# Chapter 2
# Evolution of Nervous Systems

**Abstract** This chapter starts by discussing the question of what type of organisms can be happy, concluding that it rests with the capacity to experience feelings, which also implies a capacity for consciousness. Within vertebrates, this feature is presumably limited to amniotes (i.e. reptiles, birds and mammals). Feelings evolve because they allow for a more flexible and adaptive behaviour. They have two primary values—positive and negative—aimed at respectively, instigation and avoidance. Happiness is a question of positive feelings. The brain employs the principle of a 'common currency'; i.e. the net sum in terms of positive and negative outcomes is calculated and used to motivate towards appropriate behaviour. Humans may have the capacity to be both the most happy and the most unhappy of any species. A main problem is that human feelings evolved in a Stone Age setting can easily cause problems in the case of a modern lifestyle.

**Keywords** Nervous systems · Capacity for happiness · Reflexes · Self-awareness · Emotions · Human evolution · Consciousness · Mood modules

## 2.1 Who can be Happy?

Creation of life appears to be easy. The first living cells probably evolved on Earth only a few hundred million years after the conditions were supportive for carbon-based life-forms. Based on our knowledge of the Universe and its constituents, it consequently seems likely that there is life elsewhere, and that it is founded on roughly the same chemistry; that is, it revolves around the atoms of carbon, oxygen, nitrogen and hydrogen. Unfortunately, due to the distances in the cosmos, we shall most likely never know.

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**Fig. 2.1** What types of organisms can be happy? The answer to this question suggests what happiness is about. Here exemplified with a flower and a human. (Photo: B. Grinde)

Intelligent life, however, is something else. It took evolution close to 4 billion years to come up with an organism with the capacity to understand what life and the Universe are about; and of all the millions of species the process has devised, only one of them has this faculty. In other words, conscious intelligence requires a lot more to evolve compared to simple bacterial life-forms. [I have discussed this topic in more depth in a previous book (Grinde 2011)].

In the process of getting there, evolution gradually added a long list of features. The lineage started with unicellular life and moved on to simple multicellular organisms, through invertebrates, early vertebrates, mammals, apes and finally, humans. Besides cognitive aptitude, another of the features added is our capacity for feelings, including positive and negative affect. We tend to take our capabilities for granted, but a conscious awareness of feelings, the experience of pleasure and pain, is not at all that obvious.

If you ask people whether a flower can be happy, some will claim the answer to be 'yes'. They value their flowers, and offer them the best in conditions and treatment in order to make the plants happy. The effort may help the gardens flourish, which will make the gardener happy; but the plants are unable to appreciate the effort. In order to sense anything at all, a nervous system is required; a feature only offered animals (Fig. 2.1).

The 4-billion-year-long story of life includes only a handful of really novel and great feats of evolutionary engineering. One of them was the creation of multicellular life where different types of cells collaborate in the tasks required for survival and procreation. This process started at least a billion years ago. However, the more advanced results—in forms of size (being macroscopic rather than visible only in the microscope), variety of cell types and variety of life strategies—did not appear until 600 million years ago. The radiation of life-forms that occurred then was another momentous feat, and included the development of early nervous systems. There are still many animals around that have retained much of the features seen in this early fauna, such as nematodes (roundworms) and corals. These animals have nerve circuitry, so do they have the capacity for happiness?

Again the answer is most likely 'no'. Having a nervous system is a necessary, but not sufficient requirement. In order to answer the question of which organisms can be happy, it is important to understand the function of the nervous system and how evolution moulded it in the lineage leading to humans.

## 2.2 From Reflexes to Feelings

As multicellular animals grew larger and more complex, they required a system capable of organising and coordinating the activity of the various parts of the body. Nerve cells evolved for this purpose. They offer a fast and efficient way of signalling, with more specificity as to targeting the signals to specific parts compared to the alternative: simply passing around chemical substances.

The reason why plants never obtained anything similar to a nervous system is presumably because they (or at least the more complex versions) are sedentary. They do not need to move around to find food, as their source of energy—sunlight—is available all over the surface of the Earth. If anything, they would need to grow tall in order to be first in line for the incoming rays. Animals, however, are required to seek out their food, and consume a more or less limited resource in competition with others—in short, their survival requires what we refer to as behaviour.

