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Chapter Two

Emotion and Feeling

Once More with Emotion

Without exception, men and women of all ages, of all cultures, of all levels of education, and of all walks of economic life have emotions, are mindful of the emotions of others, cultivate pastimes that manipulate their emotions, and govern their lives in no small part by the pursuit of one emotion, happiness, and the avoidance of unpleasant emotions. At first glance, there is nothing distinctively human about emotions since it is clear that so many nonhuman creatures have emotions in abundance; and yet there is something quite distinctive about the way in which emotions have become connected to the complex ideas, values, principles, and judgments that only humans can have, and in that connection lies our legitimate sense that human emotion is special. Human emotion is not just about sexual pleasures or fear of snakes. It is also about the horror of witnessing suffering and about the satisfaction of seeing justice served; about our delight at the sensuous smile of Jeanne Moreau or the thick beauty of words and ideas in Shakespeare's verse; about the world-weary voice of Dietrich Fischer-Dieskau singing Bach's *Ich habe genug* and the simultaneously earthly and otherworldly phrasings of Maria João Pires playing any Mozart, any Schubert; and about the harmony that Einstein sought in the structure of an equation. In fact, fine human emotion is even triggered by cheap music and cheap movies, the power of which should never be underestimated.

The human impact of all the above causes of emotion, refined and not so refined, and of all the shades of emotion they induce, subtle and not so subtle, depends on the feelings engendered by those emotions. It is through feelings, which are inwardly directed and private, that emotions, which are outwardly directed and public, begin their impact on the mind; but the full and lasting impact of feelings requires consciousness, because only along with the advent of a sense of self do feelings become known to the individual having them.

Some readers may be puzzled by the distinction between "feeling" and "knowing that we have a feeling." Doesn't the state of feeling imply, of necessity, that the feeler organism is fully conscious of the emotion and feeling that are unfolding? I am suggesting that it does not, that an organism may represent in neural and mental patterns the state that we conscious creatures call a feeling, without ever knowing that the feeling is taking place. This separation is difficult to envision, not only because the traditional meanings of the words block our view, but because we *tend* to be conscious of our feelings. There is, however, no evidence that we are conscious of *all* our feelings, and much to suggest that we are not. For example, we often realize quite suddenly, in a given situation, that we feel anxious or uncomfortable, pleased or relaxed, and it is apparent that the particular state of feeling we know then has not begun on the moment of knowing but rather sometime before. Neither the feeling state nor the emotion that led to it has been "in consciousness," and yet they have been unfolding as biological processes. These distinctions may sound artificial, at first glance, although my purpose is not to complicate something simple but rather to break down, in approachable parts, something that is quite complicated. For the purpose of investigating these phenomena, I separate three stages of processing along a continuum: *a state of emotion*, which can be triggered and executed nonconsciously; *a state of feeling*, which can be represented nonconsciously; and *a state of feeling made conscious*, i.e., known to the organism having both emotion and feeling. I believe these distinctions are helpful as we try to imagine the neural underpinnings of this chain of events in humans. Moreover, I suspect that some nonhuman creatures that exhibit emotions but are unlikely to have the sort of consciousness we have may well form the representations we call feelings without knowing they do so. Someone may suggest that perhaps we should have another word for "feelings that are not conscious," but there isn't one. The closest alternative is to explain what we mean.

In short, consciousness must be present if feelings are to influence the subject having them beyond the immediate here and now. The significance of this fact, that the ultimate consequences of human emotion and feeling pivot on consciousness, has not been properly appreciated (the strange history of research on emotion and feeling, addressed below, is possibly to blame for this neglect). Emotion was probably set in evolution before the dawn of consciousness and surfaces in each of us as a result of inducers we often do not recognize consciously; on the other hand, feelings perform their ultimate and longer-lasting effects in the theater of the conscious mind.

The powerful contrast between the covertly induced and outward posture of emotion and the inwardly directed and ultimately known status of human feeling provided me with an invaluable perspective for reflection on the biology of consciousness. And there are other bridges between emotion and consciousness. In this book, I propose that, just like emotion, consciousness is aimed at the organism's survival, and that, just like emotion, consciousness is rooted in the representation of the body. I also call attention to an intriguing neurological fact: when consciousness is suspended, from core consciousness on up, emotion is usually suspended as well, suggesting that although emotion and consciousness are different phenomena, their underpinnings may be connected. For all these reasons, it is important to discuss the varied features of emotion before we begin addressing consciousness directly. But first, before I outline the results of that reflection, I propose an aside on the strange history of the science of emotion, because that history may help explain why consciousness has not been approached from the perspective I am adopting here.

A Historical Aside

Given the magnitude of the matters to which emotion and feeling have been attached, one would have expected both philosophy and the sciences of mind and brain to have embraced their study. Surprisingly, that is only happening now. Philosophy, notwithstanding David Hume and the tradition that originates with him, has not trusted emotion and has largely relegated it to the dismissible realms of animal and flesh. For a time, science fared better, but then it, too, missed its opportunity.

By the end of the nineteenth century Charles Darwin, William James, and Sigmund Freud had written extensively on different aspects of emotion and given emotion a privileged place in scientific discourse. Yet, throughout the twentieth century and until quite recently, both neuroscience and cognitive science gave emotion a very cold shoulder. Darwin had conducted an extensive study of the expression of emotion in different cultures and different species, and though he thought of human emotions as vestiges from previous stages of evolution, he respected the importance of the phenomenon. William James had seen through the problem with his characteristic clarity and produced an account that, in spite of its incompleteness, remains a cornerstone. As for Freud, he had gleaned the pathological potential of disturbed emotions and announced their importance in no uncertain terms.

Darwin, James, and Freud were, of necessity, somewhat vague about the brain aspect of their ideas, but one of their contemporaries,

Hughlings Jackson, was more precise. He took the first step toward a possible neuroanatomy of emotion and suggested that the right cerebral hemisphere of humans was probably dominant for emotion, much as the left was dominant for language.

There would have been good reason to expect that, as the new century started, the expanding brain sciences would make emotion part of their agenda and solve its questions. But that development never came to pass. Worse than that, Darwin's work on the emotions vanished from sight, James's proposal was attacked unfairly and dismissed summarily, and Freud's influence went elsewhere. Throughout most of the twentieth century, emotion was not trusted in the laboratory. Emotion was too subjective, it was said. Emotion was too elusive and vague. Emotion was at the opposite end from reason, easily the finest human ability, and reason was presumed to be entirely independent from emotion. This was a perverse twist on the Romantic view of humanity. Romantics placed emotion in the body and reason in the brain. Twentieth-century science left out the body, moved emotion back into the brain, but relegated it to the lower neural strata associated with ancestors whom no one worshiped. In the end, not only was emotion not rational, even studying it was probably not rational.

There are curious parallels to the scientific neglect of emotion during the twentieth century. One of those parallels is the lack of an *evolutionary perspective* in the study of brain and mind. It is perhaps an exaggeration to say that neuroscience and cognitive science have proceeded as if Darwin never existed, but it certainly seemed so until the last decade. Aspects of brain and mind have been discussed as if designed recently, as needed, to produce a certain effect—a bit like the installation of antilock brakes in a proper new car—without any regard for the possible antecedents of mental and brain devices. Of late the situation is changing remarkably.

Another parallel concerns the disregard for the notion of homeostasis. *Homeostasis* refers to the coordinated and largely automated physiological reactions required to maintain steady internal states in a living organism. Homeostasis describes the automatic regulation of temperature, oxygen concentration, or pH in your body. Numerous scientists have been preoccupied with understanding the neurophysiology of homeostasis, with making sense of the neuroanatomy and the neurochemistry of the autonomic nervous system (the part of the nervous system most directly involved in homeostasis), and with elucidating the interrelations among the endocrine, immune, and nervous systems, whose ensemble work produces homeostasis. But the scientific progress made in those areas had little influence on the prevailing views of how mind or brain worked. Curiously enough, emotions are part and parcel of the regulation we call homeostasis. It is senseless to discuss them without understanding that aspect of living organisms and vice versa. In this book, I propose that homeostasis is a key to the biology of consciousness (see chapter 5).

A third parallel is the noticeable absence of a notion of *organism* in cognitive science and neuroscience. The mind remained linked to the brain in a somewhat equivocal relationship, and the brain remained consistently separated from the body rather than being seen as part of a complex living organism. The notion of an integrated organism—the idea of an ensemble made up of a body proper and a nervous system—was available in the work of thinkers such as Ludwig von Bertalanffy, Kurt Goldstein, and Paul Weiss but had little impact in shaping the standard conceptions of mind and brain.[1]

To be sure, there are exceptions in this broad panorama. For instance, Gerald Edelman's theoretical proposals on the neural basis of the mind are informed by evolutionary thinking and acknowledge homeostatic regulation; and my somatic-marker hypothesis is grounded on notions of evolution, homeostatic regulation, and organism.[2] But the theoretical assumptions according to which cognitive science and neuroscience have been conducted have not made much use of organismic and evolutionary perspectives.

In recent years both neuroscience and cognitive neuroscience have finally endorsed emotion. A new generation of scientists is now making emotion its elected topic.[3] Moreover, the presumed opposition between emotion and reason is no longer accepted without question.

