting bigger almost as fast as Chicago. Immigrants quadrupled its population between 1857 and 1910. Also like the other great cities where Modernism began—Paris, New York, London, Prague, Munich, Chicago, and Saint Petersburg—Vienna was rich, polyglot, and protean. Where Vienna differed from New York and Paris, however, was in its inability to rejoice in the new. What Ezra Pound (and Hugh Kenner) called "vortices" were always about to coalesce there, but Vienna foiled them all. The city was jammed with original minds, young men and women whose fathers had come from the empire's distant provinces to make their fortunes; but originality was never at home there. One by one all of the great Viennese Modernists ran into trouble in Vienna, from Sigmund Freud and Ludwig Boltzmann to Arnold Schoenberg, Arthur Schnitzler, Adolf Loos, Oskar Kokoschka, Erwin Schrödinger, and Ludwig Wittgenstein. Eventually almost all of them left. As one of them summed it up, "This Vienna possesses, in addition to other significant qualities, the extraordinary gift of banishing its most worthwhile talents, or of humiliating them."[2]

Immigrants did not stay. In time an Austrian provincial who had lived six years of his life as an artist in Vienna, surrounded by these founders of twentieth-century culture, would devote his life to wiping out everything they stood for.[3] And Hitler is only the deadliest example of the way, in Vienna, nineteenth-century culture kept muffling and misunderstanding twentieth-century ideas. Modernism was always there in Vienna, struggling to be born; but to find out what Modernism was not,

to understand what it replaced or reacted against, Vienna is the place to look.

In Vienna, even the Enlightenment was new. The orthodoxy of the nineteenth century, still fresh in old Vienna, was called Positivism. Some called it "modern," but it had been invented in the eighteenth century, and had already passed its prime in England, France, and northern Germany. Positivism, sometimes called "scientism," was a philosophical program, drawn up in the belief that the problems of philosophy were all soluble if only people could resist the temptation to be mystical. Ontology (what exists, if anything, and how?), epistemology (how do we know it?), and ethics (what should we do?) must all be predicated on "positive" knowledge of phenomena (mostly scientific) and keeping the ghosts out of one's machines. For positivists matter was what primarily existed, and only matter was capable of making or affecting mind. Positivists dismissed Immanuel Kant (who had thought there were things unknowable) and the romantics (who had thought they knew those things) as good minds sadly misled by enthusiasm. If the French inventor of positivism, Auguste Comte, had had an embarrassing decline into religious faith, and American positivists seemed strangely willing to think of religion as a measurable phenomenon, Austrian and German positivists felt an even greater obligation to keep their religions, if any, closeted away from thought. The best positivist thinker was a thrifty one. He or she would junk any concept that smelled of metaphysics, and any general term that was more than an appropriate name for a collection of measurable facts. As for facts, they could not be measurable unless they themselves were names of material things or things that happened to material things. Concepts were only conveniences, not real; and the positivist must be ready to dispense with any idea that proved ill-fitted to the ways of matter—even if there were no new idea available to fill the breach.

At the University of Vienna sat the dean of Europe's philosophical positivists, professor of philosophy and history of science, Ernst Mach. In 1895, to set a seal on his positivism at the height of a twenty-year career, Mach had been called from Prague University to Vienna to replace Franz Brentano, who had insisted so long and so unfashionably that human perception was purposeful, and who was now retiring to Italy. Mach had taken his doctorate in mathematical physics in Vienna in 1861, but his only real excursion into ordinary physics was in 1872 when he perfected a stop-motion camera with which he photographed bullets in flight and discovered the supersonic shock wave. Shock waves are still measured by the so-called Mach Numbers he came up with in 1884; but Mach's original idea had been to measure not the flight of the bullet, but the bang, and he filed his most celebrated experiment not under avionics but acoustics. He wanted to know how the senses worked and how they in-

formed the mind. Time and space themselves, he thought, might be no more than mental events. His defining moment of revelation had been the spectacle of a canted world from the window of a railroad car as it rounded a steeply banked curve. In 1864, as a new professor at Graz, he had begun his lifetime scientific program of reducing psychology to measurable and understandable behaviors by applying physics to it, and a year later was publishing his analysis of color vision. As a professor at Prague in the 1870s, he had spent some time spinning in the dark in a seat he had designed that could rotate on three axes while suspended inside a box, and he later became known for blindfolding acquaintances and swinging them in the cars of Vienna's huge Prater ferris wheel to investigate the human sense of balance. In 1874 he submitted a paper to a Vienna medical journal on how the semicircular canals of the inner ear could tell people whether they were right side up or not, beating the fashionable Viennese G. P., Josef Breuer, to the discovery by only eight days. By 1875, Mach had decided that all psychological events were behaviors that could be broken down into irreducible bits or "atoms" of action. In 1886 he wrote that there was no such thing as an ego or a consciousness, only a flow of sensations. Perhaps his greatest work, published when he was still at Prague in 1883, was a book called *The Science of Mechanics,* in which he had tried to prove that physics was less a description of reality than a convenience, a quick and efficient way for humans to store useful knowledge about how material nature usually behaved. Proudly he announced that he could dispense entirely with several old physics terms, including "ether" and "atom," and could prove that the rest of them were not really a part of nature. Even numbers like 1, 2, and 3, he suggested, were non-Platonic products of practical solutions arrived at by thousands of human beings over centuries of evolution. This was positivism in spades; but in fact most people didn't quite get it, because if you truly grasped what Mach was saying, you would have to throw out the atoms of good old-fashioned materialism as adolescent fancy, and reduce the cold, hard facts so beloved of positivists to the bare sensations of warmth, pressure, time, and space.[4]

Thinking Vienna thought of Mach as forbidding but salutary. You need to read him, Michele Besso told his friend Einstein, who was going for his degree at the Polytechnic in Zurich. In Vienna, Mach's questioning of the autonomous, conscious self moved Richard Wahle to write *On the Mechanism of Mental Life,* and Mach's public lectures in 1897 on bullet photography attracted dreamers like the poet Hugo von Hofmannsthal, anxious for edification and shaken by rumors that this sort of science might dissolve the poets' world. But Mach's reign in the capital was brief. In 1898 the investigator of the sense of motion was felled by a stroke in a railway car, and three years later, his right side incurably paralyzed, he resigned. He lived until 1916, railing in painful retirement against those

benighted physicists, among them Ludwig Boltzmann, the new occupant of his chair of Philosophy in Vienna, who continued to maintain that atoms were real. If Mach had been able to understand his own influence, the pain might well have been greater, because in case after case, what was truly Modern in his Central European successors began in their encounters with his reductionism and their attempts to embrace it or shake it off. It happened to writers like Hofmannsthal and his friend Hermann Bahr, to philosophers of knowledge Alexius Meinong and Christian von Ehrenfels, to philosophers of language Fritz Mauthner, Wahle, and Otto Stöhr, and to Vladimir Ulyanov, better known as Lenin. It even happened to some extent to thinkers of Mach's own generation like Ludwig Boltzmann and the Americans, Charles Sanders Peirce and William James. As we shall see, it happened to Einstein, Husserl, Musil, Heisenberg, and Wittgenstein. It was as if Mach had laid out a positivism so critically sharp that it was able to make one doubt the existence of phenomena, and thus cut to pieces its own foundations.