Some animals, such as corals and sea anemones, are actually sedentary, but they either have tentacles that are used to catch prey, or they simply move the food (by moving the water) towards their digestive system. In other words, these animals too need the capacity of behaviour; which may be defined as movements required for survival and procreation. Plants in general do not. The nerve system, and the concomitant use of muscles, was the evolutionary response to this requirement.

In complex animals like vertebrates, the nervous system infiltrates all parts of the body. It connects with sense organs, to extract information from the environment, and effector organs (muscles), to orchestrate behaviour. The sense organs offer the organism information that is used to decide on an action, and the muscles set the action in motion. Between these two lies a processing capacity, which in advanced animals is referred to as a brain. The simpler, invertebrate animals have small masses of nerve cells referred to as ganglia, which takes care of their, more basic, requirements for processing (Fig. 2.2).

The design has been an obvious success, as it is found in all but very small and/or primitive animals. The combination of senses, nerves and muscles allows the organisms to respond to the various challenges of living in an efficient way.

A nerve system does not imply a capacity for happiness. In order to understand the evolution of this capacity, one first needs to take a closer look at the challenges the nerves are meant to cope with.

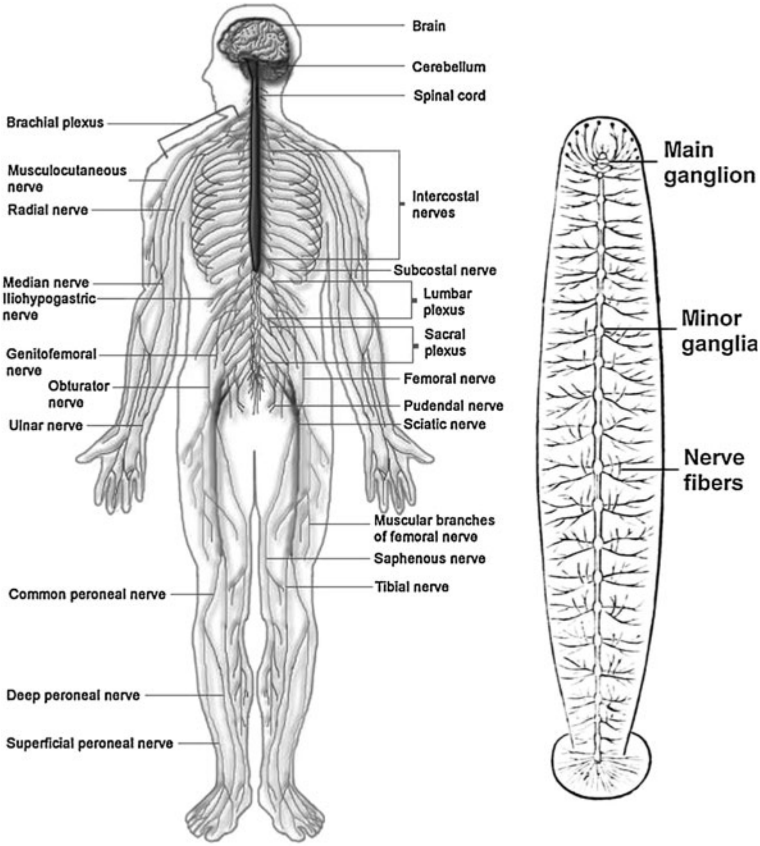


**Fig. 2.2** Nervous system of a human and a leech (a segmented worm)—not to scale. The size and complexity of the central processing unit (respectively brain and main ganglion) reflect the requirement for flexibility and adaptability of behaviour. (Modified from Wikimedia Commons, attributed to respectively Persian Poet Gal and public domain)

Biologically speaking, what matters in life are survival and procreation. In order to succeed, the organism is required to go for opportunities, for example in the form of food or a mate; and to avoid dangers, such as predators or toxic substances. Another way of putting it is to say that life is about maintaining homeostasis—e.g. to find food in order to retain energy balance, to avoid harm to befall any part of the body and to retain a proper temperature—while at the same time try to obtain a chance to procreate.

The challenges facing an animal in this pursuit can, as a rule of thumb, be divided into two types: It is a question of either moving *towards* something or *avoiding* something. This dichotomy of purpose has followed nervous systems throughout evolution. The brain is there to help direct you towards opportunities suitable for promoting your genes, and to make sure you avoid anything bad.

