HOW THE UNCONSCIOUS SHAPES MODERN SCIENCE

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. . . it still strikes me myself as strange that the case histories I should write should read like short stories and that, as one might say, they lack the serious stamp of science. I must console myself with the reflection that the nature of the subject is evidently responsible for this, rather than any preference of my own.

— Sigmund Freud, Studies on Hysteria

The great experiment in coercive social engineering that became the Soviet empire began with a striking slogan, now as forgotten as the red flag of the Soviet Union: "From each according to his abilities, to each according to his needs." The experiment was a failure, but the slogan contains an objective worth our attention. A future in which each of us got what we needed and gave what we were able would surely be a place where those whose skills and training led them to the medical sciences would be giving the rest of us a more equitable and realistic version of medicine than the one we live with today. But just as surely we will never reach that future, nor any other more desirable one, until everyone — scientists, doctors, and the rest of us — understand the particular needs of scientists and doctors themselves and decide to try to meet their special needs in turn.

Everyone alive needs to make some sense of life, to give it some meaning. The doctors and scientists who created today's medicine and who will create tomorrow's share this need. In that, they are no different from anyone else. There is a difference, though, in what they know, and that difference makes the task of giving meaning to life much more difficult for them than it might be for anyone less aware of certain facts of life.

In the past century scientists and doctors have made four interlocking discoveries that have made the task of finding meaning much more difficult. The oldest discovery has had the deepest impact: it is that DNA-based natural selection generates life in all its diversity and orderliness — including a scientist with a brain of great capacity to understand life's structures and functions — while, by itself, natural selection contains no element of design nor purpose.

The second discovery concerns the mind. Scientists have shown that the conscious mind is the product of cells in the brain, an expression of the capacity of genes in these brain cells to respond to the outside world as well as to selectively recalled memories of earlier interactions with it. Third, they have found that the brain that does this is a tissue made of cells like any other tissue, albeit one that can imagine it has — or is — an ineffable, nonmaterial soul. And most painful of all, they have found that the entropic tendency of large and complicated structures to degrade into smaller ones assures that death — including the death of the inner voice we each hear when there is no one else in the room — is irreversible.

Together these discoveries paint a coherent and clear picture of the living world and of our place in it that is notable for its complete lack of meaning. Everyone who learns of these discoveries has the double task of finding a way to accept them, despite their cumulative power to exclude design and purpose from the living world, and of helping to assure that the science of the future will be made by men and women who have found meaning in their lives despite these facts of nature.

It will not be easy. Scientists cannot simply avoid these discoveries, as so many of the rest of us do. Many aspects of today's medicine are based on precisely these discoveries, which is why medicine has come to reject any larger meaning or purpose to life beyond the workings of genes and the capricious choices of natural selection. Yet one must — or at least I think one must — see life as more meaningful than that if one is to lead a life worth living. The alternative — an unconscious rejection of one or all of these facts of life, along with grandiose promises to find a way to conquer death itself — has not worked. The reason lies in the way we are made.

Memories begin in earliest childhood. An infant's consciousness emerges as an activity of its developing brain as the infant deals with all the aspects of a new world, including those that generate strong, even unbearably strong, feelings. The brain of a very young infant includes a repository of such unconscious memories, gathered while a newborn's consciousness is but a buzzing blur, when it still depends entirely on its parents and before it can express its own feelings through language. These first years of life contain a paradox no infant can avoid. In all that time — and for some time after — the adults responsible for its well-being hold absolute authority over it; without them the infant is alone, hungry, and miserable, yet it cannot articulate its needs and fears.

In the normal course of events, adults will help it to grow by providing it with opportunities for independence and autonomy. Paradoxically, such demonstrations, intended as acts of nurturing and love, may be felt as terrible losses: how much better it would be to have one's every need immediately satisfied than to learn to be weaned to a bottle and a schedule. As a result, deep feelings of fear and anger are directed at parents in response to a late breast or bottle, a hug not forthcoming, or a harsh voice. In dealing with such situations, an infant's emotionally rich but inarticulate mind can reach full consciousness only by passing through an extended period of deeply felt but inarticulate emotional conflict, simultaneously hating and loving the authority on which its life depends.

