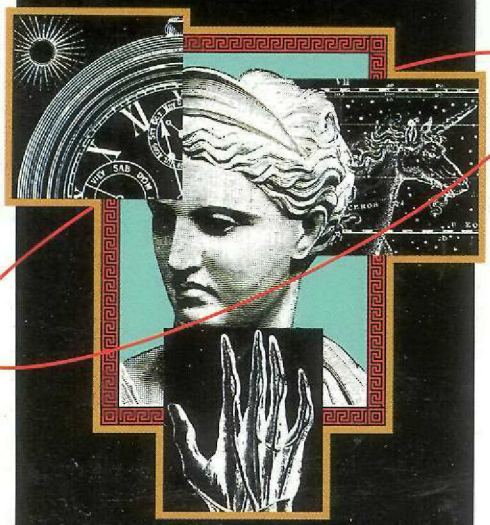
DESCARTES' ERROR



Emotion, Reason, and the Human Brain

"Antonio Damasio is a profound thinker and an elegant writer... *Descartes' Error* is a fascinating exploration of the biology of reason and its inseparable dependence on emotion."
—Oliver Sacks, author of *An Anthropologist on Mars*

ANTONIO R. DAMASIO

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Emotion, Reason, and the Human Brain

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A Passion for Reasoning

AT THE BEGINNING of this book I suggested that feelings are a powerful influence on reason, that the brain systems required by the former are enmeshed in those needed by the latter, and that such specific systems are interwoven with those which regulate the body.

The facts I have presented generally support these hypotheses, but these are hypotheses nonetheless, offered in the hope that they may attract further investigation and be subject to revision as new findings appear. Feelings do seem to depend on a dedicated multicomponent system that is indissociable from biological regulation. Reason does seem to depend on specific brain systems, some of which happen to process feelings. Thus there may be a connecting trail, in anatomical and functional terms, from reason to feelings to body. It is as if we are possessed by a passion for reason, a drive that originates in the brain core, permeates other levels of the nervous system, and emerges as either feelings or nonconscious biases to guide decision making. Reason, from the practical to the theoretical, is probably constructed on this inherent drive by a process which resembles the mastering of a skill or craft. Remove the drive, and you

will not acquire the mastery. But having the drive does not automatically make you a master.

Should these hypotheses be supported, are there sociocultural implications to the notion that reason is nowhere pure? I believe that there are, and that they are by and large positive.

Knowing about the relevance of feelings in the processes of reason does *not* suggest that reason is less important than feelings, that it should take a backseat to them or that it should be less cultivated. On the contrary, taking stock of the pervasive role of feelings may give us a chance of enhancing their positive effects and reducing their potential harm. Specifically, without diminishing the orienting value of normal feelings, one would want to protect reason from the weakness that abnormal feelings or the manipulation of normal feelings can introduce in the process of planning and deciding.

I do not believe that knowledge about feelings should make us less inclined to empirical verification. I only see that greater knowledge about the physiology of emotion and feeling should make us more aware of the pitfalls of scientific observation. The formulation I presented should not diminish our determination to control external circumstances to the advantage of individuals and society, or our resolve to develop, invent, or perfect the cultural instruments with which we can make the world better: ethics, law, art, science, technology. In other words, nothing in my formulation urges acceptance of things as they are. I must emphasize this point, since the mention of feelings often conjures up an image of self-oriented concern, of disregard for the world around, and of tolerance for relaxed standards of intellectual performance. That is, in effect, the very opposite of my view, and one less worry for those who, like the molecular biologist Gunther Stent, have been concerned, justly, that the overvaluing of feelings might result in less determination to uphold the Faustian contract that has brought progress to humanity.[1]

What worries me is the acceptance of the importance of feelings without any effort to understand their complex biological and sociocultural machinery. The best example of this attitude can be

found in the attempt to explain bruised feelings or irrational behavior by appealing to surface social causes or the action of neurotransmitters, two explanations that pervade the social discourse as presented in the visual and printed media; and in the attempt to correct personal and social problems with medical and nonmedical drugs. It is precisely this lack of understanding of the nature of feelings and reason (one of the hallmarks of the "culture of complaint"[2]) that is cause for alarm.

The idea of the human organism outlined in this book, and the relation between feelings and reason that emerges from the findings discussed here, do suggest, however, that the strengthening of rationality probably requires that greater consideration be given to the vulnerability of the world within.

On a practical note, the role outlined for feelings in the making of rationality has implications for some issues currently facing our society, education and violence among them. This is not the place to do justice to these issues but let me comment that educational systems might benefit from emphasizing unequivocal connections between current feelings and predicted future outcomes, and that children's overexposure to violence, in real life, newscasts, or through audiovisual fiction, downgrades the value of emotions and feelings in the acquisition and deployment of adaptive social behavior. The fact that so much vicarious violence is presented without a moral framework only compounds its desensitizing action.

