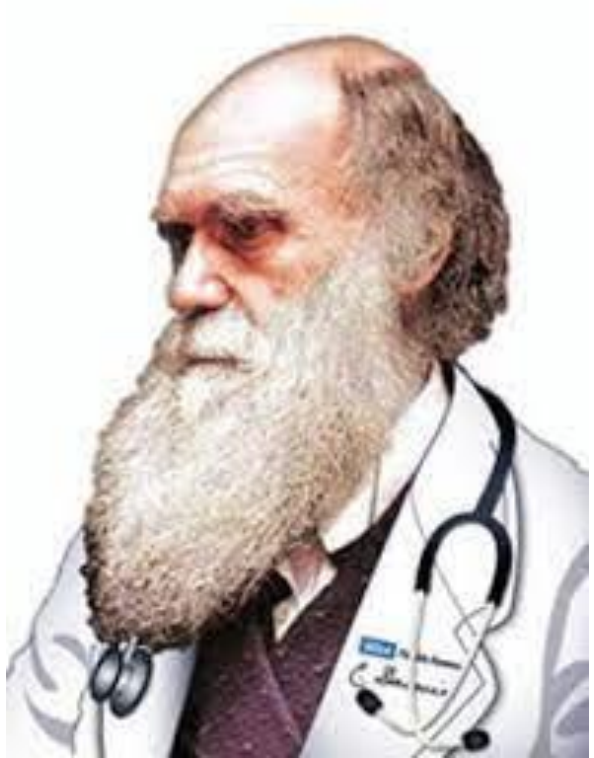
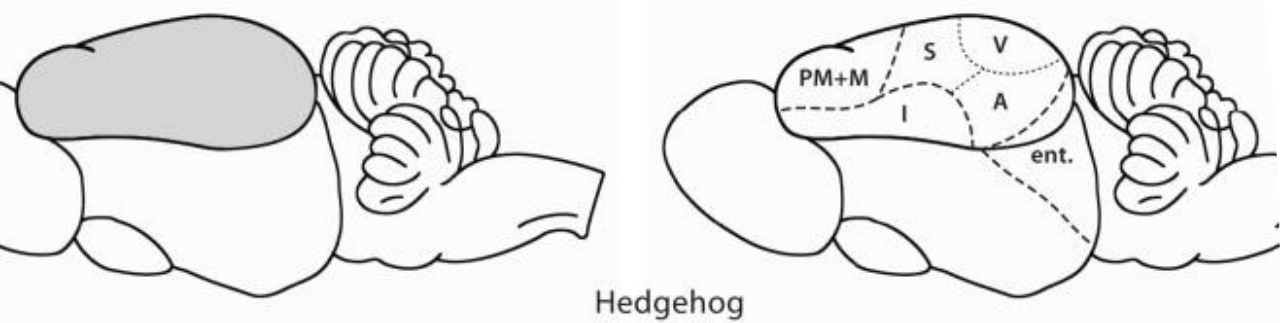
Evolutionary Medicine

Miriam Nývltová Fišáková

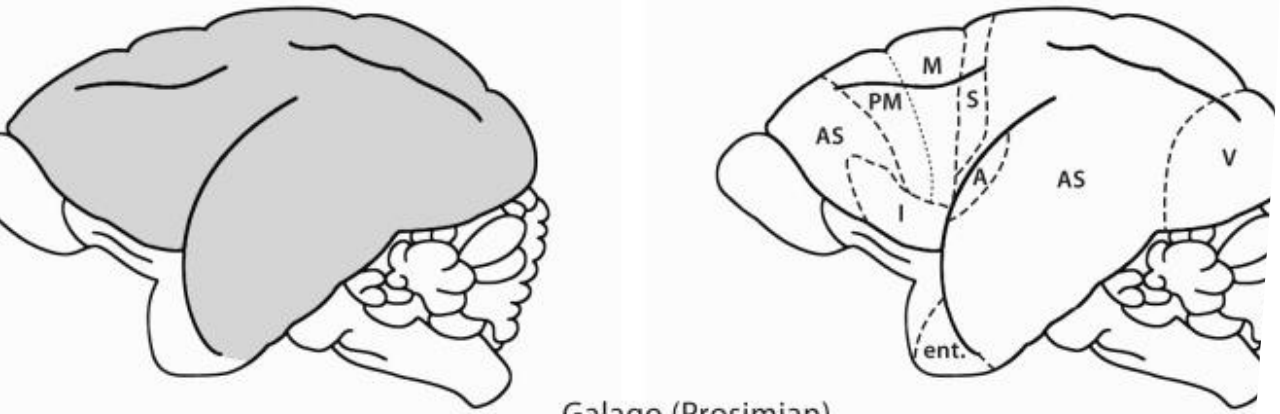
Department of Physiology



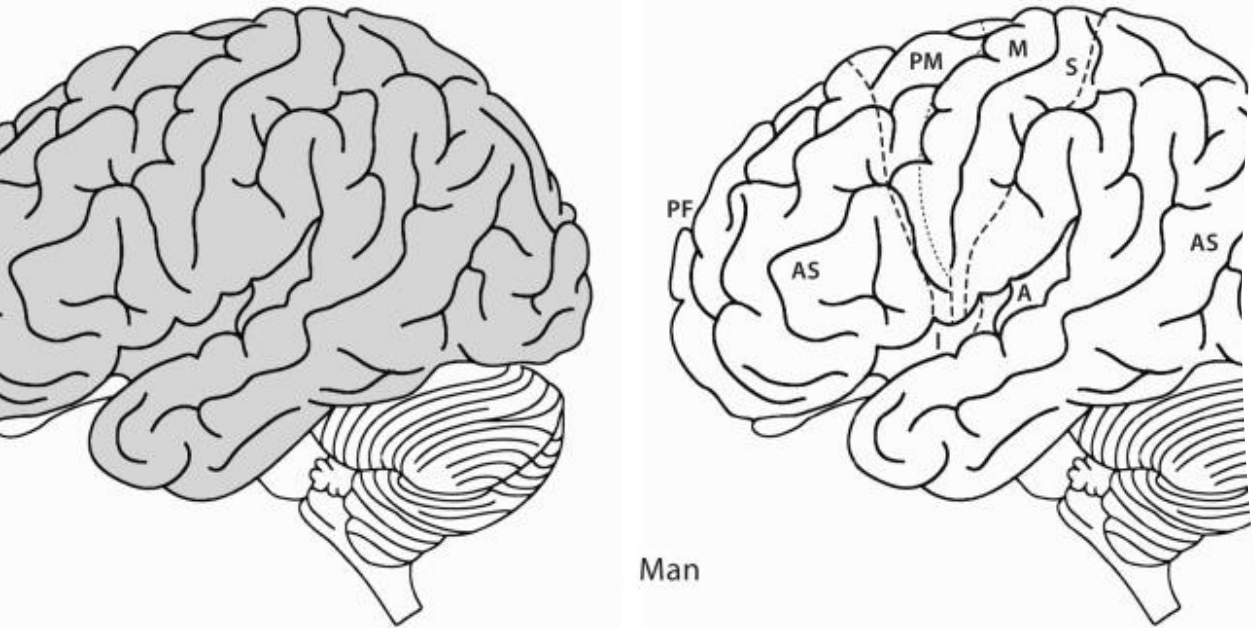
Psychology and Behavior



Hedgehog



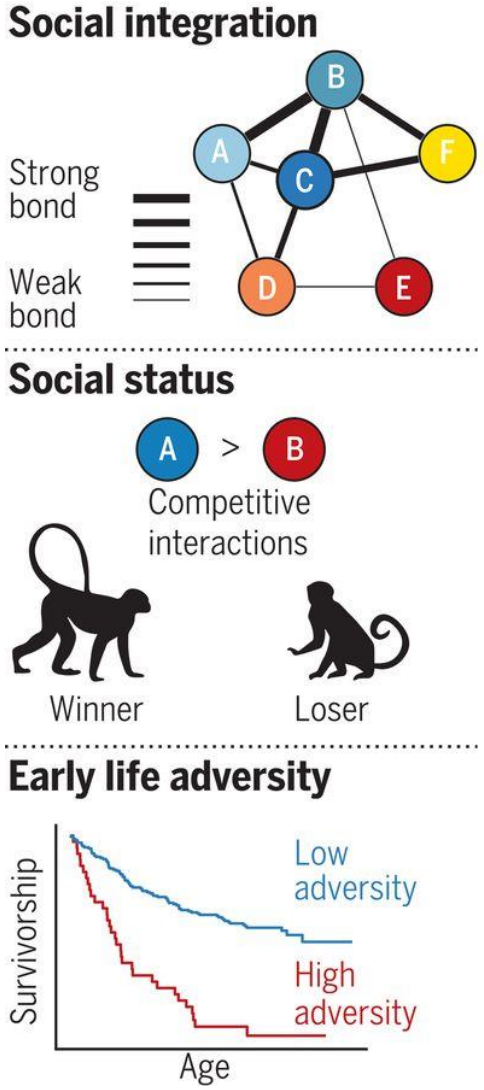
Galago (Prosimian)

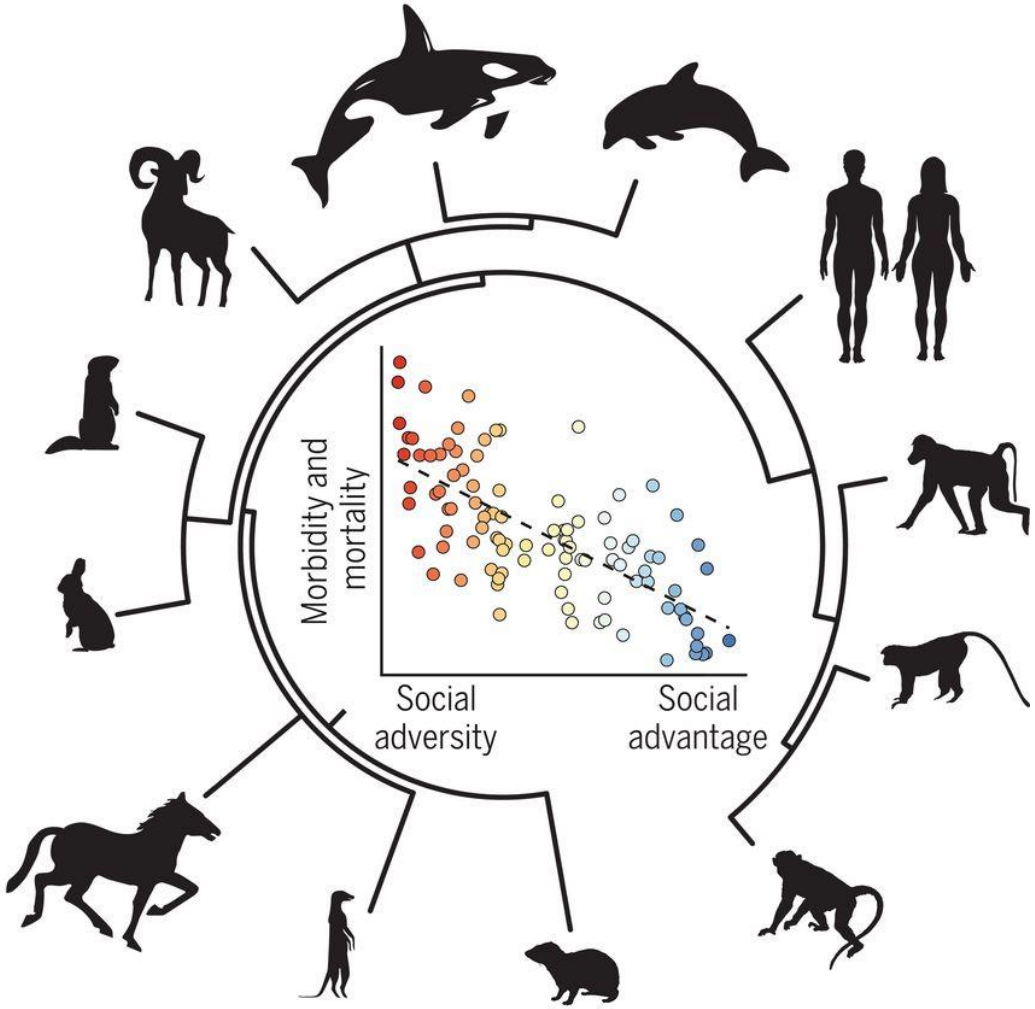


Man

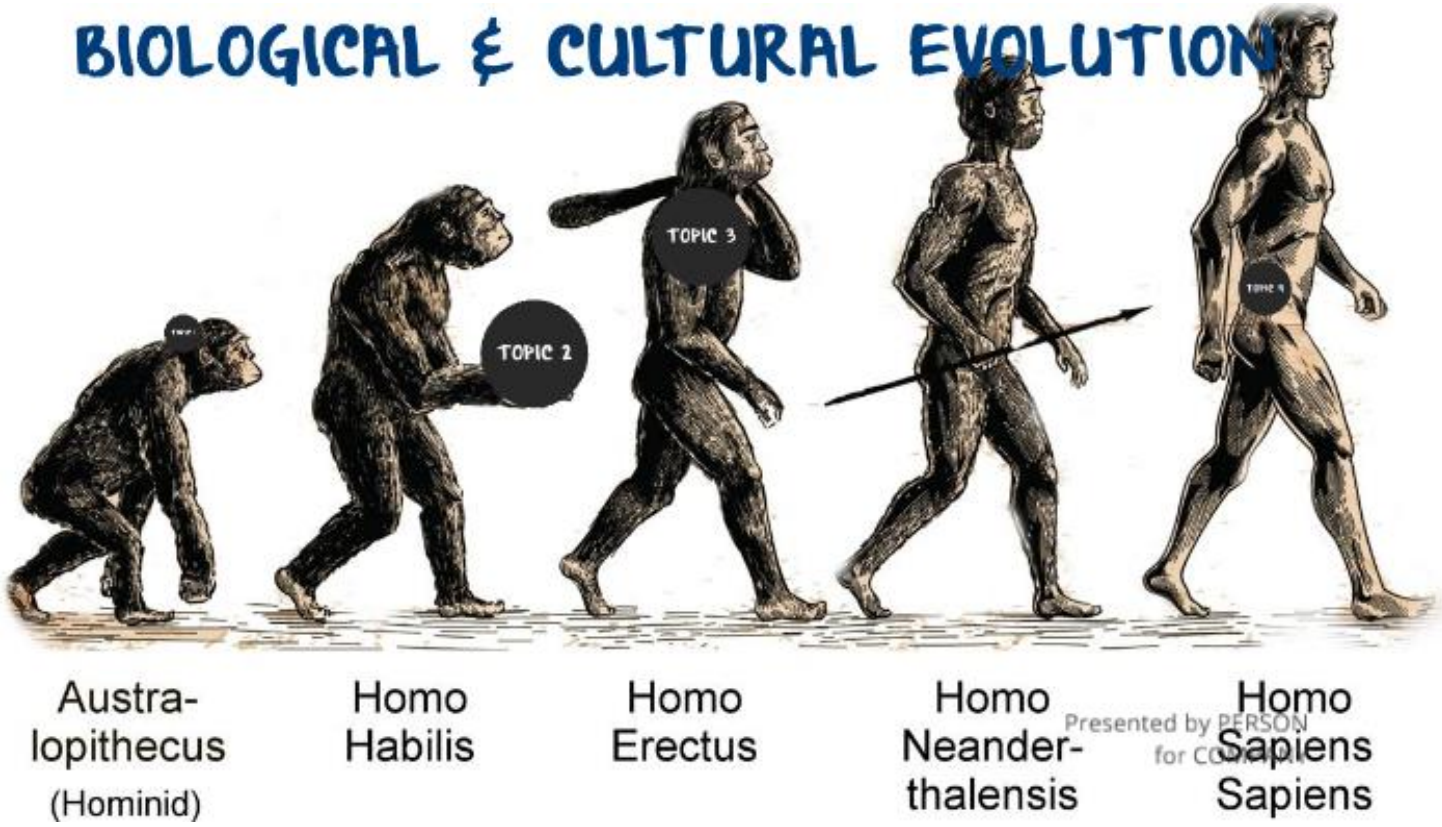
- It is a truism that humans can be distinguished from other species, at least in degree, by a large brain relative to body size. Our brain is characterized by a particularly well-developed neocortex, and this feature has had a number of profound evolutionary consequences. Our capacity to communicate, to use and develop technology, and even the nature of the social structures we have evolved can be attributed to a large neocortex. Humans are a social species. We evolved with characteristic behaviors adapted to living in groups with other members of our species. Yet our societal structure has undergone enormous changes in a few thousand years, from the small isolated clans of foraging societies to the complex organizations of cities with populations of millions. Increasingly, the social environment is changing in other ways. Family structure has changed, and communication is no longer necessarily verbal and face to face; indeed, telephone, radio, television, the internet, and social media are now all dominant forms of communication.
- We considers how human behavior has evolved and how its evolution has influenced behavioral morbidity, as reflected in a greater risk of some psychological and psychiatric disorders. These forms of disorder are now a large component of the current and anticipated burden of disease. The social environment is a major part of the selective environment which has led to the evolution of our species. But at the same time, humans have evolved with a rapidly changing capacity to alter their social and societal environments. This capacity creates the potential for a mismatch between our evolved phenotype and the environment we now inhabit. This mismatch, in turn, is likely to be a potent source of psychological disorders.