For example, work from my laboratory has shown that emotion is integral to the processes of reasoning and decision making, for worse and for better.[4] This may sound a bit counterintuitive, at first, but there is evidence to support it. The findings come from the study of several individuals who were entirely rational in the way they ran their lives up to the time when, as a result of neurological damage in specific sites of their brains, they lost a certain class of emotions and, in a momentous parallel development, lost their ability to make rational decisions. Those individuals can still use the instruments of their rationality and can still call up the knowledge of the world around them. Their ability to tackle the logic of a problem remains intact. Nonetheless, many of their personal and social decisions are irrational, more often disadvantageous to their selves and to others than not. I have suggested that the delicate mechanism of reasoning is no longer affected, nonconsciously and on occasion even consciously, by signals hailing from the neural machinery that underlies emotion.

This hypothesis is known as the somatic-marker hypothesis, and the patients who led me to propose it had damage to selected areas in the prefrontal region, especially in the ventral and medial sectors, and in the right parietal regions. Whether because of a stroke or head injury or a tumor which required surgical resection, damage in those regions was consistently associated with the appearance of the clinical pattern I described above, i.e., a disturbance of the ability to decide advantageously in situations involving risk and conflict and a selective reduction of the ability to resonate emotionally in precisely those same situations, while preserving the remainder of their emotional abilities. Prior to the onset of their brain damage, the individuals so affected had shown no such impairments. Family and friends could sense a "before" and an "after," dating to the time of neurologic injury.

These findings suggest that selective reduction of emotion is at least as prejudicial for rationality as excessive emotion. It certainly does not seem true that reason stands to gain from operating without the leverage of emotion. On the contrary, emotion probably assists reasoning, especially when it comes to personal and social matters involving risk and conflict. I suggested that certain levels of emotion processing probably point us to the sector of the decision-making space where our reason can operate most efficiently. I did *not* suggest, however, that emotions are a substitute for reason or that emotions decide for us. It is obvious that emotional upheavals can lead to irrational decisions. The neurological evidence simply suggests that selective absence of emotion is a problem. Well-targeted and well-deployed emotion seems to be a support system without which the edifice of reason cannot operate properly. These results and their interpretation called into question the idea of dismissing emotion as a luxury or a nuisance or a mere evolutionary vestige. They also made it possible to view emotion as an embodiment of the logic of survival.[5]

The Brain Knows More than the Conscious Mind Reveals

Emotions and feelings of emotions, respectively, are the beginning and the end of a progression, but the relative publicness of emotions and the complete privacy of the ensuing feelings indicate that the mechanisms along the continuum are quite different. Honoring a distinction between emotion and feeling is helpful if we are to investigate those mechanisms thoroughly. I have proposed that the term *feeling* should be reserved for the private, mental experience of an emotion, while the term *emotion* should be used to designate the collection of responses, many of which are publicly observable. In practical terms this means that you cannot observe a feeling in someone else although you can observe a feeling in yourself when, as a conscious being, you perceive your own emotional states. Likewise no one can observe your own feelings, but some aspects of the emotions that give rise to your feelings will be patently observable to others. Moreover, for the sake of my argument, the basic mechanisms underlying emotion do not require consciousness, even if they eventually use it: you can initiate the cascade of processes that lead to an emotional display without being conscious of the inducer of the emotion let alone the

intermediate steps leading to it. In effect, even the occurrence of a feeling in the limited time window of the here and now is conceivable without the organism actually *knowing* of its occurrence. To be sure, at this point in evolution and at this moment of our adult lives, emotions occur in a setting of consciousness: We can feel our emotions consistently and we know we feel them. The fabric of our minds and of our behavior is woven around continuous cycles of emotions followed by feelings that become known and beget new emotions, a running polyphony that underscores and punctuates specific thoughts in our minds and actions in our behavior. But although emotion and feeling are now part of a functional continuum, it is helpful to distinguish the steps along that continuum if we are to study their biological underpinnings with any degree of success. Besides, as suggested earlier, it is possible that feelings are poised at the very threshold that separates being from knowing and thus have a privileged connection to consciousness.[6]

WHY AM I SO confident that the biological machinery underlying emotion is not dependent on consciousness? After all, in our daily experience, we often seem to know the circumstances leading to an emotion. But knowing often is not the same as knowing always. There is good evidence in favor of the covert nature of emotion induction, and I will illustrate the point with some experimental results from my laboratory.

David, who has one of the most severe defects in learning and memory ever recorded, cannot learn any new fact at all. For instance, he cannot learn any new physical appearance or sound or place or word. As a consequence he cannot learn to recognize any new person, from the face, from the voice, or from the name, nor can he remember anything whatsoever regarding where he has met a certain person or the events that transpired between him and that person. David's problem is caused by extensive damage to both temporal lobes, which includes damage to a region known as the hippocampus (whose integrity is necessary to create memories for new facts) and the region known as the amygdala (a subcortical grouping of nuclei concerned with emotion that I will mention in the pages ahead).

Many years ago I heard that David seemed to manifest, in his day-to-day life, consistent preferences and avoidances for certain persons. For instance, in the facility where he has lived for most of the past twenty years, there were specific people whom he would frequently choose to go to if he wanted a cigarette or a cup of coffee, and there were certain people to whom he would never go. The consistency of these behaviors was most intriguing, considering that David could not recognize any of those individuals at all; considering that he had no idea whether he had ever seen any of them; and considering that he could not produce the name of any of them or point to any of them given the name. Could this intriguing story be more than a curious anecdote? I decided to check it out and put it to empirical test. In order to do so, I collaborated with my colleague Daniel Tranel to design an experiment which has become known in our laboratory as the good-guy/bad-guy experiment.[7]

Over a period of a week, we were able to engage David, under entirely controlled circumstances, in three distinct types of human interaction. One type of interaction was with someone who was extremely pleasant and welcoming and who always rewarded David whether he requested something or not (this was the good guy). Another interaction involved somebody who was emotionally neutral and who engaged David in activities that were neither pleasant nor unpleasant (this was the neutral guy). A third type of interaction involved an individual whose manner was brusque, who would say no to any request, and who engaged David in a very tedious psychological task designed to bring boredom to a saint (this was the bad guy). The task was the delayed-nonmatching-to-sample task, which was invented to investigate memory in monkeys and is probably a delight if you have the mind of a monkey.

The staging of these different situations was arranged throughout five consecutive days, in random order, but always for a specified interval of time so that the overall exposure to the good, to the bad, and to the indifferent would be properly measured and compared. The elaborate staging of this dance required varied rooms and several assistants, who were not the same, by the way, as the good, bad, and neutral guys.

After all the encounters were allowed to sink in, we asked David to participate in two distinct tasks. In one task David was asked to look at sets of four photographs that included the face of one of the three individuals in the experiment, and then asked, "Whom would you go to if you needed help?" and, for further clarification, "Who do you think is your friend in this group?"

David behaved in a most spectacular manner. When the individual who had been positive to him was part of the set of four, David chose the good guy over 80 percent of the time, indicating that his choice was clearly not random—chance alone would have made David pick each of the four 25 percent of the time. The neutral individual was chosen with a probability no greater than chance. And the bad guy was almost never chosen, again something that violated chance behavior.

In a second task, David was asked to look at the faces of the three individuals and tell us what he knew about them. As usual, for him, nothing came to mind. David could not remember ever encountering them and had no recollection of any instance in which he had interacted with them. Needless to say, he could not name any of the individuals, he could not point to any of them given the name, and he had no idea of what we were talking about when we asked him about the events of the previous week. But when he was asked who, among the three, was his friend, he consistently chose the good guy.

The results show that the anecdote was well worth investigating. To be sure, there was nothing in David's conscious mind that gave him an overt reason to choose the good guy correctly and reject the bad one correctly. He did not know why he chose one or rejected the other; he just did. The nonconscious preference he manifested, however, is probably related to the emotions that were induced in him during the experiment, as well as to the nonconscious reinduction of some part of those emotions at the time he was being tested. David had not learned new knowledge of the type that can be deployed in one's mind in the form of an image. But something stayed in his brain and that something could produce results in nonimage form: in the form of actions and behavior. David's brain could generate actions commensurate with the emotional value of the original encounters, as caused by reward or lack thereof. To make this idea clear, let me describe an observation I made on one occasion during the exposure sessions in the good-guy/bad-guy experiment.

David was being brought to a bad-guy encounter and as he turned into the hallway and saw the bad guy awaiting him, a few feet away, he flinched, stopped for an instant, and only then allowed himself to be led gently to the examining room. I picked up on this and immediately asked him if anything was the matter, if there was anything I could do for him. But, true to form, he told me that, no, everything was all right—after all, nothing came to his mind, except, perhaps, an isolated sense of emotion without a cause behind that emotion. I have no doubt that the sight of the bad guy induced a brief emotional response and a brief here-and-now feeling. However, in the absence of an appropriately related set of images that would explain to him the cause of the reaction, the effect remained isolated, disconnected, and thus unmotivated.[8]

I also have little doubt that were we to have carried out this task for weeks in a row rather than for one single week, David would have harnessed such negative and positive responses to produce the behavior that suited his organism best, i.e., prefer the good guy consistently and avoid the bad guy. But I am not suggesting that *he* himself would have chosen to do so deliberately, but rather that his *organism*, given its available design and dispositions, would have homed in on such behavior. He would have developed a tropism for the good guy as well as an antitropism for the bad guy, in much the same manner he had developed such preferences in the real-life setting.