But Ernst Mach was only the most sophisticated Viennese positivist, and perhaps the most prominent. There were many others left over outside Vienna in the rest of Central Europe, including the polymathic Hermann von Helmholtz, who had first asserted that the amount of energy in the universe could never be increased or decreased; Emil DuBois-Reymond, who had said in 1872 that there were only four questions humans would not eventually be able to answer; or Ernst Haeckel. Haeckel, Darwin's German bulldog, thought DuBois-Reymond was a pessimist and that evolution would prove a one-time materialist answer to the entire *World-Riddle,* as his 1899 best seller was called.[5]

In Vienna's academies, the positivists controlled the board. In the Law School of Vienna University, Austrian Supreme Court Justice Hans Kelsen was laying the foundations of legal positivism, teaching law not as it should be but as it was, consistent in its own logic and free of history, politics, sociology, or ideas of right and wrong. On the economics faculty there was a whole school of positivists who took philosophy too much for granted to write about it and instead spent their days providing proofs that economics was either a real science or else not worth studying. More scientific than Marx, in time Carl Menger, Friedrich von Wieser, Eugen von Böhm-Bawerk, Joseph Schumpeter, Ludwig von Mises, Friedrich von Hayek, and even Otto Bauer the socialist would come to be called the "Vienna School." (Today their intellectual descendants are called the "Chicago School.") The Vienna School had done much more than argue the value of free markets. Economics was in the area Comte had called "social science," where positivism dictated that if any generalizations were to be found at all, they would have to be strictly descriptive, rather than metaphysical or ethical. Thus it was Menger who announced, in 1871, the bemusing discovery that any value a commodity had was not

put into it by producers, but put onto it by demanders. This meant that since your demand for the last unit of a good you acquired was less than your demand for the first unit, the value of the last unit must be smaller; for example, that your first glass of water had more value—or utility—than your last. This was *Grenznutz,* marginal utility, the first of the many marginal concepts that now define microeconomics. Menger's successor, von Wieser, gave it its name, and pointed out how markets in mixed economies might improve the distribution of the total utility. He also invented "opportunity cost," or the value of roads not taken. Von Wieser's brother-in-law, Böhm-Bawerk, and his student, Schumpeter, never noticed that units of "utility" were not exactly positive knowledge, but they did discover many of the ways by which markets call forth goods. Only William Jevons in England and Léon Walras in Switzerland had the same kind of formative effect on what is today taught as the foundations of microeconomics.

In the University of Vienna's Medical School, which many said was the best in the world, medical positivism took the form of "therapeutic nihilism." Exemplified by Joseph Skoda, therapeutic nihilism was the belief that cures were so hard to explain materially that getting a diagnosis correct, or corrected, was often more important than saving the patient. Professor-Doktor Carl von Rokitansky had become famous at the Medical School for performing some 85,000 autopsies. Theodor Meynert, professor of mental diseases, spent his time trying to localize psychological functions in the continuous network of which, he taught, the brain was constituted. Though his book was called *Psychiatrie,* he spent very little time with actual lunatics because he didn't think any therapy would work. Richard von Krafft-Ebing, who would eventually fill Meynert's chair, was only a bit more concerned about treatment. He had begun assembling his definitive catalogues of mental disease in 1879, seven years before his famous tome on sexual deviations, *Psychopathia Sexualis.* Professor Josef Hirschl had proved in 1895 that the lunacy and degenerated brain tissue of some older patients like Hans Makart, Vienna's favorite painter (and Nietzsche too, raving and still alive) was the result of the tertiary action of the syphilis infection, but here especially there was not much one could do. Professor Moriz Kaposi, one of those who had made Vienna the world center of dermatology,[6] had given his name to a skin cancer with no cure. Johann Schnitzler was an up-and-coming laryngologist who could tell you anything you wanted to know about your throat except, often, how to make it better. Hermann Nothnagel did like to visit patients, but often what he did for them was decide what was wrong with them based on their blood pressure. Of almost godlike stature was Ernst Wilhelm von Brücke, who had learned materialism in Berlin as a friend and fellow-student of Helmholtz himself. DuBois-Reymond, another friend, remembered that, as young students, he and

Brücke had "pledged a solemn oath to put in power this truth: No other forces than the common physical chemical ones are active within the organism."[7]

Brücke had dominated the Medical School since the 1850s with his insistence that all disease was physico-chemical, and that even psychiatry was an extension of his specialty, physiology. In spare moments Brücke painted, so he wrote two books to show that art, too, was entirely explicable through material science. He did do cures occasionally, as did the surgeon Theodor Billroth, who wrote about music and was among the first to resection a stomach or remove a larynx. When the professors themselves wanted cures, they often went to a man who wasn't on the faculty at all—Brücke's old student, Josef Breuer, who could treat anyone from Brahms to Brentano. Meanwhile, ambitious young medical students flocked to their lectures and laboratories, among them Doctor Schnitzler's charming son Arthur, an amateur author, and Sigmund Freud, a bright young man out of rural Moravia who aspired to become a research biologist.

In the Physics department of the University of Vienna, other young scientists had wholeheartedly adopted positivism because it reinforced materialism, and materialism promised to physics precisely the exalted status that in idealist societies had historically been held by religion. In their laboratories Josef Stefan, Josef Loschmidt, and Ludwig Boltzmann worked to pin down an airtight mathematical description of the cosmos the ancient atheists had reduced to atoms and movement in the void. Their heroes were Ludwig Büchner, who had written one of their bibles, *Kraft und Stoff* (Energy and matter) in the 1850s; and Karl Vogt, who had announced in a debate with a Christian physiologist that "all is matter and nothing but matter."

Stefan had long been professor of physics at the University when in 1865 Loschmidt, then a Vienna secondary school teacher, found Loschmidt's Number (non-Viennese call it Avogadro's Number), 2.7×10^{19}, for the number of atoms or molecules in a cubic centimeter of gas. The next year Stefan gave Loschmidt a university appointment and brought him into the laboratory. In 1867 Stefan brought in Boltzmann, and together they all worked on the mathematics of these colossal assemblages of randomly active particles. Their constant motion was no less than the energy of the universe, which, as Helmholtz had said, could neither be created nor destroyed. In 1893 Loschmidt retired and Stefan died, leaving Viennese physics to Boltzmann; and when Loschmidt, too, died in 1895, it was Boltzmann who immortalized his old lab partner with the words: "Now Loschmidt's body is disintegrated into atoms. Just how many we can calculate on the basis of principles established by him. I have the number written on the blackboard." It was 10^{25}, one followed by twenty-five zeros.[8] In their universe, there was nothing but matter in motion.

Of course, the most radical materialists were Marxists, but Marxists thought positivists had missed the point, which was to change the world rather than to understand it. Karl Marx himself had died in exile in 1883, but Engels was still around in the 1890s, editing his old friend's books and writing against positivists like Eugen Dühring, polemics that would have a considerable effect on Lenin. There were indeed a few Marxists in Austria, including the great labor-socialist leader Viktor Adler; but in the 1880s and 1890s most of them were also Wagnerians. Viennese partisans of Richard Wagner, composer of the opera tetralogy *The Ring of the Nibelungs,* met in the Café Griensteidl, on the Michaelerplatz not far from Franz Josef's Hofburg Palace. That Austrians could comfortably combine Marx and Wagner, the tone-deaf materialist and the musical genius of romantic idealism, the internationalist who claimed the worker had no country and the anti-Semite who asserted the Germanness of art, is one measure of how far they still were from Modernism.

It was indeed startling how romantic and dated the celebrities of Austrian culture were in the 1890s. Most of Vienna's many theaters played nothing but operetta. The Court Opera produced bonbons. The Court Theater would play nothing that mentioned revolution. Army officers in Napoleonic-era uniforms strutted in the streets. All but a handful of the aristocracy took their cues from Franz Josef and the court. In 1900, when Prince Franz Ferdinand was unconventional enough to marry a commoner named Sophie Chotek, the Emperor forbade their children to inherit. Prince Otto was openly critical of his brother's marriage, though he was not entirely conventional himself. Otto wore a leather nose to hide what syphilis had done to the original, and he had more than once appeared wearing nothing but a sword and an officer's cap in the lobby of the posh Hotel Sacher. Vienna's favorite painter was Hans Makart, who designed the city's costume parades and whose paintings were the canvas equivalent of Court Opera and the Hotel Sacher's famous torte. Vienna's favorite "new" composer was Anton Bruckner, who would rather rewrite a symphony than offend an audience. When Gustav Mahler took over as conductor of the Court Opera in 1897, Viennese were willing—barely—to countenance a tightening of standards in the orchestra and the introduction of Wagner into the repertory, but they would not sit still for the mighty symphonies Mahler composed on his summer vacations. These works had a thoroughly nineteenth-century coherence, but too much dissonance—even irony—to be premiered in Vienna.