Biological Determinants of Culture and Behavior



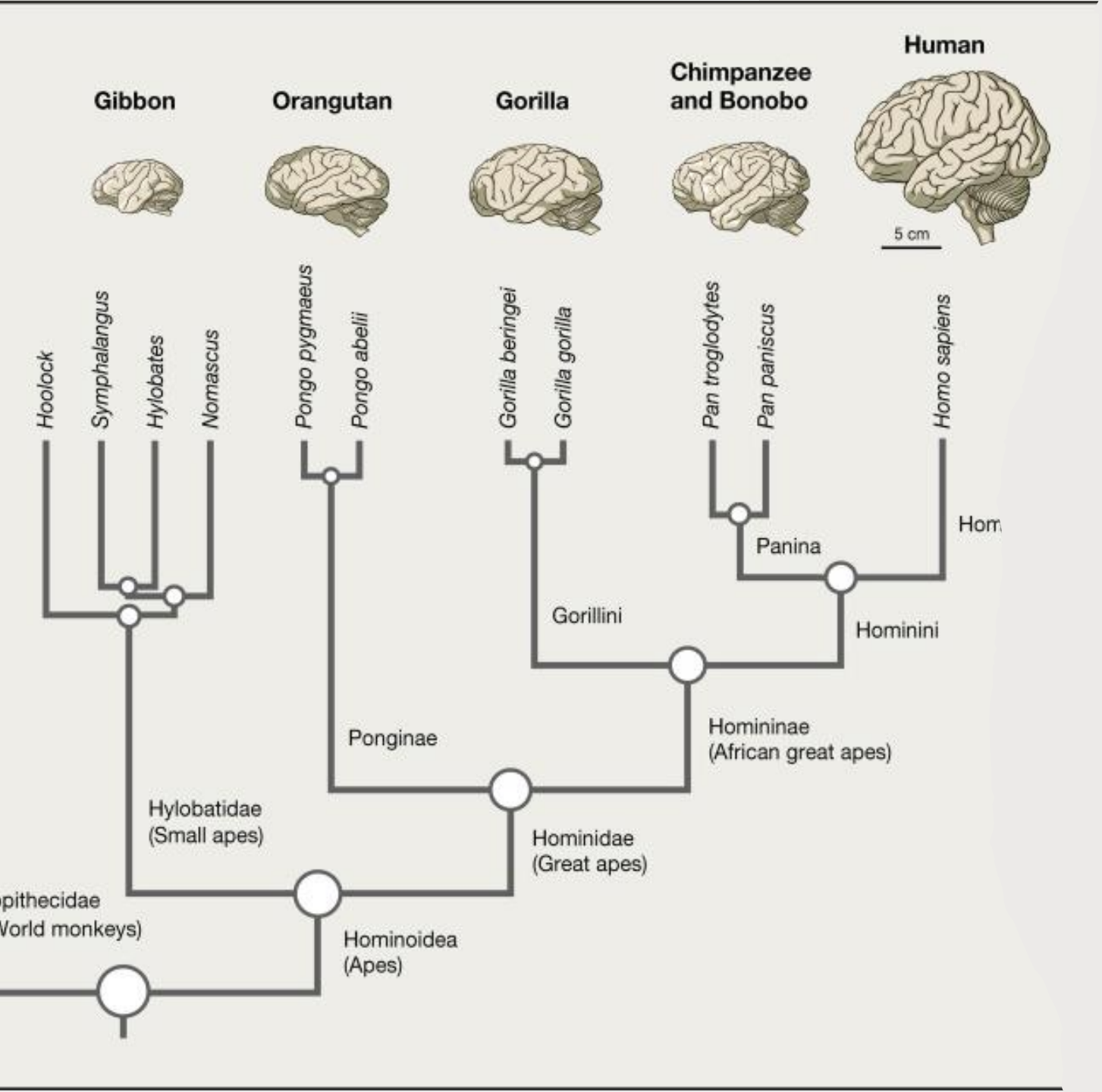


- In everyday language, culture is usually understood as an amalgamation of knowledge, behavior, and tradition within a particular community or population. But creating a formal definition of “culture” has itself been contentious. There have been intense debates among social scientists over its precise definition, and some have argued that culture must be viewed as a purely human characteristic. Modern evolutionary scientists define culture as information acquired through social learning. In this sense cultural phenomena may be observed in other species, notably primates, cetaceans, and birds. It is obvious that human culture evolves, and this cultural evolution is another form of an inheritance system with the potential for both vertical and horizontal transmission. Understanding the significance of the interplay between biological and cultural evolution is important. The evolution of the capacity to learn and the potential for learning to influence evolution are also important components of evolutionary science. But what has to be learned—and how it is learned—has changed dramatically and rapidly in the past 12,000 years, from experiential learning within the forager clan to the formalized and structured learning of modern developed societies. Because of changing attitudes to what culture is and how it originates, evolutionary explanations of human behavior have had an especially contentious history. This contention arose in part because of philosophical and political debate stemming from the ways in which various disciplines have interpreted human behavior. Some have wanted to view it as an entirely learned phenomenon, while others argue that human behavior is built on some strongly selected and therefore genetically determined components of brain function. Extreme positions have been taken, or at least interpreted as been taken, and at times the debate has been more polemical than critical. The media have not infrequently exaggerated scientific reasoning and observations into fatuous extrapolations of aspects of human behavior.



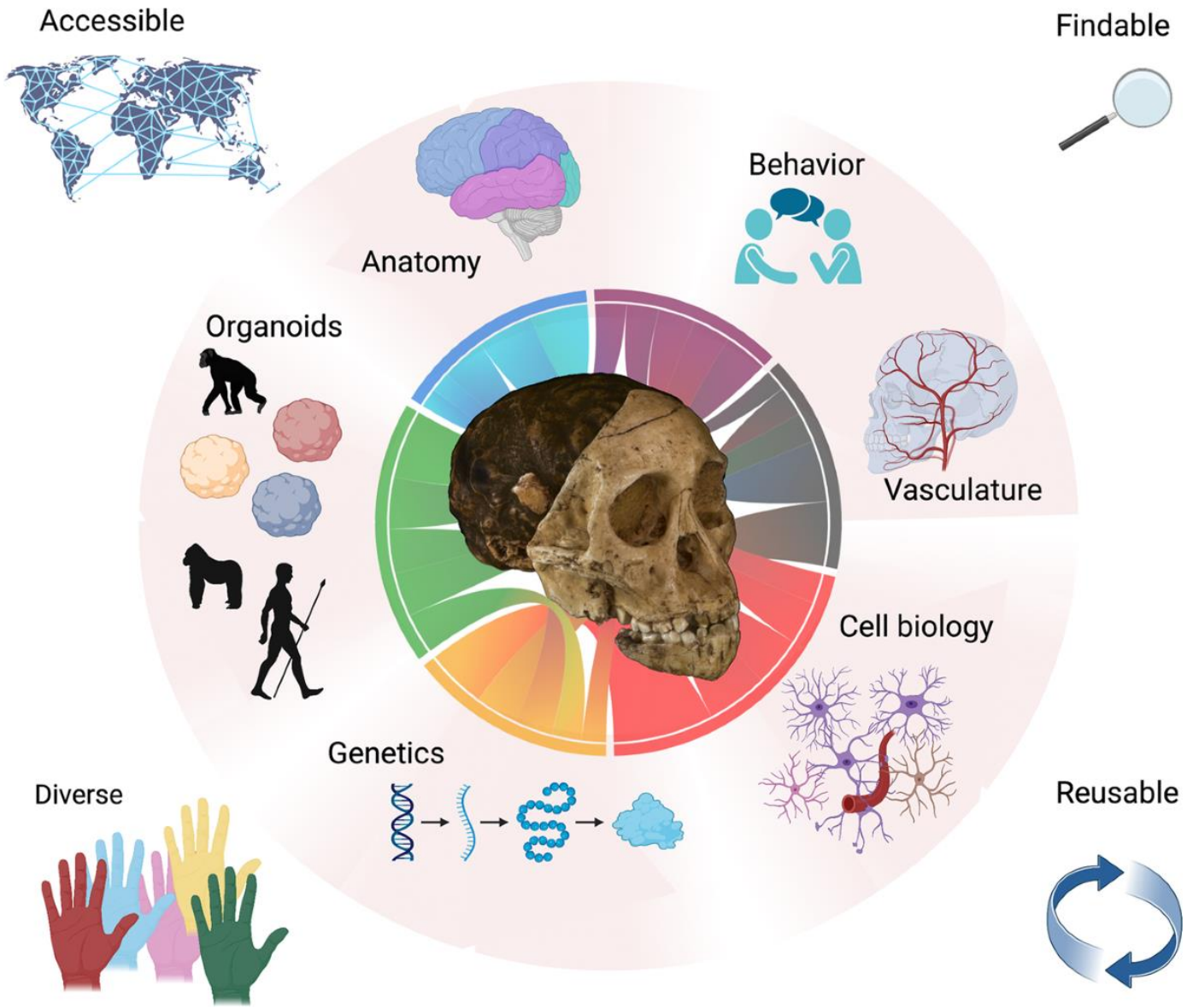
- We can reduce this discourse to the fundamental question of the extent to which human behavior is determined (or influenced) by our evolved biology. Several schools of thought have emerged to explain the evolution of human behavior, largely based on how each school conceived of culture, behavior, and learning. The debate was distorted by the strong genetic determinism of late- twentieth-century biology. The distinguished evolutionary biologist and zoologist E. O. Wilson, and subsequently many others including Richard Dawkins, put forward strongly deterministic arguments in which all aspects of behavior were essentially framed in genetic (i.e., evolved) terms (Wilson 1975). Their critics, who included equally distinguished evolutionary biologists such as Stephen Jay Gould and Richard Lewontin, saw that this stance left little room for the role of active decision- making, learning, and cultural adaptation. At its most inappropriate extreme, some critics, particularly from the social sciences and humanities, saw biological arguments being used to excuse all forms of antisocial behaviors from rape to murder, a position exploited by the media and which was a gross misuse of the actual evolutionary theories. Social scientists take a very different view from biological scientists: they see human behavior as being produced by culture, learned from others. The basis of social science is that humans are cultural organisms, and in general social scientists perceive culture as a learned rather than innate phenomenon. They argue that humans are quantitatively and qualitatively different from other species in terms of the complexity of their culture. But culture itself is a product of evolution and, as explained earlier, is not a uniquely human characteristic. Learning can be demonstrated in many animals. For example, some aspects of foraging are clearly learned, feeding behaviors are culturally transmitted in some reptiles and birds, migratory patterns are learned in some avian species, and tool use in different groups of chimpanzees and New Caledonian crows is a learned or culturally transmitted behavior. Some cetaceans have a culturally transmitted whale song.

- Language provides a sophisticated capacity for communication, and we have developed varied and complex social structures. Humans are a prescient species, possessing consciousness; we use technology in sophisticated ways, and we have developer belief systems manifesting in religion and superstition. But there is an important difference between the view that genes determine our behavior and the argument that our evolved brain is the substrate on which experience and the current environment shape our abilities and behavior.

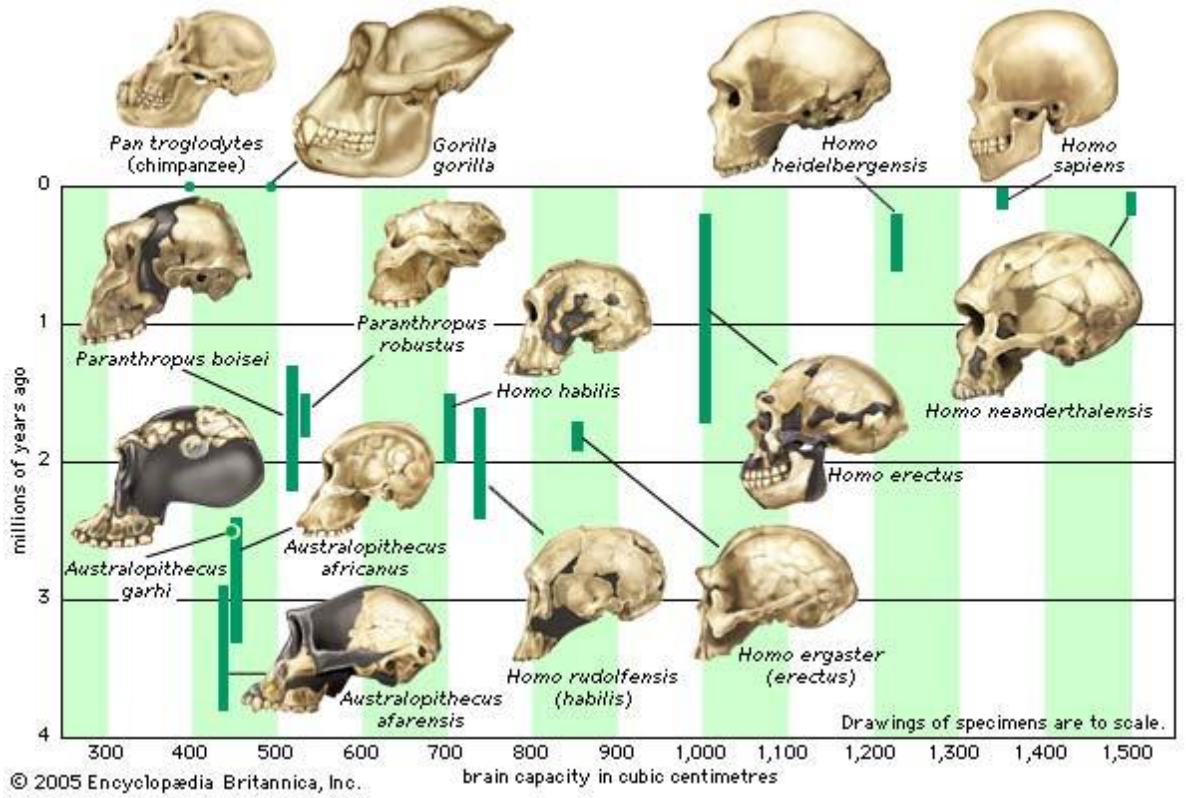


- A fair appraisal of the concepts would show that accepting that there is a genetic basis to human behavior does not mean that every aspect of human behavior is genetically determined. Rather, as we have made clear throughout this book for other systems, for neural function evolution has led to the selection of inherited neural traits that provide a substrate on which developmental and environmental influences (including the social components of the environment) can act to mold behavioral and neural phenotypes. Evolutionary biologists have been particularly concerned with explaining how altruistic behavior and the interplay between the sexes have emerged.
- We will extend the discussion to other aspects of human behavior and psychology. Each of the various schools of thought that have taken positions on the evolution of behavior can offer valuable insights, and will draw from them to describe what, in our view, is now a broadly held consensus on how evolutionary principles can, and should, be used to explain human behavior and psychology. In turn, evolutionary perspectives offer useful insights for understanding certain psychiatric disorders.

Evolution of the Human Brain and Behavior



- In considering the evolution of human behavior it is useful to bear in mind the four questions suggested by the famous ethologist Nikolas Tinbergen as a way of systematically understanding behavior (Tinbergen 1963). These are: what is the mechanism underpinning the behavior; what is the function of the behavior; how does it develop during the life course; and how does it evolve? Addressing each of these questions can help us to understand behavior from both proximate and ultimate perspectives. The ratio of brain size to body size in primates is about an order of magnitude larger than that in other mammals. But even within the primate order, humans and our ancestor species have had brain sizes that are disproportionately large. The investment in a large brain has major energetic considerations. The human brain consumes about 20% of the body's total energy but makes up only about 2% of bodyweight; the proportion of energy consumed by the brain is considerably higher in infancy. So a fundamental evolutionary question is why did primates, and particularly hominins, evolve to invest so much of their energetic resources in brain growth and function? The question does not have a single answer. A simple answer is that the sensory and processing capacities of the brain conferred adaptive advantages to the primate clade. For example, primates use senses such as color vision to a greater extent than other mammals in their search for ripe fruits. Evolutionary processes do not work on a single trait in isolation, but operate on multipleinteracting traits. Indeed there has been an interactive "ratchet" involving changing ecology, evolving social structure, better communication, and better use of technology, all of which have driven brain development.



- It is generally accepted that most adult humans operate with about five levels of intentionality. Indeed, effective social discourse requires this level of interaction to avoid unnecessary misunderstandings and conflict. Clearly the higher the level of intentionality required, the more likely it is that errors of interaction will result. Many problems in interpersonal relationships, and even wars, have arisen as we employ these higher levels of intentionality.
- Such advanced processing and engagement in social organization clearly required, and was expedited by, the development of language.
- Once higher levels of intentionality had evolved, they provided the capacity for further components of human culture to develop. They also provided the basis for a high level of reciprocal altruism and detection of cheaters, which have become fundamental to the structure of human society. Higher levels of intentionality are required for the capacity to have prescient self-awareness (including that of death), to develop beliefs and superstitions (the forerunners of ritual and religion), to form political structures, and to use language to communicate via the complexities and beauty of literature. The theory of mind develops over our life course. By the age of 4–5 years children can recognize a third order of intentionality; before that they cannot lie convincingly. The concept of a theory of the mind may be relevant to understanding autism and the related Asperger's syndrome (Baron-Cohen et al. 1997). Those afflicted have a limited ability to interpret the intent of others, suggesting that third-order and higher levels of intentionality have not developer appropriately.