The situation just described allows us to make some other points. First, David's core consciousness is intact, an issue that we shall revisit in the next chapter. Second, while in the setting of the good-guy/bad-guy experiment, David's emotions were induced nonconsciously, in other settings he engages emotions knowingly. When he does not have to depend on new memory, he senses that he is happy because he is tasting a favorite food or watching a pleasant scene. Third, given the remarkable destruction of several cortical and subcortical emotion-related regions of his brain, e.g., ventromedial prefrontal cortices, basal forebrain, amygdalae, it is apparent that those territories are not indispensable for either emotion or consciousness. We may also keep in mind, for future reference, that certain structures of David's brain remain intact: all of the brain stem; the hypothalamus; the thalamus; most of the cingulate cortices; and virtually all sensory and motor structures.

Let me close these comments by saying that the bad guy in our experiment was a young, pleasant, and beautiful woman neuropsychologist. We had designed the experiment in this way, having her play against type, since we wanted to determine the extent to which David's manifest preference for the company of young and beautiful women would countervail the contrariness of her behavior and the fact that she was the purveyor of the boring task (David does have an eye for the girls; I caught him once caressing Patricia Churchland's arm and remarking, "You are so soft . . ."). Well, as you can see, our benign bit of perverse planning paid off. No amount of natural beauty could have compensated for the negative emotion induced by the bad guy's manner and by the poor entertainment her task provided.

WE DO NOT need to be conscious of the inducer of an emotion and often are not, and we cannot control emotions willfully. You may find yourself in a sad or happy state, and yet you may be at a loss as to why you are in that particular state now. A careful search may disclose possible causes, and one cause or another may be more likely, but often you cannot be certain. The actual cause may have been the image of an event, an image that had the potential to be conscious but just was not because you did not attend to it while you were attending to another. Or it may have been no image at all, but rather a transient change in the chemical profile of your internal milieu, brought about by factors as diverse as your state of health, diet, weather, hormonal cycle, how much or how little you exercised that day, or even how much you had been worrying about a certain matter. The change would be substantial enough to engender some responses and alter your body state, but it would not be imageable in the sense that a person or a relationship is imageable, i.e., it would not produce a sensory pattern of which you would ever become aware in your mind. In other words, the representations which induce emotions and lead to subsequent feelings need not be attended, regardless of whether they signify something external to the organism or something recalled internally. Representations of either the exterior or the interior can occur underneath conscious survey and still induce emotional responses. Emotions can be induced in a nonconscious manner and thus appear to the conscious self as seemingly unmotivated.

We can control, in part, whether a would-be inducer image should be allowed to remain as a target of our thoughts. (If you were raised Catholic you know precisely what I mean, and likewise, if you have been around the Actors Studio.) We may not succeed at the task, but the job of removing or maintaining the inducer certainly occurs in consciousness. We can also control, in part, the expression of some emotions—suppress our anger, mask our sadness—but most of us are not very good at it and that is one reason why we pay a lot to see good actors who are skilled at controlling the expression of their emotions (and why we may lose a lot of money playing poker). Once a particular sensory representation is formed, however, whether or not it is actually part of our conscious thought flow, we do not have much to say on the mechanism of inducing an emotion. If the psychological and physiological context is right, an emotion will ensue. The nonconscious triggering of emotions also explains why they are not easy to mimic voluntarily. As I explained in *Descartes' Error*, a spontaneous smile that comes from genuine delight or the spontaneous sobbing that is caused by grief are executed by brain structures located deep in the brain stem under the control of the cingulate region. We have no

means of exerting direct voluntary control over the neural processes in those regions. Casual voluntary mimicking of expressions of emotion is easily detected as fake—something always fails, whether in the configuration of the facial muscles or in the tone of voice. The result of this state of affairs is that in most of us who are not actors, emotions are a fairly good index of how conducive the environment is to our well-being, or, at least, how conducive it seems to our minds.

We are about as effective at stopping an emotion as we are at preventing a sneeze. We can try to prevent the expression of an emotion, and we may succeed in part but not in full. Some of us, under the appropriate cultural influence, get to be quite good at it, but in essence what we achieve is the ability to disguise some of the external manifestations of emotion without ever being able to block the automated changes that occur in the viscera and internal milieu. Think of the last time you were moved in public and tried to disguise it. You might have gotten away with it if you were watching a movie out there in the dark, alone with Gloria Swanson, but not if you were delivering the eulogy for a dead friend: your voice would have given you away. Someone once told me that the idea of feelings occurring after emotion could not be correct since it is possible to suppress emotions and still have feelings. But that is not true, of course, beyond the partial suppression of facial expressions. We can educate our emotions but not suppress them entirely, and the feelings we have inside are a testimony to our lack of success.

An Aside on Controlling the Uncontrollable

One partial exception to the extremely limited control we have over the internal milieu and viscera concerns respiratory control, over which we need to exert some voluntary action, because autonomic respiration and voluntary vocalization for speech and singing use the same instrument. You can learn to swim underwater, holding your breath for longer and longer periods, but there are limits beyond which no Olympic champion can go and remain alive. Opera singers face a similar barrier: what tenor wouldn't love to hold on to the high C for just a while longer and irritate the soprano? But no amount of laryngeal and diaphragmatic training will allow tenor or soprano to transpose the barrier. Indirect control of blood pressure and heart rate by procedures such as biofeedback are also partial exceptions. As a rule, however, voluntary control over autonomic function is modest.

I can report one dramatic exception, however. Some years ago the brilliant pianist Maria João Pires told us the following story: When she plays, under the perfect control of her will, she can either reduce or allow the flow of emotion to her body. My wife, Hanna, and I thought this was a wonderfully romantic idea, but Maria João insisted that she could do it and we resisted believing it. Eventually, the stage for the empirical moment of truth was set in our laboratory. Maria João was wired to the complicated psychophysiological equipment while she listened to short musical pieces of our selection in two conditions: emotion allowed, or emotion voluntarily inhibited. Her Chopin *Nocturnes* had just been released, and we used some of hers and some of Daniel Barenboim's as stimuli. In the condition of "emotion allowed," her skin conductance record was full of peaks and valleys, linked intriguingly to varied passages in the pieces. Then, in the condition of "emotion reduced," the unbelievable did, in fact, happen. She could virtually flatten her skin-conductance graph at will and change her heart rate, to boot. Behaviorally, she changed as well. The profile of background emotions was rearranged, and some of the specific emotive behaviors were eliminated, e.g., there was less movement of the head and facial musculature. When our colleague Antoine Bechara, in complete disbelief, repeated the whole experiment, wondering if this might be an artifact of habituation, she did it again. So there are some exceptions to be found after all, perhaps more so in those whose lifework consists of creating magic through emotion.

What Are Emotions?

The mention of the word *emotion* usually calls to mind one of the six so-called *primary* or *universal emotions:* happiness, sadness, fear, anger, surprise, or disgust. Thinking about the primary emotions makes the discussion of the problem easier, but it is important to note that there are numerous other behaviors to which the label "emotion" has been attached. They include so-called *secondary* or *social emotions,* such as embarrassment, jealousy, guilt, or pride; and what I call *background emotions,* such as well-being or malaise, calm or tension. The label emotion has also been attached to drives and motivations and to the states of pain and pleasure.[9]

A shared biological core underlies all these phenomena, and it can be outlined as follows:

1. Emotions are complicated collections of chemical and neural responses, forming a pattern; all emotions have some kind of regulatory role to play, leading in one way or another to the creation of circumstances advantageous to the organism exhibiting the phenomenon; emotions are *about* the life of an organism, its body to be precise, and their role is to assist the organism in maintaining life.
2. Notwithstanding the reality that learning and culture alter the expression of emotions and give emotions new meanings, emotions are biologically determined processes, depending on innately set brain devices, laid down by a long evolutionary history.
3. The devices which produce emotions occupy a fairly restricted ensemble of subcortical regions, beginning at the level of the brain stem and moving up to the higher brain; the devices are part of a set of structures that both regulate and represent body states, which will be discussed in chapter 5.
4. All the devices can be engaged automatically, without conscious deliberation; the considerable amount of individual variation and the fact that culture plays a role in shaping some inducers do not deny the fundamental stereotypicity, automaticity, and regulatory purpose of the emotions.
5. All emotions use the body as their theater (internal milieu, visceral, vestibular and musculoskeletal systems), but emotions also affect the mode of operation of numerous brain circuits:

> the variety of the emotional responses is responsible for profound changes in both the body landscape and the brain landscape. The collection of these changes constitutes the substrate for the neural patterns which eventually become feelings of emotion.

A special word about background emotions is needed, at this point, because the label and the concept are not a part of traditional discussions on emotion. When we sense that a person is "tense" or "edgy," "discouraged" or "enthusiastic," "down" or "cheerful," without a single word having been spoken to translate any of those possible states, we are detecting background emotions. We detect background emotions by subtle details of body posture, speed and contour of movements, minimal changes in the amount and speed of eye movements, and in the degree of contraction of facial muscles.