In the early nervous systems the task was cared for by *reflexes*. If sensory cells reported the availability of nutritious substances, the message would be relayed to the appropriate muscle cells without further deliberation. The outcome would be that the organism moved towards the food source by following a chemical gradient. Some processing would be required by the nerve ganglia in order to recruit the right set of muscle fibres, but it is a fairly straightforward task. This sort of processing can be studied in, for example, present day worms, of which the nematode *Caenorhabditis elegans* is the prime toy for biologists seeking to dissect the system to its fine details.

Although simple animals like nematodes and leeches have the same basic requirements for life as does humans, evolution has elaborated considerably on how to solve the various tasks. Reflexes are fine as long as the exact same response is appropriate each time. Let us, for example, consider the task of feeding. If survival is cared for by filtering water pushed through a digestive system, then no advanced behaviour is required. On the other hand, when a leopard spots an antelope that may hide, or launch a counterattack, then the question of how to get that piece of nutrient into the mouth is far more challenging. To overcome such obstacles evolution created brains that allowed for more advanced computation, including the process of learning.

Learning means that the organism will base its response to the next opportunity on the outcome of former strategies in similar situations. If one particular way of dealing with a certain type of prey was almost successful last time, then the carnivore may elaborate slightly on the attack. Over time, learning offers a more versatile response to the challenges of life compared to reflexes.

In fish (and many invertebrates) some of the tasks cared for by the brain can be moderated by learning. As evolution moved on to amphibians, reptiles and mammals, the organisms came to rely even more on this capacity. Although we still find pure reflexes in the human repertoire of behaviour, for example how the pupils accommodate to changes in light intensity, in the case of more complicated situations we usually bring the task to conscious awareness and allow our advanced, computational brain to decide on the most favourable action. The decision will be based on both innate guidance and previous experience. In other words, evolution gradually added more power to the brain in order to come up with ever more advanced and adaptive deliberations.

Learning does not require feelings. Feelings were the next step in the evolution of more advanced decision making: *They were added as a means to evaluate various options*. If the opportunity is a simple ‘grab the food while you can’ setting, then the computation is easy; but in most situations there will be a long list of factors that point in different directions as to what actions ought to be taken. The better the brain is at weighing these alternatives, the more likely the individual is to end up with the best choice.

The weighing of alternatives requires a sort of ‘currency’ in the brain—a value associated with the various relevant factors that can be added and subtracted in the computation meant to end up with a decision. Positive and negative feelings were the evolutionary response. They serve as ‘legal tender’ for the (survival) value of various options–that is, potential pains and pleasures can be weighed against each other in order to derive at a best score (Cabanac 1992). The strategy may be referred to as pleasure maximisation, and in a natural environment the result will tend to be the best choice as to survival of the genes.

In the example of the leopard, the prospect of getting a kick from the antelope, or of not catching it, brings forth negative feelings; while the prospect of eating the meat brings positive feelings. The issue of whether to go for it or not, should be based on the sum of these feelings. The value given to each factor depends on previous experience (having felt the hooves of an antelope), as well as innate guidance (the degree of hunger).

Another example: When a human sights a snake there is an innate tendency to respond with fear (a negative feeling). However, previous experience, perhaps telling the individual that this particular snake is not dangerous, can neutralise the fear and instead let the positive feelings associated with curiosity decide on an action.

Before moving on with the question of who can be happy, I shall offer a brief discussion of consciousness.

Although learning does not require feelings, feelings allows for a more versatile way of learning. They permit the organism to take more factors into account, by giving the brain the equivalent of an algorithm to deal with the factors in a meaningful way—i.e. to add up their value. But for feelings to make any sense, they need to be felt.

This latter point may explain why consciousness evolved. Feeling a pain, as opposed to simply reacting to the noxious stimuli by avoidance, requires some sort of awareness—a sense of a 'self'. It is hard to conceive how feelings can function as legal tender without an awareness component. In other words, I suggest that consciousness evolved to give the animal the capacity to evaluate feelings. As the prospect of happiness depends on the ability to experience feelings, it requires a certain level of consciousness.

The early forms of consciousness probably did not imply what may be referred to as true *self-awareness*. Self-awareness, or self-recognition, is typically tested by the 'mirror test' (Kitchen et al. 1996; Reiss and Marino 2001). Here, an animal has to demonstrate that it recognises who its reflection in the mirror is. Apes, as well as some cetaceans, generally pass, while birds are more likely to seek the mirror for company, and dogs may bark at their reflections. Although these latter species flunk the test, they may still be endowed with some form of consciousness.