Reciprocal Altruism

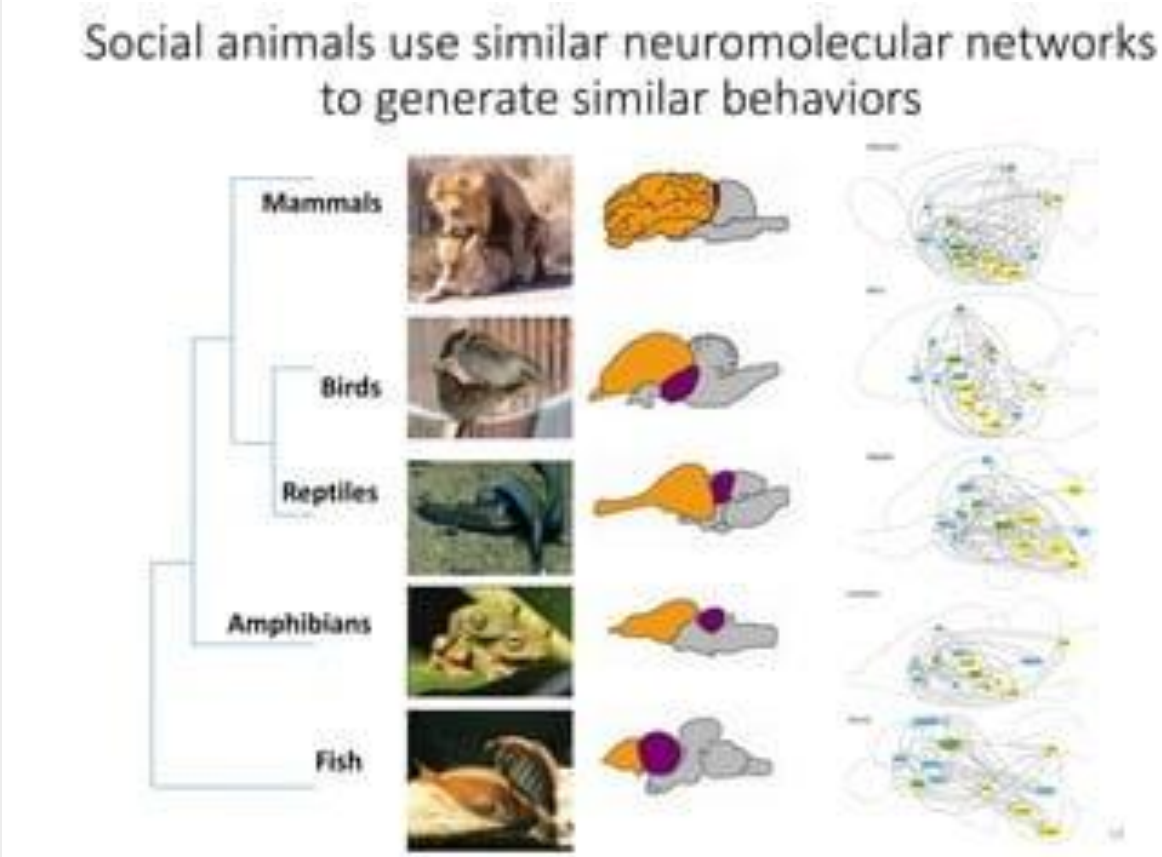
Pure Altruism

Genetic Altruism

Group-selected Altruism

BetterUp

Evolution of Social Behavior



- Humans are characterized by living in groups larger than a family and, as discussed previously, there is a compelling rationale for the view that we evolved living in clans of about 100 to 150 individuals. Thus the social environment became a key part of our selective environment, and selection would have favored traits that promoted fitness within that environment. However, we also evolved in parallel with our cultural repertoire. There has been a close link between our cultural evolution and our biological evolution, often referred to as gene-culture coevolution. The development of consistent use of tools by *H. habilis* is the first unequivocal evidence of culture in the hominin clade. Such tool-making capacity eventually evolved through learning and cultural evolution into the technological repertoire of modern society such as brain scanning, pharmaceutical development, nuclear weapons, and the internet. There are many features of society which have undergone change, many of which are self-evident. Over the past 10,000 years, virtually all human groups have changed from being foragers living in small clans into pastoralists and city dwellers. These changes have been accompanied by rising exposure to infection and malnutrition. The causes and nature of trauma and conflict have also changed, with humans becoming their own main predators, particularly through war and religious and other persecutions. There have also been enormous changes in social structure. Organizational and thus power hierarchies became necessary, and individual skills became differentiated: a surgeon and a lawyer obviously have very different skills, and interpersonal interactions often now require higher levels of intentionality.

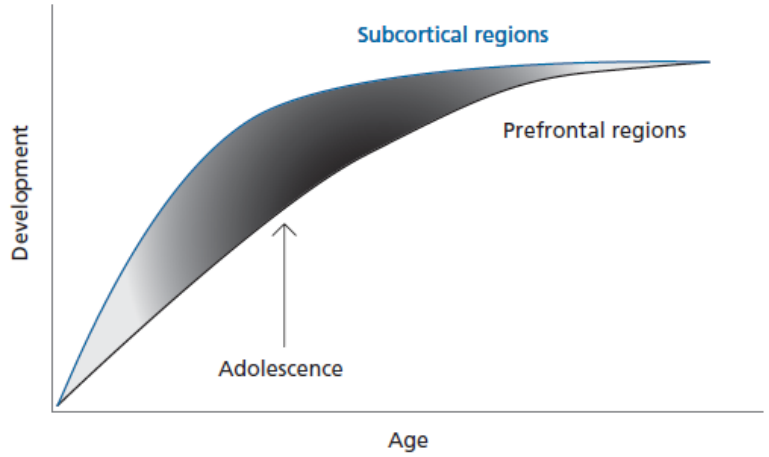


Figure 11.2 Growing neurobiological evidence indicates that brain systems that play a key role in emotional and incentive-based be as the subcortical regions (top line), mature earlier than systems modulating cognitive and impulse control, such as the prefrontal cor line). This regional discordance in structural and functional maturation is particularly marked around the period of adolescence, contrib elevated risk of acting-out and risky behaviors during this phase of life. Adapted from Somerville et al. (2010), with permission.

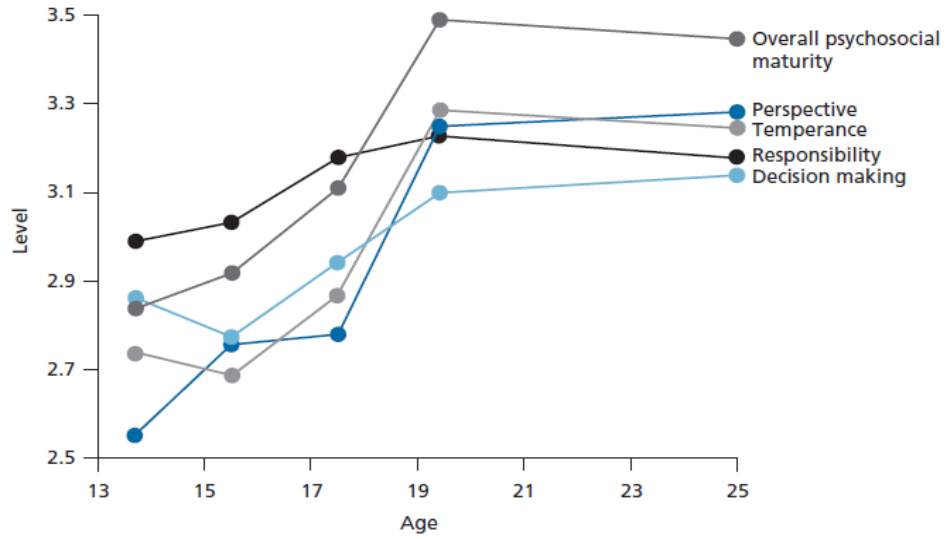
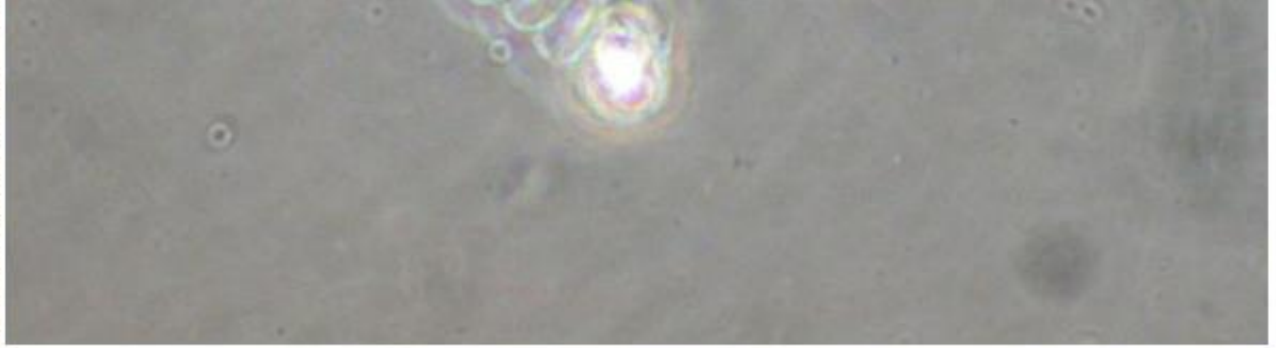


Figure 11.1 Decision-making activity may not mature until about 20 years of age. Data from Cauffman and Steinberg (2000).

- Culture evolves, and as it changes so does the selective environment in which an individual lives. How lactase persistence coevolved with pastoralism demonstrates such coevolution. Conversely, had the gene for lactase persistence not mutated, milk could not have become a major food source for that population. It is not surprising that the outcome may be maladaptive, because culture can evolve at a different pace and in a different manner from biological function. For example, the evolution of societal structure into large aggregations of population with less structured clan support may conflict with our evolved capacity to manage best psychologically in smaller groups. This mismatch may be the basis of some psychological disorders. We described how the young age of biological puberty is in conflict with the age at which we accept young people as adults in developed societies. Indeed, it may be that the change in societal complexity has affected the rate of neural maturation: there is evidence that some aspects of decision-making activity may not mature until after 20 years of age, and magnetic resonance imaging shows the prefrontal cortical structures that are involved in impulse control, strategizing, and judgment are not fully mature until after 25 years of age (Lebel et al. 2008). There is growing empirical evidence to show that this mismatch plays a role in teenage depression, acting-out behavior, drug abuse, and suicide. It has been found that boys who undergo earlier puberty, spending a longer period of their lives in a biologically mature but psychologically immature phase, are much more likely to be suicidal than those having a later puberty. This example highlights a challenge. Just as the introduction of an exotic species into a previously stable environment (e.g., rats, dogs, and humans in New Zealand, which was free of terrestrial mammals until the arrival of humans some 800 years ago) can drive species (flightless birds such as the moa) to extinction, or global warming can destroy frog habitats in the mountains of Costa Rica, rapid changes in our social environment can have impacts on human health. The human neocortex largely evolved to deal with the challenges of the social environment. As biological and cultural evolution proceed in very different ways and paces, we can anticipate that the consequences of the inevitable mismatch between brain and environment will be reflected in disorders of behavior and mental health.

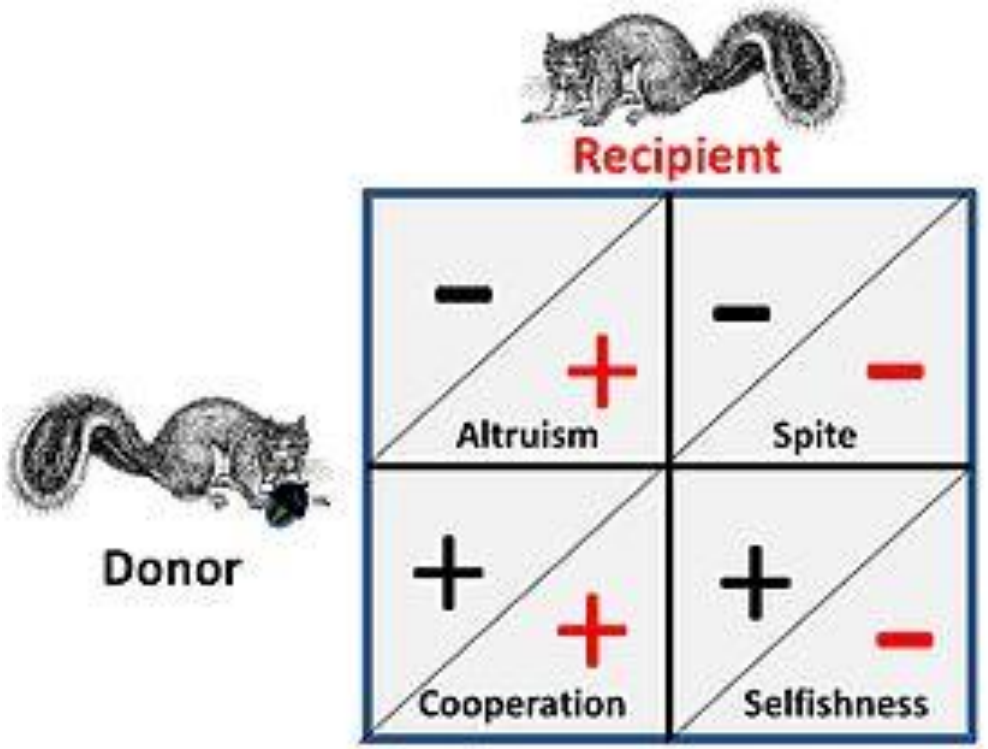
Social Competition and Altruism


- One way that living with others influences our evolution is through social selection. We discussed sexual selection—that is differential fitness created either by competition between members of the same sex for the right to mate, or by choice of mate by members of the opposite sex. Some authors have suggested that sexual selection processes are a subset of social selection (West- Eberhard 1979), the latter being a form of natural selection influenced by intraspecific social competition or choice, in sexual as well as non- sexual contexts. We have discussed the peacock's tail as an example of a trait that evolved in the context of members of the opposite sex choosing their mate. But consider the example of American coot families, where offspring display highly ornamented and bright plumage to their (gray) parents (Lyon and Montgomerie 2012).Attracting the parents' attention is crucial for provisioning food and so for offspring survival. We could say that sexual selection involves fitness advantages relative to mating (and fertilization) while nonsexual social selection influences components of fitness related to survival. Social selection may have shaped aspects of human cooperation. Being selected as a social partner would have enhanced survival for an individual of a species that lived in a social group structure, particularly in environments where being an outcast would put survival at risk. Thus there could have been selection of prosocial traits such as empathy and altruism (Nesse 2007). One of the biggest challenges in evolutionary biology has been to explain altruism, behavior that is apparently costly to the actor and beneficial to the recipient, and which at first glance is at odds with the basic tenet that selection operates on the individual. Initially altruism was used as an argument for group selection, but problems were inherent in that concept and it was largely abandoned. So if the unit of selection is the individual, how can behavior that apparently does not serve the reproductive interests of the individual (i.e., altruism) evolve? Altruism is a common feature of mammalian groups. A meerkat will take up a guard position to watch for a predatory raptor even though this entails a greater risk of being spotted and becoming prey. One member, not necessarily a parent, will guard the nest while others in the clan are out hunting. Much in human social behavior appears to be for the benefit of others rather than oneself. As discussed a favored explanation is provided in part by the concepts of kin selection and inclusive fitness.

- William Hamilton, the originator of the concept of kin selection, argued that an animal would behave altruistically with respect to other animals if they are likely to carry the same genes and thus assist indirectly the intergenerational flow of some of its own genetic material (Hamilton 1964a, b). This altruism would apply in the case of kin, and the closer the kinship the more likely it is that altruistic behavior would be beneficial. This is formulated in Hamilton's rule, which states that a gene supporting altruistic behavior would be under positive selection whenever the benefit to the recipient of the altruistic act (in terms of reproductive fitness) is greater than the cost to the individual conducting the beneficial act. This benefit is clearly dependent on the degree of relatedness: the greater the degree of relatedness the greater the benefit in terms of potential gene flow. Indeed there is considerable empirical evidence that altruistic acts in animals are more likely when there is a high degree of relatedness. This concept of kin selection has also been used to explain the development of eusociality in insect species such as the honey bee. But the degree of altruistic behavior shown towards kin may not just be determined by the degree of relatedness. From an evolutionary perspective, aged individuals have less impact on inclusive fitness than those of peak reproductive age. This consideration is termed reproductive value, and is a measure of an individual's potential to contribute to the gene pool of the lineage by virtue of their age. Generally, having a larger social network and greater number of kin has positive effects on longevity. Several studies have shown that underextreme conditions, such as the Donner Party disaster of 1847 where US settlers caught in a snowstorm resorted to cannibalism, those with kin within the group were more likely to survive as they were more likely to receive support from their relatives (Grayson 1990). Kin selection is an important component of human behavior. There is much evidence to show, for example, that people are more willing to care for a relative's child than for one who is completely unrelated. We loan money to relatives on an entirely different basis from non- relatives. The grandmother hypothesis, as a favored explanation for the evolution of menopause, can only be understood in the framework of kin selection and inclusive fitness. In general, kin selection is affected by age, as more altruism is shown to younger kin members, be it in patterns of childcare or willingness to invest in medical care. In many species, such as the lion, males will kill the offspring of another male when they are able to mate with the female who mothered those offspring, whereas they will be protective of their own offspring. This may have a parallel in humans: Daly and Wilson (1988) observed that step- fathers are more likely to abuse or murder step- children than are biological fathers.