The inducers of background emotions are usually internal. The processes of regulating life itself can cause background emotions but so can continued processes of mental conflict, overt or covert, as they lead to sustained satisfaction or inhibition of drives and motivations. For example, background emotions can be caused by prolonged physical effort—from the "high" that follows jogging to the "low" of uninteresting, nonrhythmical physical labor—and by brooding over a decision that you find difficult to make—one of the reasons behind Prince Hamlet's dispirited existence—or by savoring the prospect of some wonderful pleasure that may await you. In short, certain conditions of internal state engendered by ongoing physiological processes or by the organism's interactions with the environment or both cause responses which constitute background emotions. Those emotions allow us to have, among others, the background feelings of tension or relaxation, of fatigue or energy, of well-being or malaise, of anticipation or dread.[10]

In background emotions, the constitutive responses are closer to the inner core of life, and their target is more internal than external. Profiles of the internal milieu and viscera play the lead part in background emotions. But although background emotions do not use the differentiated repertoire of explicit facial expressions that easily define primary and social emotions, they are also richly expressed in musculoskeletal changes, for instance, in subtle body posture and overall shaping of body movement.[11]

In my experience, background emotions are brave survivors of neurological disease. For instance, patients with ventromedial frontal damage retain them, as do patients with amygdala damage. Intriguingly, as you will discover in the next chapter, background emotions are usually compromised when the basic level of consciousness, core consciousness, is compromised as well.

The Biological Function of Emotions

Although the precise composition and dynamics of the emotional responses are shaped in each individual by a unique development and environment, the evidence suggests that most, if not all, emotional responses are the result of a long history of evolutionary fine-tuning. Emotions are part of the bioregulatory devices with which we come equipped to survive. That is why Darwin was able to catalog the emotional expressions of so many species and find consistency in those expressions, and that is why, in different parts of the world and across different cultures, emotions are so easily recognized. Surely enough, there are variable expressions and there are variations in the precise configuration of stimuli that can induce an emotion across cultures and among individuals. But the thing to marvel at, as you fly high above the planet, is the similarity, not the difference. It is that similarity, incidentally, that makes cross-cultural relations possible and that allows for art and literature, music and film, to cross frontiers. This view has been given immeasurable support by the work of Paul Ekman.[12]

The biological function of emotions is twofold. The first function is the production of a specific reaction to the inducing situation. In an animal, for instance, the reaction may be to run or to become immobile or to beat the hell out of the enemy or to engage in pleasurable behavior. In humans, the reactions are essentially the same, tempered, one hopes, by higher reason and wisdom. The second biological function of emotion is the regulation of the internal state of the organism such that it can be prepared for the specific reaction. For example, providing increased blood flow to arteries in the legs so that muscles receive extra oxygen and glucose, in the case of a flight reaction, or changing heart and breathing rhythms, in the case of freezing on the spot. In either case, and in other situations, the plan is exquisite and the execution is most reliable. In short, for certain classes of clearly dangerous or clearly valuable stimuli in the internal or external environment, evolution has assembled a matching answer in the form of emotion. This is why, in spite of the infinite variations to be found across cultures, among individuals, and over the course of a life span, we can predict with some success that certain stimuli will produce certain emotions. (This is why you can say to a colleague, "Go tell her that; she will be so happy to hear it.")

In other words, the biological "purpose" of the emotions is clear, and emotions are not a dispensable luxury. Emotions are curious adaptations that are part and parcel of the machinery with which organisms regulate survival. Old as emotions are in evolution, they are a fairly high-level component of the mechanisms of life regulation. You should imagine this component as sandwiched between the basic survival kit (e.g., regulation of metabolism; simple reflexes; motivations; biology of pain and pleasure) and the devices of high reason, but still very much a part of the hierarchy of life-regulation devices. For less-complicated species than humans, and for absentminded humans as well, emotions actually produce quite reasonable behaviors from the point of view of survival.

At their most basic, emotions are part of homeostatic regulation and are poised to avoid the loss of integrity that is a harbinger of death or death itself, as well as to endorse a source of energy, shelter, or sex. And as a result of powerful learning mechanisms such as conditioning, emotions of all shades eventually help connect homeostatic regulation and survival "values" to numerous events and objects in

our autobiographical experience. Emotions are inseparable from the idea of reward or punishment, of pleasure or pain, of approach or withdrawal, of personal advantage and disadvantage. Inevitably, emotions are inseparable from the idea of good and evil.

Table 2.1. Levels of Life Regulation

HIGH REASON	Complex, flexible, and customized plans of response are formulated in conscious images and may be executed as behavior.
	CONSCIOUSNESS
FEELINGS	Sensory patterns signaling pain, pleasure, and emotions become images.
EMOTIONS	Complex, stereotyped patterns of response, which include secondary emotions, primary emotions, and background emotions
BASIC LIFE REGULATION	Relatively simple, stereotyped patterns of response, which include metabolic regulation, reflexes, the biological machinery behind what will become pain and pleasure, drives and motivations

The basic level of life regulation—the survival kit—includes the biological states that can be consciously perceived as drives and motivations and as states of pain and pleasure. Emotions are at a higher, more complex level. The dual arrows indicate upward or downward causation. For instance, pain can induce emotions, and some emotions can include a state of pain.

One might wonder about the relevance of discussing the biological role of the emotions in a text devoted to the matter of consciousness. The relevance should become clear now. Emotions automatically provide organisms with survival-oriented behaviors. In organisms equipped to sense emotions, that is, to have feelings, emotions also have an impact on the mind, as they occur, in the here and now. But in organisms equipped with consciousness, that is, capable of knowing they have feelings, another level of regulation is reached. Consciousness allows feelings to be known and thus promotes the impact of emotion internally, allows emotion to permeate the thought process through the agency of feeling. Eventually, consciousness allows any object to be known—the "object" emotion and any other object—and, in so doing, enhances the organism's ability to respond adaptively, mindful of the needs of the organism in question. Emotion is devoted to an organism's survival, and so is consciousness.

Inducing Emotions

Emotions occur in one of two types of circumstances. The first type of circumstance takes place when the organism processes certain objects or situations with one of its sensory devices—for instance, when the organism takes in the sight of a familiar face or place. The second type of circumstance occurs when the mind of an organism conjures up from memory certain objects and situations and represents them as images in the thought process—for instance, remembering the face of a friend and the fact she has just died.

One obvious fact when we consider emotions is that certain sorts of objects or events tend to be systematically linked more to a certain kind of emotion more than to others. The classes of stimuli that cause happiness or fear or sadness tend to do so fairly consistently in the same individual and in individuals who share the same social and cultural background. In spite of all the possible individual variations in the expression of an emotion and in spite of the fact that we can have mixed emotions, there is a rough correspondence between classes of

emotion inducers and the resulting emotional state. Throughout evolution, organisms have acquired the means to respond to certain stimuli—particularly those that are potentially useful or potentially dangerous from the point of view of survival—with the collection of responses which we currently call an emotion.

But a word of caution is needed here. I really mean what I say when I talk about *ranges of stimuli* that constitute inducers for certain *classes of emotion*. I am allowing for a considerable variation in the type of stimuli that can induce an emotion—both across individuals and across cultures—and I am calling attention to the fact that regardless of the degree of biological presetting of the emotional machinery, development and culture have much to say regarding the final product. In all probability, development and culture superpose the following influences on the preset devices: first, they shape what constitutes an adequate inducer of a given emotion; second, they shape some aspects of the expression of emotion; and third, they shape the cognition and behavior which follows the deployment of an emotion.[13]

It is also important to note that while the biological machinery for emotions is largely preset, the inducers are not part of the machinery, they are external to it. The stimuli that cause emotions are by no means confined to those that helped shape our emotional brain during evolution and which can induce emotions in our brains from early in life. As they develop and interact, organisms gain factual and emotional experience with different objects and situations in the environment and thus have an opportunity to associate many objects and situations which would have been emotionally neutral with the objects and situations that are naturally prescribed to cause emotions. A form of learning known as conditioning is one way of achieving this association. A new house of a shape similar to the house in which you lived a blissful childhood may make you feel well even if nothing especially good has yet happened to you in it. Likewise, the face of a wonderful, unknown person that so resembles that of someone associated with some horrible event may cause you discomfort or irritation. You may never come to know why. Nature did not prescribe those responses, but it surely helped you acquire them. Incidentally, superstitions are born this way. There is something Orwellian about the distribution of emotions in our world: All objects can get some emotional attachment, but some objects get far more than others. Our primary biological design skews our secondary acquisitions relative to the world around us.

The consequence of extending emotional value to objects that were not biologically prescribed to be emotionally laden is that the range of stimuli that can potentially induce emotions is infinite. In one way or another, most objects and situations lead to some emotional reaction, although some far more so than others. The emotional reaction may be weak or strong—and fortunately for us it is weak more often than not—but it is there nonetheless. Emotion and the biological machinery underlying it are the obligate accompaniment of behavior, conscious or not. Some level of emoting is the obligate accompaniment of thinking about oneself or about one's surroundings.

The pervasiveness of emotion in our development and subsequently in our everyday experience connects virtually every object or situation in our experience, by virtue of conditioning, to the fundamental values of homeostatic regulation: reward and punishment; pleasure or pain; approach or withdrawal; personal advantage or disadvantage; and, inevitably, good (in the sense of survival) or evil (in the sense of death). Whether we like it or not, this is the *natural* human condition. But when consciousness is available, feelings have their maximum impact, and individuals are also able to reflect and to plan. They have a means to control the pervasive tyranny of emotion: it is called reason. Ironically, of course, the engines of reason still require emotion, which means that the controlling power of reason is often modest.

Another important consequence of the pervasiveness of emotions is that virtually every image, actually perceived or recalled, is accompanied by some reaction from the apparatus of emotion. We will consider the importance of this fact when we discuss the mechanisms for the birth of consciousness in chapter 6.