DESCARTES' ERROR

It would not have been possible to present my side of this conversation without invoking Descartes as an emblem for a collection of ideas on body, brain, and mind that in one way or another remain influential in Western sciences and humanities. My concern, as you have seen, is for both the dualist notion with which Descartes split the mind from brain and body (in its extreme version, it holds less sway) and for the modern variants of this notion: the idea, for instance, that mind and brain are related, but only in the sense that

the mind is the software program run in a piece of computer hardware called brain; or that brain and body are related, but only in the sense that the former cannot survive without the life support of the latter.

What, then, was Descartes' error? Or better still, *which* error of Descartes' do I mean to single out, unkindly and ungratefully? One might begin with a complaint, and reproach him for having persuaded biologists to adopt, to this day, clockwork mechanics as a model for life processes. But perhaps that would not be quite fair and so one might continue with "I think therefore I am." The statement, perhaps the most famous in the history of philosophy, appears first in the fourth section of the *Discourse on the Method* (1637), in French (*"Je pense donc je suis"*); and then in the first part of the *Principles of Philosophy* (1644), in Latin (*"Cogito ergo sum"*).[3] Taken literally, the statement illustrates precisely the opposite of what I believe to be true about the origins of mind and about the relation between mind and body. It suggests that thinking, and awareness of thinking, are the real substrates of being. And since we know that Descartes imagined thinking as an activity quite separate from the body, it does celebrate the separation of mind, the "thinking thing" (*res cogitans*), from the nonthinking body, that which has extension and mechanical parts (*res extensa*).

Yet long before the dawn of humanity, beings were beings. At some point in evolution, an elementary consciousness began. With that elementary consciousness came a simple mind; with greater complexity of mind came the possibility of thinking and, even later, of using language to communicate and organize thinking better. For us then, in the beginning it was being, and only later was it thinking. And for us now, as we come into the world and develop, we still begin with being, and only later do we think. We are, and then we think, and we think only inasmuch as we are, since thinking is indeed caused by the structures and operations of being.

When we put Descartes' statement back where it belongs, we might wonder for a moment whether it might mean something different from what it has come to stand for. Might one read it

instead as an acknowledgment of the superiority of conscious feeling and reasoning, without any firm commitment as to their origin, substance, or permanence? Might the statement also have served the clever purpose of accommodating religious pressures of which Descartes was keenly aware? The latter is a possibility, but there is no way of finding out for sure. (The inscription Descartes chose for his tombstone was a quote that he apparently used frequently: *"Bene qui latuit, bene vixit,"* from Ovid's *Tristia* 3.4.25. Translation: "He who hid well, lived well." A cryptic disclaimer of dualism, perhaps?) As for the former, on balance, I suspect Descartes *also* meant precisely what he wrote. As the famous words first appear, Descartes is rejoicing with the discovery of a proposition so undeniably true that no amount of skepticism will shake it:

> . . . and remarking that this truth *"I think, therefore I am"* was so certain and so assured that all the most extravagant suppositions brought forward by the sceptics were incapable of shaking it, I came to the conclusion that I would receive it without scruple as the first principle of the Philosophy for which I was seeking.[4]

Here Descartes was after a logical foundation for his philosophy, and the statement was not unlike Augustine's *"Fallor ergo sum"* (I am deceived therefore I am).[5] But just a few lines below, Descartes clarifies the statement unequivocally:

> From that I knew that I was a substance, the whole essence or nature of which is to think, and that for its existence there is no need of any place, nor does it depend on any material thing; so that this "me," that is to say, the soul by which I am what I am, is entirely distinct from body, and is even more easy to know than is the latter; and even if body were not, the soul would not cease to be what it is.[6]

This is Descartes' error: the abyssal separation between body and mind, between the sizable, dimensioned, mechanically operated,

infinitely divisible body stuff, on the one hand, and the unsizable, undimensioned, un-pushpullable, nondivisible mind stuff; the suggestion that reasoning, and moral judgment, and the suffering that comes from physical pain or emotional upheaval might exist separately from the body. Specifically: the separation of the most refined operations of mind from the structure and operation of a biological organism.

Now, some may ask, why quibble with Descartes rather than with Plato, whose views on body and mind were far more exasperating, as can be discovered in the *Phaedo*? Why bother with this particular error of Descartes'? After all, some of his other errors sound more spectacularly wrong than this one. He believed that heat made the blood circulate, and that tiny, ever so fine particles of the blood distilled themselves into "animal spirits," which could then move muscles. Why not take him to task for either of those notions? The reason is simple: We have known for a long time that he was wrong on those particular points, and the questions of how and why the blood circulates have been answered to our complete satisfaction. That is not the case when we consider questions of mind, brain, and body, concerning which Descartes' error remains influential. For many, Descartes' views are regarded as self-evident and in no need of reexamination.