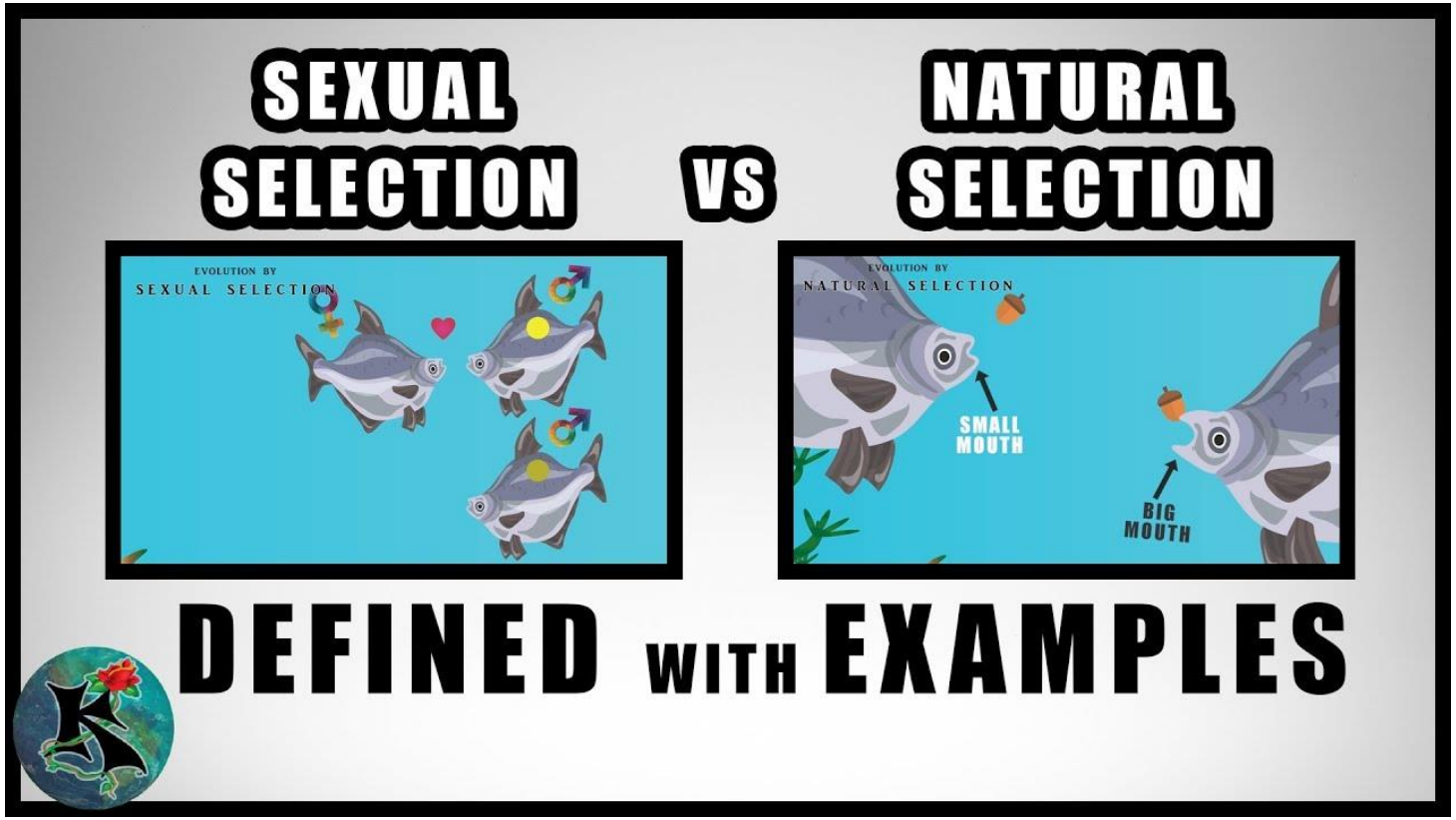
- It might be argued that the practice of adoption of unrelated children, common in the West today, is inconsistent with concepts of kin selection (Volk 2011). Indeed in many traditional societies, adoption largely has a function in kin support, with relatives (most often the maternal grandmother, in line with the evolutionary predictions based on kin selection and paternal uncertainty) temporarily or permanently looking after the children of their impoverished or deceased kin. This form of kin adoption is not uncommon today, though it usually takes the form of fostering or guardianship, where ties with the biological parents are not severed. But while for the majority of adoptions in the developer world, involving entirely unrelated individuals not necessarily from the same social or ethnic group as the adopters, the explanation of kinship selection does not work, there may be other evolutionary explanations. One is *reciprocal altruism*, with investment in non- related children generating opportunities for economic return in later life. Another form of return is social. In some traditional societies adoptions are used to forge ties between groups or rebuild damaged social relationships, similar to arranged marriages practiced, for example, historically in European dynasties or still in many Asian societies. Finally, adoption may be a byproduct of powerful adaptations, for example motivations to procreate and to parent, offering an outlet for such feelings to infertile couples. It is interesting that in studies looking at the qualities in an adopted child that the prospective adoptive parents prefer, it has been found that women emphasize cues of health (presumably because of their larger investment into care of offspring) while males valued resemblance cues (presumably because paternity is far less certain than maternity). Adoption of unrelated children (or surrogate pregnancies and egg donation without remuneration) is only one kind of example of altruistic behavior extending *beyond* relatives. We give blood not only for psychological reward but in the expectation that others will donate blood should we need a transfusion in the future. In forager communities, it is common for food to be shared between unrelated individuals. This can be seen as a form of insurance against potential hard times. The potlatches (festivals involving lavish gift- giving) of the Pacific Northwest peoples are an extreme example. Such non- kin- based apparent altruism can also be demonstrated in animals. For example, the vampire bat will give food (blood) to other unrelated bats in the colony that were unsuccessful in the hunt in expectation of the favor being returned at a later date.

- The favored explanation for such behavior comes from another major tool of evolutionary biology, namely *game theory*, and in particular the concept of *reciprocal altruism*. The basic premise is that if A does a good turn for B in the expectation that at some later time B will reciprocate by doing a good turn for A, then both parties will benefit. However, this only works if B is not a cheat (a “freeloader”): if B is a cheat, A has lost and B has gained. Working with this simple model, game theorists such as the eminent evolutionary biologist John Maynard Smith demonstrated that *evolutionarily stable strategies* can emerge based on reciprocation and cooperation. These strategies operate best where there is a great ability to detect and punish a cheat. Indeed, many aspects of modern society are based on detecting cheats and punishing them through ridicule, social isolation, or physical punishment. A higher level of intentionality may allow more individuals to try and cheat, but it also enables others to be better at detecting cheats. A further argument for the origins and sustenance of altruism has analogies with the *handicap hypothesis* or *handicap principle*. To be altruistic is to demonstrate a generosity and richness that may be of value in the competition for a social partner. If one can afford to give, it may be a signal of wealth and quality, values that a potential mate may find attractive. Indeed, in modern society we regard overt non-kin-based altruism (manifested as bravery or philanthropy) as a particularly desirable characteristic.



Selfishness and Selfish Genes

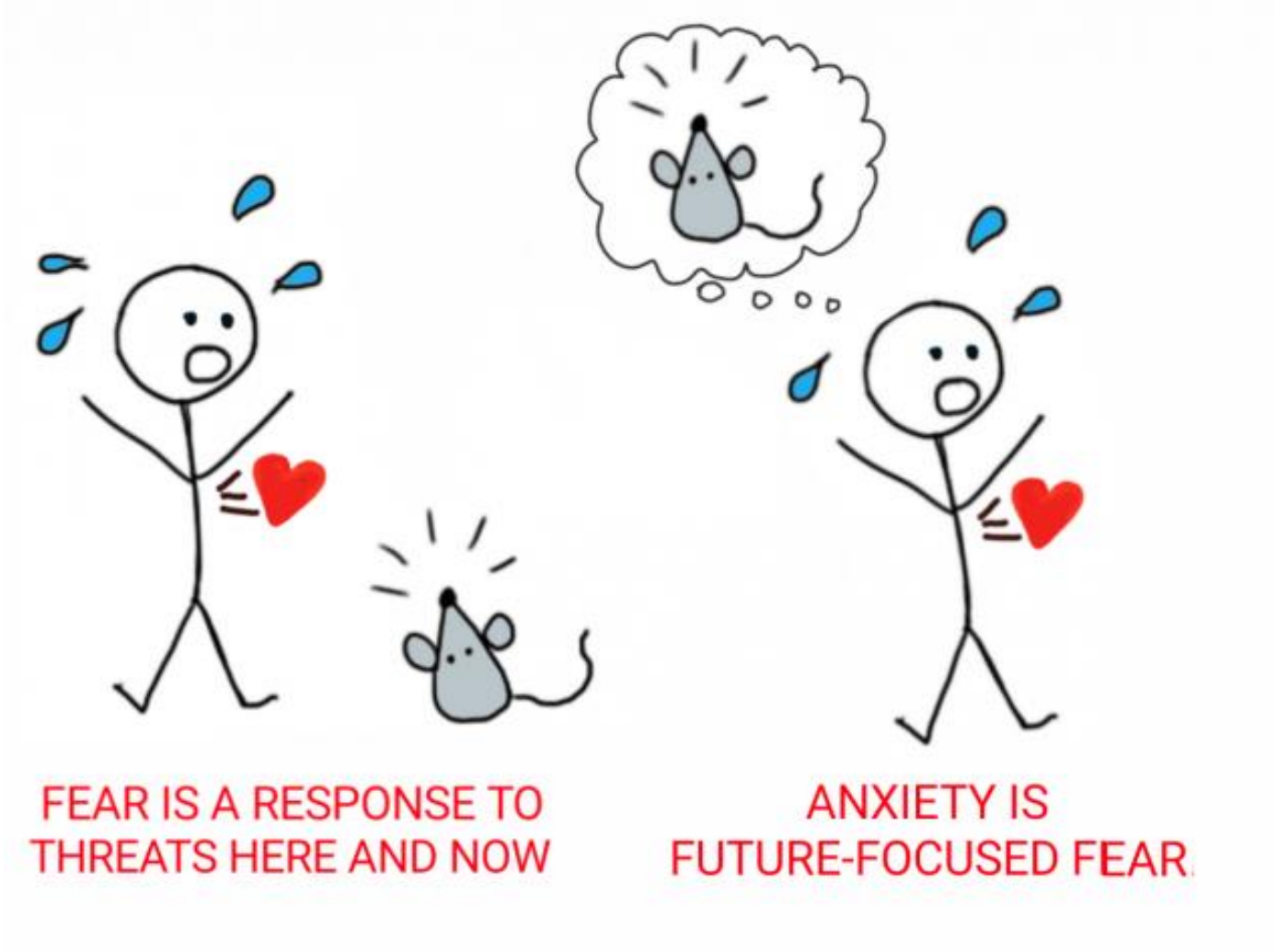
- We have reviewed the evidence suggesting that humans underwent positive selection for living in groups. It could be postulated that the psychological mechanisms allowing humans to live successfully in groups evolved because such eusociality allowed the clan to solve problems collectively, but this is not an argument for group selection. In this discussion it is important to distinguish between selfish genes and selfish behavior, a distinction often forgotten by the popular press and some academics. The phrase “selfish gene” was simply a catchy shorthand introduced by Richard Dawkins to emphasize that evolutionary processes are fundamentally about preserving gene flow, and that selection may well be acting at the level of the gene rather than the whole. Kin selection, natural selection, social selection, and sexual selection are all manifestations of processes that attempt to preserve fitness by protecting gene flow to the next generation, either directly or indirectly. In contrast, selfish behavior is a description of an individual’s behavior, but even here its interpretation depends on the level of analysis. What may have had its origin in self-interest can lead to non-selfish behaviors that we interpret as being altruistic. An example might be philanthropy, which originates from the desire of the donor for social recognition.



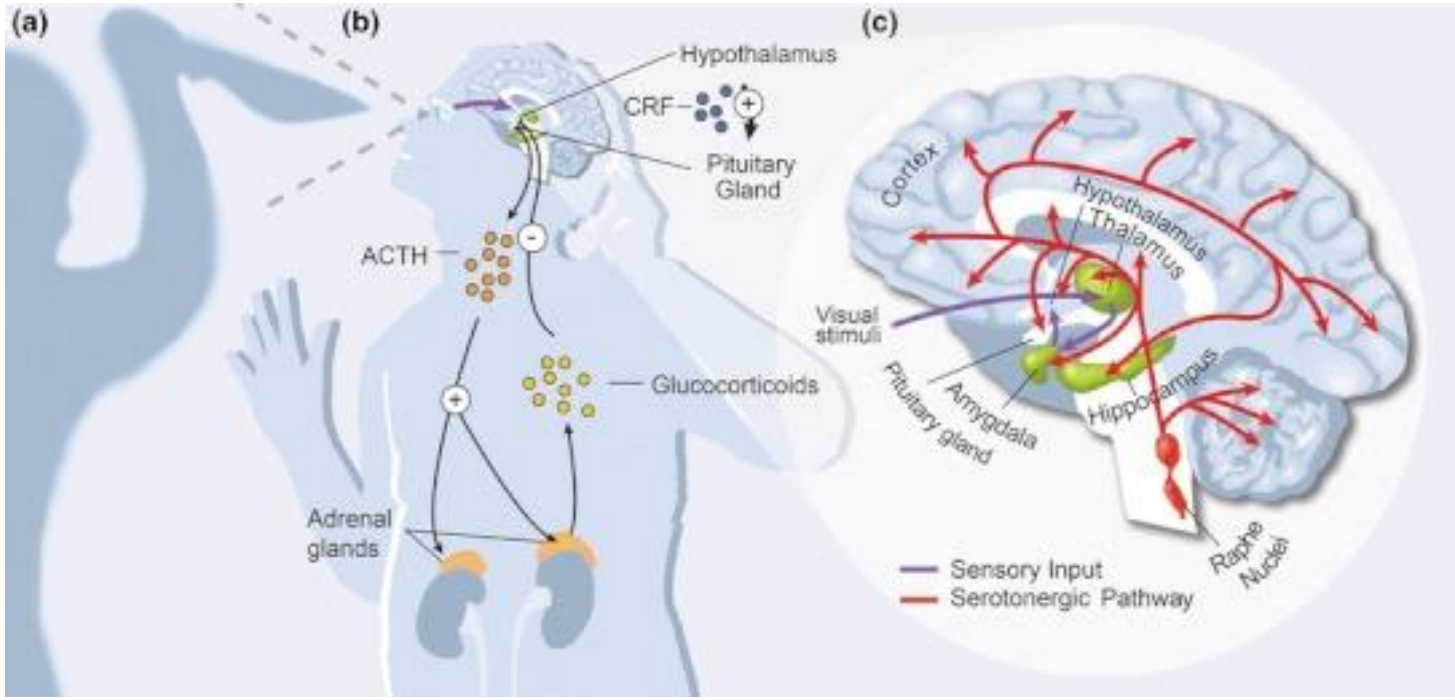
- **Emotions**

- Emotions are universal human attributes and may exist because they offered adaptive advantage in our evolution as a species. Emotions do not occur in isolation, but involve integrated physiological and behavioral responses to environmental stimuli, either at the time or in recollection. Darwin recognized that the physical manifestations of emotions can play a role in selective processes, and he wrote an extensive volume on emotion (Darwin 1872). More recently, the evolutionary psychologists Leda Cosmides and John Tooby, who developer a relatively extreme position regarding the evolution of behavior, referred to emotions as the "Darwinian algorithms of the mind," emphasizing that these are selected traits. Given their universality, emotions may have been shaped by their adaptive value in signaling and responding to situations that are frequently and universally encountered, such as fear, panic, and sexual desire. In general emotions are healthy phenomena. The challenge for medicine and psychology is when emotions become situationally inappropriate in nature or severity and impair the functioning of the individual.

Fear, Anxiety, and Response to Threat

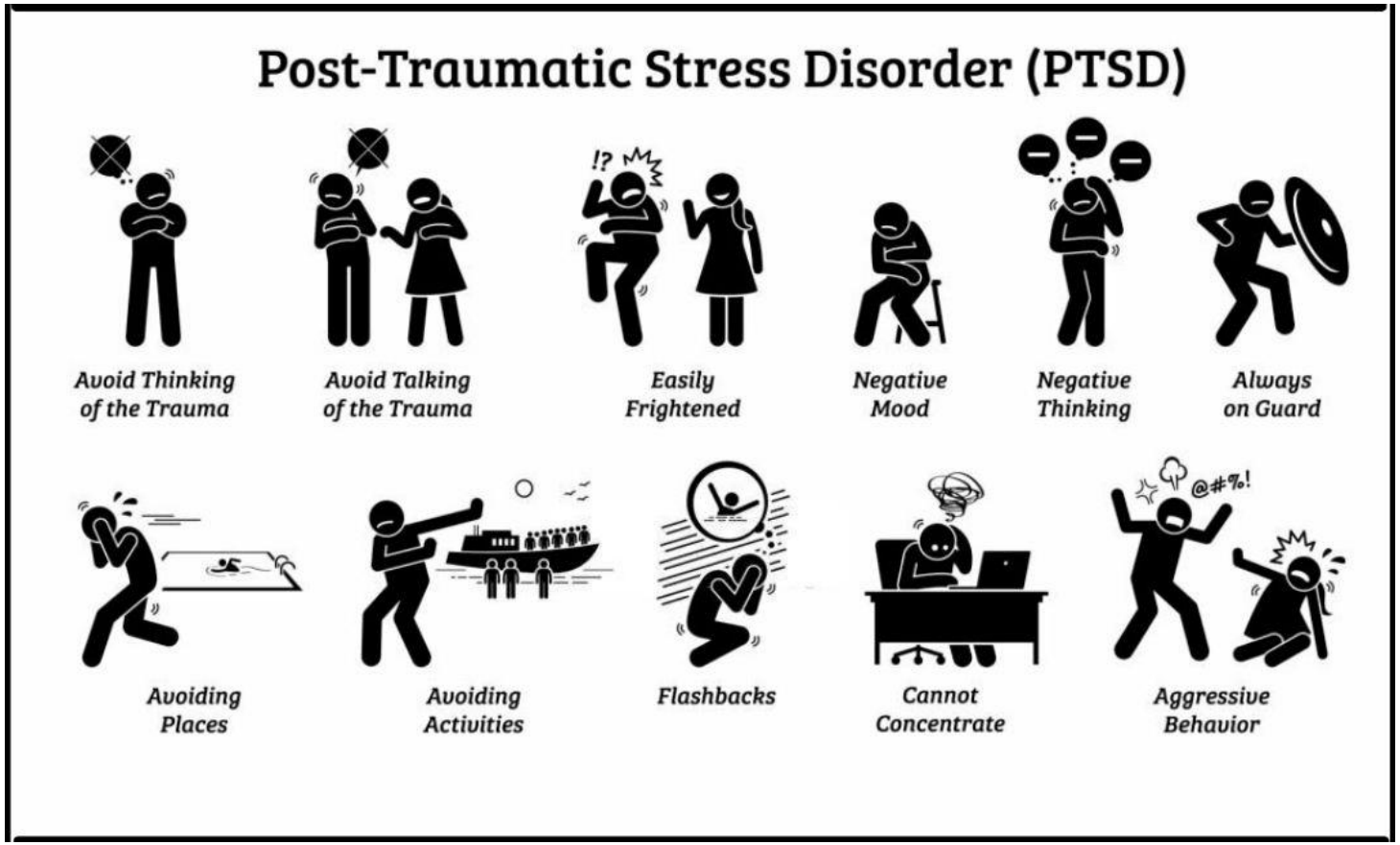


- Many aspects of our physiology defend us from external threats, and some aspects of our emotions can be viewed as serving similar functions. Fear and anxiety serve the obvious purpose of alerting us to danger and maintaining a state of vigilance. They have evolved in response to threats from predation and violence. Survival depends on the development of sensory functions and prescient capacities to detect or predict threats from other species. The development of a theory of mind allows us to understand the intentions of other humans, and we need an ability to mount so-called stress responses allowing us either to escape from predation or violence or to fight back. There is an enormous overlap in the physiological responses to threats of danger and to social stress. Humans rely on being members of a group for their survival. Just as an isolated member of a herd species is at particular risk of predation, an isolated human would have been at a disadvantage in threat detection, in hunting and foraging, and in protecting offspring. When placed in isolation, rats and many other species have a marked endocrine stress response. Humans find social exclusion threatening and stressful, as is evidenced by studies of prisoners in solitary confinement. It is useful to distinguish between a stressor and stress itself. A stressor has been defined as “a threat, real or implied, to the psychological or physical integrity of an individual.” Detection of a stressor by an organism elicits a coping strategy that may be an active (physical or behavioral) or passive (psychological) stress response. Responses to stressors are usually short term. However, the responses to chronic stressors may differ: the acute stress response may become either exaggerated or attenuated, making the effects of the sustained stressor more or less harmful. Either way, pathological consequences arise when the coping strategy fails.

