**Joseph LeDoux (1996) The Emotional Brain. The Mysterious Underpinnings of Emotional Life. TOUCHSTONE. Simon & Schuster.**

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## 5. THE WAY WE WERE (pp. 104-137, 315-317)

*"Human subtlety . . . will never devise an invention more beautiful, more simple or more direct than does nature."* Leonardo da Vinci, *The Notebooks (1508-1518)*[1]

When engineers sit down to design machines, they start off with some function they want to implement and then figure out how to make a device that will accomplish the task. But biological machines aren't assembled from carefully engineered plans. The human brain, for example, happens to be the most sophisticated machine imaginable, or unimaginable, yet it wasn't predesigned. It is the product of evolutionary tinkering, where lots of little changes over extremely long periods of time have accumulated.[2]

Organisms, according to Stephen J. Gould, are Rube Goldberg devices, patchworks of quick fixes and partial solutions that shouldn't work but somehow do the trick.[3] Evolution works with what it has, rather than starting from scratch. As evolutionary biologist Richard Dawkins points out, this is horribly inefficient on small time scales— it would have been foolish to try and construct the first jet engine by modifying an existing gasoline engine.[4] But, as Dawkins notes, evolution's strategy of tinkering works pretty well over the huge spans of time on which it operates. Besides, there's no alternative.

The problem of figuring out how a brain works has been described by the linguist Steven Pinker as "reverse engineering."[5] We've got the product and we want to know how it functions. So we pick the brain apart in the hope that we will see what evolution was up to when it put the device together. Although we often talk about the brain as if it has a function, the brain itself actually has no function. It is a collection of systems, sometimes called modules, each with different functions.[6] There is no equation by which the combination of the functions of all the different systems mixed together equals an additional function called brain function.

Evolution tends to act on the individual modules and their functions rather than the brain as a whole. For example, there is evidence that specific brain adaptations underlie certain capacities, like song learning in birds, memory for food location in foragers, sex differences, hand preferences, and language skills in humans.[7] It is true that at times evolution might act globally,[8] say increasing the size of the entire brain, but by and large most evolutionary changes in the brain take place at the level of individual modules. These modules accomplish such mental exotica as having thoughts or beliefs, but also activities as mundane as breathing. Evolutionary improvements in our ability to believe do not necessarily help us breathe any better. They may, but they don't necessarily.

Admittedly, breathing and believing are pretty distinct functions, clearly mediated by different brain regions. Breathing is controlled in the medulla oblongata, that utility station down in the subbasement of the brain, whereas believing, like all good higher cognitive functions, goes on up in the neocortical penthouse. Contrasting these is not so interesting.

So let's consider functions that are more similar, like different emotions. Do changes in our ability to detect danger and respond to it help us in our love life or make us less prone to anger or depression; They could, especially if there was a universal emotional system in the brain, a system dedicated to emotional functions and within which all emotional functions are mediated. A general improvement in the operation of this system would probably impact across the board on all emotions. We could certainly concoct an explanation for why feeling good and bad may have been beneficial to survival to our ancestors, and theirs, and therefore why an all-purpose emotion system might have evolved. In the last chapter, though, we saw that attempts to find a single unified brain system of emotion have not been very successful. It is possible that such a system exists and that scientists just haven't been clever enough to find it, but I don't think that's the case. Most likely, attempts to find an all-purpose emotion system have failed because such a system does not exist. Different emotions are mediated by different brain networks, different modules, and evolutionary changes in a particular network don't necessarily affect the others directly. There might of course be indirect effects—an increased ability to detect danger and defend against it might leave more time and resources for pursuing romantic interests—but this is a different matter.

If I'm correct, the only way to understand how emotions come out of brains is to study emotions one at a time. If there are different emotional systems and we ignore this diversity we will never make much sense of the brain's emotional secrets. If I'm wrong, though, we've lost nothing by taking this approach. We can mix the findings from fear, anger, disgust, and joy back together anytime.

For these reasons, my research on the emotional brain has been focused on the neural basis of one particular emotion—fear, and its various incarnations. Much of the remainder of this book is aimed at explaining what we know about the brain mechanisms of fear, especially what we've learned from research on fear behavior in nonhuman animals, and then seeing to what extent this knowledge can help us understand "emotion" in the broader sense of the term (especially human emotion). But before going further, I need to convince you that the study of fear behavior in animals is a good starting point. And before doing this, I need to go through some ideas about the evolution of emotions, some criticisms of them, and my take on where the balance lies.

## To Change or Not to Change, That Is the (Evolutionary) Question

For some mental functions, like language, the job facing evolutionary theorists is to try to understand how the function came to be in humans. Our species seems to be the only one living now that is endowed with natural language.[9] So the big question, in terms of origins, is what did language evolve from—what were the intermediate phases that the brain passed through in the transition from nonspeaking to speaking primates?

When it comes to emotions, though, we face a different problem. Contrary to the views of some humanists, I believe that emotions are anything but uniquely human traits and, in fact, that some emotional systems in the brain are essentially the same in many of the backboned creatures, including mammals, reptiles, and birds, and possibly amphibians and fishes as well. If this is true, and I'll try to convince you that it is, our first order of business is quite different from that of the evolutionary linguists. Rather than trying to figure out what is unique about human emotion, we need to examine how evolution stubbornly maintains emotional functions across species while changing many other brain functions and bodily traits.

If people had wings, William James would have posed his famous question about running away from the bear in terms of flying away. He would have asked whether fear is the result of flying away from danger or whether flying from danger causes us to be afraid. Stated this way, the question loses none of its meaning. Escaping from danger is something that all animals have to do to survive. Uniquely human traits, like the ability to compose poetry or solve differential equations, are irrelevant to what goes on when we are faced with a sudden and immediate threat to our existence. What is important is that the brain have a mechanism for detecting the danger and responding to it appropriately and quickly. The particular behavior that occurs is tailored to the species (running, flying, swimming), but the brain function underlying that response is the same—protection against the danger.[10] This is as true of a human animal as of a slimy reptile. And, as we will see, evolution has seen fit to pretty much leave well enough alone inside the brain when it comes to these functions.

## Emotional Descent

The belief that at least some emotions might be shared by man and other creatures has been around for a long time, at least since Plato proclaimed that the passions are wild beasts trying to escape from the human body.[11] But an understanding of how and why aspects of mind and behavior might be commonly represented in humans and other species remained completely obscure until Charles Darwin conceived of the theory of evolution by natural selection in the last century.[12]

Darwin got his ideas by looking at life around him. He noted that children resemble their parents, but differ from them as well. And he was fascinated with the ability of breeders of domestic animals to build traits in offspring by carefully mixing and matching parents— cows could be made to produce more milk and horses to run faster by preselecting the parents. He reasoned that something similar might occur naturally. Armed with these observations, and others made on his famous voyage to the Galapagos Islands, Darwin proposed that, through heritability and variability, "descent with modification" occurs.

Stephen J. Gould tells us that Darwin did not use the term "evolution" to describe natural selection.[13] At the time, evolution had two other connotations, both of which were incompatible with Darwin's theory. One had to do with the notion that embryos grow from preformed homunculi enclosed in the egg and sperm (tiny preserved versions of Adam and Eve). The other was a vernacular usage that implied constant progress toward an ideal. Darwin felt that a so-called lower form of life, like an amoeba, could be as adapted to its environment as a human is to its—humans, in other words, are not necessarily closer to some evolutionary ideal than other animals. It was really Herbert Spencer, a contemporary of Darwin's, who transformed "descent with modification" into "evolution," the catchier term that we use today.[14]

In rough-and-ready terms, Darwin's theory of natural selection went something like this.[15] Those traits that were useful to the survival of a species in a particular environment became, over the long run, characteristic traits of the species. And, by the same token, the characteristic traits of current species exist because they contributed to the survival of distant ancestors. Because of limited food supplies, not all individuals that are born survive to the point of sexual maturity and procreate. The less fit get weeded out so that over time more and more of the better fit become parents and pass on their fitness to their offspring. But if the environment happens to change, and it does so constantly, then different traits become relevant to survival, and these eventually get selected for. Species that adapt in this way survive, whereas those that do not become extinct.