The Cartesian idea of a disembodied mind may well have been the source, by the middle of the twentieth century, for the metaphor of mind as software program. In fact, if mind can be separated from body, perhaps one can try to understand it without any appeal to neurobiology, without any need to be influenced by knowledge of neuroanatomy, neurophysiology, and neurochemistry. Interestingly and paradoxically, many cognitive scientists who believe they can investigate the mind without recourse to neurobiology would not consider themselves dualists.

There may be some Cartesian disembodiment also behind the thinking of neuroscientists who insist that the mind can be fully

explained solely in terms of brain events, leaving by the wayside the rest of the organism and the surrounding physical and social environment—and also leaving out the fact that part of the environment is itself a product of the organism's preceding actions. I resist the restriction, not because the mind is not directly related to brain activity, since it obviously is, but rather because the restrictive formulation is unnecessarily incomplete, and humanly unsatisfactory. To say that mind comes from brain is indisputable, but I prefer to qualify the statement and consider the reasons why the brain's neurons behave in such a thoughtful manner. For the latter is, so far as I can see, the critical issue.

The idea of a disembodied mind also seems to have shaped the peculiar way in which Western medicine approaches the study and treatment of diseases (see the postscriptum). The Cartesian split pervades both research and practice. As a result, the psychological consequences of diseases of the body proper, the so-called real diseases, are usually disregarded and only considered on second thought. Even more neglected are the reverse, the body-proper effects of psychological conflict. How intriguing to think that Descartes did contribute to modifying the course of medicine, did help it veer from the organismic, mind-in-the-body approach, which prevailed from Hippocrates to the Renaissance. How annoyed Aristotle would have been with Descartes, had he known.

Versions of Descartes' error obscure the roots of the human mind in a biologically complex but fragile, finite, and unique organism; they obscure the tragedy implicit in the knowledge of that fragility, finiteness, and uniqueness. And where humans fail to see the inherent tragedy of conscious existence, they feel far less called upon to do something about minimizing it, and may have less respect for the value of life.

The facts I have presented about feelings and reason, along with others I have discussed about the interconnection between brain and body proper, support the most general idea with which I intro-

duced the book: that the comprehensive understanding of the human mind requires an organismic perspective; that not only must the mind move from a nonphysical cogitum to the realm of biological tissue, but it must also be related to a whole organism possessed of integrated body proper and brain and fully interactive with a physical and social environment.

The truly embodied mind I envision, however, does not relinquish its most refined levels of operation, those constituting its soul and spirit. From my perspective, it is just that soul and spirit, with all their dignity and human scale, are now complex and unique states of an organism. Perhaps the most indispensable thing we can do as human beings, every day of our lives, is remind ourselves and others of our complexity, fragility, finiteness, and uniqueness. And this is of course the difficult job, is it not: to move the spirit from its nowhere pedestal to a somewhere place, while preserving its dignity and importance; to recognize its humble origin and vulnerability, yet still call upon its guidance. A difficult and indispensable job indeed, but one without which we will be far better off leaving Descartes' Error uncorrected.

Postscriptum

THE HUMAN HEART IN CONFLICT

"THE POET'S VOICE need not merely be the record of man, it can be one of the props, the pillars to help him endure and prevail."[1] William Faulkner wrote these words about 1950, but they are just as applicable today. The audience he had in mind was that of his fellow writers, but he might as well have been exhorting those of us who study the brain and the mind: The scientist's voice need not be the mere record of life as it is; scientific knowledge can be a pillar to help humans endure and prevail. This book was written with the conviction that knowledge in general and neurobiological knowledge in particular have a role to play in human destiny; that if only we want it, deeper knowledge of brain and mind will help achieve the happiness whose yearning was the springboard for progress, two centuries ago, and will maintain the glorious freedom that Paul Éluard described in his poem "Liberté."[2]

In the same text cited above, Faulkner tells his fellow writers that they have "forgotten the problems of the human heart in conflict

with itself, which alone can make good writing because only that is worth writing about, both the agony and the sweat." He asks them to leave no room in their workshops "for anything but the old verities and truths of the heart, the old universal truths lacking which any story is ephemeral and doomed—love and honor and pity and pride and compassion and sacrifice."

It is tempting and encouraging to believe, perhaps beyond Faulkner's meaning, that neurobiology not only can assist us with the comprehension and compassion of the human condition, but that in so doing it can help us understand social conflict and contribute to its alleviation. This is not to suggest that neurobiology can save the world, but simply that the gradual accrual of knowledge about human beings can help us find better ways for the management of human affairs.