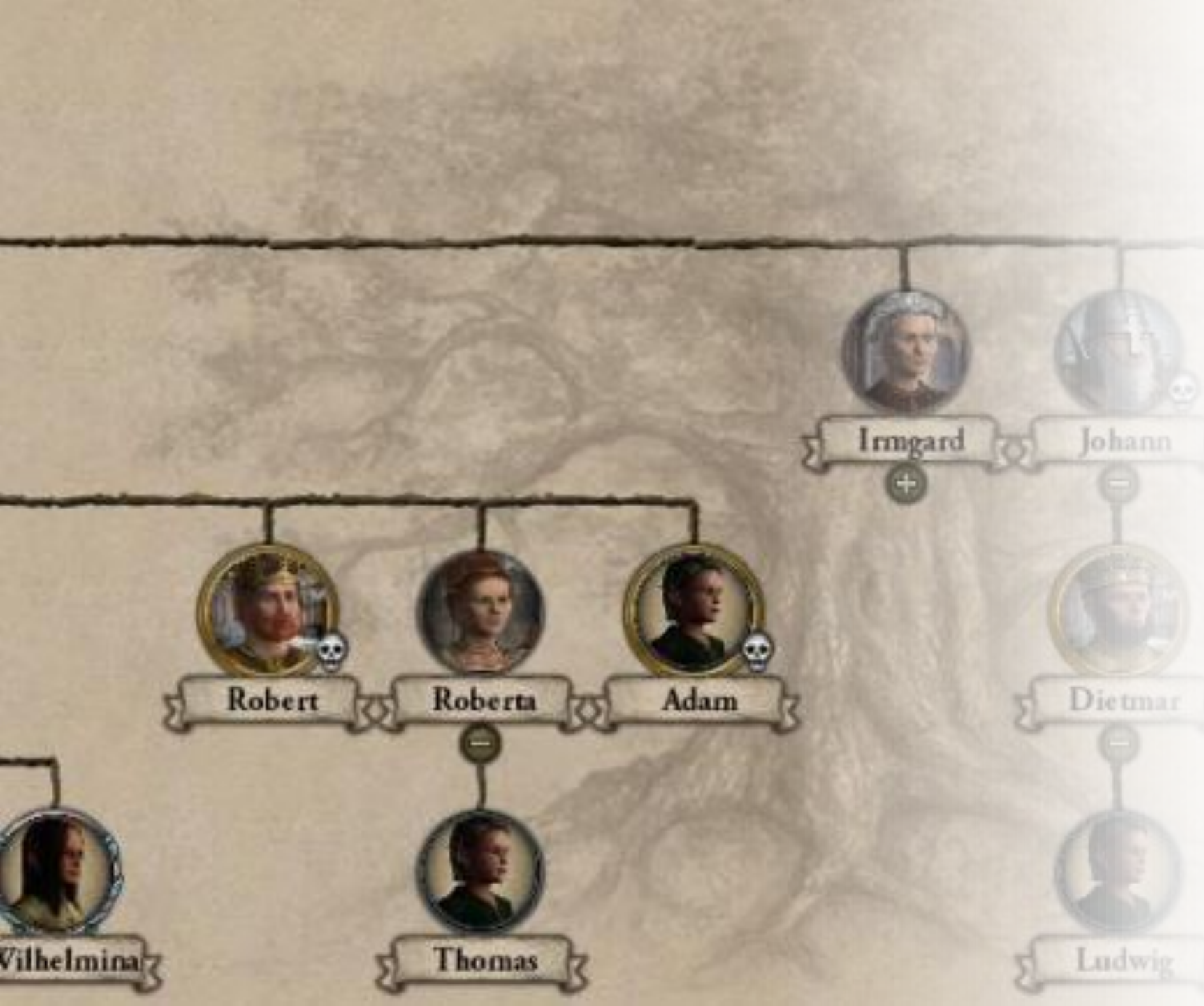


- Acute stress responses in complex organisms involve avoidance, withdrawal, or escape from the stressor, a change in central nervous system function involving greater sensory awareness and alertness, stimulation of the sympathetic nervous system, and neuroendocrine changes leading to activation of the hypothalamic– pituitary– adrenal (HPA) axis. Other hormones, such as growth hormone, which promotes lipolysis, and vasopressin, which redistributes blood flow and affects kidney function, are also released by the hypothalamic– pituitary unit. These stress responses are driven by the higher centers of the brain, from descending control by the frontal cortex (some people can become just as stressed by being asked a question by a tutor that they cannot answer as others are when physically attacked; the Trier test is a stress test used in behavioral and endocrine studies that is simply a test of public speaking). The limbic system coordinates the response and plays a role in mediating the potentiating or inhibiting effects of chronic stress. The HPA axis has built- in mechanisms for feedback control mediated by glucocorticoid receptors at various levels of the axis, with the hippocampus being a major site of feedback. Hence, changes in the expression of glucocorticoid receptors during development or during chronic stress can alter the magnitude of the response. In turn, activation of the HPA axis and catecholamine release induce metabolic changes, including glycogenolysis and gluconeogenesis to provide energy resources for “fight or flight” responses and cardiovascular responses that increase heart rate and blood pressure and redistribute blood flow. Chronic stress responses include further neural changes: for example, elevated glucocorticoid levels can change mood and affect memory and induce a wide variety of secondary physiological changes, many induced by chronic hypercortisolemia. Exposure to chronic stress in early life has been associated with later risk of depression.

- Changes in the physical, biotic, or social environment can all act as stressors. These conditions offer different challenges, yet the response is stereotypical.
- The stereotypy suggests that the stress response originally evolved to deal with one set of conditions, for example threat from a predator, but then became co- opted and selected as an advantageous response to another set of conditions (i.e., it is an exaptation). An Olympic athlete poised to sprint at the start of a race shows many of the same physiological responses as a rabbit that sees a fox or a swimmer who faces a shark. The stereotypical nature of the response is fail- safe, in that it heightens awareness of a situation in which threats may arise, even if they have not yet done so. This is akin to the “smoke detector principle”: false alarms are better than failing to react, so selection may have favored the response being set on the “sensitive” side (Nesse 2001). Anxiety allows us to acknowledge current threats and anticipate and avoid potential threats. These clearly have an adaptive origin, but if expressed inappropriately can manifest in an inappropriate form as the psychiatric disorders of anxiety and phobia. More severely threatening life experiences may manifest as post-traumatic stress disorder.

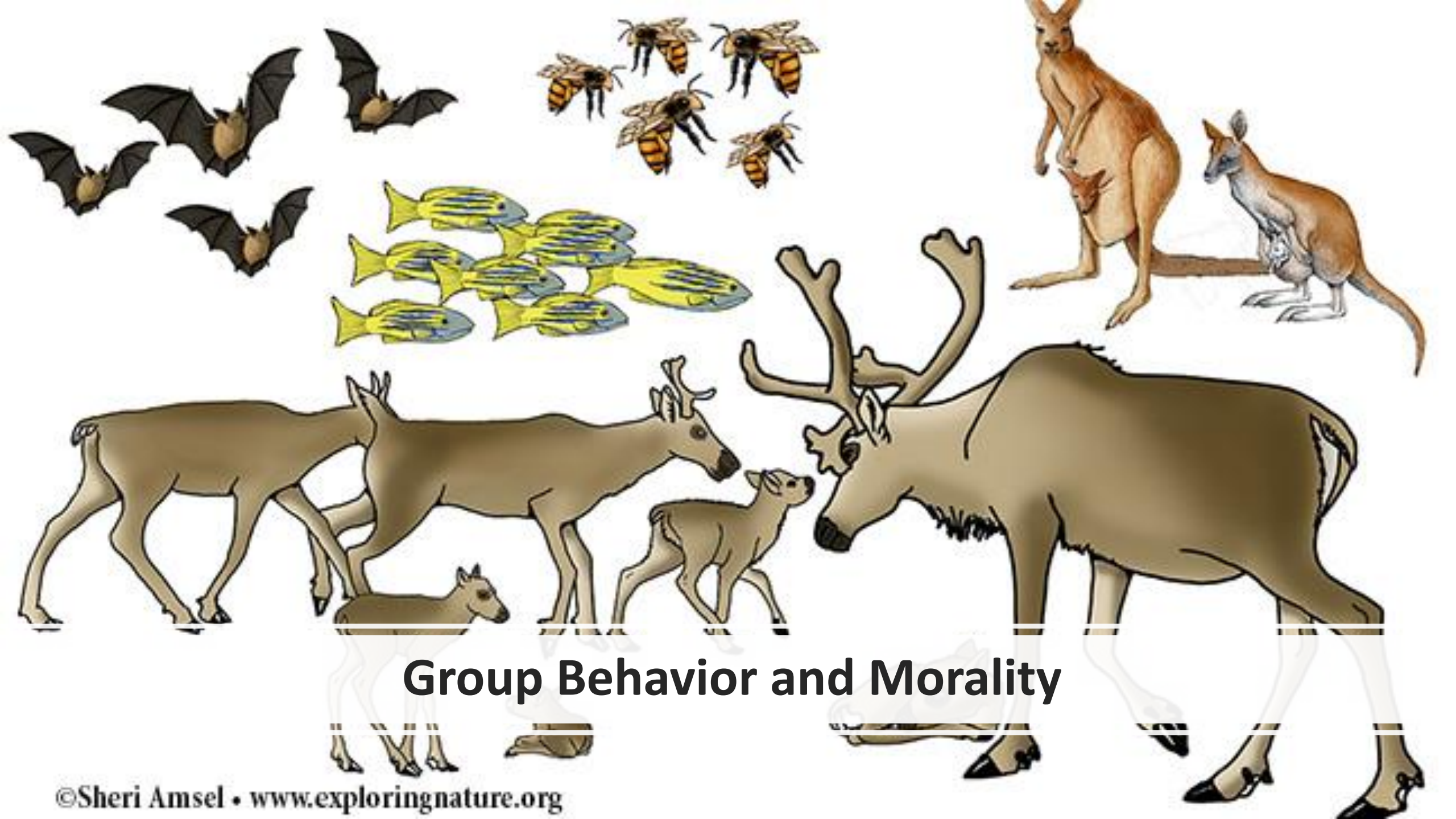


Love, Jealousy, Marriage, and Inheritance



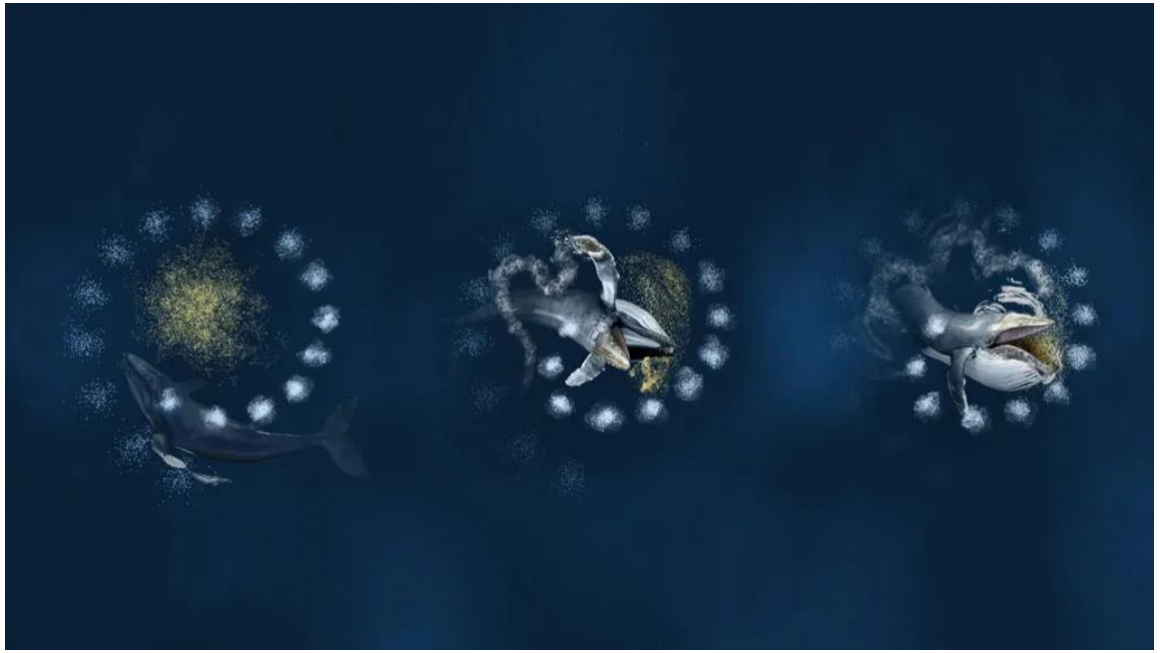
- Given the centrality of reproduction to evolutionary biology, much research in evolutionary psychology has focused on human behavior in relation to mate selection, pair bonding, sexually selected traits, familial investment strategies, the role of each gender in society, and the nature of male–female relationships. Again it is important to recognize that whereas we will focus on evolutionary determinants here, humans will overaly other cultural behaviors on top of these evolutionarily determined fundamentals. Strictly from the point of view of evolutionary biology, the pattern of interaction between parents of sexually reproducing species has evolved to maximize the fitness of their offspring. Where they can, females choose their mate in the expectation that the mate will be able to contribute to her fitness by supporting the nurture of their offspring. This is true for both polygynous and monogamous mating structures. Sexual selection has operated to favor females with those characteristics most likely to support successful pregnancies. Pair bonding helps reinforce this interaction, and romantic love may be a mechanism that evolved to help reinforce this bonding. Equally, jealousy can be envisaged as a response to the breaking of these pair bonds. The long nurturing period required for human offspring and the nature of human culture means that humans can continue throughout life to affect the potential fitness of their offspring. Complex social arrangements have emerged to enable them to do so. Again, from an evolutionary perspective, the concepts of property inheritance, marriage, dowry, and so forth are all mechanisms to protect the status and wealth of offspring in an attempt to promote their reproductive success. Different societies have developed complex rules of inheritance and marriage systems, and these can often be understood in terms of the ecology of a particular society. For example, in many societies male reproductive success is linked to wealth and a father's inclusive fitness might be greater if he concentrated his wealth in the hands of fewer of his male offspring rather than benefit them evenly. This is seen in some pastoralist societies where large herds of cattle are more viable than smaller ones, and thus spreading cattle evenly might reproductively disadvantage all of a man's sons. In such societies reproductive success is generally greater for older brothers than for younger ones. There are echoes of this approach seen in primogeniture (where the first-born son inherits all), which has been practiced in some European societies.

- Parenthetically, the economic historian Gregory Clark believes that primogeniture helps to explain why the Industrial Revolution occurred initially in England: it created a population of well-educated but impoverished younger sons who sought status through trade and innovation (Clark 2009).