It was the same with poetry. The roses that Stefan George had had delivered to Hugo von Hofmannsthal in his Vienna high school classroom announced a great poet, but not, as yet, a modern one. Hofmannsthal's verse was delicate and lyrical, fitted beautifully to meter and rhyme, and perfectly adapted to the anti-positivist mood that was roiling in Vienna's literature in the 1890s. For Hofmannsthal, the prospect of discontinuity

was fearful and depressing, especially discontinuity in the self. In 1897, Hofmannsthal had attended Mach's lectures. Five years later, in the persona of the Elizabethan nobleman Lord Chandos, Hofmannsthal would write a letter to Francis Bacon complaining that his ego, his soul, was flying to pieces under the impact of positivist analysis.[9] To Hofmannsthal, Bacon stood for Mach and all the other Baconians in the modern world, rational analysts and dissectors of experience. Hofmannsthal was afraid they would make poetry impossible, and so was his fellow author, Hermann Bahr.[10]

Hermann Bahr (1863–1934), "The Man of the Day After Tomorrow," was the critic and local impresario of the new literature. Like Bruckner and Hitler, Bahr was from the provincial town of Linz. After a beginning as one of Vienna's Wagnerites, he had gone to Paris, returning to Vienna in 1889 with news of Oscar Wilde, the new "naturalist" theater, Mallarmé, and the symbolist movement. By 1891, at the Café Griensteidl, Bahr had found his new generation and dubbed it *Jungwien* (young Vienna). Hofmannsthal, the high-school genius, was a charter member. The others included a sketch-writer with wooden shoes and no fixed address who called himself Peter Altenberg; Schnitzler, now a young dermatologist with comedies in his pocket; Felix Salten, not yet the author of *Bambi;* and another aspiring novelist named Richard Beer-Hofmann. Later Stefan Zweig became a regular. Snorting in the wings was Karl Kraus, the great satirist, who renamed the Griensteidl the Café Megalomania, and memorialized it in the unforgettable essay, "Literature Demolished," when it was torn down in 1896. The Viennese are snoring, not sleeping, Bahr told the journalist Bertha Zuckerkandl, and "I am going to wake them up."[11] Despite his optimism, they continued to sleep, accepting from *Jungwien* only what it offered in schlock and sentimentalism while judiciously ignoring its experiments with epistemology and tone, which would eventually lead to the first stream-of-consciousness narrative, the first underminings of meaning, and the first ironic deconstructions of "reality" in the German language.

In art, positivism seemed to correspond to realism, and in German, realism meant Modernism. Realism was in fact the first artistic trend to be given the name of *Modernismus.*[12] The goal proclaimed by *Modernismus* was to present life as it was, low life as well as high, sexual as well as romantic. This worked better in fiction than it did in painting, and best of all in theater, the era's most public art. Here again, Vienna was late and half-hearted. The age of Ibsen had begun in the 1880s, and Gerhart Hauptmann had already bid to become the Ibsen of Germany by putting a birth on the stage in *Before Sunrise* in 1889, but Hauptmann's plays were banned in Vienna as immoral. In Vienna there was not only no realism, there were practically no straight plays. Half a dozen theaters founded to produce them ended up putting on operettas by Strauss,

Suppé, and Franz Léhar. The state Burgtheater thought it a step forward when they added "well-made plays" by Scribe and Sardou to the repertory. In 1891 there had been an Ibsen week in Vienna's theaters, but it had had no sequel. After years of application by successful but not very Modernist playwrights Arthur Schnitzler and Hugo von Hofmannsthal, the Burgtheater agreed to put on a month's run of several of their plays in 1899; but that was all, and the Burgtheater never produced Hofmannsthal again. Vienna waited until 1905 for Strindberg, when the Lustspieltheater gave his play *Comrades* its world premiere in October, but *Comrades* is Strindberg at his least Modern. If anything smelling of *Modernismus* got onto an Austrian stage, Austria would soon squeeze it off. The plays Arthur Schnitzler managed to have produced where he lived were the ones that could get past the censors in the guise of sentimental comedies.

The source of much that was new in theater in the twentieth century was late nineteenth-century cabaret, where the dream play, the chamber drama, audience participation, discontinuity of scenes, and separation of dramatic elements were pioneered. The new ironic monologue in poetry, stream-of-consciousness in fiction, *Sprechstimme* (speak-singing) in music—even some ideas of modern art, architecture, and film—can be traced back to the avant-garde vaudeville that flourished despite censorship in places like the Chat Noir in Paris; but Vienna was a city of cafés like the Griensteidl and the Central. It had no Black Cats, no cabarets as yet.[13] Peter Altenberg had to cast his monologues as columns or *feuilletons* in the Vienna press, and Karl Kraus, after a brief career on the stage, was left to found his own newsletter and print his own satires. To the north, in Munich, the playwright Frank Wedekind would help found a cabaret called the Elf Scharfrichter (Eleven executioners), and other Modernists founded the Überbrettl in Berlin; but that was not until the new century, 1901. Vienna's first cabaret, the Nachtlicht, did not open until 1906, and the Fledermaus, its most celebrated, not until 1907.

Modernismus in painting was also banned in Vienna. In the most famous case in 1901, Gustav Klimt's allegories of Medicine and Justice were rejected by their intended patron, the University of Vienna, on the grounds that, seen from below, pale, bony, expiative nudes, flaunting buttocks and pubic hair as they floated in allegorical space, did not properly reflect the work of the medical faculty or the law school. Klimt and some of his fellow artists had earlier dropped out of the Vienna Academy of Fine Arts and set up their own exhibition society, the Sezession. But this artists' rebellion was years behind the ones in Paris, and was late even in the German world. Sezession in Vienna had come five years after the first Sezessions of German-speaking artists in Munich and Berlin. Young Berlin artists had invited the pioneer expressionist painter Edvard Munch to put on a one-man show in 1892, and had started the Berlin Sezession

when their shocked seniors had gone back on the deal. When the same thing had happened to a Munch show in Vienna in 1889, no Sezession had resulted. In France, where rebellion was an old story, rebels rarely flagged; but Klimt, the leader of Vienna's rebel artists, seemed to have shot his bolt in the University panels, and would confine himself for the rest of his life to mosaic-like portraits and nudes that were less challenging, lusher, and more romantic. He could paint, using flat Modernist color planes, something we might call modern feeling or sensibility, but never again would he paint "modern life" the way he had in 1901. That was left to his protégés: Oskar Kokoschka, a fearsome young man whose work, signed "O. K.," was thrown out of the Sezession exhibit itself for what amounts to sexual frankness; and Egon Schiele, who was later jailed for the same offense. In 1907, Kokoschka would pause in his painting career to write a one-act play that has become one of the two founding works of Modernist theater, but when it was finally produced at the Vienna Art Show in 1909, the police had to be called to contain the disturbance and would have stopped the performance if it had not been over before they could act.