For quite some time now, humans have been in a new, thoughtful phase of evolution, in which their minds and brains can be both servants and masters of their bodies and of the societies they constitute. Of course, there are risks when brains and minds that came from nature decide to play sorcerer's apprentice and influence nature itself. But there are also risks in not taking the challenge and not attempting to minimize suffering. There are, in fact, enormous risks in not doing anything. Doing just what comes naturally can only please those who are unable to imagine better worlds and better ways, those who believe they are already in the best of all possible worlds.[3]

MODERN NEUROBIOLOGY AND THE IDEA OF MEDICINE

There is something paradoxical about the conceptualization of medicine and about its practitioners in our culture. A number of physicians have interests in the humanities, from the arts to literature to philosophy. Some surprising number of them have become poets, novelists, and playwrights, of eminence, and several have reflected with depth on the human condition and dealt perceptively with its psychological, social, and political dimensions. And yet the medical

schools they have come from largely ignore those human dimensions as they concentrate on the physiology and pathology of the body proper. Western medicine, especially medicine in the United States, came to glory through the expansion of internal medicine and surgical subspecialties, both of which had as targets the diagnosis and treatment of diseased organs and systems throughout the body. The brain (more precisely, the central and peripheral nervous systems) was included in the effort since it was one such organ system. But its most precious product, the mind, was of little concern to mainstream medicine and, in fact, has not been the principal focus of the specialty that emerged from the study of brain diseases: neurology. It is perhaps no accident that American neurology began as a subspecialty of internal medicine and gained independence only in the twentieth century.

The net result of this tradition has been a remarkable neglect of the mind as a function of the organism. Few medical schools, to this day, offer their students any formal instruction on the normal mind, instruction that can come only from a curriculum strong in general psychology, neuropsychology, and neuroscience. Medical schools do offer studies of the sick mind encountered in mental diseases, but it is indeed astonishing to realize that students learn about psychopathology without ever being taught normal psychology.

There are several reasons behind this state of affairs, and I submit that most of them derive from a Cartesian view of humanity. For the past three centuries, the aim of biological studies and of medicine has been the understanding of the physiology and pathology of the body proper. The mind was out, largely left as a concern for religion and philosophy, and even after it became the focus of a specific discipline, psychology, it did not begin to gain entry into biology and medicine until recently. I am aware of commendable exceptions to this panorama, but they simply reinforce the idea I am giving of the general situation.

The result of all this has been an amputation of the concept of humanity with which medicine does its job. It should not be surprising that, by and large, the consequences of diseases of the body

proper on the mind are a second thought, or no thought at all. Medicine has been slow to realize that how people feel about their medical condition is a major factor in the outcome of treatment. We still know very little about the placebo effect, through which patients respond beneficially in excess of what a given medical intervention would lead one to expect. (The placebo effect can be assessed by investigating the effect of tablets or injections which, unbeknownst to the patient, contain no active pharmacological ingredient and are thus presumed to have no influence whatever, positive or negative.) For instance, we do not know who is more likely to respond with a placebo effect, or if all of us can. We also do not know how far the placebo effect can go and how close to the effect of the real thing it can get. We know little about how to enhance the placebo effect. And we have no idea about the degree of error the placebo effect has created for so-called double-blind studies.

The fact that psychological disturbances, mild or strong, can cause diseases of the body proper is finally beginning to be accepted, but the circumstances in which they can, and the degree to which they can, remain unstudied. Of course our grandmothers knew all about this: they could tell us how grief, obsessive worry, excessive anger, and so forth would damage hearts, give ulcers, destroy complexions, and make one more prone to infections. But that was all too "folksy," too "soft" as far as science was concerned, and so it was. It took a long time for medicine to begin discovering that the basis for such human wisdom was worth considering and investigating.

The Cartesian-based neglect of the mind in Western biology and medicine has had two major negative consequences. The first is in the realm of science. The effort to understand the mind in general biological terms has been retarded by several decades, and it is fair to say that it has barely begun. Better late than never, that is for sure, but the delay means also that the potential impact that a deep understanding of the biology of mind might have had in human affairs has so far been lost.

The second negative consequence has to do with the effective diagnosis and treatment of human disease. It is of course true that all

great physicians have been those men and women who are not only well versed in the hard-core physiopathology of their time, but are equally at ease, mostly through their own insight and accumulated wisdom, with the human heart in conflict. They have been expert diagnosticians and miracle workers, because of a *combination* of knowledge and talent. Yet we would be deluding ourselves if we thought that the standard of medical practice in the Western world is that of those notable physicians we all have known. A distorted view of the human organism, combined with the overwhelming growth of knowledge and the need for subspecialization, conspires to increase the inadequacy of medicine rather than reduce it. Medicine hardly needed the additional problems that have come from its economics, but it is getting those too, and they are certain to worsen medical performance.