The sensory system designed to instigate approach or avoidance was installed long before evolution started to elaborate on how the response should be decided on. The capacity to experience good and bad feelings is simply the most advanced tool for decision making that evolution has come up with. Rather than a simple processing to redirect sensory information to the right muscles, the signals are diverted to brain centres evolved for the purpose of producing affect: A positive experience should spur an appropriate action, while a negative experience should produce avoidance.

The original feelings were probably based on direct input from sensory organs (both external, such as touch, and internal such as thirst). As I shall return to in the next chapter, evolution co-opted the system in order to generate more advanced, or diversified, forms of feelings, which include what we refer to as emotions.

Reflexes, or fixed action patterns, cause an immediate response, while feelings generate a motivation to act. The word motivation here refers to the 'conclusion' derived at when assessing the feelings.

In cases where a fast response is required, that is still possible. When you put your finger on a hot stove, the withdrawal works like a reflex; that is, you pull your finger back without any contemplation. You still feel the pain, however, because the pain is there to teach you to avoid touching the stove on future occasions. The example illustrates that an important rational for feelings is to learn how to best cope with future situations—to give the brain information that can be used to add the appropriate value to various behavioural choices.

Theoretically, a purely cognitive assessment of options (without feelings) would be possible, but evolution did not end up with that option for good reasons: Cognition was not sufficiently advanced in our early mammalian ancestors to make this a viable strategy. Moving from fixed action patterns, to learned behaviour, and on to motivation based on feelings is a more likely evolutionary track. It is more in line with how evolution is known to work: The genes devise indirect measures to cause their wrapping (the individual) to promote their propagation.

Early vertebrate brains presumably did not include true consciousness, thus the deliberations were originally of a 'semi-conscious' manner. Full consciousness (including self-awareness) evolved gradually as a further improvement of the process, but even in humans much of the computation giving rise to the feelings aimed at directing behaviour takes place in the subconscious parts of the brain. The transfer of power to awareness is only partial (Cabanac and Bonniot-Cabanac 2007; Pessiglione et al. 2008).

We feel pain in situations where it is possible to launch a response—such as pulling the finger away from a flame. In general, we do not sense the advancement of a solid tumour before it happens to push on nerve cells installed for other purposes. The obvious reason is that sensing a tumour would make no difference—cancer is not something we can make stop or learn to avoid (not counting the advances of modern medicine). Feelings evolved to impact on behaviour in situations where it makes biological sense.

The original dichotomy of either approach or avoidance has remained, and causes the feelings to have two basal qualities, good or bad. They do, however, come in a variety of flavours. Although they all have a mood value, they serve diverse functions. For example, it will do you no good to eat if your stomach has already been filled up and what the body requires is water.

Feelings are there to fine-tune behaviour according to what is most appropriate, or most important, under the circumstances. Evolution has consequently devised many ways to activate the reward and punishment buttons, and in each case the activation can be feeble or strong. Most likely there is a preset tendency to give priority to certain types of objectives. Thus, avoiding a minor injury is probably

**Fig. 2.3** Other mammals presumably have feelings related to those we have. The point is supported by the observation that animals share emotional display features with humans to the extent that we can recognise their mood. Here, the same dog as somewhat sad (*left*) and happy (*right*). (Photo: B. Grinde)

less important than laying down a prey. And if the opportunity knocking is a chance of procreation, most other activities should be dropped.

Based on the above discussion, we may be able to formulate an answer to the question of who can be happy.

Various lines of research suggest that the capacity to have some sort of conscious awareness of pleasure and pain, and thus a propensity for happiness, evolved between the amphibian and reptilian stages of vertebrate evolution (Cabanac 1999; Edelman and Seth 2009; Cabanac et al. 2009). A reptile seeks pleasurable stimuli, such as sunbathing. Moreover, it is possible to measure a physiological response in the sunbathing reptile, and the response is akin to what we can measure in humans when they are engaged in positive experiences. Fish and amphibians do not show the same response; their behaviour appear to be more instinctive and less influenced by an actual awareness of sensations (Braithwaite and Boulcott 2007). Birds, on the other hand, presumably can be happy as they evolved from the reptilian lineage.

At the very least we share the capacity for happiness with other mammals. The conserved nature of the corresponding mental states can be deduced from the observation that different mammals display similar affective expressions related to both liking and disliking (Hallcrest 1992; Steiner et al. 2001). We recognise the mood of these animals by their face and body language (Fig. 2.3).