Austria's incipient Moderns were sunk even more completely by neglect than they were by hostility. Stefan Zweig's memoir describes how Vienna's middle- and upper-class women were shoehorned into clothing whose complexity only advertised their vulnerability and helplessness.[14] Vienna, like other great and soon to be Modernist cities, had a smart and vocal women's movement. Adelheid Popp led the first women's strike there. Bertha Pappenheim ("Anna O."), once she had recovered from Breuer's psychoanalysis, became one of the pioneers of social work. Rosa Mayreder and Auguste Fickert founded the Austrian Women's Union (Allgemeiner österreichischer Frauenverein) in 1893, but they made little headway, and were all but forgotten a century later. Austria simply could not decide, as northern Europe sometimes did, how to deal publicly with sex and gender. Then there was that extraordinary baroness, Bertha von Suttner, whose campaign for the elimination of war first gained notoriety in 1889 with the publication of her autobiographical novel, *Die Waffen Nieder! Eine Lebensgeschichte* (Lay down your arms: A life story). She had gone on to found the Austrian Peace Society and to edit and publish an antiwar periodical, where she predicted in 1899 what we now call total war. Von Suttner was awarded the fifth Nobel Peace Prize in 1905, becoming the second woman (after Marie Curie) to win a Nobel; but the journal had folded six years before, and the Austrian reaction to her prize seems to have been embarrassment. Von Suttner died on June 21, 1914, one week after the Austrian Archduke Franz Ferdinand was assassinated at Sarajevo.

In 1891, von Suttner's husband, the Baron, had founded the Vienna branch of the *Verein zur Abwehr des Antisemitismus* (Union for defense

against anti-Semitism), which included Johann Strauss; but there was no way for the Baron or his Union to alter the ugly truth that anti-Semitism was becoming mainstream in Austria, and perhaps even the wave of the future. The word itself had been coined there in 1880 by a right-wing writer named Wilhelm Marr, who was looking for a way to distinguish the new biological and cultural separatism from the old religious variety. Three years later a professor at the Austrian university of Graz, Ludwig Gumplowicz, had a book in print called *The Race War,* whose arguments for the inevitability of ethnic separatism would be carried on by Gumplowicz's disciple, Gustav Ratzenhofer.[15] By 1894, Modernism's Viennese champion, Hermann Bahr, had published the first international inquiry about anti-Semitism, and his fellow journalist, Theodor Herzl, had founded Zionism, anti-Semitism's antithesis, after trying and failing to assimilate as a citizen of Vienna. Vienna's favorite politician, "Handsome Karl" Lueger, would eventually win eight elections for mayor on the Christian Social Party platform, composed of roughly equal parts anti-Semitism and municipal socialism. (Franz Josef, who approved of neither -ism, would refuse to allow Lueger to take office until after his fifth election.) A Viennese industrialist's son who led the German Nationalist Party, Georg von Schönerer, would be banned from his seat in the imperial Parliament for repeatedly urging his followers to violence and destruction of property. A proper English racist, Houston Stewart Chamberlain would make his home in Vienna for twenty years and would publish his magnum opus there in German. The Viennese disciple "Jörg" Lanz "von Liebenfels" of a Viennese crank named Guido von List would recast cultural Germanness as a racist ideology, turning the Aryan language family into a race and resurrecting the swastika. The twentieth century owes these things to Vienna.

Yet anti-Semitism and the nationalism of "blood and soil" were neither Modernist nor modern. In effect they were a resurgence of the romanticism of the earliest decades of the nineteenth century—perhaps an example of what Freud was later to call a "return of the repressed." The free-form romantic nostalgia that found poetic expression in Hofmannsthal and drew him later into the movement to found the Salzburg Festival found political expression in Theodor Herzl, as it did no less in Marr, Liebenfels, and Schönerer. In his now celebrated book on *Fin-De-Siècle Vienna,* the historian Carl Schorske noticed that "all three"—Lueger of the Christian Socials, Schönerer of the Nationalists, and Theodor Herzl of the Zionists—"connected 'forward' and 'backward,' memory and hope, in their ideologies. . . ."[16] What they were seeking was a way to combat the growing discontinuity in art, the fragmentation of professions and of knowledge itself, a subrational continuity that could overcome the ethical effects of competitive capitalism and liberal individualism. What they came up with was ethnic solidarity and separatism, of which the

opposition to Modernism has made use throughout the twentieth century and turned into a new form of discontinuity.

Perhaps Austria was destined to be the cradle of this sort of anti-Modernism because it was so unusually vulnerable to it. It was a decrepit multicultural empire, economically only a little more modernized than its neighbors Russia and Turkey. Politically it was balkanized, deliberately divided ethnically so as to be easier to rule from the center; indeed the Balkans themselves were part of it, balkanized centuries ago by the Turkish Empire and further divided by the Austrian. The reactionary nationalism of the Empire's Serbs, Croats, Muslims, and Slovenes was responsible no less than imperialism for starting the century's first Great War. The reactionary nationalism of its Italians, and the nationalist reaction of its Germans, had a lot to do with bringing on the Second. As we look back on it with embarrassment from the end of the twentieth century, the Austro-Hungarian Empire's domestic politics look like little more than a series of unsuccessful attempts to shake it apart from within, its foreign policy little more than an extended effort to keep other nations from pulling it apart from without. The 1867 constitution essentially gave the Hungarian minority parity with Austro-Germans; but as soon as the novelty wore off, it was attacked on all sides by every other nationality in the Empire. It survived into the twentieth century only because "all nations in the empire hate the government—but they all hate each other, too, and with devoted and enthusiastic bitterness" even more than the Hungarians and the Germans.[17]

And so it was that as roads and railroads were built in Austria-Hungary all through the modernizing, industrializing, increasingly democratic nineteenth century, people cared not nearly so much about the roads as they did about what language the government would write the road signs in.

The issues came to a head spectacularly in 1897, the year of the artists' Sezession and Freud's most critical dreams, when the Emperor signed an act of the Austro-Hungarian parliament. This act guaranteed for the first time the right of all men, rich and poor, to vote, and set aside seats for working-class representatives in both the parliament and the Vienna city council. Its author was Franz Josef's new prime minister, a Polish count named Kasimir Badeni. Elections held in March under the new franchise yielded a chamber with more than twenty-five different parties, most of them ethnic, the rest ideological, and a majority in Vienna for Karl Lueger's Christian Social Party. Badeni proceeded to patch together a coalition, decreeing in April that all government employees in what is now the Czech Republic be required to speak and write in Czech as well as they did in German and that all lawsuits there be tried in the plaintiff's language. The result was pandemonium. Indignant Austro-Germans called for demonstrations all over the Empire, and so did the defensive

but jubilant Czechs. By autumn, several other minorities had mounted pro-Badeni demonstrations, while Austro-German nationalists had raised the German flag in western Bohemia and killed a man in Graz. The chief of the Pan-German Party had wounded Badeni in a duel. It had been under these circumstances that Franz Josef finally agreed to let Karl Lueger take office as mayor of Vienna. Later in November, when crowds poured into the streets of the capital, Lueger thanked his emperor by calling on him to fire Badeni. The emperor did so, but not before some of the most memorable filibusters in the history of parliamentary government had convulsed the new parliament house on the Ringstrasse. There was a twelve-hour speech, and legislators shouted, whistled, blew a fireman's trumpet, and even threw inkstands at each other. Georg von Schönerer's party of German nationalists had forced the parliament to suspend its sessions for months by picking up their parliamentary chairs and throwing them at the multiculturalists. Mark Twain, who was in Vienna to give lecture readings, described as many of these absurdities as he could, deadpan, from a perch in the visitors' gallery; but when at last the chairman had been driven to order the arrest and expulsion of members, Twain's sense of the ridiculous left him. "And now," he wrote, "we see what history will be talking of five centuries hence: a uniformed and helmeted battalion of bronzed and stalwart men marching in double file down the floor of the house—a free parliament profaned by an invasion of brute force. . . . I think that in my lifetime I have not twice seen abiding history made before my eyes, but I know that I have seen it once."[18]

Hitler was eight years old in 1897. When he got to Vienna "Handsome Karl" Lueger, reelected in 1903 and 1909, was still mayor, and Hitler learned the practice of politics from him. He learned the tactics of street violence from Schönerer, and ideology and swastika-symbolism from List and Liebenfels. But Hitler was still in high school in Linz when the very first "National-Socialist German Workers Party" was founded in the Sudetenland by German-speaking wage-workers yearning for ethnic solidarity in a sea of Bohemian Czechs.