The problem with the rift between body and mind in Western medicine has not yet been articulated by the public at large, although it seems to have been detected. I even suspect that the success of some "alternative" forms of medicine, especially those rooted in non-Western traditions of medicine, is probably a compensatory response to the problem. There is something to be admired and learned in those alternative forms of medicine, but unfortunately, regardless of how humanly adequate they may be, what they offer is not enough to deal effectively with human disease. In all fairness, we have to recognize that even mediocre Western medicine does solve a remarkable number of problems, quite decisively. But alternative forms of medicine do point to a blatant area of weakness in Western medical tradition that should be corrected scientifically, within scientific medicine itself. If, as I believe, the current success of alternative medicine is a symptom of public dissatisfaction with traditional medicine's inability to consider humans as a whole, then this dissatisfaction is likely to grow in the years ahead, as the spiritual crisis of Western society deepens.

The proclamation of bruised feelings, the desperate plea for the correction of individual pain and suffering, the inchoate cry for the loss of a never-achieved sense of inner balance and happiness to

which most humans aspire are not likely to diminish soon.[4] It would be foolish to ask medicine alone to heal a sick culture, but it is just as foolish to ignore that aspect of human disease.

A NOTE ON THE LIMITS OF NEUROBIOLOGY NOW

Throughout this book I have spoken about accepted facts, disputed facts, and interpretations of facts; about ideas shared or not shared by many of us in the brain-mind sciences; about things that are as I say, and things that may be as I say. The reader may have been surprised at my insistence that so many "facts" are uncertain and that so much of what can be said about the brain is best stated as working hypotheses. Naturally, I wish I could say that we know with certainty how the brain goes about the business of making mind, but I cannot—and, I am afraid, no one can.

I hasten to add that the lack of definitive answers on brain/mind matters is not a cause for despair, however, and is not to be seen as a sign of failure of the scientific fields now engaged in the effort. On the contrary, the spirit of the troops is high since the rate at which new findings are accruing is greater than ever. The lack of precise and comprehensive explanations does not indicate an impasse. There is reason to believe that we will arrive at satisfactory explanations, although it would be foolhardy to set a date for the arrival, and even more so to say that they are around the corner. If there is any cause for worry, it comes not from a lack of progress but rather from the torrent of new facts that neuroscience is delivering and the threat that they may engulf the ability to think clearly.

If we have this wealth of new facts, you may ask, why are definitive answers not available? Why can we not give a precise and comprehensive account of how we see and, more important, how there is a self doing that seeing?

The principal reason for the delay—one might even say the only reason—is the sheer complexity of the problems for which we need answers. It is obvious that what we want to understand depends largely on the operation of neurons, and we do have a substantial

knowledge about the structure and function of those neurons, all the way down to the molecules constituting them and making them do what they do best: fire, or engage in patterns of excitation. We even know something about the genes that make those neurons be and operate in a certain fashion. But clearly, human minds depend on the overall firing of those neurons, as they constitute complicated assemblies ranging from local, microscopic scale circuits to macroscopic systems spanning several centimeters. There are several billion neurons in the circuits of one human brain. The number of synapses formed among those neurons is at least 10 trillion, and the length of the axon cables forming neuron circuits totals something on the order of several hundred thousand miles. (I thank Charles Stevens, a neurobiologist at the Salk Institute, for the informal estimate.) The product of activity in these circuits is a pattern of firing that is transmitted to another circuit. This circuit may or may not fire, depending on a host of influences, some local, provided by other neurons terminating in the vicinity, and some global, brought by chemical compounds such as hormones, arriving in the blood. The time scale for the firing is extremely small, on the order of tens of milliseconds—which means that within one second in the life of our minds, the brain produces millions of firing patterns over a large variety of circuits distributed over various brain regions.

It should be clear, then, that the secrets of the neural basis of mind cannot be discovered by unraveling all the mysteries of one single neuron, regardless of how typical that neuron might be; or by unraveling all the intricate patterns of local activity in a typical neuron circuit. To a first approximation, the elementary secrets of mind reside with the interaction of firing patterns generated by many neuron circuits, locally and globally, moment by moment, within the brain of a living organism.

There is not one simple answer to the brain/mind puzzle, but rather many answers, keyed to the myriad components of the nervous system at its many levels of structure. The approach to understanding those levels calls for various techniques and proceeds at various paces. Some of the work can be based on experiments in

animals and tends to develop relatively fast. But other work can be carried out only in humans, with the appropriate ethical cautions and limitations, and the pace must be slower.