Emotions are primarily a phenomenon associated with social life. They are displayed for the purpose of informing other individuals, otherwise the visual (or auditory) expression would not have evolved. In other words, emotions are presented to the extent that the display serves a purpose—for example in the form of chasing away intruders or obtaining support from comrades. The observation, that we can read the emotions of other mammals, suggests that the underlying neurobiology evolved early in the mammalian lineage. Most emotions can trigger the reward and punishment buttons in the brain, indicating that all mammals have the capacity to experience the positive and negative effects.

In fact, the happiness of chimpanzees has been assessed by human observers. The resulting score correlated with factors that would be expected to be important for happiness, such as place in hierarchy and stress level (Weiss et al. 2002). Similar results have been obtained with orangutans (Weiss et al. 2006).

It should be mentioned that opinions differ as to whether fish (and other non-mammalian vertebrates) have feelings (Braithwaite and Boulcott 2007; Mosley 2011; Sneddon 2009). There is no doubt that these animals can respond to relevant stimuli in ways reminiscent to what we see in mammals, for example, in relation to pain and fear. The issue is to what extent this response is based on true feelings. We do not know how fish experience their lives, but even if we could have gauged their level of affect, the answer to the question of who can be happy would still rely on a semantic choice.

In order to illustrate the semantic nature of the question, one may ask whether various animals have a nose? In the case of a dog, some people will claim the answer to be 'yes', while others may insist that dogs have a snout and not a nose. Fish have an olfactory organ with a shared evolutionary history to the human nose, but most people would probably claim that they do not have a nose. The point being that all (or most) vertebrates have features homologous to both noses and feelings. The features have a shared evolutionary background, but have evolved in different directions since the time of species divergence. Whether animals have a nose, or a capacity for happiness, is consequently a question of how narrow (in relation to evolutionary divergence) these terms are defined.

In my vocabulary, all mammals (and more likely all amniotes, which includes reptiles and birds as well) can experience happiness, but not necessarily in the exact same way. Our closest relatives, the chimpanzees, have a nose, but it is different from that of a human—so, presumably, is their emotional set-up.

It might be possible to design an advanced computational brain without any feelings, and thus without an aptitude for happiness. Many invertebrates, for example insects, have a considerable capacity to learn, and they display complex behaviour. The dance form of communication used by bees is an extraordinary example, yet it seems to rely solely on innate instincts (Gould and Grant-Gould 1995). Presumably, there are no true feelings involved. Their learning is rather a question of changes in the nerve circuits controlling action patterns with the result of modifying future behaviour. The behaviour in question may require too much computation to be referred to as reflexes, but is still covered by the term 'instinctive'. Instincts can be acted out without conscious considerations, and without the use of motivational instigation.

Actually, even advanced forms of behaviour do not necessarily require learning. The birds' capacity to fly, for example, is apparently not something the bird learns, but is rather a matter of maturation. If one restrains the wings of some of the chicks in a litter from birth, they will still fly at the same time as their siblings once the necessary muscles, and their control, have developed.

Combining a capacity for learning with an awareness of feelings presumably offers the most flexible and versatile way for the nervous system to orchestrate behaviour. It is more costly (as to brain power) than reflexes and instinctive behaviour, thus we only expect to observe it in situations sufficiently complex to make it worthwhile.

Advanced, flexible behaviour has actually evolved outside the vertebrate lineage as well. The cephalopods (octopuses and squids) appear to be highly intelligent. They have a relatively large nervous system—for some species, similar in size to that of a dog—but organised in a very different way. Only a small part is located in a central brain, the rest is divided between several (large) ganglia. Their capacity to learn includes navigating a maze, using tools, learning from each other and solving complex problems (Thomas 2011). In other words, octopuses apparently make decisions based on previous experience in ways that are more versatile than the type of learning seen in most other invertebrates.

The sense organs, and the basal dichotomy of the nervous system that distinguishes between approach and aversion, presumably appeared before the split between our ancestors and those of octopuses some 500 million years ago. Have these animals also evolved feelings and concomitant consciousness? Do they distinguish between pleasure and pain? If so, they too should have the capacity for happiness. [See (Edelman and Seth 2009; Mather 2008) for recent discussions on the topic.]