Darwin's theory is most often thought of as an explanation of how physical features of species evolved. However, he argued that mind and behavior are also shaped by natural selection. James G,ould, a behavioral biologist, makes this point forcefully:

> Darwin's revolutionary insights into evolution . . . demonstrated for the first time the inextricable link between an animal's world and its behavior. His theory of natural selection made it possible to understand why animals are so well endowed with mysterious instincts— why a wasp, for example, gathers food she has never eaten to feed larvae she will never see. Natural selection, Darwin hypothesized, favors animals which leave the most offspring. Through countless generations the survivors of the unceasing struggle for a limited amount of food have to be ever more perfectly adapted to their worlds, both morphologically and behaviorally.... Carefully programmed behavior like that of the wasp must provide an enormous competitive advantage for animals.[16]

In *The Expression of the Emotions in Man and Animals*, Darwin proposed that "the chief expressive actions, exhibited by man and by the lower animals, are now innate or inherited,—that is, have not been learnt by the individual.[17] As evidence for emotional innateness, he noted the similarity of expressions both within and between species. In humans, Darwin was particularly impressed with the fact that the bodily expressions (especially of the face) occurring during emotions are similar in people around the world, regardless of racial origins or cultural heritage. He also pointed out that these same expressions are present in persons born blind, and thus lacking the opportunity to have learned the muscle movements from seeing them in others, and are also present in very young children, who also have had little opportunity to learn to express emotions by imitation.[18]

Darwin mustered instances of all sorts of bodily expressions that are similar in different species. Although the greatest similarities were found between closely related species, Darwin was able to identify some striking similarities, even within fairly dissimilar organisms. He pointed out how common it is for animals of all varieties, including humans, to urinate and defecate in the face of extreme danger. And many animals erect body hair in dangerous situations, presumably to make themselves look more vicious than they otherwise would. Piloerection, according to Darwin, is probably one of the most general of the emotional expressions, occurring in dogs, lions, hyenas, cows, pigs, antelopes, horses, cats, rodents, bats, to name a few. Darwin suggested that goose bumps, a mild form of piloerection in humans, occur as a vestige of the more dramatic displays in our mammalian cousins. He points out that it is a remarkable fact that the thinly scattered hairs on the human body are erected in rage and terror, emotional states that cause body hair to stand on end in furry animals, where body piloerection has some purpose. But he noted that piloerection also occurs on the part of the human body that is well endowed with hair, the head, using Brutus' statement to the ghost of Caesar as evidence: "that mak'st my blood cold, and my hair stare."

Darwin gave many other examples of common emotional expression in different species. For example, he equated the snarl of an angry human with similar behaviors in other creatures. Again turning to literature for support, he quotes Dickens' description in Oliver Twist of a furious mob witnessing the capture of an atrocious murderer on the streets of London: "the people as jumping up one behind another, snarling with their teeth, and making at him like wild beasts." Darwin goes on to note that "Everyone who has had much to do with young children must have seen how naturally they take to biting, when in a passion. It seems as instinctive in them as in young crocodiles, who snap their little jaws as soon as they emerge from the egg." He also quotes from Dr. Maudsley, who specialized in human insanity and for whom the renowned Maudsley Hospital in London is named: "whence come 'the savage snarl, the destructive disposition, the obscene language, the wild howl, the offensive habits, displayed by some of the insane? Why should a human being, deprived of his reason, ever become so brutal in character, as some do, unless he has the brute nature within him?'" In response, Darwin says, "This question must, as it would appear, be answered in the affirmative."

For Darwin, an important function of emotional expressions is communication between individuals—they show others what particular emotional state one is in. Emission of vicious sounds and enlarging body parts (flashing of feathers, extension of fins or pointy spines, puffing up, and, as we have seen, erection of body hair), are used throughout the animal kingdom to dissuade an enemy from attacking. Sounds, smells, and various postures and displays of body parts or hidden colors serve as signals of sexual receptiveness as well. Sounds are also used to warn others that danger is near. While these signals are somewhat relevant to humans, in the passage below Darwin describes some emotional expressions that are particularly important to our species:

> The movements of expression in the face and body, whatever their origin may have been, are in themselves of much importance in our welfare. They serve as the first means of communication between the mother and her infant; she smiles approval, and thus encourages her child on the right path, or frowns disapproval. We readily perceive sympathy in others by their expression; our sufferings are thus mitigated and our pleasures increased; and mutual good feeling is thus strengthened. The movements of expression give vividness and energy to our spoken words. They reveal the thoughts and intentions of others more truly than do words, which may be falsified.

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**FIGURE 5-1 Commonality of Emotional Expression in the Faces of Animals and People.** Some emotional expressions are similar in humans and other animals. These two drawings illustrate angry facial expressions in a chimpanzee and human. In both species an expression of anger often involves a direct gaze and a partly opened mouth with lips retracted vertically so that the teeth show. (Drawings by Eric Stoelting, are reprinted with permission from S. Chevalier-Skolnikoff 1973], Facial expression of emotion in nonhuman primates. In P. Ekman, Darwin and Facial Expression. New York Academic Press.)

A picture may be worth a thousand words, but bodily expressions are priceless commodities in the emotional marketplace.

Darwin argued that although emotional expressions can sometimes be muted by willpower, they are usually involuntary actions. He pointed out how easy it is to tell the difference between a real, involuntary smile and one that is feigned. And he gives us an example from his own life to illustrate how difficult it is to suppress an emotional reaction that has been elicited naturally: "I put my face close to the thick glass-plate in front of a puff-ader in the Zoological Gardens, with the firm determination of not starting back if the snake struck at me; but, as soon as the blow was struck, my resolution went for nothing, and I jumped a yard or two backwards with astonishing rapidity. My will and reason were powerless against the imagination of a danger which had never been experienced."

Within the general class of innate emotions, Darwin suggested that some have older evolutionary histories than others. He noted that fear and rage were expressed in our remote ancestors almost as they are today in humans. Suffering, as in grief or anxiety, though, he placed closer to human origins. Nevertheless, Darwin was well aware of the pitfalls of such ideas about the time of origin of different emotions and noted: "It is a curious, though perhaps an idle speculation, how early in the long line of our progenitors the various expressive movements, now exhibited by man, were successively acquired."

## Basic Instinct

A number of modern theorists carry on Darwin's tradition in their emphasis on a set of basic, innate emotions. For many, basic emotions are defined by universal facial expressions that are similar across many different cultures. In Darwin's day, the universality of emotional expression across cultures was presumed from casual observation, but modern researchers have gone into remote areas of the world to firmly establish with scientific methods that at least some emotions have fairly universal modes of expression, especially in the face. On the basis of this kind of evidence, the late Sylvan Tomkins proposed the existence of eight basic emotions: surprise, interest, joy, rage, fear, disgust, shame, and anguish.[19] These were said to represent innate, patterned responses that are controlled by "hard-wired" brain systems. A similar theory involving eight basic emotions has been proposed by Carroll Izard.[20] Paul Ekman has a shorter list, consisting of six basic emotions with universal facial expression: surprise, happiness, anger, fear, disgust and sadness.[21] Other theorists, like Robert