Some have asked why neuroscience has not yet achieved results as spectacular as those seen in molecular biology over the past four decades. Some have even asked what is the neuroscientific equivalent of the discovery of DNA structure, and whether or not a corresponding neuroscientific fact has been established. There is no such single correspondence, although some facts, at several levels of the nervous system, might be construed as comparable in practical value to knowing the structure of DNA—for instance, understanding what an action potential is all about. But the equivalent, at the level of mind-producing brain, has to be a *large-scale outline of circuit and system designs,* involving descriptions *at both microstructural and macrostructural levels.*

Should the reader find that the above justifications for the limits of our current knowledge seem insufficient, let me note two more. First, as I previously indicated, only a part of the circuitry in our brains is specified by genes. The human genome specifies the construction of our bodies in great detail, and that includes the overall design of the brain. But not all of the circuits actively develop and work as set by genes. Much of each brain's circuitry, at any given moment of adult life, is individual and unique, truly reflective of that particular organism's history and circumstances. Naturally, that does not make the unraveling of neural mysteries any easier. Second, each human organism operates in collectives of like beings; the mind and the behavior of individuals belonging to such collectives and operating in specific cultural and physical environments are not shaped merely by the activity-driven circuitries mentioned above, and even less are they shaped by genes alone. To understand in a satisfactory manner the brain that fabricates human mind and human behavior, it is necessary to take into account its social and cultural context. And that makes the endeavor truly daunting.

LEVERAGE FOR SURVIVAL

In some species, nonhuman and even nonprimate, in which memory, reasoning, and creativity are limited, there are, nonetheless, manifestations of complex social behavior whose neural control must be innate. Insects—ants and bees in particular—offer dramatic examples of social cooperation that might easily put to shame the United Nations General Assembly, most any day. Closer to home, mammals abound in such manifestations, and the behaviors of wolves, dolphins, and vampire bats, among other species, even suggest an ethical structure. It is apparent that humans possess some of those same innate mechanisms, and that such mechanisms are the likely basis for some ethical structures used by humans. The most elaborate social conventions and ethical structures by which we live, however, must have arisen culturally and been transmitted likewise.

If that is the case, one may wonder, what was the trigger for the cultural development of such strategies? It is likely that they evolved as a means to cope with the suffering experienced by individuals whose capacity to remember the past and anticipate the future had attained a remarkable development. In other words, the strategies evolved in individuals able to realize that their survival was threatened or that the quality of their post-survival life could be bettered. Such strategies could have evolved only in the few species whose brains were structured to permit the following: First, a large capacity to memorize categories of objects and events, and to memorize unique objects and events, that is, to establish dispositional representations of entities and events at the level of categories and at unique level. Second, a large capacity for manipulating the components of those memorized representations and fashioning new creations by means of novel combinations. The most immediately useful variety of those creations consisted of imagined scenarios, the anticipation of outcomes of actions, the formulation of future plans, and the design of new goals that can enhance survival. Third, a large capacity to memorize the new creations described above, that is, the

anticipated outcomes, the new plans, and the new goals. I call those memorized creations "memories of the future."[5]

If enhanced knowledge of the experienced past and the anticipated future was the reason why social strategies had to be created to cope with suffering, we still must explain why suffering arose in the first place. And for that we must consider the biologically prescribed sense of pain as well as its opposite, pleasure. The curious thing is, of course, that the biological mechanisms behind what we now call pain and pleasure were also an important reason why the innate instruments of survival were selected and combined the way they were, in evolution, when there was no individual suffering or reason. This may simply mean that the same simple device, applied to systems with very different orders of complexity and in different circumstances, leads to different but related results. The immune system, the hypothalamus, the ventromedial frontal cortices, and the Bill of Rights have the same root cause.

Pain and pleasure are the levers the organism requires for instinctual and acquired strategies to operate efficiently. In all probability they were also the levers that controlled the development of social decision-making strategies. When many individuals, in social groups, experienced the painful consequences of psychological, social, and natural phenomena, it was possible to develop intellectual and cultural strategies for coping with the experience of pain and perhaps reducing it.

Pain and pleasure occur when we become conscious of body-state profiles that clearly deviate from the base range. The configuration of stimuli and of brain-activity patterns perceived as pain or pleasure are set a priori in the brain structure. They occur because circuits fire in a particular way, and those circuits exist because they were instructed genetically to form themselves in a particular way. Although our reactions to pain and pleasure can be modified by education, they are a prime example of mental phenomena that depend on the activation of innate dispositions.

We should distinguish at least two components in pain and pleasure. In the first, the brain plots the representation of a local body-state change, which is referred to a part of the body. This is a somatosensory perception in the proper sense. It derives from the skin, or from a mucosa, or from part of an organ. The second component of pain and pleasure results from a more general change in body state, in fact an emotion. What we call pain or pleasure, for example, is the name for a concept of a particular body landscape that our brains are perceiving. The perception of that landscape is modulated further in the brain by neurotransmitters and neuromodulators, which affect signal transmission and the operation of the brain sectors concerned with representing the body. The release of endorphins (the organism's own morphine), which bind to opioid receptors (which are similar to those on which morphine acts), is an important factor in the perception of a "pleasure landscape," and can cancel or reduce the perception of a "pain landscape."