Let me close this comment on inducers of emotions with a reminder of a tricky aspect of the induction process. So far, I have referred to direct inducers—thunder, snakes, happy memories. But emotions can be induced indirectly, and the inducer can produce its result in a somewhat negative fashion, by blocking the progress of an ongoing emotion. Here is an example. When, in the presence of a source of food or sex, an animal develops approach behavior and exhibits features of the emotion happiness, blocking its way and preventing it from achieving its goals will cause frustration and even anger, a very different emotion from happiness. The inducer of the anger is not the prospect of food or sex but rather the thwarting of the behavior that was leading the animal to the good prospect. Another example would be the sudden suspension of a situation of punishment—for instance, sustained pain—which would induce well-being and happiness. The purifying (cathartic) effect that all good tragedies should have, according to Aristotle, is based on the sudden suspension of a steadily induced state of fear and pity. Long after Aristotle, Alfred Hitchcock built a brilliant career on this simple biological arrangement, and Hollywood has never stopped banking on it. Whether we like it or not, we feel very comfortable after Janet Leigh stops screaming in the shower and lies quietly on the bathtub floor. As far as emotion goes, there is not much escape in the setup that nature prepared for us. We get it coming and we get it going.

The Mechanics of Emotion

From experience, you know that the responses that make up emotions are most varied. Some responses are easily apparent in yourself and in others. Think of the muscles in the face adopting the configurations that are typical of joy or sorrow or anger; or of the skin blanching as a reaction to bad news or flushing in a situation of embarrassment; or consider the body postures that signify joy, defiance, sadness, or discouragement; or the sweaty and clammy hands of apprehension; the racing heart associated with pride; or the slowing, near-stillness of the heart in terror.

Other responses are hidden from sight but no less important, such as the myriad changes that occur in organs other than blood vessels, skin, and heart. One example is the secretion of hormones such as cortisol that change the chemical profile of the internal milieu; or the secretion of peptides, such as β-endorphin or oxytocin, that alter the operation of several brain circuits. Another is the release of neurotransmitters, such as the monoamines, norepinephrine, serotonin, and dopamine. During emotions, neurons located in the hypothalamus, basal forebrain, and brain stem release those chemical substances in several regions of the brain up above and, by so doing, temporarily transform the mode of working for many neural circuits. Typical consequences of the increase or decrease of release of such transmitters include the sense we have of the mind processes speeding up or slowing down, not to mention the sense of pleasantness or unpleasantness that pervades mental experience. Such sensing is part of our feeling of an emotion.

Different emotions are produced by different brain systems. In the very same way that you can tell the difference between a facial expression of anger and a facial expression of joy, in the very same way in which you can feel the difference between sadness or happiness in your flesh, neuroscience is beginning to show us how different brain systems work to produce, say, anger or sadness or happiness.

The study of patients with neurological diseases and focal brain damage has yielded some of the most revealing results in this area, but these investigations are now being complemented by functional neuroimaging of individuals without neurological disease. I should note that the work with human subjects also permits a rich dialogue with investigators who are approaching some of these same problems in animals, another welcome novelty in this area of research.

The essence of the available findings can be summarized as follows. First, the brain induces emotions from a remarkably small number of brain sites. Most of them are located below the cerebral cortex and are known as subcortical. The main subcortical sites are in the brain-stem region, hypothalamus, and basal forebrain. One example is the region known as periaqueductal gray (PAG), which is a major coordinator of

emotional responses. The PAG acts via motor nuclei of the reticular formation and via the nuclei of cranial nerves, such as the nuclei of the vagus nerve.[14] Another important subcortical site is the amygdala. The induction sites in the cerebral cortex, the cortical sites, include sectors of the anterior cingulate region and of the ventromedial prefrontal region.

Second, these sites are involved in processing different emotions to varying degrees. We have recently shown, using PET imaging, that the induction and experience of sadness, anger, fear, and happiness lead to activation in several of the sites mentioned above, but that the pattern for each emotion is distinctive. For instance, sadness consistently activates the ventromedial prefrontal cortex, hypothalamus, and brain stem, while anger or fear activate neither the prefrontal cortex nor hypothalamus. Brain-stem activation is shared by all three emotions, but intense hypothalamic and ventromedial prefrontal activation appears specific to sadness.[15]

Third, some of these sites are also involved in the recognition of stimuli which signify certain emotions. For instance, a series of studies in my laboratory has shown that a structure known as the amygdala, which sits in the depth of each temporal lobe, is indispensable to

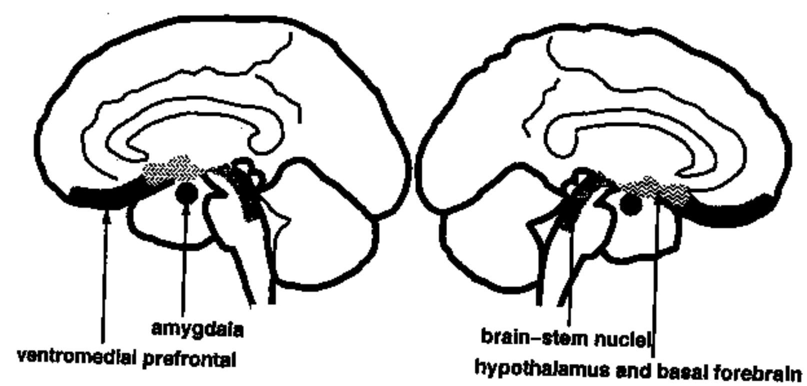

Figure 2.1. Principal emotion induction sites. Only one of these four sites is visible on the brain's surface (the ventromedial prefrontal region). The other regions are subcortical (see figure A.3 in the appendix for exact location). They are all located close to the brain's midline.

recognizing fear in facial expressions, to being conditioned to fear, and even to expressing fear. (In a parallel body of work, the studies of Joseph LeDoux and Michael Davis have shown that the amygdala is necessary for fear conditioning and revealed details of the circuitry involved in the process.[16]) The amygdala, however, has little interest in recognizing or learning about disgust or happiness. Importantly, other structures, just as specifically, are interested in those other emotions and not in fear.

The following description illustrates the fine etching of brain systems related to the production and recognition of emotion. It is but one among several examples that might be adduced to support the idea that there is no single brain center for processing emotions but rather discrete systems related to separate emotional patterns.

Have No Fear

Almost a decade ago, a young woman, to whom I shall refer as S, caught my attention because of the appearance of her brain CT scan. Unexpectedly, her scan revealed that both amygdalae, the one in the left and the one in the right temporal lobes, were almost entirely calcified. The appearance is striking. In a CT scan the normal brain shows up in myriad gray pixels, and the shade of gray defines the contours of the structures. But if a mineral like calcium has been deposited within the brain mass, the scan shows it as a bright milky white that you cannot possibly miss.

All around the two amygdalae, the brain of patient S was perfectly normal. But the amount of calcium deposition was such within the amygdalae that it was immediately apparent that little or no normal function of the neurons within the amygdalae could still take place. Each amygdala is very much a crossroads structure, with pathways from numerous cortical and subcortical regions ending in it and pathways emanating from it to just as many sites. The normal operations carried out by such profuse pathway cross signaling could simply not take place on either side of the brain of S. Nor was this a recent condition in her brain. The deposition of minerals within brain tissue takes

a long time to occur and the thorough and selective job we could witness in her brain had probably taken many years to accomplish, having begun within the first years of her life. For those who are curious about the causes behind the problem, I will say that S suffers from Urbach-Wiethe disease, a rare autosomal recessive condition characterized by abnormal depositions of calcium in the skin and throat. When the brain is affected by calcium deposits, the most frequently targeted structures are the amygdalae. Those patients often have seizures, fortunately not severe, and a minor seizure was indeed the reason why S first came to our care. We were able to help her and she has not had any seizures since.

My first impression of S was of a tall, slender, and extremely pleasant young woman. I was especially curious to find out about her learning and memory ability and about her social demeanor. The reason for this curiosity was twofold. There was considerable controversy at the

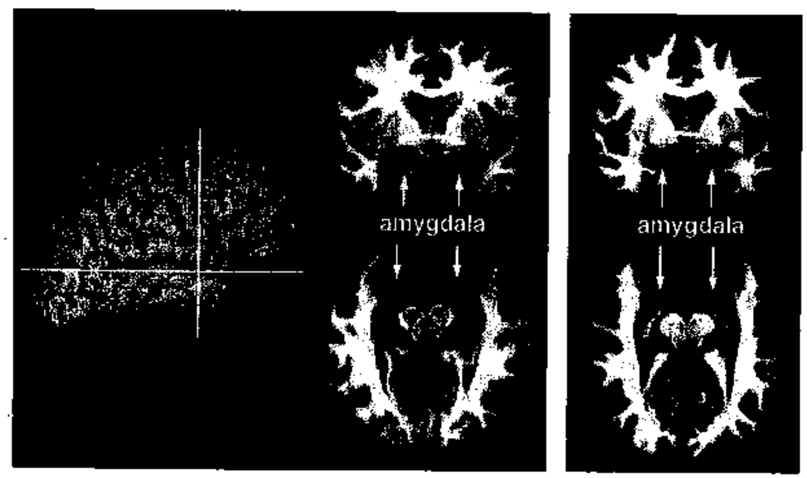

Figure 2.2. Bilateral damage of the amygdala in patient S (left panel) and normal amygdala (right panel). The sections were obtained along the two perpendicular planes shown by the white lines drawn over the brain's external surface. The black areas identified by the arrows are the damaged amygdalae. Compare with the normal amygdalae of a control brain shown in the exact same sections in the two panels on the right.

time regarding the contribution of the amygdalae to the learning of new facts, some investigators believing the amygdala was a vital partner to the hippocampus in the acquisition of new factual memory, other investigators believing it had little to contribute on that score. The curiosity regarding her demeanor was based on the fact that from studies involving nonhuman primates, it was known that the amygdala plays a role in social behaviors.[17]

I can make a long story short by telling you that there was nothing wrong whatsoever with S's ability to learn new facts. This was evident when I met her for only the second time and she clearly recognized me, smiled, and greeted me by name. Her one-shot learning of who I was, what my face looked like, and of my name was flawless. Numerous psychological tests would bear out this first impression, and that is precisely how things remain today. Years later, we were to show that a particular aspect of her learning was defective, but this had nothing to do with learning facts: it had to do with conditioning to unpleasant stimuli.[18]

Her social history, on the other hand, was exceptional. To put it in the simplest possible terms, I would say that S approached people and situations with a predominantly positive attitude. Others would actually say that her approach was excessively and inappropriately forthcoming. S was not only pleasant and cheerful, she seemed eager to interact with most anyone who would engage her in conversation, and several members of the clinical and research teams felt that the reserve and reticence one would have expected from her was simply lacking. For instance, shortly after an introduction, S would not shy away from hugging and touching. Make no mistake, her behavior caused no discomfort to anyone, but it was invariably perceived as a far cry from the standard behavior of a patient in her circumstances.