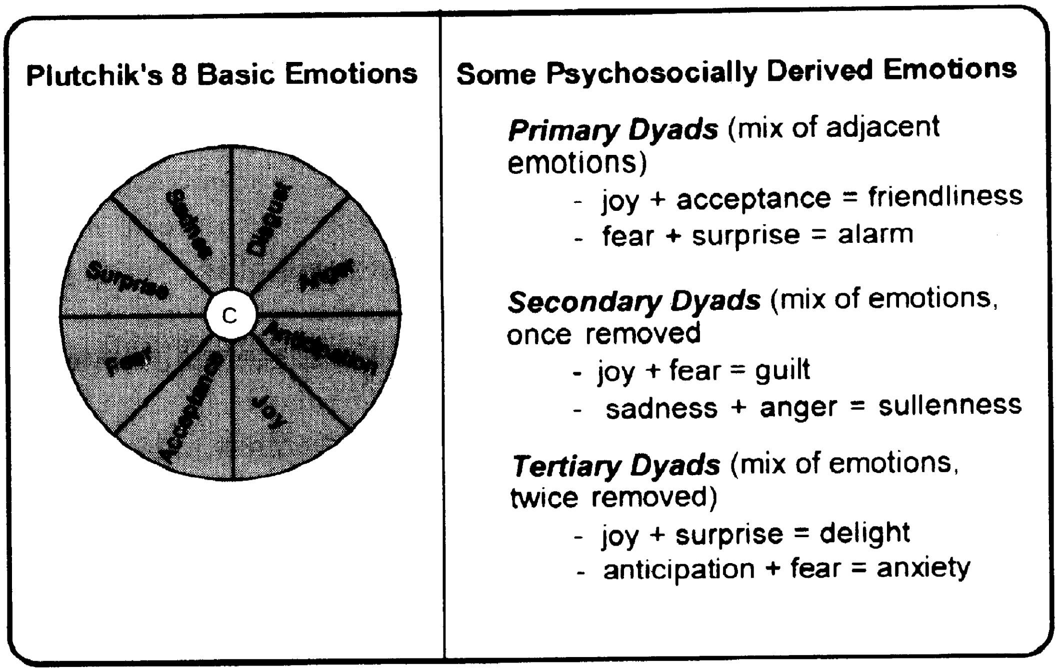
Plutchik[22] and Nico Frijda,[23] do not rely exclusively on facial expressions, but instead argue for the primacy of more global action tendencies involving many body parts. Plutchik points out that as one goes down the evolutionary scale there are fewer and fewer facial expressions, but still lots of emotional expressions involving other bodily systems. Plutchik's emotions list overlaps with the others, but also diverges to some extent—it is similar to Ekman's, with the addition of acceptance, anticipation, and surprise. Philip Johnson-Laird and Keith Oatley approach the problem of basic emotions by looking at the kinds of words we have for talking about emotions.[24] They come up with a list of five that overlaps with Ekman's six, dropping surprise. Jaak Panksepp has taken a different approach, using the behavioral consequences of electrical stimulation of areas of the rat brain to reveal four basic emotional response patterns: panic, rage, expectancy, and fear.[25] Other theorists have other ways of identifying basic emotions and their lists also overlap and diverge from the ones already described.[26]

Most basic emotions theorists assume that there are also non-basic emotions that are the result of blends or mixes of the more basic ones. Izard, for example, describes anxiety as the combination of fear and two additional emotions, which can be either guilt, interest, shame, anger, or distress. Plutchik has one of the better developed theories of emotion mixes. He has a circle of emotions, analogous to a circle of colors in which mixing of elementary colors gives new ones. Each basic emotion occupies a position on the circle. Blends of two basic emotions are called dyads. Blends involving adjacent emotions in the circle are first-order dyads, blends involving emotions that are separated by one other emotion are second-order dyads, and so on. Love, in this scheme, is a first-order dyed resulting from the blending of adjacent basic emotions joy and acceptance, whereas guilt is a second-order dyad involving joy and fear, which are separated by acceptance. The further away two basic emotions are, the less likely they are to mix. And if two distant emotions mix, conflict is likely. Fear and surprise are adjacent and readily blend to give rise to alarm, but joy and fear are separated by acceptance and their fusion is imperfect—the conflict that results is the source of the emotion guilt.

The mixing of basic emotions into higher order emotions is typically thought of as a cognitive operation. According to basic emotions theorists, some if not all of the biologically basic emotions are shared with lower animals, but the derived or non-basic emotions tend to be more uniquely human. Since the derived emotions are constructed by cognitive operations, they could only be the same to the extent that two animals share the same cognitive capacities. And since it is in the area of cognition that humans are believed to differ most significantly from other mammals, nonbasic, cognitively constructed emotions are more likely than basic emotions to differ between humans and other species. Richard Lazarus, for example, proposes that pride, shame, and gratitude might be uniquely human emotions.[27]

**FIGURE 5-2 Plutchik's Theory of Basic and Derived Emotions.**

(Based on figure 11.4 and table 11.3 in R. Plutchik [1980], Emotion: A Psychoevolutionary Synthesis. NewYork: Harper and Row.)

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## Being a Wild Pig

The idea of biologically primitive emotions has many supporters but has also had its detractors. One challenge comes from various forms of cognitive emotion theory that propose that specific emotions, even those that are described as basic emotions, are psychological, not biological, constructions. Emotions, in this view, are due to the internal representation and interpretation (appraisal) of situations, not to the mindless workings of biological hardware.

We saw many examples of cognitive views of emotion in Chapter 3. Here, however, I want to focus on the social constructivist approach, which is even further removed from the biology of emotion than most other cognitive approaches. These theorists argue that emotions are products of society, not biology.[28] Cognitive processes play an important role in these theories by providing the mechanism through which the social environment is represented and, on the basis of past experience and future expectations, interpreted. Emotional diversity across cultures is used as evidence in support of this position.

James Averill, a major proponent of social constructivism, describes a behavior pattern, called "being a wild pig," that is quite unusual by Western standards, but is common and even "normal" among the Gururumba, a horticultural people living in the highlands of New Zealand.[29] The behavior gets its name by analogy. There are no undomesticated pigs in this culture, but occasionally, and for unknown reasons, a domesticated one will go through a temporary condition in which it runs wild. But the pig can, with appropriate measures, be redomesticated and returned to the normal pig life among the villagers. And, in a similar vein, Gururumba people can act this way, becoming violent and aggressive and looting and stealing, but seldom causing harm or taking anything of importance, and eventually returning to routine life. In some instances, after several days of living in the forest, during which time the stolen objects are destroyed, the person returns to the village spontaneously with no memory of the experience and is never reminded of the event by the villagers. Others, though, have to be captured and treated like a wild pig—held over a smoking fire until the old self returns. The Gururumba believe that being a wild pig occurs when one is bitten by the ghost of someone who recently died. As a result, social controls on behavior are lost and primitive impulses are set free. According to Averill, being a wild pig is a social, not a biological or even an individual, condition. Westerners are prone to think of this as psychotic, abnormal behavior, but for the Gururumba it is instead a way of relieving stress and maintaining community mental health in the village. Averill uses "being a wild pig" to support his claim that "most standard emotional reactions are socially constructed or institutionalized patterns of response" rather than biologically determined events (one wonders, though, where the wild impulses come from).

Another example of an emotional condition that is not common in Western cultures is the state of mind called "amae" in Japan.[30] Amae has no literal translation in Indo-European languages. The condition it represents is believed by some to be a key to understanding important aspects of Japanese personality structure.[31] It roughly means to presume upon another's love or to indulge in another's kindness. The Japanese psychiatrist Doi calls amae a sense of helplessness and the desire to be loved, to be a passive love object.[32] He believes that amae also occurs in Westerners, but in a much more limited way. The Japanese frequently amaeru (the verb form) but seldom talk about it because it is a nonverbal condition and it would be inappropriate to point it out in another. According to Doi, "those who are close to each other—that is to say, who are privileged to merge with each other—do not need words to express their feelings. One surely would not feel merged with another (that is amae), if one had to verbalize the need to do so!" Doi says that Americana feel encouraged and reassured by such verbal exchanges, but the Japanese neither need it nor find it desirable.

## Display Rules

Social constructivists can produce endless lists of all sorts of ways that emotions differ in different cultures or social situations.[33] Certain emotion words from islands in the South Pacific or other remote areas have no translation in English. And even amongst Western cultures, there are differences in emotion words.[34]

But these kinds of observations are not enough to take down the basic emotions view. Basic emotions theorists do not deny that some differences exist in the way emotions are labeled and even expressed between cultures, or even between individuals within a culture. They simply say that some emotions and their expressions are fairly constant in all people. The social constructivists can then counter with the fact that a given individual may express a basic emotion, like anger, differently in different situations—overt anger is more likely to be displayed at those below than those above one in a social hierarchy.

In an attempt to reconcile theories that emphasize the similarity of facial expression across cultures and those that emphasize differences, basic emotions theorist Paul Ekman proposed a distinction between universal emotional expressions (especially facial expressions), which are common to all cultures, and other bodily movements (emblems and illustrators, for example) that vary from culture to culture.[35] Emblems are movements with a specific verbal meaning, such as head nodding to signify yes or no, or shrugging to indicate that you don't know the answer to a question. Emblems could be expressed in words but are not. Illustrators are closely tied to the content and flow of speech. They punctuate speech, help fill in when words cannot be found, or help explain what is being said. In some cultures people "talk with their hands" more than in others. Ekman suggests that social constructivists may be focusing on learned cultural differences in emotional expression, while the basic emotions theorists have been focused on the unlearned, universal expressions that occur in the movement of facial muscles during the occurrence of basic (innate) emotions in all cultures.