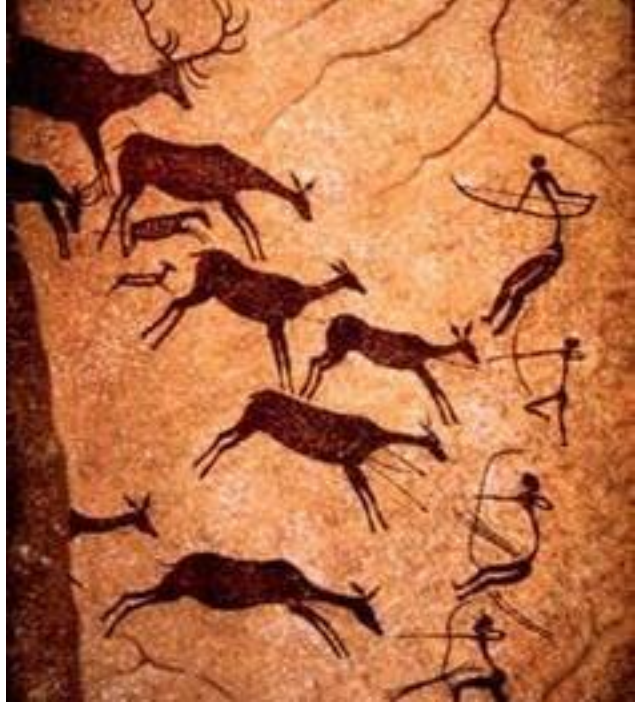


Group Behavior and Morality

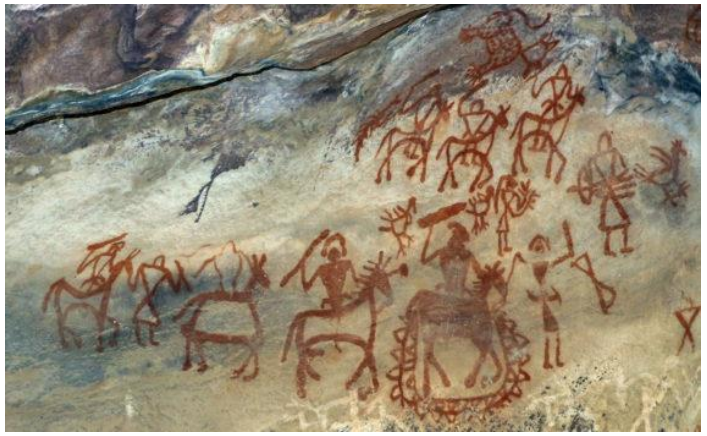
- Animals living in groups have a set of behaviors that are necessary for harmony within the group. In some species, such as the hyena and wolf, this involves an obvious hierarchy within the group, with clear roles and rights for the alpha male or female. Humpback whales hunt fish together in the phenomenon known as bubble net feeding, and fish school because it reduces the risk of any individual member being eaten. Humans live within a particularly pronounced group structure. This group structure evolved because it provided a fitness advantage for its individuals, probably for cooperative food gathering and defense against predators or rival groups. Highly social species exhibit a number of behaviors that reinforce group bonds, such as grooming in the chimpanzee and sexual stimulation in the bonobo. It was suggested that the evolution of language and gossip played a major role in generating and stabilizing bonds within early human groups. As group living requires multiple behaviors and is an integrated phenotype, all these selective pressures would have acted to determine the social and behavioral phenotype of our species. Natural selection, unlike artificial selection, does not act on any one trait in isolation. Therefore, teasing apart and arguing for greater weight for one component or another is neither practical nor sensible. But as we have already suggested, membership of a well-bonded social group requires adherence to the rules of reciprocity. Human groups are particularly sensitive to freeloaders or cheaters. We respond to cheating behavior with exposure, ridicule, embarrassment, and punishment. Frameworks of what behaviors are acceptable or unacceptable become formalized within the group. As group size becomes greater than about 150, a formal internal structure is required for stability. Concepts of morality may be derived in part from these context-specific frameworks necessary to control freeloaders. They may be manifest in custom, aboos, rules, and tradition. But other factors also play an important role in a particular societal view of morality. These include rules and concepts imposed in part by hierarchical organizations to protect the social structure, and in part by the formalization of belief systems.



Belief and Religion



- Every human society is characterized by one or more belief systems that are reflected in its organization, tradition, and ritual. These belief systems generally involve some concept of the supernatural. Ritual burial implies a sense of afterlife and has existed for at least 70,000 years. Belief in the supernatural was almost universal until modern rationalism emerged. The issue of why and how belief in the supernatural arose has been the subject of considerable evolutionary reflection since the initial musings of Freud (Boyer 2001; Norenzayan 2013). The evolutionary question is whether belief in the supernatural has an adaptive advantage or is simply an epiphenomenon related to other group behaviors. Supernatural belief is counter-factual and the adaptive advantage of suspending reality is not entirely clear. Its origin is also highly controversial. Perhaps it allowed individuals and the groups they were members of to develop an emotional stability in the face of events (such as drought) that they could not comprehend or predict. Ritual, which often accompanies superstition, helps build group cohesion. Sagas and story-telling are often part of a belief system, and these may have helped reinforce group identity and thus cohesion. In addition, belief in the supernatural as a potential external source of punishment or reward could help a group deal with the problem of freeloaders. The 30,000-year-old wall paintings in the caves of France and Spain may well be some of the earliest representations of ritual and belief, though other explanations are possible. The organization of belief into formalized religion from perhaps 5000 years ago occurred in parallel with the development of larger population groups and the associated political organization.

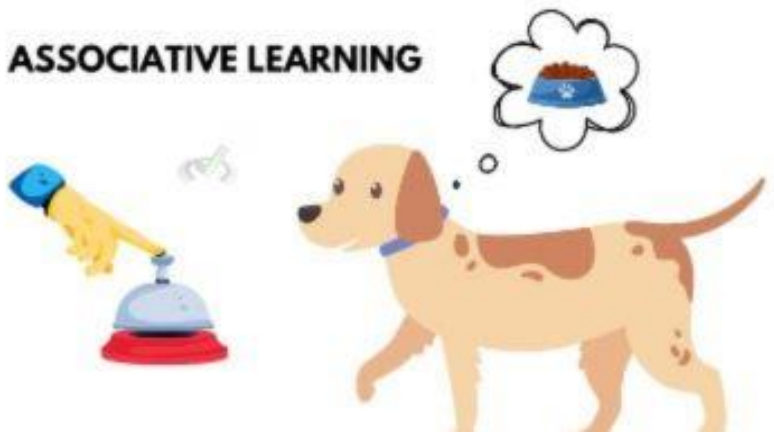


On the Origin of Art

• The existence of “art” across human societies throughout history has puzzled scholars for a long time. Stylized etchings on bone and stone dating back at least 70,000 years have been found in southern Africa. Representational art dates from at least 32,000 years ago, in the cave paintings of Western Europe, and perhaps even longer ago in the rock art of Australia. Indeed evidence of art can be found in all human societies, from the Australian Aboriginal painters to the audience attending the Metropolitan Opera House in New York or the graffiti on a subway station wall. Though some critics deny its universality, arguing that it is Western culture that has invented art as we know it, the same major forms appear everywhere in the world: music, dance, visual arts, and storytelling. Art does not appear to require formal training in the way that, for example, reading does; it is sustained despite its costs; and it provokes a strong emotional response. Explanations of art include those that ascribe certain functions to it— for instance as means of communication or expression— but such explanations beg the question of why art would survive alongside other, less costly, means of communication and expression. The ubiquity and antikvity of art have stimulated questions about its biological origin. Darwin thought that the “high cost, apparent uselessness, and manifest beauty” indicated the origin of a trait/ behavior in sexual selection (Darwin 1871). Dance, for instance, often occurs in mating rituals. But sexual selection can only account for some aspects of art. Drawing on a large body of evolutionary and humanities literature, the literary scholar Brian Boyd has explained the evolutionary origin of art in play (Boyd 2009). Play, which is widely found among animals and is an essential part of human early development, is understood as a way to develop, finetune, and practice mental, physical, and social skills within a safe context. Art is an advanced form of cognitive play that builds on several aspects that are unique or especially evolved in humans. One is the preference for patterned information. Humans search for patterns— discernible order in things, actions, and situations— in order to understand the underlying rules, to make inferences, and thus make predictions. Musical motifs, visual themes, storylines, can all be understood as patterns with which the human mind engages and plays. But art could not evolve without the shared attention and sociality characteristic of humans: think of chanting, dance, body adornment; of traditional styles of pottery and woodcarving; or indeed of folk poems and storytelling traditions. The intense emotional response provoked by art might make it more effective than other forms of communication and expression. Indeed, art fosters intense group cohesion: an example would be sports teams (and their audiences) singing national anthems before international games. These properties of art can explain why art, in various forms, was extensively used by religion: who can separate Christianity from the soaring, highly decorated forms of Gothic cathedrals or spectacular visual representations of the textual tradition, for instance Michelangelo’s paintings on the ceiling of the Sistine Chapel.

- David Sloane Wilson and others have suggested that organized religion became a major way to control freeloaders and stabilize a large group (Wilson 2002). Some have argued that organized religion largely developed as a political tool within a hierarchical control system. Many societies have conflated political rule and concepts of deity. Until the seventeenth century, British monarchs were considered to have divine powers of healing, and today they are still nominally head of an organized religious structure. A common hypothesis is that religion evolved as a way of confronting the problem of inevitable death, and that complying with the group's behavior would hopefully lead to a deferred reward. But Wilson also suggested that the religious group needs signs of commitment from an individual if they are to receive the rewards of group membership. This could take the form of sacrifices, tithes, or changed behavior (e.g., not eating meat on specific days). Paying a price to be a member of a group reduces the risk of someone being a freeloader. The risk of being involved in cheating is not only exclusion from the group but also punishment by some higher authority such as deity or supernatural force. Wilson developed this hypothesis to argue that religion evolved through a group- selection process. His position remains controversial, and this discussion, alongside related ones, plays a considerable part in the framing of multilevel selectionist arguments. Those who would focus on individual-level selection and reject any concepts of group-level selection would argue that the adaptive value of reciprocal altruistic behavior and group living for an individual provides a sufficient evolutionary explanation. Within the context of the parallel processes of biological and cultural evolution, ritual and religion can be seen to have adaptive advantage for the individual and a group selection argument is not necessary.

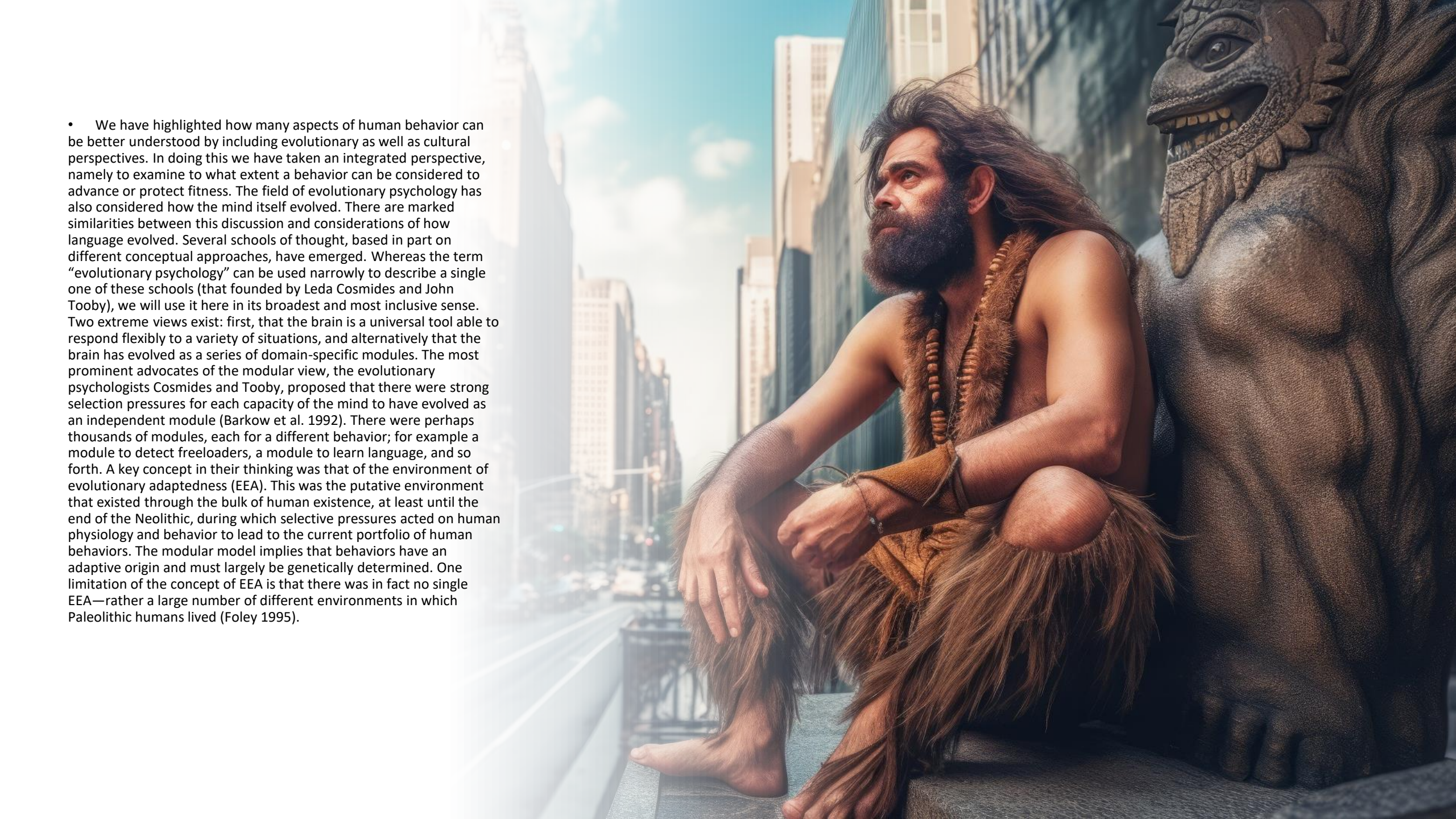
Learning



- Humans are born in a relatively immature neurological state compared with other primates. Nevertheless, the human infant is not born with a total inability to perceive or react to its world, and is certainly not as immature as more altricial species such as the rat. Much experimental and clinical data now show that human babies have very active sensory processes. They prefer symmetrical objects and images of an organized (rather than a scrambled) face. Their sense of smell has also developer to the point that they can identify the smell of their mother. By the age of 9 months, babies are clearly able to recognize and respond to the psychological state of others, and by 15 months they can persuade their mother to react by pointing to an object. Learning then becomes a process of acquiring skills and changes induced through interactions with adults, which leads to new skills. Humans have evolved “goal-based” imitative learning, which allows the growing child to learn about the goal and the actions necessary to reach it. Gradually this permits children to engage in their culture, and this process is greatly accelerated by the acquisition of language. By the age of 4 years children have moved to a level of cognitive development for which at least second-level intentionality can be demonstrated. Learning from experience is a key adaptive capacity of many species, but is particularly well developed in humans. Learning by forming associations between events, called *associative learning*, is present even in children and is a necessary precursor to inferential reasoning. The capacity to learn is regarded by some as simply another module of them mind in the context of orthodox evolutionary psychology. Others regard it as flexible and generic, rather than domain specific. Again, we see this argument as unnecessary in the context of this book. Humans have evolved with a brain capable of assessing environmental information, storing information as memories, and thus guiding decisions and consequent behavior. Rather than trying to encode all possible responses in our genes, selection has endowed us with an advanced organic “computer” that can learn by association and experience, and make appropriate decisions. Indeed, in developmental learning, experience reinforces particular synaptic pathways and neuronal networks. Human learning is effectively a process of reinforcement by positive outcomes and avoidance following negative outcomes. Thus we learn to seek ripe fruits, but not to eat toadstools.

Evolutionary Perspectives on Psychology

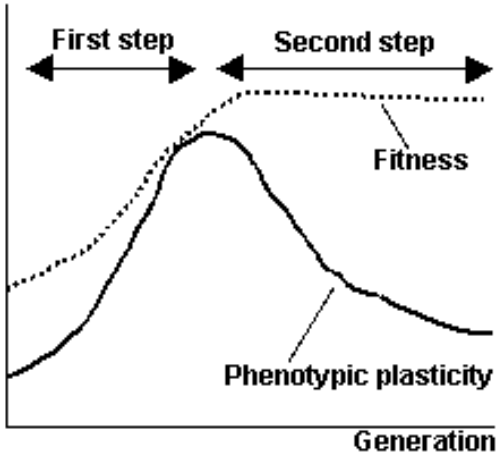
- We have highlighted how many aspects of human behavior can be better understood by including evolutionary as well as cultural perspectives. In doing this we have taken an integrated perspective, namely to examine to what extent a behavior can be considered to advance or protect fitness. The field of evolutionary psychology has also considered how the mind itself evolved. There are marked similarities between this discussion and considerations of how language evolved. Several schools of thought, based in part on different conceptual approaches, have emerged. Whereas the term “evolutionary psychology” can be used narrowly to describe a single one of these schools (that founded by Leda Cosmides and John Tooby), we will use it here in its broadest and most inclusive sense. Two extreme views exist: first, that the brain is a universal tool able to respond flexibly to a variety of situations, and alternatively that the brain has evolved as a series of domain-specific modules. The most prominent advocates of the modular view, the evolutionary psychologists Cosmides and Tooby, proposed that there were strong selection pressures for each capacity of the mind to have evolved as an independent module (Barkow et al. 1992). There were perhaps thousands of modules, each for a different behavior; for example a module to detect freeloaders, a module to learn language, and so forth. A key concept in their thinking was that of the environment of evolutionary adaptedness (EEA). This was the putative environment that existed through the bulk of human existence, at least until the end of the Neolithic, during which selective pressures acted on human physiology and behavior to lead to the current portfolio of human behaviors. The modular model implies that behaviors have an adaptive origin and must largely be genetically determined. One limitation of the concept of EEA is that there was in fact no single EEA—rather a large number of different environments in which Paleolithic humans lived (Foley 1995).