We were to learn that this very same attitude pervaded all areas of her life. She made friends easily, formed romantic attachments without difficulty, and had often been taken advantage of by those she trusted. On the other hand, she was and is a conscientious mother, and she tries hard to abide by social rules and be appreciated for her efforts. Human nature is indeed hard to describe and full of contradictions in the best of circumstances and the prime of health. It is almost impossible to do justice to it when we enter the realm of disease.

The first years of research on S yielded two important results. On the one hand, S did not have any problem learning facts. In fact, it was possible to say that her sensory perceptions, her movements, her language, and her basic intelligence were no different from those of an entirely healthy average individual in terms of elementary competence. On the other hand, her social behavior demonstrated a consistent skewing of her prevailing emotional tone. It was as if negative emotions such as fear and anger had been removed from her affective vocabulary, allowing the positive emotions to dominate her life, at least by greater frequency of occurrence if not by greater intensity. This was of special interest to me because I had noticed a similar pattern in patients with bilateral damage to the anterior sector of the temporal lobe, who, as a part of their large lesions, also had damage to the amygdalae. It was reasonable to hypothesize that their affective lopsidedness was traceable to damage in the amygdala.

All of these suppositions were to be turned into hard fact when Ralph Adolphs joined my laboratory. Using a variety of clever techniques in the investigation of several patients, some with damage to the amygdala and some with damage to other structures, Adolphs was able to determine that the affective lopsidedness was mostly caused by the impairment of one emotion: fear.[19]

Using a multidimensional scaling technique, Adolphs showed that S cannot consistently tell the expression of fear in another person's face, especially when the expression is ambiguous or other emotions are being expressed simultaneously. She has no such problem with the recognition of other facial expressions of emotion, namely, that of surprise which is, in many respects, similar in general configuration. Curiously, S, who has a remarkable gift for drawing and has good drafting skills, cannot draw a face that represents fear although she can draw faces that represent other emotions. When asked to mimic facial expressions of emotions she does so easily for the primary emotions but not for fear. Her attempts produce little change in her facial expression after which she confesses her complete failure. Again, she has no difficulty producing a facial expression of surprise. Lastly, S does not experience fear in the same way you or I would in a situation that would normally induce it. At a purely intellectual level she knows what fear is supposed to be, what should cause it, and even what one may do in situations of fear, but little or none of that intellectual baggage, so to speak, is of any use to her in the real world. The fearlessness of her nature, which is the result of the bilateral damage to her amygdalae, has prevented her from learning, throughout her young life, the significance of the unpleasant situations that all of us have lived through. As a result she has not learned the telltale signs that announce possible danger and possible unpleasantness, especially as they show up in the face of another person or in a situation. Nowhere has this been proved more clearly than in a recent study requiring a judgment of trustworthiness and approachability based on human faces.[20]

The experiment called for the judgment of one hundred human faces that had been previously rated by normal individuals as indicating varied degrees of trustworthiness and approachability. There were fifty faces that had been consistently judged as inspiring trust and fifty that were not. The selection of these faces was made by normal individuals who were asked a simple question: How would you rate this face on a scale of one to five, relative to the trustworthiness and approachability that the owner of the face inspires? Or, in other words, how eager would you be to approach the person with this particular face if you needed help?

Once the one hundred faces were properly distributed based on the ratings of the forty-six normal individuals, we turned to patients with brain damage. S was one of three patients with bilateral damage to the amygdala included in the study, but we also investigated the performance of seven patients with damage to either the left amygdala or right amygdala, three patients with damage to the hippocampus and an inability to learn new facts, and ten patients with damage elsewhere in the brain, i.e., outside the amygdala and outside the hippocampus. The results were far more remarkable than we expected.

S, along with other patients who also have damage to the amygdalae on both sides of the brain, looked at faces that you or I would consider trustworthy and classified them, quite correctly, as you or I would, as faces that one might approach in case of need. But when they looked at faces of which you or I would be suspicious, faces of persons that we would try to avoid, they judged them as equally trustworthy. The patients with damage to only one amygdala, the amnesic patients, and the other brain-damaged patients performed as normals do.

The inability to make sound social judgments, based on previous experience, of situations that are or are not conducive to one's welfare has important consequences for those who are so affected. Immersed in a secure Pollyanna world, these individuals cannot protect themselves against simple and not-so-simple social risks and are thus more vulnerable and less independent than we are. Their life histories testify to this chronic impairment as much as they testify to the paramount importance of emotion in the governance not just of simple creatures but of humans as well.

How It All Works

In a typical emotion, then, certain regions of the brain, which are part of a largely preset neural system related to emotions, send commands to other regions of the brain and to most everywhere in the body proper. The commands are sent via two routes. One route is the bloodstream, where the commands are sent in the form of chemical molecules that act on receptors in the cells which constitute body tissues. The other route consists of neuron pathways and the commands along this route take the form of electrochemical signals which act on other neurons or on muscular fibers or on organs (such as the adrenal gland) which in turn can release chemicals of their own into the bloodstream.

The result of these coordinated chemical and neural commands is a global change in the state of the organism. The organs which receive the commands change as a result of the command, and the muscles, whether the smooth muscles in a blood vessel or the striated muscles in the face, move as they are told to do. But the brain itself is changed just as remarkably. The release of substances such as monoamines and peptides from regions of nuclei in the brain stem and basal forebrain alters the mode of processing of numerous other brain circuits, triggers certain specific behaviors (for example, bonding, playing, crying), and modifies the signaling of body states to the brain. In other words, both the brain and the body proper are largely and profoundly affected by the set of commands although the origin of those commands is circumscribed to a relatively small brain area which responds to a particular content of the mental process. Now consider this: Beyond emotion, specifically described as the collection of responses I just outlined, two additional steps must take place before an emotion is *known*. The first is feeling, the imaging of the changes we just discussed. The second is the application of core consciousness to the entire set of phenomena. Knowing an emotion—feeling a feeling—only occurs at that point.

These events can be summarized by walking through the three key steps of the process:

1. Engagement of the organism by an inducer of emotion, for instance, a particular object processed visually, resulting in visual representations of the object. Imagine running into Aunt Maggie, whom you love and have not seen in a long time. Chances are you will immediately recognize Aunt Maggie, but even if you do not, or even before you do, the basic process of emotion will continue on to the next step.
2. Signals consequent to the processing of the object's image activate all the neural sites that are prepared to respond to the particular class of inducer to which the object belongs. The sites I am talking about—for instance, in the ventromedial prefrontal cortices, amygdala, and brain stem—have been preset innately, but past experience with things Maggie has modulated the manner in which they are likely to respond, for instance, the ease with which they will respond. By the way, Aunt Maggie is not traveling all over your brain in the form of a passport photo. She exists as a visual image, arising out of neural patterns generated by the interaction of several areas in early visual cortices, largely in occipital lobes. Signals consequent to the presence of her image travel elsewhere and do their job when parts of the brain that are interested in things Maggie respond to such signals.
3. As a result of step 2, emotion induction sites trigger a number of signals toward other brain sites (for instance, monoamine nuclei, somatosensory cortices, cingulate cortices) and toward the body (for instance, viscera, endocrine glands), as previously discussed. Under some circumstances the balance of responses may favor intrabrain circuitry and engage the body minimally. This is what I have called "as if body loop" responses.

The combined result of steps 1, 2, and 3 is a momentary and appropriate collection of responses to the circumstances causing the whole commotion: for instance, Aunt Maggie in sight; or the death of a friend announced; or nothing that you can tell consciously; or, if you are a baby bird in a high nest, the image of a large object flying overhead. Take the latter example. The baby bird has no idea that this is a predatory eagle, and no conscious sense of the danger of the situation. No thought process, in the proper meaning of the term, tells the baby bird to do what it does next, which is to crouch as low as possible in the nest, as quietly as possible, such that it may become invisible to the eagle. And yet, the steps of the process that I have just described were engaged: visual images were formed in the baby bird's visual brain, some sectors of the brain responded to the *kind* of visual image the brain formed, and all the appropriate responses, chemical and neural, autonomic and motor, were engaged at full tilt. The quiet and slow tinkering of evolution has done all the thinking for the baby bird, and its genetic system has dutifully transmitted it. With a little bit of help from mother bird and earlier circumstances, the miniconcert of fear is ready to be played whenever the situation demands it. The fear response that you can see in a dog or a cat is executed in exactly the same manner, and so is the fear response you can examine in yourself when you walk at night on a dark street. That we, and at least the dog and the cat, can also come to know about the feelings caused by those emotions, thanks to consciousness, is another story.