Ekman does not claim that basic emotional expressions always look exactly the same. He points out that even universal facial expressions can be regulated by learning and culture. They can be interrupted, diminished, or amplified by learned factors, or even masked by other emotions.[36] He uses the term "display rules" to refer to the conventions, norms, and habits that people develop to manage their emotional expressions. Display rules specify who can show what emotion to whom and when and how much. In Western cultures, there is a grief hierarchy at funerals. As Mark Twain said, "Where a blood relation sobs, an intimate friend should choke up, a distant acquaintance should sigh, a stranger should merely fumble sympathetically with his handkerchief.[37] According to Ekman, if the secretary looks sadder than the wife, suspicions may be aroused. Ekman also suggests that display rules can be personalized and override cultural norms. Some people end up being stoics and show little emotion, even in situations where society allows emotions to flow freely. In Ekman's view, the concept of basic emotions accounts for the similarity of basic emotional expression across individuals and cultures and display rules take care of many of the differences.

Ekman performed a powerful test of his hypothesis.[38] Starting with the assumption that Westerners are more emotionally expressive than Orientals, he studied the facial expressions of Japanese and American subjects while they watched an emotion-arousing film. The subjects were tested in their native countries, and they watched the film while either sitting alone in a room or sitting in a room with an authoritative-looking experimenter in a white coat. Their faces were secretly recorded on videotape throughout. Later, facial expressions were coded by observers who were ignorant of what the subjects were watching. In the private viewing condition, there was a tremendous similarity in the emotions expressed at various points in the film by the Japanese and American subjects. But when the white-coated experimenter was present, the facial movements were no longer the same. The Japanese looked more polite and showed more smiling and less emotional diversity than the Americans. Interestingly, slow-motion analysis of the film revealed that the smiles and other polite facial expressions of the Japanese subjects were superimposed over brief, prior-occurring facial movements that were, according to Ekman, the basic emotions leaking through.

Display rules are learned as part of one's socialization and become so ingrained that, like the basic emotional expressions themselves, they occur automatically, which is to say without conscious participation. At the same time, an individual may sometimes deliberately choose to conceal emotions for a particular advantage in a specific situation. This, however, is a skill that is hard to master—we aren't all good poker players.

## Emotional Responses: Parts or Wholes?

The combination of universal emotional expressions and display rules goes a long way toward accounting for individual and cross-cultural variation in the expression of basic emotions, but has not completely inoculated the idea of basic emotions against further challenge. Cognitive scientists Andrew Ortony and Terrance Turner have raised important questions about whether basic emotions can be defined by universal facial expressions, or any other means.[39] They asked why, if basic emotions are so basic, there is so much disagreement about what the basic ones are, and why emotions that are considered basic by some theorists (like interest and desire) are not even considered to be emotions by others. Ortony and Turner then go on to argue that perhaps it is not the emotions and their expressions that are so basic. Instead, they propose that there might be basic, maybe even innate response components that can be utilized in the expression of emotions, but that are used in other non-emotional situations as well. They note, "emotion expressions are built up by drawing on a repertoire of biologically determined components, and . . . many emotions are often, but by no means always, associated with the same limited subset of such components." They point out that bodily expressions similar to those in an emotion can arise independent of emotions and that the expression typical of one emotion can appear during a different emotional state. Shivering can occur because you are cold or because you are afraid. Crying can occur in extreme happiness as well as sadness. Frowning occurs in anger, but also in frustration, and eyebrows are raised in anger, but also in any condition that requires that we carefully attend to the environment.

For Ortony and Turner, emotion involves higher cognitive processes (appraisals) that organize the various responses that are appropriate to the situation faced by the organism. They accept that component responses can be biologically determined, but place emotion itself in the world of psychological rather than biological determinism. Fear, in their view, is not a biological package that is unwrapped by danger. It is a psychologically constructed set of responses and experiences that are tailored to the particular dangerous situation. There are no emotional responses, there are just responses, and these are put together on the spot when appraisals are made— the particular set of responses that occurs depends on the particular appraisal that occurs. As a result, the number of different emotions is limited only by the number of different appraisals that one can make. And because certain appraisals occur frequently and are often talked about by people, they are easily and reliably labeled with precise terms in most languages and this makes them seem basic (universal).

The reason that Ortony and Turner pushed for a difference between the innateness of emotional expressions and the innateness of response components is simple. If there are no universal expressions characteristic of certain emotions, then the evidence that some emotions, the so-called basic emotions, are biologically determined is brought to its knees. And if emotions are not biologically determined, then they must be psychologically determined. But Ortony and Turner seem to make two unacceptable assumptions. First, just because an appraisal is mental does not mean that it is not also biological. In fact, appraisals play a biological role in some basic emotions theories as the link between emotional stimuli and the characteristic responses they produce. Second, the innateness of individual response components does not preclude the possibility that higher levels of expression are also innate. Some innate behavioral patterns are known to involve hierarchically organized response components.[40] For example, reproductive behavior is often brought on by the presence of hormones that act on certain parts of the brain. When an organism is in the right hormonal state, either mating or fighting can occur, depending on whether a receptive female or a competitive male happens to be around. And these behaviors, though innate, involve many complex levels of control. Mating, for example, may start with a courtship dance, approach toward the partner, and ultimately end in copulation. Each phase, itself, has a complex hierarchy of events controlled by different levels of the nervous system, with the lower levels controlling the most specific components (individual patterns of muscle contraction and relaxation) and higher levels of the nervous system specifying more general aspects of behavior (the act of copulation).

Ortony and Turner caused quite a stir in the world of basic emotions. They made it painfully clear that basic emotions theorists could no longer continue to agree that basic emotions exist and at the same time disagree about what the basic ones are. But now that the dust has settled, it seems that Ortony and Turner were probably too hard on the basic emotions view. Some of the differences between the basic emotions lists of different investigators have to do with the words used rather than with the emotions implied by the words.[41] For example, joy and happiness, basic emotions in different lists, are probably just different names for the same emotion. If we allow these kinds of translations, there turns out to be a good deal of overlap of the different lists: many if not most of the lists include some version of fear, anger, disgust, and joy. Most of the remaining disagreement is over the fringe cases, like interest, desire, and surprise. The basic emotions theorists are not as divergent as they appeared, and, as we will see, at least for some emotions, the evidence for an innate, biological organization is quite strong.

## If It Ain't Broke . . .

As has been apparent since Darwin's time (and even before) different animals can act in very similar ways under similar circumstances. This is what led Darwin to propose that certain human emotions have their roots in our animal ancestors. But behavioral commonalities between species can occur at several different levels, and not all of them involve responses that look the same.[42] In other words, the gold standard of whether two animals are doing the same thing is not necessarily whether the two things look exactly the same—emotional commonalities between species might be even broader than conceived by Darwin.

In order for behavior to occur, muscles have to move. So the reason that facial expressions of particular emotions look the same in different people is because everyone contracts and relaxes facial muscles in roughly the same way when exposed to a stimulus that characteristically evokes that emotion. And to the extent that different species show similar kinds of expressions it is because they are contracting and relaxing the same or similar muscle groups—the muscle movements required to furrow the brow and expose the teeth in anger are similar in a human and a chimp. At the same time, the behaviors may be similar at some broader level, but not at the level of individual muscles. People run from danger on two legs, but many other land mammals tend to do so on all four: although quadrupeds use more muscles and different patterns of muscle coordination than bipeds, the function performed is the same—escape. Most important, even when the behaviors are very different, the function achieved may be the same. Plutchik puts this nicely: "although a deer may run from danger, a bird may fly from it, and a fish may swim from it, there is a functional equivalence to all the different patterns of behavior; namely, they all have the common function of separating an organism from a

threat to its survival."[43] Obviously, running, flying, and swimming are different behaviors involving different muscles, but each achieves escape.
The implication of Plutchik's notion is that certain basic functions that are necessary for survival have been conserved throughout evolution. They have been modified as needed, but the changes have occurred against a fairly consistent background. In an influential treatise on mother-child bonding in humans, the psychoanalytic theorist John Bowlby makes a similar point:

> The basic structure of man's behavioral equipment resembles that of infra-human species but has in the course of evolution undergone special modifications that permit the same ends to be reached by a much greater diversity of means.... The early form is not superseded: it is modified, elaborated, and augmented but it still determines the overall pattern.... Instinctive behavior in humans ... is assumed to derive from some prototypes that are common to other animal species.[44]