Such ambivalence prefigures the awkward and painful way many of us deal with similar conflicts in adult life. We are reliving our earliest experiences when we deny that we have feelings of hatred toward someone in authority or when we convert the unacceptable love or hate we feel toward a person into the notion that the person feels this way about us — or when we do the reverse, acting as if we felt toward someone the way we wished someone felt toward us. By exercising these three survival mechanisms of the very young mind — denial, projection, and introjection — we discover how to put away the pain of our real feelings, how to show a cooler, calmer face to the world than we actually feel.

When all three mechanisms fail and a painful early memory threatens, consciousness has one further defense against full exposure to its painful affect: fantasy. We all create fantasies of control, fantasies in which we have found ways to prevent the loss of love, the loss of our body's integrity, the loss of self, or, most dramatically, the loss of both self and of all loved objects we consciously realize must accompany our own

death. Unlike the repressed memories that engender them, fantasies can emerge into consciousness: as dreams when we are asleep or as daydreams when we are awake. Dreams and daydreams are conscious outcroppings, processed versions of the unconscious fantasies we create to fend off our worst memories. When a daydream is not sufficient to contain an inexpressible wish, the wish may also bring about specific behaviors — obsessions — whose purpose is to fulfill it. Obsessions may be trivial — the need, for example, to wear a certain article of clothing at special times — but they are vested with enormous emotional weight.

The interaction between repressed memory and conscious perception is complicated by the way bits of unconscious memories break off and float up into consciousness as dreams, daydreams, and obsessions. The mind of a person who is fully awake, able to easily recall some pleasant moments from the past and equally good at not recalling a host of other, particularly unpleasant memories but unable to prevent them from surfacing as dreams, is experiencing many different internal times at once. Like certain genes that are expressed early in one tissue, later in another, and never at all in the germ line's frozen developmental clock, at least some of our earliest memories seem quite free from the constraints of objective time, both in their unconscious storage and in the way fantasies and daydreams recall them to consciousness.

About a century ago, a close examination of the ambiguities of time in the content of dreams and daydreams led the Viennese physician and experimental psychologist Sigmund Freud to the clinical methodology he called psychoanalysis. From his clinical observations, he came up with a series of models of the mind that included — for the first time — an unconscious component to all mental functions, including the rational ones that seemed least likely to have any relation to the unremembered past. The strategies of psychoanalysis subsequently devised through trial and error by Freud and his followers have acquired a certain mystical patina. Actually, psychoanalysis is rather straightforward.

It is based on the clinical observations that talking and listening carefully to a person's unguarded ramblings can help him to safely and reproducibly bring painful and embarrassing memories out of repression into consciousness; as careful and reflective conversation bring these memories to consciousness, it also uncovers the hidden emotional connections between current and past difficulties. The purpose of this exercise in memory recall is also straightforward in clinical terms: to help a person to learn how to release the past's control of present emotions, actions, and beliefs. Once the underlying emotional connection of the past with the present is understood, the emotional content of the current difficulty — now understood in terms of earlier events — can in many cases be brought under conscious control.

Psychoanalysis reconfigured the meaning of childhood memory for all time. In the analytic model, an infant grows into full consciousness as it learns to balance perceptual information from the outside world with remembered emotional affects and conditioned habits. Full self-awareness requires merging memories with each new experience. Some memories reach consciousness easily, others — particularly of experiences or fantasies too painful, embarrassing, or threatening to consciously bear — are either repressed and remain unconscious or they reach consciousness in masked ways that lead to otherwise inexplicable behaviors.

The notion that a person's destructive, self-defeating behaviors and disturbing dreams may be conscious manifestations of otherwise repressed and unconscious impulses gave childhood itself an altogether new and somewhat ominous aspect. Many

turned away from psychoanalysis deeply offended, and some still do. Disconcerting though it may be to them, and to anyone else who still dreams of an innocent childhood, the psychoanalytic narrative of the mind has withstood almost a century of scrutiny, and it remains a viable way to reach a deeper understanding of one's behavior as well as a clinically useful tool to understand, predict, and help to alleviate various self-destructive behaviors.

Psychoanalysis spent its own childhood in fin de siècle Vienna, and memories of that time and place permeate the model. Its map of the mind, with its conscious and unconscious portions and its border-crossing filters, began as a clinical protocol that depended on the oddities of the analytic conversation — slips, pauses, free associations, and descriptions of daydreams and nightmares. Some of its earliest presumptions — that a girl is little different from a boy without a penis, for instance — are likely to be based on some unexamined repressions of middle-aged, middle-class men of the late nineteenth century. Despite these self-referential flaws, Freud and the other early analysts drew on a solid nineteenth-century knowledge of the brain's anatomy in mapping the realms of conscious and unconscious thought, and the boundary between them, as the products of an inner trinity of contesting, unconscious mental states: the id, the superego, and the ego. The unconscious ego is the part of the Freudian psyche whose conscious manifestation is a grown person's sense of himself or herself; the unconscious id is the reservoir of all motivation, however irrational; and the unconscious superego is the memory of idealized authority, setting the standard of allowable thought and behavior.