Let us clarify the idea a bit further with an example of pain processing. I would say things work like this: From nerve terminals stimulated in an area of the body where there is tissue damage (say, the root canal in a tooth), the brain constructs a transient representation of local body change, different from the previous representation for that area. The activity pattern that corresponds to pain signals and the perceptual characteristics of the resulting representation are prescribed entirely by the brain but otherwise are not neurophysiologically different from any other kind of body perception. If this were all, however, I submit that all you would experience would be a particular image of body change, without any troublesome consequence. You might not enjoy it, but you would not be inconvenienced either. My point is that *the process does not stop there.* The innocent processing of body change rapidly triggers a wave of additional body-state changes which further deviate the overall body state from the base range. *The state that ensues is an emotion, with a particular profile.* It is from the subsequent body-state deviations that the unpleasant feeling of suffering will be formed. Why are they experienced as suffering, you may ask. Be-

cause the organism says so. We came to life with a preorganized mechanism to give us the experiences of pain and of pleasure. Culture and individual history may change the threshold at which it begins to be triggered, or its intensity, or provide us with means to dampen it. But the essential device is a given.

What is the use of having such a preorganized mechanism? Why should there be this additional state of annoyance, rather than just the pain image alone? One can only wonder, but the reason must have something to do with the fact that suffering puts us on notice. Suffering offers us the best protection for survival, since it increases the probability that individuals will heed pain signals and act to avert their source or correct their consequences.

If pain is a lever for the proper deployment of drives and instincts, and for the development of related decision-making strategies, it follows that alterations in pain perception should be accompanied by behavioral impairments. This seems to be the case. Individuals born with a bizarre condition known as congenital absence of pain do not acquire normal behavior strategies. Many seem to be eternally giggly and pleased, in spite of the fact that their condition leads to damage in their joints (deprived of pain, they move their joints well beyond the affordable mechanical limits, thus tearing ligaments and capsules), severe burns, cuts (they will not withdraw from a hot plate or a blade destroying their skin).[6] As they can still feel pleasure, and thus can be influenced by positive feelings, it is all the more interesting to find that their behavior is defective. But even more fascinating is the hypothesis that the leverage devices play a role not just in the development but also in the deployment of acquired decision-making strategies. Patients with prefrontal damage have curiously altered pain responses. Their localizable image of pain itself is intact, for example, but the emotional reactions that are part and parcel of the pain process are missing, or in the very least, the ensuing feeling is not normal. There is other evidence about this dissociation to consider, pertaining to patients in whom surgical brain lesions have been made for the treatment of chronic pain.

. . .

Certain neurological conditions involve intense and frequent pain. One example is trigeminal neuralgia, also known as *tic douloureux*. The term neuralgia stands for pain with a neural origin, and the term trigeminal refers to the trigeminal nerve, the nerve which supplies face tissues and which ferries signals from the face to the brain. Trigeminal neuralgia affects the face, generally on one side and in one sector, for instance the cheek. Suddenly an innocent act such as touching the skin or an even more innocent breeze caressing the same skin may trigger a sudden excruciating pain. People afflicted complain of the sensation of knives' stabbing their flesh, of pins sticking in their skin and bone. Their whole lives may become focused on the pain; they can do or think of nothing else while the jabbing lasts, and the jabbing may come on frequently. Their bodies close in a tight, defensive coil.

For patients in whom the neuralgia is resistant to all available medication, the condition is classified as intractable or refractory. In such cases, neurosurgery can come to the rescue and offer the possibility of relief with a surgical intervention. One modality of treatment attempted in the past was prefrontal leucotomy (described in chapter 4). The results of this intervention illustrate better than any other fact the distinction between pain itself, that is, the perception of a certain class of sensory signals, and suffering, that is, the feeling that comes from perceiving the emotional reaction to that perception.

Consider the following episode, which I witnessed personally, when I was training with Almeida Lima, the neurosurgeon who had helped Egas Moniz develop cerebral angiography and prefrontal leucotomy and in fact had performed the first such operation. Lima, who was not only a skillful surgeon but a compassionate man, had been using a modified leucotomy for the management of intractable pain and was convinced the procedure was justifiable in desperate cases. He wanted me to see an example of the problem from the very beginning.