We do not know, but we may speculate. In order to install advanced forms of behaviour, the concept of feelings seems to be a rational strategy. It enhances the adaptiveness of actions. It may be possible to erect a complex and versatile response without any feelings, but based on our present understanding on how evolution operates, I do not see any obvious alternatives. Computers certainly do not require either awareness or feelings, but their construct is very different from what one would expect evolution to come up with. Given that the basics of the nervous systems are similar in octopuses and mammals, a convergent evolution towards some form of conscious experience of affect seems plausible.

To sum up this section: A capacity to learn, in conjunction with feelings, offers the most advanced strategy for ensuring flexible and adaptive behaviour. For feelings to make sense, an awareness of their positive or negative quality is required. In fact, the need to evaluate feelings may have been the necessary rational for evolution to install consciousness.

The complexity of the computational task needed to consider options, is best cared for by a unifying entity in the brain. This entity, conscious awareness, should gather all relevant information and make decisions aimed at maximising positive feelings. Humans possess the relevant brain functions in the form of mood modules. Other mammals have functions sufficiently similar to warrant the use of a shared terminology.

## 2.3 Recent Human Evolution

Our closest relatives are the chimpanzee, the bonobo and two species of gorilla (Fig. 2.4). According to genetic evidence we split with the chimpanzees some 5–6 million years ago, and the gorillas not long before that (Carroll 2003). Evolutionarily speaking, 5 million years is a short period, particularly when considering that large mammals evolve slowly. Consequently, we have retained a genetic similarity to the great apes in the order of 98–99%, but there is still enough change in the DNA to explain unique human features.

Even we do not have total flexibility as to the control of behaviour. The heart muscles, for example, are left outside of conscious control, because a more reflexive type of management serves the purpose. No advanced calculations are required, solely a response to the varying need for oxygen. Moreover, rendering the heart to the whims of the ego might be dangerous, because if it stops, or beats too slowly, unconsciousness and death may follow.

There are at least three reasons why evolution has not created a species with complete, personal control over behaviour:

1. Versatility of behavioural choice is only advantageous in certain situations.
2. Originally, all brain functions were on auto control. It is difficult for the evolutionary process to move far away from this deeply embedded strategy.
3. Cognition could end up serving some particular concern of the individual rather than the interest of the genes contained within.

A more parsimonious scenario is that evolution expanded on early reflexive or instinctive behaviour associated with attraction and aversion by adding mood value, and gradually increased the cognitive capacity for the purpose of a more fine-tuned assessment of select types of behaviour. In short, the four-level hierarchy of operating procedures detailed below seems to reflect the evolutionary strategy. The availability of a particular procedure depends on where on the evolutionary three a species is. Humans possess all four alternatives, and the choice of procedure is decided on by the subconscious brain and depends on the situation:

1. Reflexive behaviour.
2. Subconscious, instinctive tendencies or action patterns, including a capacity for learning.
3. Feelings and superficial consciousness designed for instigation or avoidance.
4. Higher cognition called upon when needed in order to further evaluate options.

As an extension of the above line of reasoning, it may be theorised that with the advent of self-awareness and free will, a concurrent enhancement of the mood values would be called for. Mammals presumably have stronger feelings than reptiles, because evolution points in that direction. The values attached to various feelings, and used in calculating preferred behaviour, expanded with the degree of consciousness. A solid dose of free will should point in the direction of more