The Freudian unconscious of ego, id, and superego do not map completely to current diagrams of the functional anatomy of the brain, but unconscious matters of hunger, sexual desire, aggression, and fear occupy portions of the inner brain, while outer, cortical regions of the brain — especially the cortical regions behind the forehead — deal with conscious ego-like matters of subjective thought, abstraction, language, and planning. The unconscious superego's world of values, rules, standards, goals, rewards, and punishments is least centered.

The first data systematically demonstrating that the unconscious repression of difficult memories was an aspect of normal brain function came from studies of survivors of head wounds. Working to understand and help brain-damaged soldiers and civilians, the Russian psychiatrist Alexandr Luria was able to partially align the analytic model of the mind with the anatomy of the brain. His most dramatic conclusion was that the normal brain was indeed functionally as well as anatomically divided into inner and outer parts. The centers of the inner brain were concerned with unconscious processes, affects, and memories; the centers of the outer brain carried out abstract conscious thought, perception of the outer world, directed action, and judgment; and at their boundary, a set of centers called the limbic systems carried out the balancing acts of bringing together the past and the present.

Luria's work, at the work of many others since then, has shown the repressive capacity of the mind — its ability to prevent certain memories and fantasies from reaching consciousness — and its ability to let these memories emerge in the form of fantasies and daydreams have an anatomical correlate in the limbic systems where the two brains and their worlds meet. Damage to one particular place on the boundary between the inner and outer brains, where the most frontal of the limbic centers meets the most internal portion of the frontal zones of the cortex, has a spectacular effect on the

place of dreams in a person's life: victims become unable to distinguish their dreams from reality. These lesions leave people in a permanent dream world, unable to tell whether what they see and hear is happening in the outside world or in their imagination. They suffer from "a constellation of vivacious dreams, hallucinations, confabulation and a breakdown of the distinction between thought and reality." In unaffected people, this portion of the brain must be constantly choosing among fantasy, unconscious memory, and current reality.

Each part of the brain thus contributes to the one inner voice of consciousness. Even the conscious act of learning from an event — the minimal unit of scientific observation — is the sum of at least four different kinds of neural activity taking place simultaneously in the two brains and in their shared limbic boundary. At the conscious level, the right cortical hemisphere of the outer brain internalizes the sensory experience of the event in terms of self-definition — what does this mean to me? — while the left cortical hemisphere retains the event cognitively, in language, as a set of facts and observations.

Simultaneously, the limbic system attaches an emotional affect associated with the event; the hippocampal memory retains a trace of both the event and the affect; while the hypothalamic regions of the inner brain generate their unconscious responses to the event. Of these various expressions of the brain's functional anatomy, someone doing mental work — a scientist analyzing her data, for instance — is consciously aware of only the first two.

The emotional affects and memories of the past will not be part of a scientist's conscious experience, but because they are registered as changes in brain circuitry, they necessarily will be part of each act of observing and understanding the natural world. Scientists may insist that no aspect of nature is hidden from them, but inevitably their own nature — the conscious manifestations of their unconscious fears and needs — shapes the questions they ask of nature and thus what they can discover about the body and the mind. With that in mind (so to speak), let us apply this empirical, clinical model of the relation between conscious thought and unconscious memory to the question of how the agenda of a science may keep unwanted unconscious memories from emerging to trouble the consciousness of its scientists.

The conscious part of science begins with an act of faith, the ancient Greek belief that the natural world works by mechanisms that we can understand, even though they may initially be hidden from view. Today, as in Democritus's time, science works within the Greek belief that despite the smallness of atoms, the largeness of the cosmos, the rapidity of atomic transmutation or chemical catalysis, and the imperceptible slowness of evolutionary change, the underlying reality of any aspect of nature will be consistent, understandable, and therefore knowable. Everyone who plays the game of science must come to it infused with the belief that the way the natural world works can be understood to any degree of detail by sufficiently clever experimental manipulation.