Nevertheless, for a few years on either side of 1900, when Hitler was only a student artist, and no masses had ever been told of Nietzsche, Vienna teetered on the edge, full of not-yet-discouraged youth and hope. The young composers who would shape twentieth-century music—Arnold Schoenberg, Anton Webern, and Alban Berg—were living and working in Vienna, and the man who held court at the Court Opera, Gustav Mahler, could reach out to encourage them. Young Franz Kafka could encounter Brentano's ideas and German Modernist theater in his native Prague and visit Vienna for more. Rainer Maria Rilke, perhaps the greatest of all twentieth-century poets in the German language, could leave his Prague childhood behind, meet Hofmannsthal in Vienna and launch a new life. Architect Otto Wagner, who had designed his first

Modernist building in 1882, could be commissioned by Karl Lueger's city government to design street railway stations more Modernist than anything in Louis Sullivan's Chicago. Wagner wrote that nothing could be beautiful that was not practical.[19] His disciple, Adolf Loos, who proclaimed that ornament was crime, could build a house opposite the site of the demolished Café Griensteidl with nothing on its façade but holes for the windows.

Edmund Husserl, born like Freud in rural Moravia, could come from the University of Berlin to the University of Vienna to learn philosophical psychology from Brentano (who believed that perceptions came into the mind through intention) and his successor Mach (who did not), thereby founding a new philosophical field: phenomenology. Other new philosophers conjuring the twentieth century out of Brentano and Mach included Alexius Meinong and Christian von Ehrenfels. Meinong thought intention could give a new reality to mental events, and founded the first experimental psychology laboratory in Austria. Ehrenfels was recoining the word *Gestalt* to refer to the formal bundles by which the mind receives perceptions. Sigmund Freud, also a former student of Brentano's psychology, was joining a medical specialty—psychiatry—full of Austrian pioneers, including Moritz Benedikt, Obersteiner, Krafft-Ebing, and Julius Wagner-Jauregg. Young physicists strolled the Ringstrasse, too, brought to the University of Vienna by the work of Mach and Ludwig Boltzmann: Paul Ehrenfest, who would codify the consequences of turning matter into molecular statistics; Erwin Schrödinger, who would discover the quantum wave equation for subatomic particles; and Lise Meitner, Boltzmann's last student, who would in her Berlin laboratory in 1938 become the first to realize that the nucleus of the uranium atom had been split.

When Ludwig Boltzmann briefly took over as Mach's successor in the philosophy chair and delivered a blast against the meaningless romantic abstractions of Schopenhauer, he was being more than a positivist. The new drive to set limits to discourse and restrict words to what they could truthfully say had begun with Viennese writers like Fritz Mauthner and Otto Stöhr. When the sharpest of all Viennese satirists, Karl Kraus, began editing *Die Fackel* (The torch) on April Fool's Day 1899, the assault on schlock and obfuscation in language began in earnest. In time Kraus made Vienna so synonymous with pretense that the world would forget that the attack on Viennese hypocrisy had been led by Viennese. Ludwig Wittgenstein did not forget, however, writing in the first of his great philosophy texts in 1915 that when we get to things we cannot talk about, we must learn to stop talking. In 1904, at the Linz scientific high school, a fifteen-year-old Wittgenstein was studying hard and looking forward to learning honest subjects like physics and engineering with Boltzmann and Mach. Young Robert Musil, the Proust of Austria, had nursed the same

ambitions at the Vienna Military Science high school and the Brunn Technical Institute not long before. (So had Einstein in Zurich, though he was no Viennese.) In 1904 Musil was planning his first novel and a doctoral thesis on Mach. In 1904 Mauthner had just published the last volume of his masterwork on honest language. And in 1904 one of Wittgenstein's classmates in the Linz high school—Adolf Hitler—flunked out.

Hitler was a misfit, but he was also a romantic, and romanticism was worse than outdated; it could survive only by overcoming the new. Romantics who idealized social solidarity could not be reconciled to the temporal, spatial, and social fragmentation of urban communities. Romantics like Hofmannsthal and his friends, who idealized the self in its wholeness and singleness and power, knew that positivists like Mach were irresistibly dismantling it. Romantic lovers of nature had found their love undermined by the realist and naturalist demand for faithful and scientific reproduction of nature. Decadents had tried, unsuccessfully, to contradict nature, and symbolists had tried to break through to an ultimate reality by a method of ellipsis. But there was no going back on the positivist demand for analysis. When Modernism emerges it is seen to be a culture of analysis, a culture at home with bits and pieces and proud of contradictions. What Modernists have not accepted is the nineteenth-century assumption that we can analyze nature, whether it be physical, biological, or human, without analyzing the means we use to become aware of it: language, symbols, and what we persist in calling "mind." For Modernists the constant dialogue between perceiver and perceived has no predictable outcome and may alter either or both of them beyond recognition. This is because both sides of the dialogue have parts, irreducible, separable parts with nothing in between, for which many different configurations may be possible.

It is on this point that what we might call the mind of Vienna refused to be changed, and that young Viennese Modernists like Loos, Kokoschka, Wittgenstein, and Schoenberg eventually felt obliged to leave. In this distempered part, one may also argue, Vienna's twentieth-century political tragedy originated. Hermann Bahr, for example, stayed in Vienna but he changed to fit it, circling back from the incipient Modernism of his Young Vienna group to positivism and romantic pan-Germanism, and ending his life as a Catholic monarchist, author of guides to Old Salzburg and biographies of its bishop.

Vienna had insisted on continuity for a very long time. Bernard Bolzano, the first mathematician to try to define the meaning of discontinuous curves and functions, had been underestimated by Vienna way back in the 1820s, and there were others. A promising physics student, who had dropped out of the University of Olmütz to become an Augustinian monk in the 1840s, reenrolled at the University of Vienna a decade later. There, in May, 1856, he failed his teacher qualification exam for the sec-

ond time and went home to the Bohemian provincial city of Brno (Brünn) to serve the rest of his monastic life as a substitute high school science teacher and amateur botanist. The exam he failed had come after several years of study at the University of Vienna in physics and philosophy, including Professor Andreas von Ettingshausen's course in the new science of statistics. Ten years after his failed exam, the monk, Gregor Mendel, published the results of a seven-year botanical experiment on garden peas, in which he proved that traits like wrinkled seed-coats are not inherited in any continuous way, but either all at once, or not at all. Applying the methods of statistics, he had found simple whole-number ratios among the offspring bearing the traits—the telltale signature of the atoms of heredity that would later be called the genes. Mendel sent the publication out to every major botanist in the German-speaking world. Only one replied, advising him to try a different plant the next time. In this, the first appearance of modern "digital" thinking in biology, Austrian culture had blinked again.

> "We have as much talent as other nations," [said an Austrian citizen to Mark Twain] resignedly, and without bitterness, "but for the sake of the general good of the country we are discouraged from making it overconspicuous; and not only discouraged, but tactfully and skillfully prevented from doing it. . . . Consequently we have no renowned men. . . . We can say today what no other nation of first importance in the family of Christian civilizations can say: that there exists no Austrian who has made an enduring name for himself which is familiar all around the globe."[20]

Such Austrians did indeed exist in 1897, like Freud, who went to see Twain perform; but the world, like Twain, did not know their names yet. As Austrian Modernists achieved renown, more and more simply ceased to be Austrian. The war came, and Austria-Hungary itself simply ceased to exist, falling into ethnic pieces. Few cities have this option, and so, instead of falling apart, Vienna shrank in 1918 like a pricked balloon.