I don't mean to minimize the importance of species differences. The things that distinguish one species from another are often things that allowed its ancestors to survive their particular struggle for existence and pass on their traits to their offspring. The kind of body an animal has obviously limits the kinds of behaviors in which the animal can engage. Nevertheless, evolutionary solutions to problems that are common to many species may have some underlying functional equivalence that cuts across the behavioral differences imposed by the uniqueness of body forms.
The obvious question that this discussion raises is, how could a functional equivalence of behavior be maintained across species, especially across species in which the way the function is expressed behaviorally is radically different? The short answer to this very complicated issue is that the brain systems involved in mediating the function are the same in different species.
We know that there is a great deal of similarity in brain organization across the various vertebrate species. All vertebrates have a hindbrain, midbrain, and forebrain, and within each of the three divisions, one can find all of the basic structures and major neural pathways in all animals.[45] At the same time there are obvious differences between the brains of widely different groups of animals. Species differences can involve any brain region or pathway, due to particular brain specializations required for certain species-specific adaptations or to random changes. However, as one follows brain evolution from fish, through amphibians and reptiles, to mammals, and ultimately to humans, the greatest changes appear to have taken place in the forebrain.[46] But evolution should not be thought of as an ascending scale. It is more like a branching tree.[47] The long process of human brain evolution has not just been a matter of making the forebrain bigger and bigger; it has also become more diversified.4[8] For example, as we saw in Chapter 4, it was long thought that the neocortex was a mammalian specialization, one that did not exist in other classes of animals (the designation "neo" reflects the supposed evolutionary newness of this part of the brain). However, it is now known that all vertebrates have areas of the cortex that correspond with what is called the neocortex in mammals—these are just located in a different place in non-mammalian species (birds and reptiles, for example) than in mammals, which caused anatomists to misjudge what these regions are.[49] Nevertheless, there are areas of the human neocortex that are apparently not present in the brains of other animals.[50] In

spite of this diversification, though, brain evolution is basically conservative, and certain systems, especially those that have been generally useful for survival and have been around for a long time, have been preserved in their basic structure and function.

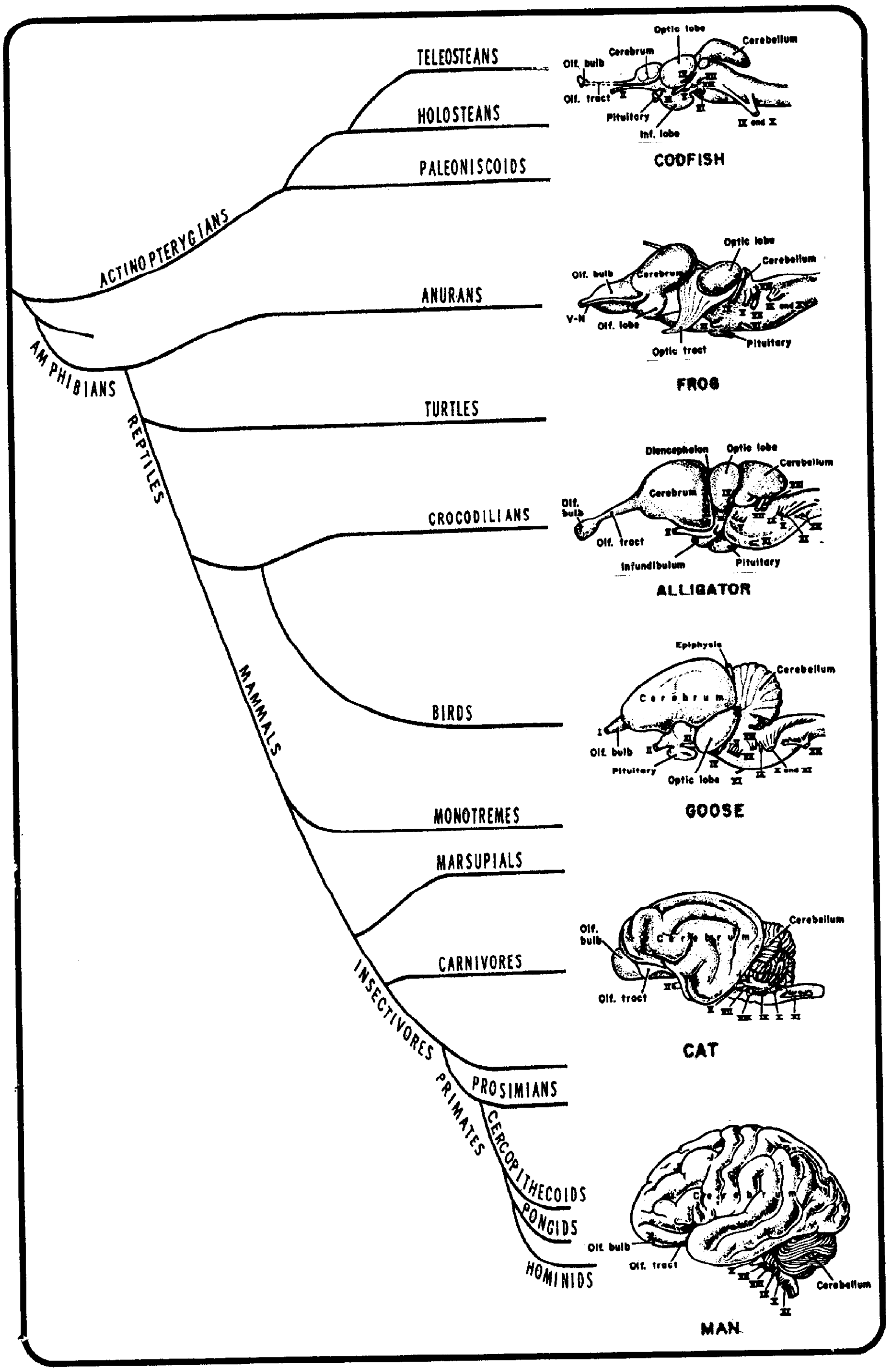


**FIGURE 5-3 The Branching Tree of Brain Evolution.**

(Modified from figure 5 of W. Hodos [1970], Evolutionary interpretation of neural and behavioral studies of living vertebrates. In F. O. Schmitt, ed., The Neurosciences: Second Study Program. New York: Rockefeller University Press. Used by permission of the Rockefeller University Press.)

Circuits in the brain, like all other body parts, are assembled during embryonic development by processes encoded in our genes. If different animals indeed have circuits that achieve some common function, but do it by controlling different behaviors, we would be led to the conclusion that the genetic code that controls the wiring of the functions in the brain during development is conserved across species in spite of the fact that the genetic code that constructs the body parts used to express those functions is different. Evolution, in other words, creates unique behavioral solutions to the problem of survival in different species, but it may do so by following a kind of "if it ain't broke don't fix it" rule for the underlying brain systems.

For now, I'm going ask you to take it on faith that the brain systems underlying certain emotional behaviors have been preserved throughout many levels of brain evolution. In the next chapter, though, I will present very strong evidence that this is true within the mammalian class, and also describe some hints that it may extend to existing reptiles and birds as well.

Throughout this discussion of the evolution of emotion, I've said nothing about what most people consider the most important, in fact, the defining feature of an emotion: the subjective feeling that comes with it. The reason for this is that I believe that the basic building blocks of emotions are neural systems that mediate behavioral interactions with the environment, particularly behaviors that take care of fundamental problems of survival.[51] And while all animals have some version of these survival systems in their brains, I believe that feelings can only occur when a survival system is present in a brain that also has the capacity for consciousness. To the extent that consciousness is a recent (in evolutionary time) development,[52] feelings came after responses in the emotional chicken-and-egg problem. I'm not going to say which animals are conscious (which ones have feelings) and which ones are not (which ones don't have feelings). But I will say that capacity to have feelings is directly tied to the capacity to be consciously aware of one's self and the relation of oneself to the rest of the world. We will return to these issues in Chapter 9. For now, I want to continue to pursue some ideas about the evolution of behaviors that are crucial to survival, or more precisely, some ideas about the evolution of the neural systems underlying these behaviors.