In fact, you can find the basic configurations of emotions in simple organisms, even in unicellular organisms, and you will find yourself attributing emotions such as happiness or fear or anger to very simple creatures who, in all likelihood, have no feeling of such emotions in the sense that you or I do, creatures which are too simple to have a brain, or, having one, too rudimentary to have a mind. You make those attributions purely on the basis of the movements of the organism, the speed of each act, the number of acts per unit of time, the style of the movements, and so on. You can do the same thing with a simple chip moving about on a computer screen. Some jagged fast movements will appear "angry," harmonious but explosive jumps will look "joyous," recoiling motions will look "fearful." A video that depicts several geometric shapes moving about at different rates and holding varied relationships reliably elicits attributions of emotional state from normal adults and even children. The reason why you can anthropomorphize the chip or an animal so effectively is simple: emotion, as the word indicates, is about movement, about externalized behavior, about certain orchestrations of reactions to a given cause, within a given environment.[21]

Somewhere between the chip and your pet sits one of the living creatures that has most contributed to progress in neurobiology, a marine snail known as *Aplysia californica*. Eric Kandel and his colleagues have made great inroads in the study of memory using this very simple snail which may not have much of a mind but certainly has a scientifically decipherable nervous system and many interesting behaviors. Well, *Aplysia* may not have feelings as you or I do, but it has something not unlike emotions. Touch the gill of an *Aplysia*, and you will see the gill recoil swiftly and completely, while the heart rate of *Aplysia* goes up and it releases ink into the surroundings to confuse the enemy, a bit like James Bond when he is hotly pursued by Dr. No. *Aplysia* is emoting with a miniconcert of responses that is formally no

different, only simpler, from the one that you or I could display under comparable circumstances. To the degree that *Aplysia* can represent its emotive state in the nervous system, it may have the makings of a feeling. We do not know whether *Aplysia* has feelings or not, but it is extremely difficult to imagine that *Aplysia* would know of such feelings if it does have them.[22]

Sharpening the Definition of Emotion: An Aside

What qualifies for an emotion? Does pain? Does a startle reflex? Neither does, but if not, why not? The closeness of these related phenomena calls for sharp distinctions but the differences tend to be ignored. Startle reflexes are part of the repertoire of regulatory responses available to complex organisms and are made up of simple behaviors (e.g., limb withdrawal). They may be included among the numerous and concerted responses that constitute an emotion—endocrine responses, multiple visceral responses, multiple musculoskeletal responses, and so on. But even the simple emotive behavior of the *Aplysia* is more complicated than a simple startle response.

Pain does not qualify for emotion, either. Pain is the consequence of a state of local dysfunction in a living tissue, the consequence of a stimulus—impending or actual tissue damage—which causes the sensation of pain but also causes regulatory responses such as reflexes and may also induce emotions on its own. In other words, emotions can be caused by the same stimulus that causes pain, but they are a different result from that same cause. Subsequently, we can come to know that we have pain and that we are having an emotion associated with it, provided there is consciousness.

When you picked up that hot plate the other day and burned the skin of your fingers, you had pain and might even have suffered from having it. Here is what happened to you, in the simplest neurobiological terms:

First, the heat activated a large number of thin and unmyelinated nerve fibers, known as C-fibers, available near the burn. (These fibers, which are distributed literally everywhere in the body, are evolution- arily old and are largely dedicated to carrying signals about internal body states, including those that will end up causing pain. They are called *unmyelinated* because they lack the insulating sheath known as myelin. Lightly myelinated fibers known as A-δ fibers travel along with C-fibers and perform a similar role. Together they are called *noci- ceptive* because they respond to stimuli that are potentially or actually damaging to living tissues.)

Second, the heat destroyed several thousand skin cells, and the de- struction released a number of chemical substances in the area.

Third, several classes of white blood cell concerned with repairing tissue damage were called to the area, the call having come from some of the released chemicals (e.g., a peptide known as substance P and ions such as potassium).

Fourth, several of those chemicals activated nerve fibers on their own, joining their signaling voices to that of the heat itself.

Once the activation wave was started in the nerve fibers, it traveled to the spinal cord and a chain of signals was produced across several neurons (a neuron is a nerve cell) and several synapses (a synapse is the point where two neurons connect and transmit signals) along the appropriate pathways. The signals went all the way into the top levels of the nervous system: the brain stem, the thalamus, and even the cerebral cortex.

What happened as a result of the succession of signals? Ensembles of neurons located at several levels of the nervous system were tem- porarily activated and the activation produced a neural pattern, a sort of map of the signals related to the injury in your fingers. The central nervous system was now in possession of multiple and varied neural patterns of tissue damage selected according to the biological specifi- cations of your nervous system and of the body proper with which it connects. The conditions needed to generate a sensation of pain had been met.

The question that I am leading to arrives at this point: Would one or all of those neural patterns of injured tissue be the same thing as

knowing that you had pain? And the answer is, not really. Knowing that you have pain requires something else that occurs *after* the neural patterns that correspond to the substrate of pain—the nociceptive signals—are displayed in the appropriate areas of the brain stem, thalamus, and cerebral cortex and generate an image of pain, a feeling of pain. But note that the "after" process to which I am referring is not beyond the brain, it is very much in the brain and, as far as I can fathom, is just as biophysical as the process that came before. Specifi- cally, in the example above, it is a process that interrelates neural pat- terns of tissue damage with the neural patterns that stand for *you*, such that yet another neural pattern can arise—the neural pattern of you knowing, which is just another name for consciousness. If the latter interrelating process does not take place, you will never know that there was tissue damage in your organism—if there is no you and there is no knowing, there is no way for you to know, right?

Curiously, if there had been no you, i.e., if you were not conscious and if there had been no self and no knowing relative to hot plates and burning fingers, the wealthy machinery of your self-*less* brain would still have used the nociceptive neural patterns generated by tis- sue damage to produce a number of useful responses. For instance, the organism would have been able to withdraw the arm and hand from the source of heat within hundreds of milliseconds of the be- ginning of tissue damage, a reflex process mediated by the central nervous system. But notice that in the previous sentence I said "or- ganism" rather than "you." Without knowing and self, it would not have been quite "you" withdrawing the arm. Under those circum- stances, the reflex would belong to the organism but not necessarily to "you." Moreover, a number of emotional responses would be engaged automatically, producing changes in facial expression and posture, along with changes in heart rate and control of blood circula- tion—we do not learn to wince with pain, we just wince. Although all of these responses, simple and not so simple, occur reliably in compa- rable situations in all conscious human beings, consciousness is not needed at all for the responses to take place. For instance, many of these responses are present even in comatose patients in whom consciousness is suspended—one of the ways in which we neurologists evaluate the state of the nervous system in an unconscious patient consists of establishing whether the patient reacts with facial and limb movements to unpleasant stimuli such as rubbing the skin over the sternum.

Tissue damage causes neural patterns on the basis of which your organism is in a state of pain. If you are conscious, those same patterns can also allow *you* to know you have pain. But whether or not you are conscious, tissue damage and the ensuing sensory patterns also cause the variety of automated responses outlined above, from a simple limb withdrawal to a complicated negative emotion. In short, pain and emotion are not the same thing.

You may wonder how the above distinction can be made, and I can give you a large body of evidence in its support. I will begin with a fact that comes from direct experience, early in my training, of a patient in whom the dissociation between *pain as such* and *emotion caused by pain* was vividly patent.[23] The patient was suffering from a severe case of refractory trigeminal neuralgia, also known as tic douloureux. This is a condition involving the nerve that supplies signals for face sensation in which even innocent stimuli, such as a light touch of the skin of the face or a sudden breeze, trigger an excruciating pain. No medication would help this young man who could do little but crouch, immobilized, whenever the excruciating pain stabbed his flesh. As a last resort, the neurosurgeon Almeida Lima, who was also one of my first mentors, offered to operate on him, because producing small lesions in a specific sector of the frontal lobe had been shown to alleviate pain and was being used in last-resort situations such as this.

I will not forget seeing the patient on the day before the operation, afraid to make any movement that might trigger a new round of pain, and then seeing him two days after the operation, when we visited him on rounds; he had become an entirely different person, relaxed, happily absorbed in a game of cards with a companion in his hospital

room. When Lima asked him about the pain, he looked up and quite cheerfully that "the pains were the same," but that he felt now. I remember my surprise as Lima probed the man's state of m a bit further. The operation had done little or nothing to the sens patterns corresponding to local tissue dysfunction that were be supplied by the trigeminal system. The mental images of that tis dysfunction were not altered and that is why the patient could rep that the pains were the same. And yet the operation had been a s cess. It had certainly abolished the emotional reactions that the s sory patterns of tissue dysfunction had been engendering. Suffer was gone. The facial expression, the voice, and the general depo ment of this man were not those one associates with pain.