3 GEORG CANTOR, RICHARD DEDEKIND, AND GOTTLOB FREGE

WHAT IS A NUMBER

1872–1883

> I will not go so far as to say that to construct a history of thought without profound study of the mathematical ideas of successive epochs is like omitting Hamlet from the play that is named after him. That would be claiming too much. But it is certainly analogous to cutting out the part of Ophelia. The simile is singularly exact. For Ophelia is quite essential to the play, she is charming—and a little mad.
>
> —Alfred North Whitehead, "Mathematics as an Element in the History of Thought"

> The question "What is a number?" is one which has been often asked, but has only been correctly answered in our own time. The answer was given by Frege in 1884, in his *Grundlagen der Arithmetik.*
>
> —Bertrand Russell, *Introduction to Mathematical Philosophy*

According to one of the great mathematicians of the early twentieth century, "The 'real' mathematics of the 'real' mathematicians . . . is almost wholly 'useless.'"[1] In fact, it only seems useless to those who, like Hardy, allowed themselves to be convinced that the paradigm of usefulness is the broad back, the cancer cure, or the machine. Gottlob Frege, Georg Cantor, and Richard Dedekind were pure mathematicians who built no machines; but they did provide a means, laying the foundations of a new way of thinking in the West. If there is any utility to Modernism, Dedekind did something profoundly useful. The great event of his quiet life came in the year he wrote his first letter to a fellow mathematician named George Cantor, and soon after published a mathematical definition of irrational numbers now known as the "Dedekind Cut." Separating forever the digital from the continuous, at least in arithmetic, Dedekind became the West's first Modernist in 1872.

Everyone who has heard of Modernism has heard of Picasso. Most have heard of Joyce. But who has heard of Dedekind? Only mathemati-

cians, the least likely-looking of those who aspire to change the world by using their minds. The public doesn't know what mathematicians are doing, and mathematicians are just as happy it doesn't, for they are as genuinely unworldly as artists claim to be. To find an ivory tower in the late 1860s one would not have to go much further than the mathematics faculty in one of the bucolic university towns of central Germany—Heidelberg, Halle, Jena, or tiny Göttingen—a world limited to mathematicians, their spouses, students, and a few professors of the sciences, lubricated by rustic vacations and lager beer. At the height of this age of steam, other professors could be known beyond the town, some to all Germany. Chemists were respected as the makers of explosives. A steely aristocracy of engineers was sallying forth from the new "Polytechnics" of the Western world to build Suez Canals and Brooklyn Bridges. Economists and even historians had found the ears of the powerful. At one time philosophers, especially German philosophers, had been thought to be more unworldly even than mathematicians; but after the Prussians crushed the Austrians in the Seven Weeks War in 1866, Europe had begun to take a different view of the colleagues of Nietzsche and Schopenhauer.

But mathematicians? Even the waving flags and marching legions of Bismarck's Second Reich had left them out. Their problems were abstract—so ethereal and remote that the practical bourgeois of the Victorian period dismissed them as useless. Everyone knew, in a vague sort of way, that mathematics was essential to engineers, but this did not make a bridge-builder like John Roebling seem any less godlike or independent, nor did it help explain to ordinary educated people why the taciturn son of a bricklayer, Karl Friedrich Gauss, was somehow so important that his small university town of Göttingen had become the world capital of mathematics. Actually this question rarely came up, because only real mathematicians knew about Gauss and Göttingen. It could hardly be relevant to a conversation about building railroads or empires in Africa that there were now three different plane geometries or that the fundamental theorem of calculus remained without an airtight proof. Mathematicians did not invent. Instead, many insisted, they discovered things as Plato had—searching in a complicated alternate universe for elegant and beautiful relationships among objects that could not be said to exist outside the mind.

Without their knowledge, however, the mathematicians of 1870s Germany were about to change the world. As a clutch of Victorian professors, avuncular, ascetic, and a little disheveled, they were gathering unawares around the cradle of an infant Briar Rose that would one day be christened Modernism. It is true they would build no bombs or skyscrapers, but as they focused in on an ancient and exasperating problem of pure mathematics, they would become the first creative thinkers in any field to look at the world in a fully twentieth-century manner.

In a way it was simply the nature of the problem. In part it was the nature of the mathematicians. The problem had been posed in terms that the solution itself would blow away, the terms of nineteenth-century positivism, which in mathematics had been taken to mean "rigor". Positivists were suspicious of mathematics because the objects of mathematical study were not material. If mathematicians were to legitimate themselves, they would have to define without a loophole, prove beyond a shadow of a doubt, and consider only objects that were reducible, ultimately to number.

But they were at least as creative as artists. The first one off the mark, Georg Cantor of Halle, was the sort of person who could run with anything. The son of immigrants (by no means poor ones) from St. Petersburg, Russia, Cantor was energetic, bearded, and forbidding. He was known to lose all decorum in claiming he had been cut out of a professorship in the capital, Berlin, because of the envy and censoriousness of the German mathematical establishment. That did not prevent him from taking a leading role in the founding of the Deutsche Mathematiker-Vereinigung, the first German professional mathematicians' association, and the organizing of the first international mathematical congresses in 1897 and 1900. In 1884 came the first of his descents into manic-depressive psychosis. A switch to philosophy made it easier for Cantor to get published but did nothing for his therapy, and in 1918 he died in an asylum, the Nervenklinik in the university town of Halle where he had lived his entire professional life.

Cantor's fellow explorer, the bespectacled and goateed Herr Professor Richard Dedekind (he had shortened it from Julius Wilhelm Richard Dedekind), was older and more proper, very much in the German academic tradition that made an associate professor in a university bureaucratically equal to a colonel in the Prussian army, and hard not to salute. He had been born in 1831, and arrived at Göttingen in time to become one of old Gauss's last students and a pallbearer at his funeral. Dedekind then taught for a while in Switzerland, returned to his home town, and, unmarried, spent the rest of his life teaching in the college in Brunswick where both his father and his grandfather had been professors. Until 1872, the year he contacted Cantor, Dedekind's scholarly career had largely consisted of reconstructing and publishing the legacy of his other great teacher, Robert Lejeune-Dirichlet (he had by then reached Supplements 10 and 11) on differentiable functions and trigonometric series. To this he had allowed himself to add some original work of his own, often in the form of notes and prefaces. In fact the most original idea Dedekind had had so far had been rattling around in his head, unpublished, for nearly fourteen years. It had struck him when he was twenty-seven years old, on November 24, 1858, a month or two into teaching the required

introductory calculus course he had been assigned at one of the great new European engineering schools, the Technische Hochschule of Zurich.

In 1872 the forty-one-year-old Dedekind finally published his idea in a pamphlet called *Stetigkeit und irrationale Zahlen* (Continuity and irrational numbers). It didn't look like much, twenty-odd pages of good German prose, containing a minimum of equations and the simplest of proofs. Today it is universally admitted to be the closest that exact thinking has come to defining something mathematicians call the "numerical continuum." It was based, Dedekind wrote, on an idea so simple that "my readers will be very much disappointed in learning that by this commonplace remark the secret of continuity is to be revealed."

The modern reader, especially one untrained in mathematics, will not find the idea so simple. To understand it she will have to back up a bit, to the ancient Greeks in fact, for the problem of continuity is one of the oldest in mathematics, a sort of figured bass that can be heard beneath the work of all the great Western mathematicians from Pythagoras to Isaac Newton. And perhaps it is fitting that cultural Modernism should begin with a revival of the oldest conundrum in mathematics.

Continuity becomes a problem when you try to figure out what it means to be "between." In the sixth century B.C., Pythagoras already knew that the whole numbers (1,2,3, . . .) were not all there was. Like any American fifth- or sixth-grader, he knew that fractions—one whole number divided by another—lay between them. Fractions were a little messy, but they were quite real and reasonable; and for a long time Pythagoras believed that every conceivable quantity could be expressed as a ratio (*ratio* in Latin is reason) of two of the available infinity of whole numbers—as for example 3/5 is the ratio of three and five or 119/120 is the ratio of one hundred and nineteen and one hundred and twenty. Then one day, one of Pythagoras's disciples pointed out to him that the diagonal of a square whose side was one unit could not be expressed that way. The two whole numbers needed to give the diagonal as their ratio simply did not exist; it was true and could be proved. Instead, one had to use the square root of 2, which is in this sense irrational and never "comes out even." Since they were all on a boat at the time, Pythagoras threw his student overboard and swore everyone else in his class to secrecy.