I vividly recall the particular patient, sitting in bed waiting for the operation. He was crouched in profound suffering, almost immobile, afraid of triggering further pain. Two days after the operation, when Lima and I visited on rounds, he was a different person. He looked relaxed, like anyone else, and was happily absorbed in a game of cards with a companion in his hospital room. Lima asked him about the pain. The man looked up and said cheerfully: "Oh, the pains are the same, but I feel fine now, thank you." Clearly, what the operation seemed to have done, then, was abolish the emotional reaction that is part of what we call pain. It had ended the man's suffering. His facial expression, his voice, and his deportment were those one associates with pleasant states, not pain. But the operation seemed to have done little to the image of local alteration in the body region supplied by the trigeminal nerve, and that is why the patient stated that the pains were the same. While the brain could no longer engender suffering, it was still making "images of pain," that is, processing normally the somatosensory mapping of a pain landscape.[7] In addition to what it may tell us about the mechanisms of pain, this example reveals the separation between the image of an entity (the state of biological tissue which equals a pain image) and the image of a body state which qualifies the entity image by dint of juxtaposition in time.

I believe that one of the main efforts of neurobiology and medicine should be directed at alleviating suffering of the sort described above. A no less important target for biomedical efforts should be the alleviation of suffering in mental diseases. But how to deal with the suffering that arises from personal and social conflicts outside the medical realm is a different and entirely unresolved matter. The current trend is to make no distinction at all and utilize the medical approach to eliminate any discomfort. The proponents of the attitude have an attractive argument. If an increase in serotonin levels, for instance, can not only treat depression but also reduce aggression, make you less shy, and turn you into a more confident person, why not take advantage of the opportunity? Would any but the most spoilsport, puritanical creature deny a fellow human being the bene-

fits of all these wonder drugs? The problem, of course, is that the choice is not clear-cut, for a large number of reasons. First, the long-range biological effects of the drugs are unknown. Second, the consequences of socially massive drug intake are equally mysterious. Third, and perhaps most important of all: If the proposed solution to individual and social suffering bypasses the causes of individual and social conflict, it is not likely to work for very long. It may treat a symptom, but it does nothing to the roots of the disease.

I have said little about pleasure. Pain and pleasure are not twins or mirror images of each other, at least not as far as their roles in leveraging survival. Somehow, more often than not, it is the pain-related signal that steers us away from impending trouble, both at the moment and in the anticipated future. It is difficult to imagine that individuals and societies governed by the seeking of pleasure, as much as or more than by the avoidance of pain, can survive at all. Some current social developments in increasingly hedonistic cultures offer support for this opinion, and work that my colleagues and I are pursuing on the neural correlates of various emotions lends further support. There seem to be far more varieties of negative than positive emotions, and it is apparent that the brain handles positive and negative varieties of emotions with different systems. Perhaps Tolstoy had a similar insight, when he wrote, at the beginning of *Anna Karenina:* "All happy families are like one another, each unhappy family is unhappy in its own way."

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G. Edelman, see note 6 above.

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8. F. Plum and J. Posner (1980). *The Diagnosis of Stupor and Coma* (Contemporary Neurology Series, 3rd ed.). Philadelphia: F. A. Davis.

9. J. Kagan (1989). *Unstable Ideas: Temperament, Cognition, and Self.* Cambridge, MA: Harvard University Press.

CHAPTER 11

1. G. S. Stent (1969). *The Coming of the Golden Age: A View of the End of Progress.* New York: Doubleday.

2. A rich description of this state of affairs can be found in Robert Hughes (1992). *The Culture of Complaint.* New York: Oxford University Press.

3. R. Descartes (1637). *The Philosophical Works of Descartes,* rendered into English by Elizabeth S. Haldane and G. R. T. Ross, vol. 1, page 101. New York: Cambridge University Press (1970).

4. R. Descartes. See note 3 above.

5. R. Cottingham (1992). *A Descartes Dictionary.* Oxford: Blackwell, pg. 36. Plato. *Phaedo* (1971). *The Collected Dialogues of Plato.* E. Hamilton and H. Cairns, eds. Bollingen Series. Pantheon Books. pp. 47–53.

6. See note 3 above.

ENDNOTES FOR POSTSCRIPTUM

1. W. Faulkner (1949). Nobel Prize acceptance speech. The precise context for Faulkner's words was the mounting nuclear threat, but his message is timeless.

2. P. Éluard (1961). Liberté, in G. Pompidou, ed., *Anthologie de la poésie française*. Paris: Hachette.

3. The writings of Jonas Salk and Richard Lewontin (cited above), which these words evoke, contain the optimism and resolve that are indispensable for a comprehensive human biology.

4. See footnote 2, page 290.

5. David Ingvar has also used the term "memories of the future," with precisely the same meaning.

6. Howard Fields (1987). *Pain*. New York: McGraw-Hill Book Co. B. Davis (1994). Behavioral aspects of complex analgesia (to appear).

7. New, less mutilating surgical procedures to manage pain have also been developed since Lima's time. Although prefrontal leucotomy was not as damaging as other so-called psychosurgical procedures, and although it did have the positive result of relieving intractable suffering, it had a negative result as well: the blunting of emotion and feeling, whose long-term consequences are only now being appreciated fully.