## Specialized versus General-Purpose Neural Systems

Modern evolutionarily minded emotions theorists, like Ekman, argue that emotions deal with "fundamental life tasks."[53] A similar point is made by Johnson-Laird and Oatley, who say that each emotion "prompts us in a direction which in the course of evolution has done better than other solutions to recurring circumstances."[54] And Tooby and Cosmides argue that emotions involve situations that have occurred over and over throughout our evolutionary history (escaping from danger, finding food and mates) and cause us to appraise present events in terms of our ancestral past—that the structure of the past imposes an interpretive landscape on the present.[55]

In a sense, coming up with a list of the special adaptive behaviors that are crucial to survival would essentially be a list of basic emotions. I think starting with universal behavioral functions is a better way of producing a list of basic emotions than the more standard ways—facial expressions, emotion words in different languages, or conscious introspections. However, I'm not concerned with defining, from the start, what the different emotions are and I have no interest in producing yet another basic emotions list. Obviously, it is ultimately important to understand what all the biologically derived and socially constructed emotions are, and to determine where the line should be drawn between them. It is also important to draw the line between mental phenomena that are emotions and those that are not. However, for good reasons, efforts to identify what all of the emotions are frequently get bogged down in arguments over the fringe instances, as when Ortony and Turner took basic emotions theorists to task for their inability to agree about what the various basic emotions are, and especially for disagreeing about the fuzzy cases, like surprise, interest, and desire. I believe that once we've built up a core knowledge about the clear instances we will be in a better position to deal with the fuzzy ones, but we haven't reached that point yet.

To the extent that emotional responses evolved, they evolved for different reasons, and it seems obvious to me that there must be different brain systems to take care of these different kinds of functions. Lumping all of these together under the unitary concept of emotional behavior provides us with a convenient way of organizing things—for distinguishing behaviors that we call emotional (for example, those involved with fighting, feeding, sex, and social bonding) from those that reflect cognitive functions (like reasoning, abstract thinking, problem solving, and concept formation). However, the use of a label, like "emotional behavior," should not necessarily lead us to assume that all of the labeled functions are mediated by one system of the brain. Seeing and hearing are both sensory functions, but each has its own neural machinery.

I think that the most practical working hypothesis is that different classes of emotional behavior represent different kinds of functions that take care of different kinds of problems for the animal and have different brain systems devoted to them. If this is true, then different emotions should be studied as separate functional units.

At the neural level, each emotional unit can be thought of as consisting of a set of inputs, an appraisal mechanism, and a set of outputs. The appraisal mechanism is programmed by evolution to detect certain input or trigger stimuli that are relevant to the function of the network. We'll call these "natural triggers."[56] The sight of a predator is a good example. It is not uncommon for prey species to recognize predators the first time they see them. Evolution has programmed the prey brain so that certain features of the way the predator looks, sounds, or smells will be automatically appraised as being a source of danger. But the appraisal mechanism also has the capacity to learn about stimuli that tend to be associated with and predictive of the occurrence of natural triggers. These we'll call "learned triggers." The place where a predator was seen last, or the sound it made when it was charging toward the prey are good examples. When the appraisal mechanism receives trigger inputs of either type, it unleashes certain patterns of response that have tended to be useful in dealing with situations that have routinely activated the appraisal mechanism in ancestraI animals. These networks evolved because they serve the function of connecting trigger stimuli with responses that are likely to succeed in keeping the organism alive. And because different kinds of problems of survival have different trigger stimuli and require different kinds of responses to deal with them, different neural systems are devoted to them.[57]

The particular functional unit that I have focused my research on is the fear system of the brain. In the next several chapters, we will look closely at the fear system, which is understood as well or better than other emotional systems. Once we see how this system is organized, we will be in a better position to consider the manner in which other emotions are organized in the brain, and how these relate to the fear system.

## Why Fear?

I'm going to now lay out some of the reasons why I believe the fear system of the brain is a particularly good one to focus on as an anchoring point. However, I want to first be explicit about what I think the fear system is. The system is not, strictly speaking, a system that results in the experience of fear. It is a system that detects danger and produces responses that maximize the probability of surviving a dangerous situation in the most beneficial way. It is, in other words, a system of defensive behavior. As noted above, I believe that emotional behaviors, like defensive behaviors, evolved independent of, which is to say before, conscious feelings, and that we should not be too quick to assume that when an animal, other than a human one, is in danger it feels afraid. We should, in other words, take defensive behaviors at face value—they represent the operation of brain systems that have been programmed by evolution to deal with danger in routine ways. Although we can become conscious of the operation of the defense system, especially when it leads to behavioral expressions, the system operates independently of consciousness—it is part of what we called the emotional unconscious in the Chapter 3. Interactions between the defense system and consciousness underlie feelings of fear, but the defense system's function in life, or at least the function it evolved to achieve, is survival in the face of danger. Feelings of fear are a by-product of the evolution of two neural systems: one that mediates defensive behavior and one that creates consciousness. Either one alone is not enough to produce subjective fear. Feeling afraid can be very useful, but this is not the function programmed into the neural system of defense by evolution.

With the territory staked out in this way, let's now consider why the defensive system of the brain and its associated subjective emotion, fear, are attractive starting points for studying the emotional brain. I'll discuss three points below: fear is pervasive, fear is important in psychopathology, and fear is expressed similarly in man and many other animals. In the next chapter, another crucial point will be considered, namely that the neural basis of fear is similar in humans and other animals.

**Fear Is Pervasive:** William James once said that nothing marks the ascendancy of man from beast more clearly than the reduction of the conditions under which fear is evoked in humans.[58] By this, it would seem that James meant that man has managed to establish a less dangerous way of living. It is certainly true that in comparison to our primate ancestors, who lived in a world in which being someone's dinner was an ever-present possibility, humans have created a way of living in which the likelihood of encountering predators is greatly reduced. But not all dangers come in the form of blood-thirsty beasts. Snakes and tigers are rare in modern cities, except in zoos, where viewing dangerous animals in captivity reinforces our hope that life is safe. But in our quest to conquer nature we have created new forms of danger. Automobiles, airplanes, weapons, and nuclear energy give us a step up on the wild, but each is also a potential source of harm. We've traded in the dangers of a life amongst the wild things for other dangers that may, in the end, be far more harmful to our species than any natural predator. The dangers we face are not fewer or less significant than those of our animal ancestors, they're just different.

Even a casual analysis of the number of ways the concept of fear can be expressed in the English language reveals its importance in our lives: alarm, scare, worry, concern, misgiving, qualm, disquiet, uneasiness, wariness, nervousness, edginess, jitteriness, apprehension, anxiety, trepidation, fright, dread, anguish, panic, terror, horror, consternation, distress, unnerved, distraught, threatened, defensive.[59] The so-called ascent of man occurred in spite of the continued existence of fear rather than at its expense. As the renowned human ethologist Eibl-Eibesfeldt notes, "Perhaps man is one of the most fearful creatures, since added to the basic fear of predators and hostile conspecifics come intellectually based existential fears."[60] Indeed, for the existential philosophers (like Kierkegaard, Heidegger, and Sartre), dread, angst, and anguish are at the core of human existence.[61]

One can find evidence of fear lurking in the background of many kinds of emotions that on the surface might seem to be the antithesis of fear. Courage is the ability to overcome fear. Children learn to be moral to some extent by their fear of what will happen if they are not. Laws reflect our fear of social disorder and, by the same token, social order is maintained, however imperfectly, by fear of the consequences of breaking the rules. World peace is a desirable humanitarian goal, but in practice war is avoided, at least in part, because the weak fear the strong. These are bleak statements, hopefully overstatements, but even as partial truths they emphasize how deeply fear cuts into the mental fabric of persons and societies.

**Fear Plays an Important Role in Psychopathology**: While fear is a part of everyone's life, too much or inappropriate fear accounts for many common psychiatric problems. Anxiety, a brooding fear of what might happen, was at the core of Freud's psychoanalytic theory. Phobias are specific fears taken to extreme. Phobic objects (snakes, spiders, heights, water, open places, social situations) are often legitimately threatening, but not to the extent believed by the phobic person.

Obsessive-compulsive disorder often involves extreme fear of something, like germs, and the patients will engage in compulsive rituals to avoid the feared object or event or to rid themselves of the fear object once it is encountered. Panic disorder involves the rapid onset of a host of physical symptoms and often the overwhelming fear that death is near. Post-traumatic stress disorder (PTSD), previously referred to as shell shock, often occurs in war veterans, who can be sent into intense distress by a stimulus that has some resemblance to events associated with battlefield trauma. Thunderclaps and the sound of a car backfiring are common examples. But PTSD extends to many other kinds of traumatic situations, including physical and sexual abuse. Fear is a core emotion in psychopathology.