This sort of dissociation between "pain sensation" and "pain affe has been confirmed in studies of groups of patients who underwe surgical procedures for the management of pain. More recent Pierre Rainville, who is now an investigator in my laboratory, h shown by means of a clever manipulation using hypnosis that pa sensation and pain affect are clearly separable. Hypnotic suggestio designed to influence pain affect specifically without altering pa sensation modulated cerebral activity within the cingulate cortex, t same overall region that neurosurgeons can damage to alleviate su fering from chronic and intractable pain. Rainville has also show that when hypnotic suggestions were aimed at pain sensation rath than at the emotions associated with pain, not only were the changes in *both* unpleasantness and intensity ratings, but also the were changes in SI (the primary somatosensory cortex) and the cin gulate cortex.[24] In brief: hypnotic suggestions aimed at the emotion that follow pain rather than at pain sensation reduced emotion bu not pain sensation and also caused functional changes in cingulat cortex only; hypnotic suggestions aimed at pain sensation reduce *both* pain sensation and emotion, and caused functional changes in S and in the cingulate cortex. Perhaps you have had the direct exper ence of what I am describing if you have ever taken beta-blockers t treat a heart-rhythm problem or if you have taken a tranquilizer such as Valium. Those medications reduce your emotional reactivity, and should you also have pain at the time, they will reduce the emotion caused by pain.

We can verify the different biological status of pain and emotion by considering how different interventions interfere with one but not the other. For instance, the stimuli that cause pain can be specifically reduced or blocked by analgesia. When the transmission of signals leading to the representation of tissue dysfunction is blocked, neither pain nor emotion ensue. But it is possible to block emotion and *not* pain. The would-be emotion caused by tissue damage can be reduced by appropriate drugs, e.g., Valium or beta-blockers, or even by selective surgery. The perception of tissue damage remains but the blunting of emotion removes the suffering that would have accompanied it.

And what about pleasure? Is pleasure an emotion? Again, I would prefer to say it is not, although, just like pain, pleasure is intimately related to emotion. Like pain, pleasure is a constituent quality of certain emotions as well as a trigger for certain emotions. While pain is associated with negative emotions, such as anguish, fear, sadness, and disgust, whose combination commonly constitutes what is called suffering, pleasure is associated with many shades of happiness, pride, and positive background emotions.

Pain and pleasure are part of biological design for obviously adaptive purposes, but they do their job in very different circumstances. Pain is the perception of a sensory representation of local living-tissue dysfunction. In most circumstances when there is actual or impending damage to living tissues there arise signals that are transmitted both chemically and via nerve fibers of the C and A-δ type, and appropriate representations are created in the central nervous system, at multiple levels. In other words, the organism is designed to respond to the actual or threatened loss of integrity of its tissue with a particular type of signaling. The signaling recruits a host of chemical and neural responses all the way from local reactions of white blood cells, to reflexes involving an entire limb, to a concerted emotional reaction.

Pleasure arises in a different setting. Turning to the simple example of pleasures associated with eating or drinking, we see that pleasure is commonly initiated by a detection of imbalance, for instance, low blood sugar or high osmolality. The unbalance leads to the state of hunger or thirst (this is known as a motivational and drive state), which leads in turn to certain behaviors involving the search for food or water (also part and parcel of the motivational and drive state), which leads to the eventual acts of eating or drinking. The control of these several steps involves many functional loops, at different hierarchies, and requires the coordination of internally produced chemical substances and neural activity.[25] The pleasurable state may begin during the search process, in anticipation of the actual goal of the search, and increase as the goal is achieved.

But between the cup and the lip many a slip. A search for food or drink that takes too long or is unsuccessful will not be accompanied by pleasure and positive emotions at all. Or, if in the course of a successful search, an animal is prevented from actually achieving its goal, the thwarting of the consummation may actually cause anger. Likewise, as I noted in my comment on Greek tragedy, the alleviation or suspension of a state of pain may cause the emergence of pleasure and positive emotions.

The point to retain here is the possible interrelationship between pain and pleasure and the attending emotions, as well as the fact that they are not the mirror image of each other. They are different and asymmetric physiological states, which underlie different perceptual qualities destined to help with the solution of very different problems. (The duality of pain and pleasure should not make us overlook the fact that there are more than two emotions, some of which are aligned with pain and some with pleasure, mostly the former. The apparent symmetry of this deep division vanishes as behaviors become more complex in evolution.) In the case of pain, the problem is coping with the loss of integrity of living tissue as a result of injury, be it internally caused by natural disease or externally induced by the attack of a predator or by an accident. In the case of pleasure, the problem is to lead an organism to attitudes and behaviors that are conducive to the maintenance of its homeostasis. Curiously, pain, which I regard as one of the main determinants of the course of biological and cultural evolution, may have begun as an afterthought of nature, an attempt to deal with a problem that has already arisen. I used to think of pain as putting a good lock on the door after a house has been robbed, but Pierre Rainville has suggested a better metaphor to me: putting a *body*-guard in front of the house while you repair the broken window. After all, pain does not result in preventing yet another injury, at least not immediately, but rather in protecting the injured tissue, facilitating tissue repair, and avoiding infection of the wound. Pleasure, on the other hand, is all about forethought. It is related to the clever anticipation of what can be done *not* to have a problem. At this basic level, nature found a wonderful solution: it seduces us into good behavior.

Pain and pleasure are thus part of two different genealogies of life regulation. Pain is aligned with punishment and is associated with behaviors such as withdrawal or freezing. Pleasure, on the other hand, is aligned with reward and is associated with behaviors such as seeking and approaching.

Punishment causes organisms to close themselves in, freezing and withdrawing from their surroundings. Reward causes organisms to open themselves up and out toward their environment, approaching it, searching it, and by so doing increasing both their opportunity of survival and their vulnerability.

This fundamental duality is apparent in a creature as simple and presumably as nonconscious as a sea anemone. Its organism, devoid of brain and equipped only with a simple nervous system, is little more than a gut with two openings, animated by two sets of muscles, some circular, the others lengthwise. The circumstances surrounding the sea anemone determine what its entire organism does: open up to the world like a blossoming flower—at which point water and nutrients enter its body and supply it with energy—or close itself in a contracted flat pack, small, withdrawn, and nearly imperceptible to others. The essence of joy and sadness, of approach and avoidance, of vulnerability and safety, are as apparent in this simple dichotomy of brainless behavior as they are in the mercurial emotional changes of a child at play.

The Substrate for the Representation of Emotions and Feelings

There is nothing vague, nothing elusive, nothing nonspecific, about the collection of responses I have just described as constituting an emotion. The substrate for the representation of emotions is a collection of neural dispositions in a number of brain regions located largely in subcortical nuclei of the brain stem, hypothalamus, basal forebrain, and amygdala. In keeping with their dispositional status, these representations are implicit, dormant, and not available to consciousness. They exist, rather, as potential patterns of activity arising within neuron ensembles. Once these dispositions are activated, a number of consequences ensue. On the one hand, the pattern of activation represents, within the brain, a particular emotion as neural "object." On the other, the pattern of activation generates explicit responses that modify both the state of the body proper and the state of other brain regions. By so doing, the responses create an emotional state, and at that point, an external observer can appreciate the emotional engagement of the organism being observed. As for the internal state of the organism in which the emotion is taking place, it has available both the emotion as neural object (the activation pattern at the induction sites) and the sensing of the consequences of the activation, a feeling, provided the resulting collection of neural patterns becomes images in mind.

The neural patterns which constitute the substrate of a feeling arise in two classes of biological changes: changes related to body state and changes related to cognitive state. The changes related to body state are achieved by one of two mechanisms. One involves what I call the "body loop." It uses both humoral signals (chemical messages conveyed via the bloodstream) and neural signals (electrochemical messages conveyed via nerve pathways). As a result of both types of signal, the body landscape is changed and is subsequently represented in somatosensory structures of the central nervous system, from the brain stem on up. The change in the representation of the body landscape can be partly achieved by another mechanism, which I call the "as if body loop." In this alternate mechanism, the representation of body-related changes is created directly in sensory body maps, under the control of other neural sites, for instance, the prefrontal cortices. It is "as if" the body had really been changed but it has not.

The changes related to cognitive state are no less interesting. They occur when the process of emotion leads to the secretion of certain chemical substances in nuclei of the basal forebrain, hypothalamus, and brain stem, and to the subsequent delivery of those substances to several other brain regions. When these nuclei release certain neuromodulators (such as monoamines) in the cerebral cortex, thalamus, and basal ganglia, they cause several significant alterations of brain function. The full range of alterations is not completely understood yet, but here are the most important I envision: (1) the induction of specific behaviors such as those aimed at generating bonding, nurturing, exploration, and playing; (2) a change in the ongoing processing of body states such that body signals may be filtered or allowed to pass, be selectively inhibited or enhanced, and their pleasant or unpleasant quality modified; and (3) a change in the mode of cognitive processing such that, for example, the rate of production of auditory or visual images can be changed (from slow to fast or vice versa) or the focus of images can be changed (from sharply focused to vaguely focused); changes in rate of production or focus are an integral part of emotions as disparate as those of sadness or elation.

Assuming that all the proper structures are in place, the processes reviewed above allow an organism to undergo an emotion, exhibit it, and image it, that is, feel the emotion. But nothing in the above review indicates how the organism could know that it was feeling the emotion it was undergoing. For an organism to know that it has a feeling, it is necessary to add the process of consciousness in the aftermath of the processes of emotion and feeling. In the chapters ahead I give you my idea of what consciousness is and of how it may work so that we can "feel" a feeling.