Since nature is clearly silent and uninterested in a scientist's curious faith, the first step toward understanding is for the scientist to come up with a hypothesis to explain how some natural phenomenon works. The hypothesis is then tested through experiments that compare its predictions to the actual behavior of nature. Good experiments must often use elaborate machinery, so science can be expensive. But a good experiment need not be complicated because it is never simply a set of measurements; it is a test of the usefulness of a figment of the imagination and a moment of risk and drama.

If experiments confirm a hypothesis — for why a ball bounces, a cell dies, the moon turns, or a muscle contracts — then the scientist must expand the range of tests to determine whether the hypothesis explains a little or a lot. As in backgammon, the stakes in science always go up; the game is never more risky than when a hypothesis proven right in a small corner of the natural world is tested in a bigger one. Each successive confirmation carries with it the obligation to push a hypothesis into ever-larger realms of nature by more extensive and subtler experiments. When — usually sooner than later — careful experimentation confounds a hypothesis, it has reached the limits of its usefulness, and it must be redrawn or withdrawn. One may think that a hypothesis that explained even a little would be treasured and preserved. But once a hypothesis has been bounded by contradiction, the faith of science demands that it be altered or entirely replaced so that the task of understanding nature more fully may go on. Solely on the conscious level, science is thus reduced to a mixture of ritual and game, complete with a game's obedience to its own rules, austere unworldliness, and willful naïveté.

The conscious part of science is what most scientists would insist is all there is to science: an agenda for understanding nature. However, based on what we know of some minds, we can expect that the minds of scientists and therefore perhaps even the mind of science — the communality of experience and motivation shared by most scientists — have both conscious and unconscious parts. Just as the conscious part of science is shaped by the set of simple and universal rules that govern the conscious activity of all scientists, engaging and pooling the efforts of many different people's conscious minds, the unconscious parts of the mind of science — in particular, the sciences that serve medicine — would be expected to emerge as fantasies and obsessions shared by scientists in these fields.

While the notion that scientists may share their unconscious fears and conscious fantasies, dreams, and myths may seem disingenuous, meaningless, or just plain silly, recall that until not too long ago, many serious observers thought it was disingenuous, meaningless, or silly to imagine that an individual brain might contain — within its biological functions — any individual mind at all. The early behaviorist assumption that the mind is an illusory, ineffable byproduct of the brain's mindless application of instinctive rules had to be set aside in light of what we now know about the brain's functional anatomy.

It is time to follow up on that conclusion, to set aside the notion that science can operate in the present moment without an unconscious component to its deliberations. Science is the product of the unconscious sources of imagination and introspection as much as it is the product of a set of rules. The emotions and memories shared by scientists in the same field are its inner voice, and there is no reason that these inner voices should not be dealing with the same unconscious, repressed memories as do any of a field's practitioners. The question is not whether but how the unconscious aspects of science, refracted in maturity through its methods, resurface in ways that deflect the course of science itself.

Taking into account what we now know about the mind's operations in the brain, we can predict that shared fantasies of science are likely to be built from early memories of scientists, especially memories storing very strong negative or positive limbic affects and ordinarily kept from consciousness by repression. Though science may seem at first remote from unconscious memory or conscious fantasy and obsessive behavior, it remains a human enterprise, and the fantasies of infancy are likely to be the

same, whatever a person's later career. When negative affects are dealt with in the same way by a group of people linked by language and culture, their shared fantasies can crystallize into a core of collective myth.

Every time biomedical scientists look at a piece of the human body through the lens of science, the lens becomes a mirror. What they see in it is at once familiar and completely strange. The human mind and body, but especially the mind and body of the scientist, become uncanny; the German word unheimlich best conveys the way each becomes more strange as it becomes better understood. This uncanny element of the life sciences derives from the fact that we can neither fully accept nor consciously and rationally even understand our own death.

Nature makes us mortal; surely that affects the behavior of every thinking person. For the scientist, what better way to reduce the feared figure of our own mortality than to make it our experimental material? This is a modern version of the original Greek notion of science, born in a world that did not distinguish between science and religion. The underlying myth of science concerns one of their immortal but otherwise altogether human gods. Asklepios, the demigod of medicine, was the son of the immortal god Apollo and a human princess named Coronis. The centaur Chiron — a physician of consummate medical skill who also happened to be an early human-horse recombinant hybrid — taught Asklepios the arts of medicine, and Asklepios became so skilled at healing that he was able to resurrect the dead. Hades, the immortal god who ruled the underworld, complained to Zeus, the father of the gods, that he feared the loss of future subjects if humans were no longer to die. Zeus's response — he killed Asklepios with a thunderbolt — explains our present mortality and leaves us with the fantasy that by rediscovering the skills of Chiron and Asklepios, we may yet one day escape death.