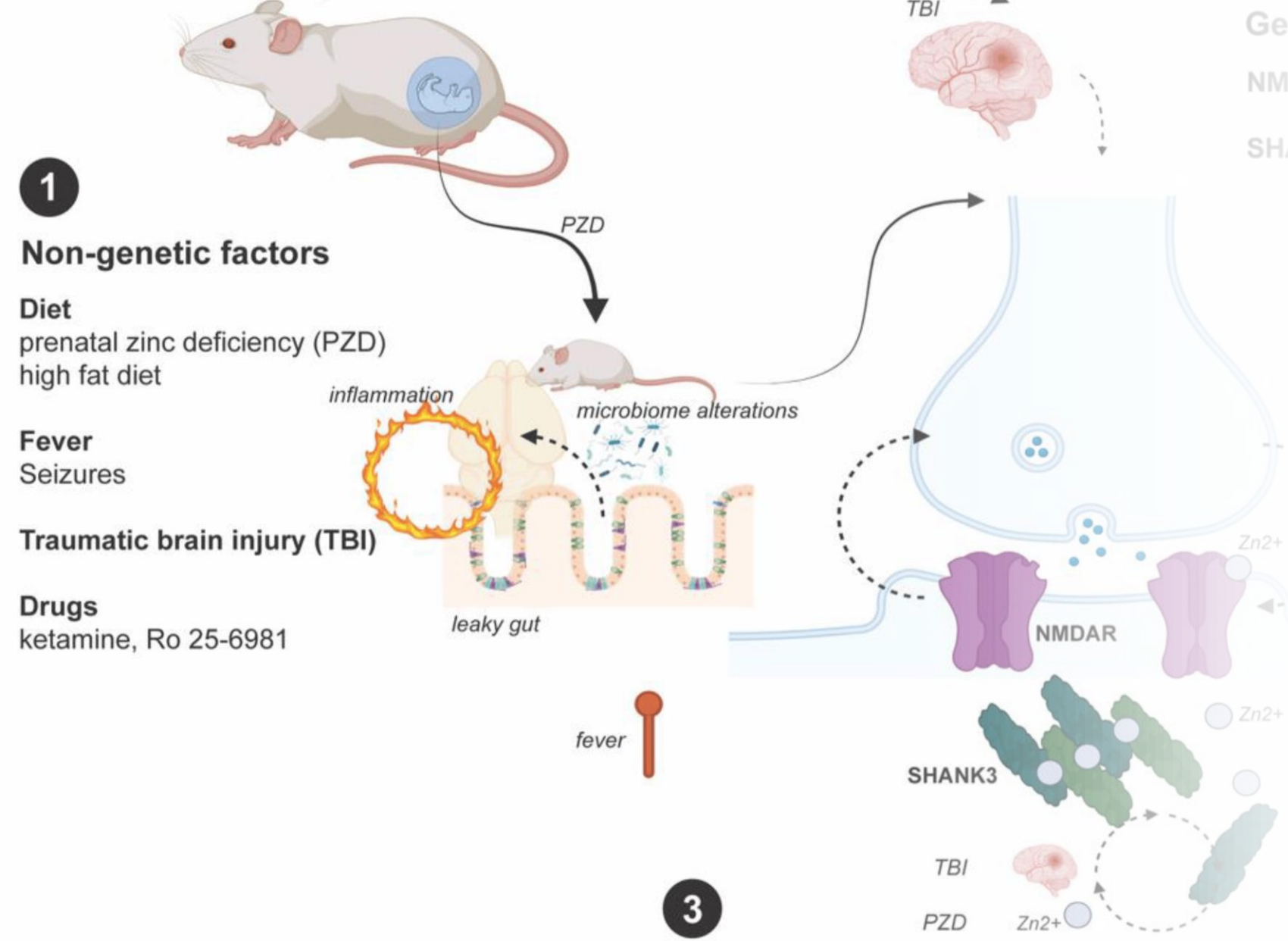
In contrast, the opposing model would suggest that most behaviors are learned, but can only be learned because of the evolved neural substrate. This dichotomy is an exaggeration made by advocates of particular schools of thought in order to make specific points, and is to some extent unnecessary. What is clear is that humans have evolved with a neural infrastructure that is capable of learning, and with a series of cognitive abilities able to cope with novel situations and living within a complex social organization. But there is some stereotypy in a number of behaviors and emotions, and evidence for genetic determinants suggests that a finer grain of selection has operated. There is a renewed interest in the role of genetic assimilation as a process by which learned behaviors are converted into genetically based behaviors. Indeed, the first description of what we now term genetic assimilation was called the Baldwin effect after the psychologist James Baldwin who was one of the first theorists to describe how behavior might affect evolution (Bateson and Gluckman 2011). Despite its limitations, the modular model does emphasize an important point. The human brain evolved under very different social and macro-environmental conditions from those in which humans now commonly live. If these modules were based on appropriate psychological adaptations when they evolved, then there will now be a mismatch between those modules and the modern constructed world. There will therefore be situations where the adaptations that underlie human behaviors have lost their adaptive advantage, and may instead become manifest as maladaptive pathologies. This argument has echoes of that used to describe the evolutionary origins of metabolic disease. Key to this school of thought has been the understanding of how the original selective circumstances led to a particular module of behavior being selected. For example, a module for fear of dangerous animals such as snakes could be envisaged. Jealousy could also be conceived as a module that had an adaptive advantage, as a jealous individual was more likely to have a selective advantage over someone who took a passive view of being the victim of infidelity.

In the arguments over the origins of language, linguistic researchers view universals, patterns that appear in all natural languages, as having a selected origin. The debate among linguists on this issue has been extensive and somewhat vexed, and the evidence for universals is not compelling. Similarly, there are obvious universals manifest in the human emotions, in the patterns of infant development, and in many aspects of social interactions such as mate choice and avoidance of incest. These can be taken as evidence for an evolved mind. While there is considerable merit in this approach, the caveats are equally valid here. Certainly, not all aspects of human biology need have an adaptive origin. There is a danger of falling into the trap of "just-so stories," since spandrels and exaptations may apply equally to neural functions as they do to other aspects of biology. For example, while jealousy has been suggested to have an adaptive origin, there are no data to suggest it has a genetic basis and it might merely be the by-product of other capacities of the brain. Obviously there are limits to the empirical proof that is possible in evolutionary psychology, although the science is no less important for this.

Baldwin effect

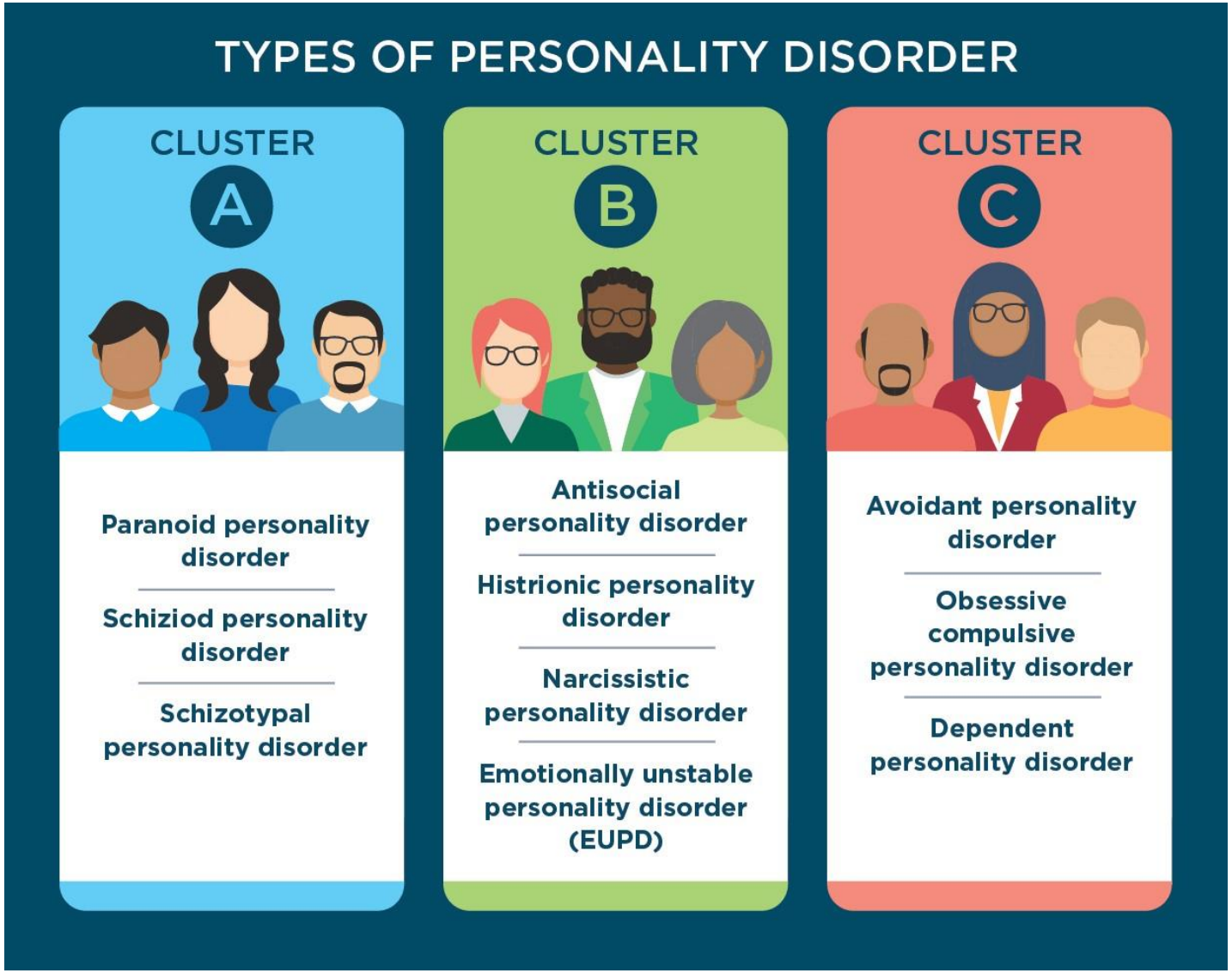


Evolutionary Psychiatry



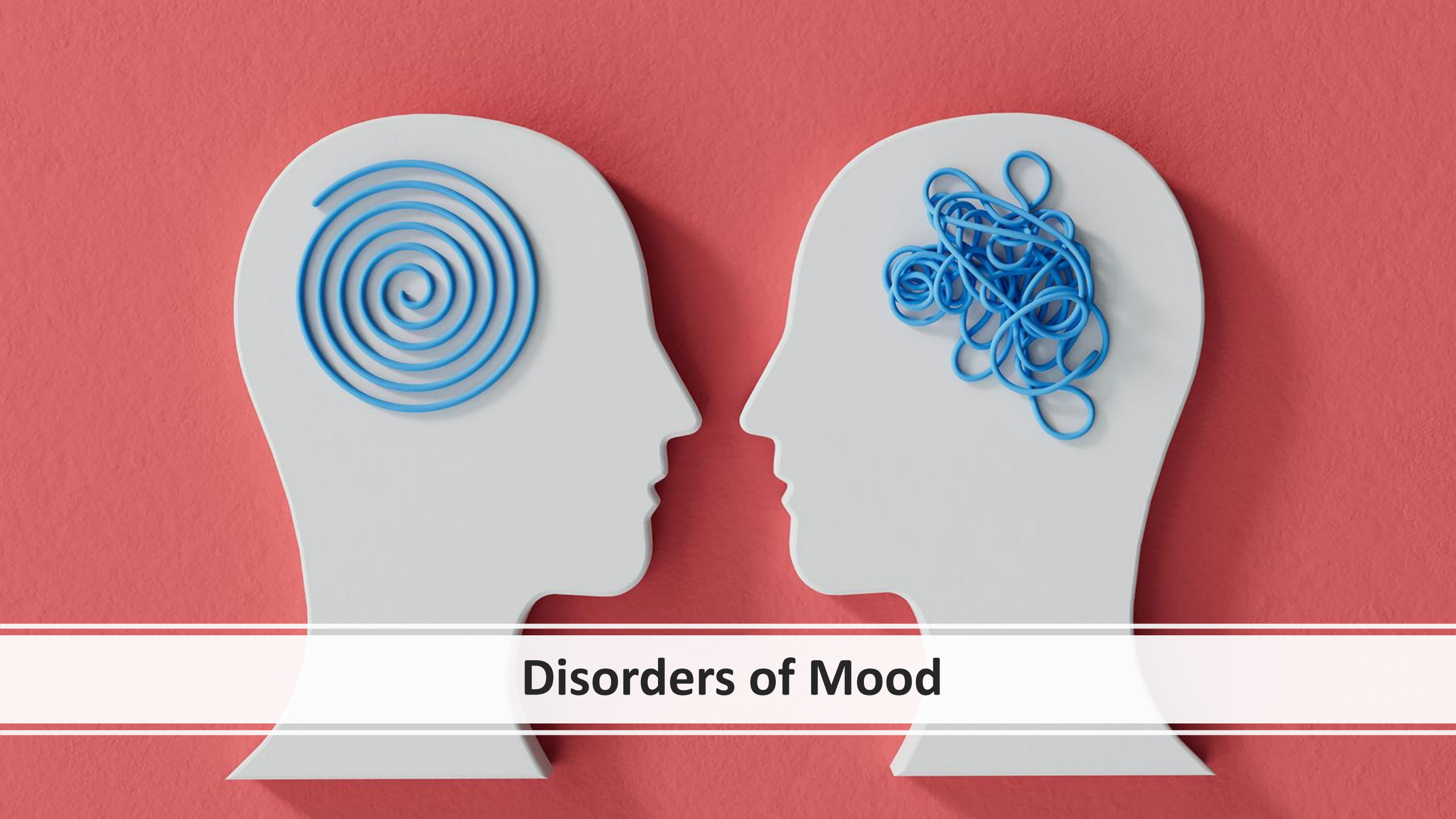
- The application of evolutionary principles to psychiatry builds on the previous discussion. The various schools of evolutionary psychology have given rise to diverse views on psychiatric states. Because mental health disorders such as depression and anxiety are particularly common, affecting perhaps 25% of the Western population, it is necessary to consider why the evolved brain is vulnerable in the modern world. Some psychopathologies occur at high frequency and cannot be explained by single causes such as a monogenic trait. In these cases, the origin of syndromes such as affective disorders may be due to a discrepancy between our evolved biology and the current environment, resulting in maladaptive consequences of a selected (adapted) trait. The key issue is the capacity to adapt to conditions that require a particular behavior. As with metabolic physiology, there are a range of psychological responses that can be called upon to deal with a particular situation. Just as metabolic disease can develop when individuals live in environments with an energetic load beyond their selected capacity to cope, psychological systems can be limited in their capacity to adapt. These limitations may then be revealed in different societal or social conditions. The limits of this plasticity are genetically and thus evolutionarily determined. It is important to note that, irrespective of the conceptual model being used, specific genes do not link to specific behaviors but rather to the functional neural networks that are involved. However, this does not mean that there are no associations between SNPs and some psychiatric disease—recent work has identified two SNPs associated with major depressive disorder in a population of Chinese women (CONVERGE Consortium 2015). The debate between different schools of evolutionary psychology is essentially over the extent to which the brain remains plastic and the extent to which it is constrained in its plasticity by genetic determinants.

Personality Traits and Disorders



- Personality traits can be defined as particular and somewhat inflexible ways of behaving. Individuals are recognized as having quite different personalities, and indeed we can recognize distinct personalities in domestic pets and in well-studied colonies of wild primates. One view of personality traits is that they represent constrained plasticity within the behavioral system. In general, evolutionary psychiatry assumes that a number of personality traits may have originated through adaptive advantage, but have become maladaptive in the current context. For example, a paranoid or anxious tendency may have originated from an evolved and fitness-enhancing trait that helped avoid predators. Risk-taking behavior may have been a trait that was advantageous in finding both a mate and new food supplies. When a personality trait is particularly exaggerated or constrained, it is considered pathological and is termed a personality disorder. Evidence from twin studies (despite their limitations) shows that even when reared apart, monozygotic twins exhibit concordance for a number of personality traits (Tellegen et al. 1988). This may reflect evidence of genetic determinants. In evolutionary terms, individuals with antisocial personality disorder can be viewed as a manifestation of the cheater/freeloader. These individuals, whose personality often emerges in adolescence, are characterized by behaviors representing their willingness to take from the group without reciprocation. Game theory explains how cheaters can persist in a society made up primarily of reciprocators, and this theory suggests that if they reproduce their genes will persist even if societies attempt to exclude them. A key feature of antisocial behavior is the extent to which deception is used to hide it. It is inevitable that some cheaters will persist in any population.

- It is important to distinguish this type of behavior from the acting-out behaviors of adolescence. Such behaviors are transitional and arise because physical maturation precedes complete psychosocial maturation. Thus, adolescent acting-out behaviors occur during a period in the life cycle when there may be additional value in showing exploratory and risk-taking behavior as a form of reproductive display. Indeed, males show a persistent tendency towards risk-taking behavior throughout life. Many individuals can be seen as pushy and attention-seeking, or as impulsive or aggressive. Again, such behaviors could be seen to have had adaptive value in the mating game. There are individuals who have difficulties in maintaining interpersonal relationships and have a poor self-image. As a result they may have a tendency towards suicidal or other self-damaging behaviors, inappropriate temper, and chronic feelings of emptiness. These individuals are unable to adapt to their social circumstance, often because they have a lack of insight or a limited capacity to interpret the circumstances they are in. This manifests as a pathology known as borderline personality disorder. Affected individuals are constrained in their ability to participate in their group and their behaviors can be perceived as unsuccessful attempts to be integrated and accepted as active members of the group. The recognition that they are unsuccessful can lead to overt efforts to exit the group. Narcissism is defined by a need for admiration, and is generally associated with a lack of empathy for others. Narcissists often have great difficulty in a social environment and in maintaining relationships, and are highly sensitive to criticism. Again their behaviors could be viewed as an exaggerated attempt to socialize despite limitations in their capacity to do so.