The truth, however, did not drown, and Greek mathematics was brought face to face with a brand new question. If it were true that irrational numbers lay hidden between the whole numbers and the rational fractions, how many parts did a line have? How often could one subdivide a line, and how many numbers were there really between zero and one?

A later Greek, Zeno of Elea, and his school promptly turned the new knowledge into a series of paradoxes which even today lie at the root of

physics. The most famous still comes up in school. Called "Achilles and the Tortoise," it goes like this: if the tortoise gets a head start on Achilles, Achilles can never catch him because first he will have to halve the distance between himself and the tortoise, then halve what remains, and so on. Since there is no mathematical end to these halvings, Achilles will never come to the end of his task. Soon after pointing this out, Zeno was answered by Leucippus and Democritos, who said in effect that Achilles would catch the tortoise because one cannot subdivide something forever, certainly not something material like a race course. After a certain amount of subdividing, said Democritos, one reaches the "indivisibles" for which he used the Greek word *atomoi* "atoms." Epicurus, who came later, even seems to have made the startling suggestion that time itself has atoms of this sort. In other words, Achilles can catch the tortoise because during his atoms of time he can do more than halve the distance while the tortoise can do much less than double it.

Aristotle tried to sum up and settle the debate in Book 6 of his *Physics,* but neither he nor the legions of his commentators during the Middle Ages could find their way out of the paradoxes.[2] Continuous things, like motion, would seem to require an infinity of parts, but how can an infinity of parts make up a finite whole? What is an "instant" of time, or an "atom" of matter, if it is not nothing? Is the universe continuous or not? Is a line continuous? Is a trajectory? An interval? If it is, how can you count the parts? If parts have no size, how can even an infinity of them make a whole? By the time the seventeenth century rolled around, Newton and Leibniz had created a whole new branch of mathematics to deal with the problems of continuity. It was called the calculus.

The calculus Newton devised in the seventeenth century came in handy in deriving Kepler's three laws of planetary motion from Newton's own law of gravitation, and vice versa. The physical problem that founded calculus was how to find a speed when the speed keeps changing. Speeds are given in miles per hour, meters per second, or any distance divided by a time interval. We say somewhat blithely that the speed is such and such at a particular time, but in fact we cannot really find such an "instantaneous" velocity unless we can find a way to divide by zero, since zero is what an "instantaneous" time interval is. Newton and his rival Leibniz had to assume the existence of "infinitesimal" instants and intervals, marvelous creatures that manage in some way to exist though they have no duration and no length. For their "infinitesimal calculus" to work there had to be an infinite number of these infinitesimals; but if instants have some duration, however small, and intervals some minimum length—that is, if they are atoms—then lining up an infinite number of them creates an infinite sum—eternal times or endless lengths. If, on the other hand, these instants and intervals don't exist—if they are true zeros—then no matter how many of them you may assemble, finite or

infinite, they still add up to nothing. Then the time is zero, and zero is what you must divide your distance by; but if you do it, the speed you get will be infinite. The philosopher Berkeley wrote that Newton's "fluxions" and Leibniz's "differentials" had to be either religious or ridiculous.

Calculus obviously raises the same dilemma Zeno had proposed, once you look beyond the veil of dazzling mathematical algorithms. Accept continuity and you get infinities; reject infinities and you are left with discontinuity. The reaction? It is part of the lore of mathematics that everyone ignored the impossibilities, and that this enabled the mathematical giants of the eighteenth and early nineteenth centuries—D'Alembert, Euler, Laplace, Lagrange, Lacroix, Fourier, and Monge—to be so prodigiously creative. Lovely theorems proliferated, sometimes without any proofs at all. In 1781 the philosopher Immanuel Kant decided, in his *Critique of Pure Reason,* that mathematics was essentially intuitive, or a priori, a science that came not from the structure of the world but from the way humans think. This view, in turn, was embraced by even the least mathematical of the romantic generation of the early 1800s.

The infinitesimal tangle would have been ignored even longer, but attitudes changed in the century of rails and heavy machinery. The new wave was the metaphor of evolution and development, and the new hard-nosed attitude toward truth was called "positivism." For its inventor, Auguste Comte, and his followers in the 1850s, experimental science became the model for the acquisition of all knowledge. Positivists saw the experimenter, or observer, as "objective"—separate from the material reality he or she observed. Any knowledge you had that looked as if it did not depend on material reality was suspect as "theological" or "metaphysical" until you could show that relationship with matter. All the sciences, furthermore, were related up and down a ladder of increasing rigor. The simplest and most objective was the "mechanics of a material point" (that is, physics), and this lay at the root of all the others. Such talk brought back materialism, the ancient Epicurean philosophy that asserts there is nothing in the world but atoms of matter and motion.

Most science did well under positivism. Biology thrived on this attitude. Anthropology stood theology on its head and took the occasion to be born. Even psychology moved smoothly into the new era by setting aside its lovely general theories of consciousness, admitting that the mind was made of matter, and experimenting with how the senses worked. But mathematics could not entirely respond to the positivist program. When Comte himself had called mathematics the first science and a model of the method to be used in all the others, he neglected to point out the material reality it investigated. Only nonmathematicians could maintain that Euclidean geometry was derived from or confirmed by experiments on the real world. Perhaps if one thought of it as a branch of psychology, a byproduct of perception implied by the shape of the cornea or the abil-

ity to distinguish one note from another . . . but mathematicians, idealists since Plato, bridled at this.

Instead the mathematicians responded to positivism by looking carefully at their two methods of establishing truth: intuition and proof. Intuition could not be "positivized," except perhaps through psychology, but surely proof could. It would therefore be necessary to set the most rigorous standards for proof, and indeed to expel from mathematics everything that had not been positively proved, from Fermat's famous "last theorem" to the fundamental postulates of calculus. In the words of Newton (who by now had been somewhat ironically adopted by positivism as a saint), "Hypotheses non fingo" [I feign no hypotheses]. Moreover, if this were to be the program, then the leading scandal (as they called it) in mathematics was clearly the basic concept of the calculus: the derivative, or quotient of infinitesimals (dy/dx). No one at the beginning of the nineteenth century knew positively what the derivative was. It was not going to be easy to find out, either, especially in a period Hegel, Darwin, Marx, Maxwell, and even Tolstoy were to make into the triumphal era of continuous fields, continuous energy, continuous change, evolution, and development.

Much of nineteenth-century mathematics, then, took the form of a Victorian-sounding search for "rigor," particularly in that branch of mathematics called "analysis," or the study of the behavior of functions at its most general—what the calculus was now called after its centuries of imperial expansion. (An early attempt to pin down the philosophical work of our own twentieth century was a book called *The Age of Analysis,* meaning by "analysis" nothing more mathematical than the intellectual tendency to break things down into finite constituent parts; but the mathematical meaning of "analysis," and its effect on twentieth-century thought, makes for a truer title.)[3] At the frontiers of analysis, the continual discovery of bizarre, ambiguous, and even "pathological" functions was making Newton's elegant but intuitive calculus look more and more primitive. How, asked the Austrian Bernhard Bolzano (1781–1848) as early as 1834, could one differentiate (find a tangent or derivative to) a curve with a number of sharp bends, something like  ? How could one integrate (find the area under) a function where, for any value of the argument, X, the function, Y, was always either $+1$ or -1, but was $+1$ for every X that was rational and -1 for every X that was irrational? How could one be sure of what Fourier had asserted around 1811, that a function was completely represented by an infinite trigonometric series—or that it was represented by only one such series?