The rest of the myth as it has come down from the Greeks tells us that Apollo, the immortal god of song and light, took such offense at this act of Zeus that he slew the Cyclopes, the makers of Zeus's thunderbolts, in revenge. Revenge, however, came too late to help poor mortals then or now. This myth and the hope it expresses have survived for thousands of years longer than any of the gods it describes. Despite all the rewards of scientific understanding, Apollo — science itself — has not yet overcome mortality. But we all vest the same hope in Asklepios — consciously or unconsciously — just as the Greeks did each time we visit the doctor.

The original Greek myth is alive not only in the minds of patients; it also lives in the minds of many doctors and scientists. Sometimes a great scientist will let the dream of Asklepios surface, allowing it to peek out from behind that other ancient Greek mask, the rationality of science. For instance, in his autobiography, the French Nobel laureate François Jacob is ostensibly discussing what it feels like to carry out a series of experiments, and the American Nobel laureate Arthur Kornberg is writing an editorial explaining why the scientific endeavor is unique among human activities, when both emerge with unexpected confessions of faith:

Jacob: "And with this idea that the essence of things, both permanent and hidden, was suddenly unveiled, I felt emancipated from the laws of time. More than ever, research seemed to be identified with human nature. To express its appetite, its desire to live. It was by far the best means found by man to face the chaos of the universe. To triumph over death!"

Kornberg: "The ultimate scientific languages used to report results are international, tolerate no dialects, and remain valid for all of time. . . . Science not only enables the scientist to contribute to the progress of grand enterprises, but also offers an endless frontier for the exploration of nature."

Only faith or obsession — if they are not the same — can expect a method for observing nature to give a vision of endlessness or of triumph over death. Hyperbole like Jacob's may be intended or read as metaphysical metaphor, but the underlying fantasy remains clearly expressed: omnipotence of thought will bring immortality. This notion does not stand up to rational analysis; that is why the conscious, operational agenda of science masks the fantasy in Kornberg's "endless frontier," the cloak of institutional immortality. But institutional immortality itself, born from the unconscious will that one's name not be scattered, is just a different version of the same fantasy, an ancient impulse not limited to the sciences.

Myths of immortality — personal or institutional — distort scientists' conscious behavior. They steer the game of science in directions that have less utility than the scientists themselves may believe but that point away from an explicit confirmation of the underlying fears that create these myths. The uncanny familiarity of death, always on the threshold of being rediscovered by the rules of science, obliges scientists unconsciously to subvert the rules of their game, turning away from some of their most important discoveries.

The denial of the fear of nature's terrible power of mortality, the projection of the suppressed wish not to die into a vision of nature as capable of bestowing immortality; these are the marks of a masked unconscious creating a biomedical science at war with its own stated purposes. When scientists say "give us your bodies, and we will cure you," they have found a way to deal with an otherwise unbearable ambivalence toward their own experimentally vulnerable existence. They protect themselves, not necessarily by curing anyone, but by gaining control of someone else's body if not their own. Freud, incidentally, recognized this role of medical science as the one "higher superstition" he himself believed in.

In its disciplined way of looking at the natural world, science requires its practitioners to act as if they were observers, not participants. The first and last scientific instrument, the one that must be used in every experiment, is the scientist's brain; scientists who choose the human body and mind as their playing field cannot fully meet this requirement without dislodging themselves from their own bodies and minds. The strain of trying to meet a standard of dispassionate curiosity without flying into pieces imposes an irrational gap between the student of the brain and the brain of the student, between the scientist and his or her body and mind. To deal with the emergence of this intolerable thought, medical scientists have created the myth that their instruments and procedures somehow free them from the boundaries of their minds and bodies. This is the myth of absolute rational control of the physician and scientist over their material, the notion that the metaphor of scientist as sculptor will not break down even when the sculptor and the sculpture are one and the same. This myth may work to keep thoughts repressed, but at the cost of requiring the belief in an invented, institutional immortality based on the dry fact of precedence.