**Fear Is Expressed Similarly in Humans and Other Animals**: It may not be the case that every form of emotional behavior has a long evolutionary history. Guilt and shame, for example, may be special human emotions.[62] Nevertheless, as we will see, human defensive, behavior clearly seems to have a long evolutionary history. As a result, we can study fear responses in animals for the purpose of illuminating the mechanisms of human fear, including pathological fear. This is crucial, since for both ethical and practical reasons it is not possible to study brain mechanisms in much detail in humans.

All animals have to protect themselves from dangerous situations in order to survive, and there are only a limited number of strategies that animals can call upon to deal with danger. Isaac Marks, who has written extensively on fear, summarizes these as withdrawal (avoiding the danger or escape from it), immobility (freezing), defensive aggression (appearing to be dangerous and/or fighting back), or submission (appeasement).[63] The extent to which these strategies apply across the various vertebrates is striking.

Consider the following description of human defense by Caroline and Robert Blanchard, pioneers in fear research:

> If something unexpected occurs—a loud noise or sudden movement—people tend to respond immediately . . . stop what they are doing . . . orient toward the stimulus, and try to identify its potentiality for actual danger. This happens very quickly, in a reflex-like sequence in which action precedes any voluntary or consciously intentioned behavior. A poorly localizable or identifiable threat source, such as a sound in the night, may elicit an active immobility so profound that the frightened person can hardly speak or even breathe, i.e. freezing. However, if the danger source has been localized and an avenue for flight or concealment is plausible, the person will probably try to flee or hide.... Actual contact, particularly painful contact, with the threat source is also likely to elicit thrashing, biting, scratching, and other potentially damaging activities by the terrified person.[64]

Though anecdotal, the Blanchards' description goes a long way toward accounting for the way people behave when threatened. And different people tend to do roughly the same things in similar kinds of situations. This uniformity suggests that either we all learn to be fearful in the same way, or, more likely, that patterns of fear reactivity are genetically programmed into the human brain.

Research by the Blanchards and others has shown that the reaction pattern described above for a frightened human also occurs when rats are in danger.[65] For example, if a laboratory-reared rat (one that has never had the opportunity to see a cat or be threatened by one) is exposed to a cat, it stops what it is doing and turns toward the cat. Depending on whether the cat is close or far away and whether the two animals are in an enclosed or an open area, the rat will either freeze or try to escape. If trapped by the cat, the rat will vocalize and ultimately will attack the cat. This striking functional correspondence between human and rat fear responses holds for many mammals and other vertebrates: it is quite common to observe startle, orienting, then freezing or fleeing or attack, in the face of danger. We've already seen examples from Darwin about how hair erection is a common defense response in many animals, including people, and how it may be related to the flashing of feathers in birds and fin extensions in fish.

Not only are some general patterns of behavior similar in different animals, but so too are some of the underlying physiological changes that occur in dangerous or stressful situations. For example, it is well known that soldiers in battle fail to notice injuries that would, under less traumatic circumstances, be excruciatingly painful. Similarly, a rat, when exposed to a cat, will fail to notice painful heat applied to its tail.[66] The cat poses a greater overall threat than a wound to the tail, and pain suppression in the face of danger allows the organism to use its resources to deal with the most significant danger. In both humans and rats, stress-induced analgesia is a consequence of activation of the brain's natural opiate system.[67] When the brain detects danger, it also sends messages through the nerves of the autonomic nervous system to bodily organs and adjusts the activity of those organs to match the demands of the situation. Nerves reaching the gut, heart, blood vessels, and sweat and salivary glands give rise to the taut stomach, racing heart, high blood pressure, clammy hands and feet, and dry mouth that typify fear in humans. The cardiovascular responses associated with defensive behavior have been examined in birds, rats, rabbits, cats, dogs, monkeys, baboons, and people, to name a few of the better studied species, and the responses are controlled by similar kinds of brain networks and body chemistry in these different species.68 Threatening stimuli also cause the pituitary gland to release adrenocorticotropic hormone (ACTH) that results in the release of a steroid hormone from the adrenal gland.[69] The adrenal hormone then travels back to the brain. Initially, these hormones help the body deal with the stress, but if the stress is prolonged the hormone can begin to have pathological consequences, interfering with cognitive functions and even causing brain damage.[70] This so-called stress response is ubiquitous amongst mammals, and also occurs in other vertebrates.[71] These various bodily responses are not random activities. They each play an important role in the emotional reaction and each functions similarly in diverse animal groups.

Nevertheless, it would be wrong to give the impression that all animals respond exactly the same in the face of danger. Obviously, they do not. Each animal is the product of its own evolutionary history. Within the general classes of defense reactions, much variation is possible. In fact, defense reactions should be thought of as constantly changing, dynamic solutions to the problem of survival. They are not static structures created in ancestral species and maintained unchanged. They change as the world in which they operate changes. For example, Richard Dawkins describes predators and prey as involved in evolutionary arms races, where a particular adaptation that makes a prey better at defending against a predator can lead to the selection of traits that then give the predator the edge up—the color of the prey may change so that it blends in better with the environment, and the predator may, in turn, evolve a more sensitive perceptual system for detecting the camouflaged prey.[72] But Dawkins also notes a certain imbalance in these arms races, what he calls the "life/dinner" principle. According to this notion, rabbits run faster than foxes because rabbits are running for their life but foxes are only running for their dinner. As a result, genetic mutations that make foxes run more slowly are more likely to survive in the gene pool than mutations that make rabbits run more slowly, since the penalty of slowness is more severe for rabbits than foxes—a fox may reproduce after being outrun by a rabbit, but no rabbit ever reproduced after being caught by a fox.

In spite of the fact that species can have their own special ways of responding to danger, commonality of functional patterns is the rule. In fact, what distinguishes fear reactions in humans and other animals is not so much the ways in which fear is expressed as the different kinds of trigger stimuli that activate the appraisal mechanism of the defensive system. Each animal has to be able to detect the particular things that are dangerous to it, but there is an evolutionary economy to using universal response strategies—withdrawal, immobility, aggression, submission—and universal physiological adjustments. Added cognitive power opens up the defensive hardware to new kinds of events, new learned triggers. Humans fear things that a rat could never conceptualize, but the human and rat body respond much the same to their special triggers.

The implications of this situation are enormous. For the purpose of understanding how fear is generated, it does not matter so much how we activate the system or whether we activate the system in a person or a rat. The system will respond in pretty much the same way using a limited set of given defense response strategies available to it. We can thus design experiments in rats (or other laboratory animals) for the purpose of understanding how the human fear system works.

## Genetic Determinism and Emotional Freedom

All this talk about the evolution of emotional behavior is likely to make the imagination run wild with ideas about genetic determination of our emotions. After all, any characteristic that has evolved has done so because of the representation of that characteristic in the genes of the species. But I want to make clear two different implications of the genetiics of emotional behavior.

On the one hand, there is the way genes maintain similar behavioral expressions of defense within a species and similar defensive functions across diverse species. This occurs, as I've argued, because the neural system of defense is conserved in evolution. As a result, all humans have the same general ways of expressing themselves when in danger, and these tend to be similar to the ways that other animals have for expressing themselves in the face of danger. This view of emotional genetics tries to find the common ground of emotional reactions across individuals and species—the stuff that particular emotional systems evolved to do.[73]

On the other "and, there is the question of how genes contribute to differences between individuals. Some people are good fighters, others are not. Some are adept in detecting dangers, others are oblivious to their surroundings. Differences between individuals in fearful behavior are due, at least in part, to genetic variation.

So far, I've emphasized the first implication—the way genes make emotional reactions similar amongst humans and between humans and other animals. But it is important to also consider in some detail the ways in which genes make us different from each other. We will then discuss whether, and if so to what extent, such differences pre-destine us to act in some particular way, again concentrating on the fear system.

Temperament runs through bloodlines. Some breeds of horses or dogs are jumpy, others complacent. These characteristics can sometimes be side-effects of some other trait that was selected for, like running speed, but temperament can also be selected for itself. Indeed, selective breeding has been used to create strains of rats and mice that are particularly timid or courageous.[74]

For example, rats don't normally congregate in wide-open spaces. This makes a lot of sense evolutionarily—open places are unprotected from land and air predators and can be very dangerous for rodents. Those ancestral rodents that tended to hang out in an open area probably did not do so well in their struggle to survive, whereas those that hightailed it out to the nearest safe place did.