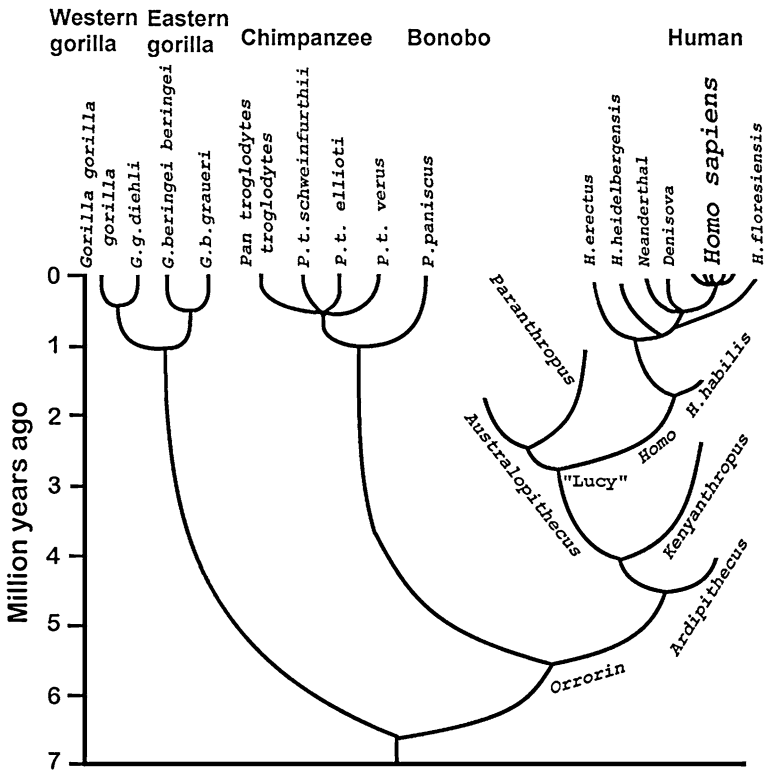


**Fig. 2.4** Human family tree. While there are few fossil remains of gorillas and chimpanzees, the human lineage can be followed back to the time of divergence with the apes. Interestingly, 100,000 years ago there were probably six different species, or subspecies, of humans on this planet—today there is only one

potent motivational incentives, as the individual might otherwise use the free will to choose options that diverge from the interest of the genes. That is, higher cognitive functions imply a further gain in flexibility, but at the risk of ending up with behaviour that is less conducive to procreation. Stronger emotional incitements should keep the behaviour in line with the interest of the genes.

This conjecture implies that humans may have the capacity to be the most happy—and most unhappy—of any animal. The conjecture is supported by the observation that endorphins, key neurotransmitters in relation to reward and pain, are expressed at a higher level in human brains as compared to apes (Cruz-Gordillo et al. 2010).

There is one important caveat to the evolutionary strategy of relying on affective motivation: It requires that the instigations really point in the right directions. If the environment changes, this may not be the case. The recent availability of contraceptives is a 'modification of the environment' that exemplifies the point. We get ample rewards from our sexual activity, but readily dupe the genes by harvesting these rewards even when fertilisation is impossible. Similarly, the easy access to food designed for maximum stimulation of taste rewards will tend to cause overindulgence.

For the sake of happiness, however, duping the genes may be an excellent strategy—as long as the long-term prospects of health and well-being are not jeopardised.

Most experts agree that hominids evolved to live in a tribal setting. The tribe would comprise a number of adults of each sex, including several family groups, presumably totalling some 20–50 individuals. The members spent a great deal of time together and relied on each other for survival. Consequently, the tribe became a strong socially unit. In fact, humans have probably evolved some of the strongest innate tendencies to social affiliations of any mammal.

Interestingly, sociability has evolved independently on several occasions in the mammalian lineage. Although many species of monkeys are social, most apes, including the gorillas, do not form large groups; the exceptions being the chimpanzees (de Wall 2001). Both the regular chimpanzee and the bonobo are social, suggesting that the evolution of social life started in our lineage some 6 million years ago. Humans are unique in combining a highly organised social life with strong pair-bonding.

Research suggests that we are endowed with the capacity to retain relations with some 150–200 individuals (Dunbar 2009). In the Stone Age, the number presumably included one's own tribe plus members of neighbouring tribes. Neighbouring tribes would meet occasionally, as they depended on each other for exchange of mates, and probably traded information and tools as well. Only rarely would there be total strangers present, suggesting that in the absence of specific conflicts, an individual could trust the people with whom he interacted.

We are certainly more collaborative and empathic than the regular chimpanzee; and although the bonobo chimpanzee may be even more goodnatured and peaceful (de Wall and Lanting 1997), it is possible that humans have the deepest social ties.

The neurobiology and neurogenetics of mammalian social life has recently been reviewed (Robinson et al. 2008; Donaldson and Young 2008). Briefly, it is assumed that the underlying brain structures first evolved early in mammalian evolution for the purpose of bonding between mother and child (Panksepp 1998). The structures were later co-opted for pair-bonding (Lim and Young 2006). Additional bonding, such as between fathers and infants, and between adults of the same sex, most likely reflects an extension of the neurobiology used in these earlier forms of bonding. Thus, even though social life evolved independently in different lineages, the underlying brain modules appear to be related. In other words, once the neurobiology required for mother–child attachment was in place, expansion towards further social bonds could evolve relatively easily.