Every discovery must have at least one discoverer, and many have more than one. As competing sculptors may race to clear the excess stone from blocks of marble to reveal their different visions of what lay hidden inside, competing scientists clear away

layers of plausible models, racing to uncover a demonstrably accurate schematic explanation of a part of the natural world's inner workings. Consciously and conscientiously followed, these rules work; they permit at least some scientists to uncover the mechanisms and structures of the natural world, and they do permit a few to win the game.

The dream of winning takes on an obsessive quality in the medical sciences, where the subject of scientific study is the mind and body and the reality of mortality becomes unavoidable. The result is an obsessive hope: that a big enough win in the game of science will confer a form of immortality on the winner. Discoveries that set the agenda for the future work of a large group of other scientists do this after a fashion, permanently associating a scientist's name with an aspect of nature. Think of the Freudian slip and the Watson-Crick model of DNA. Players in a game that can confer even this sort of immortality — however rarely — cannot be playing only for conscious stakes. In the medical sciences, the belief in winning immortality of this sort can become problematic when it supports the denial of an unpleasant biological reality, especially when that reality emerges from precedent-setting discoveries themselves. It is not that science and medicine wish to avoid finding cures. It is that they are too strongly motivated by an irrational, unconscious need to cure death to be fully motivated by the lesser task of preventing and curing disease simply to put off the inevitable end of their patients' lives and, by extension, their own.

No scientist — nor any science, no matter how rich or creative — has time to look at all the data that all possible experiments may generate; it would be a form of madness as well for any single scientist to examine all the data — all the memories and feelings and perceptions — of his own brain, bypassing the filter that keeps much of it unconscious. Instead, every science chooses selectively all the time, and with each choice some data are precisely not gathered, let alone examined. Choices are necessary, and it is at the moment when choices are made that the scientific method departs from the wholly conscious tool of scientific experimentation and enters the human world in which all choices are made in a personal and social historical context, replete with emotional affects and barely remembered feelings.

There is a way for the life sciences to end their denial of their own unconscious, freeing it from the obfuscations and inefficiencies it creates today out of its own fantasies. An enlightened medical science would acknowledge that there are limits to conscious thought and to life itself that cannot be transcended by any rational agenda. It would then be able to stop making promises that it cannot keep, whether to itself or to the rest of us who pay its way. Having next acknowledged the unconscious memories of its practitioners and the shared fantasies they have generated, it would then be ready to find ways to diminish the influence of these fantasies on its conscious agendas.

For example, the denial of mortality is often accompanied by the denial of another aspect of the human genetic birthright: we are intrinsically social beings. The mind is the product of social interactions; there would not be enough DNA in the world to encode a single mind. From birth on, minds develop in brains by the imitation of other minds, partly but not solely the minds of biological parents. Most of the few behaviors wired into our genes at birth maintain and thicken the bonds through which this imitation can proceed. The current biomedical model of a person as an autonomous object lacks a proper respect for these social interactions. It severs the patient from family and social context, and it devalues preventive — social — medicine to an afterthought or a charity.

This denial of the reality of the social bond, like the denial of mortality, is an avoidable mistake of science. These and other strains that have opened between scientific medicine and society are not simply matters of resource allocation. They are signs that the knowledge of death and the need for others in one's life cannot be suppressed any longer, that the dreams of science are no longer satisfying even the dreamers.

In the United States the costs of medical care for eighty-four percent of the people is rapidly closing on a trillion — a million times a million — dollars each year, with no satisfactory national commitment to deliver it to the remaining sixteen percent. It is unlikely that the two intertwined mistakes of today's medical science can be corrected without a renewal of interest in preventive medicine. But what is to be prevented? Prevention has two meanings, depending on what is meant by a healthy person. If health is given a functional definition — you're healthy if you are free to work and think and play to the best of your born abilities — then preventive medicine — in the form of a vaccine, for instance — simply lowers the risk of developing a disease later in life. If, on the other hand, one imagines there is an ideal of human form and function to which we all must aspire, then preventive medicine takes on a different, perhaps alluring, but in the end sinister purpose: the elimination of avoidable deviation from this ideal.

Neither the economic pressure to reduce costs nor the new technologies developed through molecular biology will determine which definition of prevention sets policy. Physicians have already begun to take on the role of gatekeepers, inadvertent agents of selection, eugenicists manqué, deciding on the relative value of different human lives. Should that become even more common, definitions of disease will once again become less a matter of biology than of politics.