Psychologists created an apparatus for testing this behavior—a large, well-lit circular arena called "the open field."[75] If you put your garden-variety rat in the center of an open field apparatus, it will make a beeline to the wall, which is the most protected place available. The rats also defecate—like people, rats can have the "$#!+" scared out of them. Defecation is controlled by the autonomic nervous system and the number of fecal pellets (poops) that are dropped is a reliable and measure of ANS activity. Defecation in the open field or other potentially dangerous situations has become a fairly standard measure of "fearfulness" in rodents.[76] But not all rats drop the same number of pellets in the open field, and the amount one rat drops tends to be fairly constant. If you divide a large group into those that drop more and fewer pellets in the open field, and then start breeding them on the basis of this selected trait, you can, in a few generations, create strains of timid and courageous rats—rats from the low pellet-dropping line act more courageous in the open field (they stay in the unprotected area longer) and in a variety of other tests. From this example, it is easy to imagine how personality traits might come to be part of a family, or even a culture. All you need is a few generations of inbreeding amongst a limited gene pool to begin to stabilize behaviorally significant characteristics.

In fact, considerable evidence shows that there is a genetic component to fear behavior in humans.[77] For example, identical twins (even those reared in separate homes) are far more similar in fearfulness than fraternal twins. This conclusion applies across many kinds of measurements, including tests of shyness, worry, fear of strangers, social introversion/extroversion,.and others. Similarly, anxiety, phobic, and obsessive compulsive disorders tend to run in families and to be more likely to occur in both identical than in both fraternal twins.

The genetics of defensive behavior has been studied most extensively in bacteria.[78] Although not known as a particularly sophisticated organism from the psychological point of view, they do protect themselves from danger and there may be some biological lessons to be learned. Their defensive repertoire consists of moving away from substances assessed as harmful. The specific gene mutations controlling this behavior, which involves complex coding of chemical constituents in the immediate environment, have been identified. Similarly, much progress has been made in genetic analyses of fruit fly defensive behavior.[79] Through some ingenious experiments, Tim Tully has shown that these creatures can learn to avoid danger (electric shock) on the basis of stimulus cues (odors)—once shocked in the presence of a certain smell, they tend to avoid a chamber that has the smell. Using the modern tools of molecular biology and genetics, mutant flies have been created that are unable to use the smell cues to avoid the shock. They can smell just fine, they just can't link the smell with danger. It is admittedly a far leap from defensive responses in flies to humans, and at least a quantum leap from bacterial to human behavior. However, studies in these simple creatures may pave the way for future researchers to perform similar kinds of experiments in mammals, and these kinds of studies may shed light on the genetics of fear in humans. There is, after all, massive overlap in the genetic makeup of humans and chimpanzees, and a good deal of overlap in humans and other mammals as well.[80]

There's no denying that genes make each of us different from one another and explain at least part of the variability in the way different people act in dangerous and other situations. But we have to be very careful in interpreting differences in behavior between different people. As Richard Dawkins puts it, "If I am homozygous for a gene G, nothing save mutation can prevent my passing G on to all my children. So much is inexorable. But whether or not I, or my children, show the phenotypic effect normally associated with possession of G may depend very much on how we are brought up, what diet or education we experience, and what other genes we happen to possess."[81]

The bottom line is that our genes give us the raw materials out of which to build our emotions. They specify the kind of nervous system we will have, the kinds of mental processes in which it can engage, and the kinds of bodily functions it can control. But the exact way we act, think, and feel in a particular situation is determined by many other factors and is not predestined in our genes. Some, if not many, emotions do have a biological basis, but social, which is to say cognitive, factors are also crucially important. Nature and nurture are partners in our emotional life. The trick is to figure what their unique contributions are.

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**LeDoux' Footnotes**

1. Leonardo da Vinci (1939).
2. Dawkins (1982).
3. Quoted by Dawkins (1982).
4. Dawkins (1982).
5. Pinker (1995).
6. Fodor (1983); Gazzaniga (1988).
7. Nottebohm, Kasparian, Pandazis (1981); Krebs (1990); Sherry, Jacobs, and Gaulin (1992); Sengelaub (1989); Purves, White, and Andrews (1994); Geschwind and Levitsky (1968); Galaburda et al (1987). These references were taken from Finlay and Darlington (1995).
8. Finlay and Darlington (1995).
9. Pinker (1994).
10. This point is nicely made by Plutchik (1980) and will be considered in more detail later.
11. Plato, *Phaedo*, cited in Flew (1964).
12. Darwin (1859).
13. S.J. Gould (1977).
14. Cited by S.J. Gould (1977).
15. Simpson (1953); J.M. Smith (1958); Ayala and Valentine (1979), J.L. Gould (1982).
16. J.L. Gould (1982).
17. Darwin (1872). All references to Darwin below are from this source, unless otherwise indicated.
18. Summarized by Plutchik (1980).
19. Tomkins (1962).
20. Izard (1977); Izard (1992a).
21. Ekman (1984).
22. Plutchik (1980).
23. Frijda (1986).
24. Johnson-Laird and Oatley (1992).
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26. Arnold (1960); Fehr and Russell (1984); J.A. Gray (1982).
27. C.A. Smith and R.S. Lazarus (1990).
28. Harré (1986).
29. Averill (1980). Averill's account of the Gururumba is based on research conducted by Newman [P.L. Newman (1960)].
30. Morsbach and Tyler (1986).
31. Ibid.
32. Doi (1973).
33. Heelas (1986); Davitz (1969); Geertz (1959).
34. Wierzbicka (1994).
35. Ekman (1980).
36. Ibid.
37. Twain (1962).
38. Ekman (1980).
39. Ortony and Turner (1990).
40. Gallistel (1980).
41. Ekman (1992a); Izard (1992a).
42. Plutchik (1980).
43. Ibid.
44. Bowlby (1969).
45. Shepherd (1983).
46. Nauta and Karten (1970).
47. S.J. Gould (1977); Pinker (1994).
48. Preuss (1995); Reep (1984); Uylings and van Eden (1990).
49. Nauta and Karten (1970); Karten and Shimizu (1991); Northcutt and Kaas (1995).
50. Preuss (1995); Geschwind (1965).
51. For example, protection from danger, finding food and shelter and suitable mates, and the like.
52. For example, see Jaynes (1976).
53. Ekman (1992a).
54. Johnson-Laird and Oatley (1992).
55. Tooby and Cosmedies (1990).
56. Natural triggers are what ethologists call sign stimuli. These elicit behavioral and/or physiological responses innately. They are also similar to unconditioned stimuli, which elicit responses innately as well (see Chapter 6).
57. Examples include sexual partner recognition or food detection networks.
58. James (1890).
59. Marks (1987).
60. Eibl-Eibesfeldt and Sutterlin (1990).
61. Kierkegaard (1844); Sartre (1943); Heidegger (1927).
62. Lazarus (1991).

63. Marks (1987).
64. D.C. Blanchard and R.J. Blanchard (1989).
65. D.C. Blanchard and R.J. Blanchard (1988); R.J. Blanchard and D.C. Blanchard (1989).
66. Bolles and Fanselow (1980); Watkins and Mayer (1982); Helmstetter (1992).
67. Bolles and Fanselow (1980); Watkins and Mayer (1982); Helmstetter ( 1992),
68. Among vertebrates, the organizational plan of autonomic nervous system function is similar from amphibians through mammals, including man [Shepherd (1983)].
69. Jacobson and Sapolsky (1991).
70. This will be discussed in some detail in Chapter 8.
71. The neuroendocrine systems, like most other neural systems, is similarly organized in different species. For examples, see: Shepherd (1983); J.A. Gray (1987); McEwen and Sapolsky (1995).
72. Dawkins (1982).
73. This is similar to the approach of ethologists, who look at the invariant, evolutionarily prescribed aspects of behavior, and of evolutionary psychologists, who tend to emphasize evolution's effects on the mind. For a summary of ethological approaches, see J.L. Gould (1982). For an example of the evolutionary psychology approach, see Tooby and Cosmedies (1990).
74. This work is summarized in: J.A. Gray (1987).
75. Wilcock and Broadhurst (1967).
76. See J.A. Gray (1987); Marks (1987).
77. Marks (1987); Kagan and Snidman (1991).
78. J.L. Gould (1982).
79. Tully (1991).
80. Sibley and Ahlquist (1984).
81. Dawkins (1982).