Disorders of Mood

ANXIETY

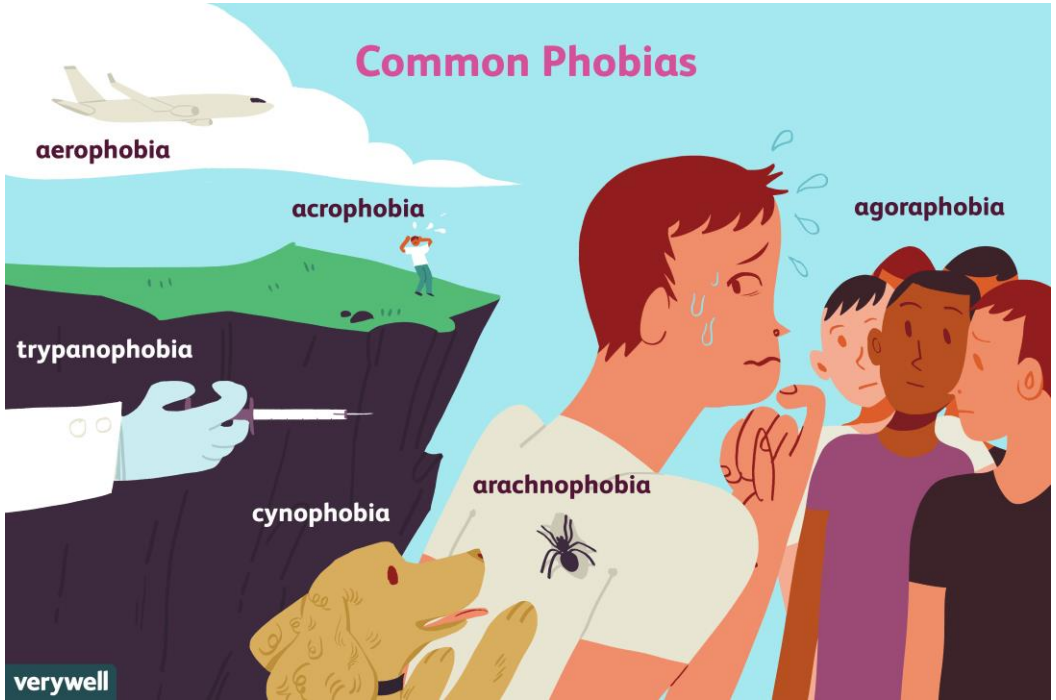
- Emotions are the result of the brain evolving ways of controlling physiology and behavior for advantage in particular situations. A feature of human behavior is the pursuit of individual goals which, in turn, can be mapped back to their potential fitness advantages. For example, controlling more material resources is likely to have been advantageous for a male when seeking a mate. Humans experience a wide range of emotions in the course of pursuing their social and physical goals. These emotions are part of the equipment necessary for achieving these fitness-related goals and coping with any challenges encountered in doing so. However, inappropriate or exaggerated emotions are maladaptive and can become pathological. This can occur because the substrate is abnormal [e.g., a polymorphism at the promoter region of the 5-hydroxytryptamine serotonin-transporter (5-HTT) gene has been associated with emotional disorders (Lesch et al. 1996)], or because the social environment exceeds the individual's capacity to adapt emotionally. As we have discussed, there is a compelling argument that humans are not evolved to live in a "concrete jungle" with an enormous and broad level of interpersonal interaction. The constructs of hierarchy, family structure, and individual role are now very different from those that existed even five generations ago in Western society, and even more so from those that existed prior to agriculture and settlement. This dramatic change in social environment may have exceeded the capacity of some people to adjust, and the consequences are emotional disorders such as anxiety and depression.

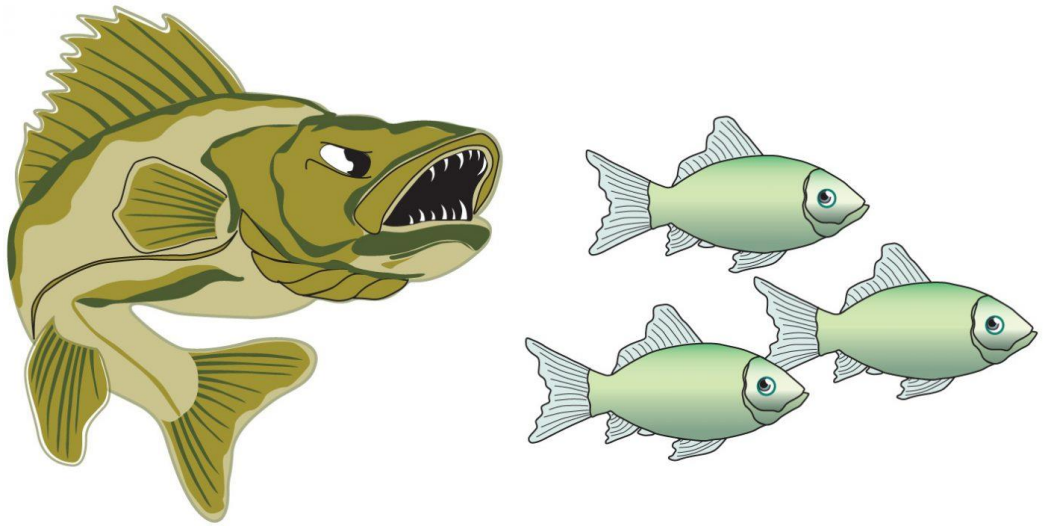
Anxiety

There is ample empirical evidence that anxiety can have adaptive value. Within a school, timid fish are more likely than bold fish to survive a predator. Anxiety is a way of being alerted to potential danger, but, even so, no individual can sustain a state of maximum alertness all the time. Anxiety has an energetic cost resulting from physiological changes such as sweating and increased metabolic rate (the effects of catecholamine release), blood pressure, and heart rate. As discussed above, chronic stress and chronic anxiety states are very similar, so, not surprisingly, both are maladaptive and can have deleterious effects on the individual.

Phobias

Phobias may represent exaggerated forms of what would otherwise be healthy, adaptive responses that enhanced survival in their original form. Most phobias arise from situations of perceived danger from attack, predation, or trauma. Agoraphobia and claustrophobia can be interpreted as originating from fear of exposure to attack or inability to escape. Transient phobias are normal, and fear is an important part of learning what to be afraid of. Failure to be fearful would have been a selective disadvantage, and it has been pointed out that the costs of an exaggerated fear response are less than the costs of not being fearful and being eaten! A psychological disturbance arises when there is loss of the capacity to distinguish between legitimate causes of fear and responding inappropriately to innocent stimuli. In the latter case, the psychological responses become maladaptive because they inhibit the capacity of the individual to function in society. Thus phobias can be seen as having a hypersensitive “smoke detector” function and this understanding has proved valuable in developing therapeutic approaches (Nesse 2001).



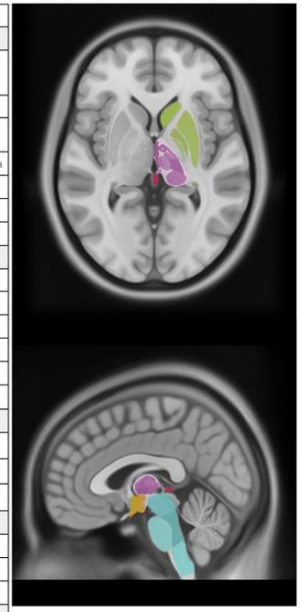


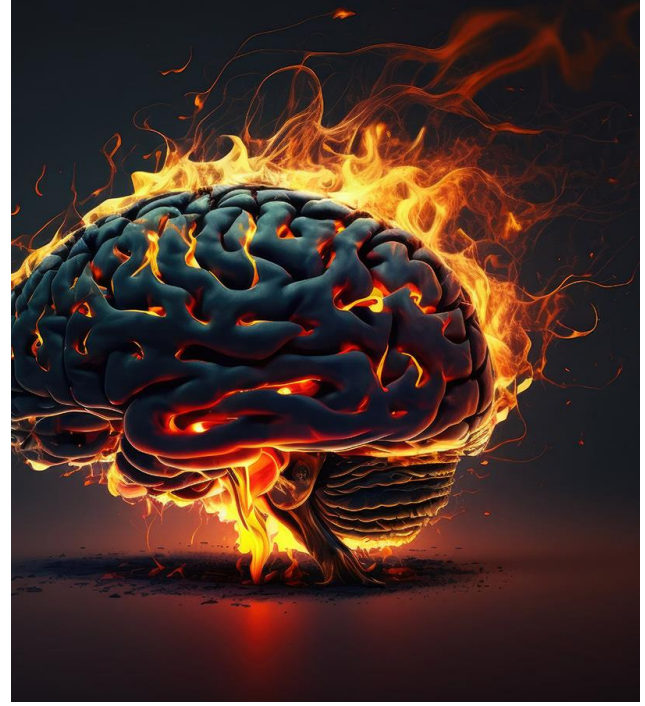
Depression

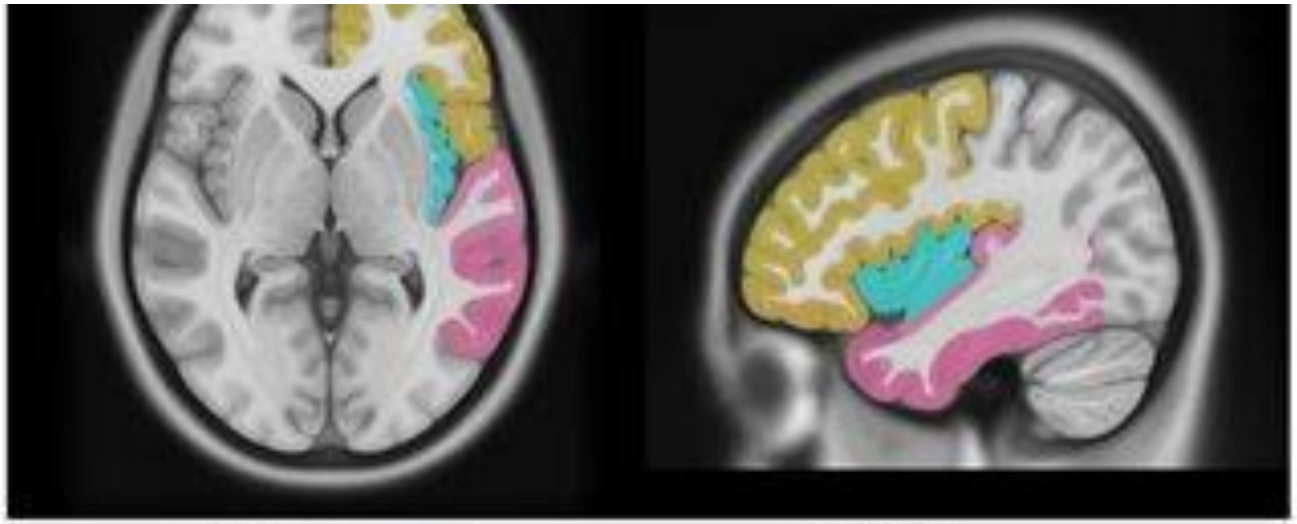
- Happiness and sadness are universal human emotions, and changes in mood are a normal part of the life course. Sadness is a normal response to a fitness-impairing event such as loss of a child, a spouse, material resources, or injury to the group in which the individual lives. Sadness may be a way of becoming transiently demotivated, thus helping the individual to avoid making decisions under stressed conditions that might be maladaptive in the long run. Being sad may lead the individual to stop a behavior that had caused an initial loss, and promote a period of self-reflection. It may induce a pause and a period of rethinking that could rebuild a threatened pair-bond relationship or change a hunting strategy that had led to the loss of a group member. It may stop the individual confronting a more powerful member of the group following loss of power or status, a situation likely to lead to an adverse and perhaps fatal outcome. Equally, sadness may be a way of communicating within a group the need for support from other group members. It is argued that the emotion of sadness emerged to act as a brake on some behaviors, and happiness as a way of promoting others. Essentially, they are tools for changing the responsiveness of an individual to a particular situation and communicating with others in the group. While these emotions may have evolved in such a manner, they have been incorporated into other components of our existence. Inappropriate extremes of mood are reflected in pathological depression or hypomania. The *socioeconomic gradient in health* is well recognized.

- A major part of our construct as a social species involves hierarchy and control. Loss of esteem, reputation, or power induces depression. This can be seen as a response to reduced status in the battle of sexual or social selection, and as a consequent form of submissiveness. It may allow the individual to survive to reproduce rather than being killed or expelled from the group. There is ample evidence that individuals who are disempowered or at the bottom of hierarchies are more stressed, and have more emotional disorders and physical illnesses.

	BRAIN IMAGING
	BASAL GANGLIA
cumulation s)	Bilateral T2 signal anomalies in basal ganglia : high central T2 with low peripheral T2 signal in both globi pallidi, symmetrically - "eye-of-the-tiger" sign in PKAN ; low T2 signal in PLA2G6
n	Bilateral T2 high signal in the basal ganglia
iopathic deletion	CT: bilateral basal ganglia calcification (+/- cerebellum) Multiple FLAIR anomalies in basal ganglia (low signal) and WM (high signal)
	High FLAIR/T2 basal ganglia signal + diffuse periventricular / spinal extension
	High FLAIR/T2 signal in globus pallidus bilaterally
	Unilateral FLAIR high signal in the left globus pallidus
	Caudate atrophy with enlargement of the anterior horn of lateral ventricles
	THALAMUS
	Unilateral high T2 due to infarcts (in ventral anterior or posterior left regions)
	Bilateral nonspecific FLAIR anomalies consistent with encephalopathy
r (?)	Mixed FLAIR and iso-T1, ill-perfused ovoid lesion in postero-lateral thalamus
	CT: enhancing mass with central acute hemorrhage and hydrocephalus
ophrenia	Bilateral high T2/FLAIR - "pulvinar sign"
	Low T2 signal in the thalamus and the dentate nucleus + cortical atrophy
	HYPOTHALAMUS AND PITUITARY GLAND
optica	High T2/FLAIR signal in hypothalamus and right optic nerve
	Hypothalamic mass with isointense T2 signal
	Iso-intense pituitary mass
	PINEAL GLAND
	High FLAIR/T2, low T1 homogeneous pineal mass
	Pineal mass with isointense grey matter signal + small basal ganglia stroke
	Pineal mass with pituitary extension (psychosis occurred after irradiation)
	BRAIN STEM
	Cystic mass in left midbrain and cerebral peduncle + thalamus, hypothalamus
	Low T1 and high T2 pontine signal + lenticular lesion
	High T2/FLAIR signal in brainstem, amygdala, hippocampus, internal capsule







DISEASE	BRAIN IMAGING
	FRONTAL LOBE
NMDAR encephalitis	FLAIR high signal in left precentral and anterior cingulate gyri

Psychoses

- Hallucinations, paranoia, detachment from reality, and withdrawal are symptoms of psychoses, and in particular the schizophrenia syndromes, which affect about 1% of all populations. Generally, *schizophrenics* behave as if they are living in a different world from others in their social group. Developmental and genetic factors both appear to play a role. People with schizophrenia are characterized by having deficiencies in their ability to exhibit higher orders of intentionality, and there are data to suggest that early life factors may have disturbed the normal development of their neocortex. For example, there is an increase in the incidence of schizophrenia in offspring whose mothers experienced famine when pregnant or were exposed to viral infection during pregnancy (Susser and Lin 1992). This finding suggests that there can be developmental constraints imposed on behavior which are later exposed as psychopathology in some individuals. There are also data showing that those born small are more likely to develop depressive disorders. However, it is well recognized that there are also genetic determinants of schizophrenia, and when a common disease with genetic determinants persists at a steady proportion in a population the question of whether there has been a selective heterozygote advantage will arise. That schizophrenia may be a result of balancing selection was first proposed as early as the 1960s by such leading theorists of evolutionary biology as Julian Huxley and Ernst Mayr (De Bont 2010). But the selective advantage of schizophrenia has remained elusive, the most popular proposals being (without any compelling evidence) enhanced creativity and novelty seeking. The role of schizophrenic and drug-induced hallucinations in the origin of belief in the supernatural and religion is an equally fertile ground for wild speculation. Most recently the origin of schizophrenia has been explained using the “imprinted brain” hypothesis (Crespi and Badcock 2008). This hypothesis relies on the concept of genetic conflict and the phenomenon of imprinting arguing that, because the father of a child may not father the mother’s later children, it is in his interest to maximize the child’s growth even at the expense of maternal health and future reproductive success. The mother, by contrast, would do better to limit the investment in the child to preserve some resources for future (and possibly existing) children. As a result, genomic imprinting with a maternal bias would arguably lead to a smaller child, more tractable behavior, and in its extreme form, schizophrenia. By contrast, a paternal bias would lead to a large child, willful behavior, and, in the extreme form, risk of autism spectrum disorder. This theory has possibly received some support from Danish health registry data that indicated that babies of above average size had a significantly higher risk for autism spectrum disorder and a lower risk for schizophrenia, while babies below average size had a lower risk for autism spectrum disorder and a higher risk for schizophrenia (Byars et al. 2014). The increase in risk, however, appears small, and it is also not clear if there other causal factors at play: for instance, while for schizophrenia the relative risk decreased from the smallest birth weight towards larger, in the case of autism spectrum disorder the curve appeared almost U-shaped, with small babies (under 2500 g) having a similar relative risk to babies weighing 4500 g. This remains a field full of speculation, with some association studies but no compelling conclusions possible at the moment.

Key Points

- • Human behavior is built on selected, and therefore genetically determined, components of brain function.

- • The evolved brain is the substrate on which individual experience and the current environment shape abilities and behavior, giving humans the flexibility to exist in a wide range of societal environments.

- • Humans are social animals characterized by living in groups larger than their immediate family. Selection has favored traits that promoted fitness within this environment, such as cooperation, reciprocal altruism, and the abilities to interpret the actions of other members of our species and to detect freeloaders.

- • Emotions have adaptive value for a social species, but they can become maladaptive with consequences for psychological and psychiatric well-being.

- • Such maladaptations may have arisen because of changes in the human social environment, or because of genetic/developmental factors creating functional variation in pathways determining behavior.

Thank you for your Attention!