Answers eventually came from Augustin Cauchy, a contemporary of Comte's in France, and from Karl Weierstrass in Berlin. Weierstrass moved to the city's university from a high school faculty in 1858 when he was forty-three and became a name to be conjured with among

nineteenth-century mathematicians. He and his colleagues, Leopold Kronecker and Ernst Kummer, were credited with corralling the calculus after a century of creative abandon. The leader of a "Berlin School" that demanded absolute rigor in the definitions used in analysis, branded the so-called "infinitesimal" quantities unscientific and occult, and insisted (like Comte himself) that all of mathematics could be boiled down to arithmetic, Weierstrass became the saint of positivism in mathematics. Unable to claim the same "objectivity" as other scientists, the mathematical positivists at Berlin satisfied themselves by making their definitions and proofs as airtight as possible and by reducing the number of ideal (or undefined) objects needed to a minimum: whole numbers, for instance. In Kronecker's words: "God made the integers. All else is the work of man." In 1861 Weierstrass went Bolzano one better by finding a function with an infinite number of sharp bends that had no derivative at any point, but was continuous at every point.[4] In lectures given in the mid-1860s, Weierstrass claimed success in arithmetizing the concept of limit. It was not a value that a function "approached" as its variable(s) changed; it was a neighborhood of values whose difference from the value of the function remained smaller than an arbitrarily small number. At last, he thought, there was an answer to the question of what the derivative was. If he was right, he had made rigorous not only the analysis of trigonometric and other functions, but also its ancestor, the calculus. All around the Western world, from Baltimore to Turin, a phalanx of young professors of calculus began to close in on what they thought would be the mopping-up operations after a successful campaign.

Dedekind, you will recall, taught calculus. His 1858 idea, the Dedekind Cut, simply defines a continuous function or number field as one that can be "cut" by choosing one point or number anywhere such that all remaining points or numbers are either greater or smaller than it is. This idea, as Dedekind knew, was simple only in form, but in its consequences exceedingly deep—what mathematicians call "elegant."[5] With the Cut it was no longer necessary to examine numbers themselves to find out if they were "between" or "next to" other numbers.

Dedekind knew that ordinary numbers ("real numbers" to mathematicians) come in at least three varieties: whole (0, 1, 2, 3, 119, etc.), rational (ratios of whole numbers, 2/1, 2/3, 118/119, etc. plus zero), and irrational, like $\sqrt{2}$. Irrationals were like droplets of fog among the numbers; seemingly everywhere but impossible to distinguish properly. Integers like 1 or 2 were consecutive all right, but their sequence wasn't continuous. There were rational fractions like 5/3 between them. Rational fractions were not continuous either; between any two of them, no matter how nearly equal, there were more numbers. These included the irrationals, which were even less likely to be consecutive. How many irrationals between 5/3 and 2? There seemed to be no limit. In fact there seemed to be no fewer real numbers

between 1 and 2 than there were between 1 and 1,000. On a line, as the geometers define it, one could more easily understand why there should be no gaps and that point must succeed point without any "space" between. By extension, there ought to be no gaps among the real numbers.

It was Dedekind's insight that this difficulty by itself amounted to a definition of that grail of nineteenth-century metaphor, smooth change, which in mathematics was called "continuity." So, he wrote, if one could choose one and only one number, *a,* which divided all the others in the interval into two classes, *A* and *B,* such that all numbers in *A* were less than *a,* all in *B* were greater than *a,* while *a* itself could be assigned to either class, then the interval was continuous by definition. And *A* might have no maximum and *B* no minimum, in which case *a* would be an irrational number like $\sqrt{2}$. You didn't have to specify the number *a* to have a definition, either. In our example, as long as there are always one or more numbers between any two other numbers in the interval, then the interval (in our example, the interval between 1 and 2) is "continuous." As Aristotle had put it in yet another of his deceptively dull definitions, "That which a changing thing, if it changes continuously in a natural manner, naturally reaches before it reaches that to which it changes last, is 'between.'"[6] The real numbers are "continuous" because, given any two, regardless of how small the difference between them, there is always another "between." Dedekind had defined the numerical meaning not only of continuity but of the very concept of between.

The Dedekind Cut solved a host of problems and seemed vastly to advance the positivist program in the area of number theory; but new and even deeper problems arose from it almost immediately, and before long Dedekind himself was trying to solve them. Weierstrass had based calculus on number and Dedekind had discovered what numerical continuity meant. But what was a number anyway? Besides, if the class of all whole numbers was infinite, how could one be sure of the characteristics of "all" of them? And even if you grant that any number can be generated by arithmetical operations, or that most arithmetical operations can be reduced to some kind of addition, just what in the world is addition? These questions that only a mathematician might ask were the ultimate challenge to the positivist attitude. Consistent answers could banish metaphysics and Kantian intuition from the very groundwork of mathematics and, a fortiori, of science itself. This, in fact, is the enterprise in which Dedekind was joined by Cantor.

Georg Ferdinand Ludwig Philipp Cantor, born in 1845, was a member of the most materialist generation Europe had yet seen. Nevertheless, he turned out to be a poor positivist who believed not only in intuition but in God. A devout Lutheran, Cantor became convinced when he discovered infinite cardinal numbers that God had revealed them to him. Like Nietzsche he eventually went mad, but between 1872 and 1897 he

almost singlehandedly created the theory of sets and the arithmetic of infinite numbers, cabalistic giants of the mathematical imagination to which Cantor gave names based on the first letter, *aleph*, of the Hebrew alphabet. Cantor's first paper of 1872 reached Dedekind on March 20, as he was sending the last parts of *Stetigkeit und irrationale Zahlen* to the printer. "I find," he wrote, "on a hasty perusal, the axioms given in Section II of that paper, aside from the form of the presentation, agrees with what I designate in [my] section III as the essence of continuity."[7]

Cantor had been a student of Karl Weierstrass in Berlin until 1866. From him he had learned the "arithmetization of analysis," the centrality of number, and the rigorous requirements of proof that constituted Berlin mathematical positivism. Cantor never lost the contempt for infinitesimals he had learned in Berlin, calling them "nonsense . . . a cholera bacillus in mathematics"[8] long after he had discovered something far stranger—the "transfinite" numbers and the arithmetic of the infinitely large. Weierstrass had eliminated the "infinitesimal" changes and unspecifiable functional values on which calculus depended by defining them as restricted to an "interval" of real numbers (or a "domain" of points) whose bounds were "arbitrarily small". It was this new doctrine (since Weierstrass published very little) that Cantor explained to his colleague Heine, who then drew on it for his own paper, "The Elements of Function Theory."[9] Since the world of mathematics was (and still is) small, we are not surprised to find Dedekind "confirmed" in his decision to publish his *Continuity* by the appearance of Heine's paper.

The relationship of Cantor and Dedekind, begun in 1872, would end only with the death of Dedekind many years later. In the summer of 1874 they finally met, in Interlaken, Switzerland, where Cantor had gone on his honeymoon. To the Cantors, who were eventually to have four daughters and two sons, Dedekind remained a bachelor uncle, "taken care of" by his sister Julie, a novelist, in a then unremarkable Victorian arrangement. In 1899, Teubner's *Calendar for Mathematicians* reported that Dedekind had died on September 4. Dedekind responded by writing to the editors that they must have been exaggerating, that he had been having lunch that day with his "honored friend" Cantor and talking shop.[10] In fact Dedekind did not die until 1916, and Cantor a year later. In the course of their long friendship, their work was to convulse mathematics and even revolutionize philosophy.

The paper Cantor sent to Dedekind, titled "On the Consequences of a Theorem in the Theory of Trigonometric Series," did not seem that consequential. It set forth a way to relate the infinite trigonometric series for which Cantor had, in 1870, found a uniqueness theorem, to irrational numbers and to the totality of points in one of those Weierstrass intervals. It seemed to Cantor that there was not just one infinite set or space of points (*Punktmenge* or *Punktmannigfaltigkeit*) within which solutions