Scientists must accept the validity of their own inner voices and see their research as an expression of their innermost feelings. This will be difficult, but it is not impossible. In a sense, it is just an extension inward of the fundamental methods of science. The great physicist Richard Feynman of Cal Tech saw the possibility as an obligation:

"It is our responsibility as scientists, knowing the great progress which comes from a satisfactory philosophy of ignorance, the great progress which is the fruit of freedom of thought, to proclaim the value of this freedom; to teach how doubt is not to be feared but welcomed and discussed; and to demand this freedom, as our duty to all coming generations."

Today, few scientists accept this obligation, and the public knows it. The popular vision of scientists as white-coated practitioners of a pagan religion is grounded in an understandable uneasiness about the way many scientists present themselves, obeying only their own arcane rules. I first saw the need for scientists to do better when I was an undergraduate. Though I was majoring in physics at Columbia in the late 1950s, I tagged along with my friends to literature classes taught by Lionel Trilling. He was a distant, somewhat foggy creature to me, since he dragged constantly on his cigarettes, and I always wound up at the back of one or another very smoke-filled room. Nevertheless, I knew he was serious about the books he taught, and serious about the world, because an overlap of concerns — the text and the world — marked Trilling's teaching. Even though he sometimes claimed to be interested solely in the words of the text, the world could not keep from informing his interpretations. My colleague Edward Said caught this

twenty years ago, in this quote from an article about Said's book Orientalism: "In a recent interview [Said] cites with approval Lionel Trilling's assertion that `there is a mind of society' and argues that it is this mind that the critic should `address, tutor, doctor, inform, evaluate, criticize, reform.'"

The notion of a "mind of society" ought to be entirely congenial to scientists. The imagination of a scientist creates a vision of one aspect of the natural world, usually of the world outside the mind, but sometimes an aspect of the mind itself. But that vision is never enough: physical action — experimentation — weighs in immediately to test the model. This back-and-forth of theory and practice works because in science the imagination must either yield to, or encompass, the results of experiment. There is no room in science for empty speculation nor for its complement, the cynical despair we find in so much of today's critical theory.

While the narratives of successful science — discoveries, we call them — are bounded by culture no less than any other narrative, the models they stem from, confirm, and alter are not. These models, the most recently adapted, current working hypotheses of science, float above all their previous narrative versions, persisting through time, never final. We live by such models because they mold the patterns of our thought. In Hamlet's soliloquies, Shakespeare gave us our way of seeing ourselves as having inner voices and developing through inner dialogue. In a similar way, the sciences continue to give us new and sometimes precarious perspectives from which to see ourselves. These, in time, become as completely taken for granted as the Shakespearean notion of a private monologue. In just this way Freud's unconscious and Darwin's natural selection have not merely been added to our vocabulary. They have become aspects of the way we understand ourselves; it is left for scientists to learn that these insights of self-understanding apply to them as well.

I first read Dante's Inferno in a general education course at Columbia in 1958. A while ago I returned to it, reading Robert Pinsky's new translation with great pleasure. The Inferno is about many things; but to me, it was and still is, above all, an extraordinary example of the power of words to transcend death. Dante meets the damned souls of hell and has the audacity to promise they will have eternal life on Earth if they will allow him to write their stories. They tell him their stories, he writes them out brilliantly, and, after seven hundred years, we still read those stories.

In Canto 31, scientists meet themselves face-on. At the bottom of the last circle Dante sees, in the distance, a Stonehenge of monstrous, missile-like towers. Thinking these to be the Giants of Genesis surrounding the very pit of Hell, he says to us in a parenthetical aside:

(Nature
indeed, When she
abandoned making these
animals,
Did well to keep
such instruments from
man;
Though she does not repent
of making whales
Or elephants, a person who
subtly inquires
Into her ways will find her
both discrete

And just, in her decision: if
one confers
The power of the mind,
along with that
Of immense
strength, upon an evil will
Then people will have no
defense from it.)

I have no doubt there will continue to be moments when a science unable to plumb its own unconscious fears and dreams will indeed leave people with no defense from an evil will. It is hard to learn, and then hard to believe, that death is inevitable regardless of the efforts of science. There is a tendency among scientists to respond to this knowledge by withdrawing into themselves, closing the world off by peer review, yet not withdrawal but action is needed. The task that remains, then, is to convert this knowledge into actions of a sensible, honest, and honorable sort, actions consistent with the limitations of science that bring science to its very limits, making it do its best to extend our lives.