Both acts of aggression and acts of compassion can be highly useful for survival and procreation, consequently, one would expect them to elicit brain rewards. As I have discussed in more detail elsewhere (Grinde 2004, 2009), compassion—perhaps somewhat surprisingly—appears to be considerably more rewarding than acts of violence. This disparity may be related to the conjecture that the two types of behaviour were shaped at different periods of our evolutionary history. As discussed above, early on in vertebrate evolution, the behaviour repertoire was presumably instigated more by instinctive tendencies than by rewarding sensations. As consciousness (and the concomitant capacity for free will) expanded, incentives in the form of rewards became more important. Human social propensities most likely evolved much later than our aggressive instincts, offering a possible explanation for why hugging people seems to be more useful for the purpose of feeling good compared to hitting people.

In fact, the act of giving, as in charitable donations, can cause a stronger activation of the reward network than receiving the same sum of money (Moll et al. 2006). As would be expected, the rewards of giving, and otherwise acting with empathy, can improve personal well-being (Borgonovi 2008; Decety and Lamm 2006).

The main point is that social relations offer a rich source of brain rewards. The rewards include those we sense when falling in love, old love, being with friends and engaging in the fate of others with compassion. Relations are arguably our most potent source of positive feelings; a point underlined by research on well-being, which concludes that a social network offers the strongest, and most pervasive, correlate with happiness (Layard 2005; Aked et al. 2008). Besides being an excellent strategy for personal happiness, expanding on our propensity for compassion carries obvious benefits for society.

According to the present model, evolution intensified the role of mood modules in the lineage leading towards humans. Not only did the feelings become stronger, but the modules became engaged in an increasing variety of situations and behavioural encouragements.

This development may not be due solely to the regular forces of evolution, which primarily move in the direction of improved capacity for survival. The evolutionary process also operates by what is referred to as *sexual selection*. The peacock's tail is the most cited example; it is a considerable handicap in terms of survival, but evolved because the female birds came to prefer cocks with a large tail.

As humans began to understand the difference between joy and sorrow, they probably would start to prefer the company of those displaying positive feelings. We are able to read the moods of other people, and it is well known that happiness (and sadness) is 'contagious' (Wild et al. 2001). This translates to say that humans eventually may have considered mood when making partner choices—a notion that implies sexual selection. Thus, our present propensity for happiness may have evolved by a mechanism similar to that of the peacock's tail—perhaps without the associated burden as to survival. I have already pointed out that the strength of emotional instigations may correlate with the level of free will, an aptitude where humans top the list; sexual selection would mean that our capacity for happiness is even further elevated compared to other mammals.

The final major step in human history started with the invention of agriculture some 10,000 years ago (Fig. 2.5). Although early agriculture may not have improved the condition of life—that is, it apparently required more toil, and caused a

**Fig. 2.5** Was the invention of our own gardens a step away from the Garden of Eden? And was the development of an industrialised society a step forward, or backward, in relation to quality of life? We have gained a lot, but we may also have lost something. (Photo: B. Grinde)

reduction in stature and life expectancy (Balter 1998; Teaford and Ungar 2000)—the invention eventually brought forth the probably most dramatic population increase ever witnessed on Earth. It also brought along scientific advances—not the least in the form of modern medicine—and, for a select part of the human population, a chance to live a life of comfort with ample food and resources.

Although the size of the human gene pool has expanded enormously, and with that the total genetic variation (in the form of rare mutations), 10,000 years is too short a time for selection to make much of a difference (Stearns et al. 2010). In other words, for most practical purposes we are still adapted to the life we lived prior to the invention of agriculture—rather than being adapted to an industrialised society. We live in what may be referred to as a 'human zoo' (Morris 1969).

In a traditional zoological garden, animals are removed from the environment they are adapted to; and unless the zookeeper takes the effort to compensate as much as possible to this predicament, the animals are likely to suffer both physically and emotionally (Moberg and Mench 2000). The question is therefore: Do industrialised societies cause human mental suffering by offering an environment different from what we are adapted to? I shall return to this question later.

The main points to remember from this chapter are:

1. The function of the nervous system is to orchestrate behaviour for the purpose of survival and procreation.
2. Feelings evolved because they allow for a more flexible and adaptive behaviour in that more factors can be taken into consideration when deciding on an action.

3. Feelings have two primary values—positive and negative—aimed at respectively instigation and avoidance. The brain employs the principle of a 'common currency'; i.e. the net sum in terms of positive and negative outcomes is calculated and used to motivate towards appropriate behaviour.
4. Consciousness was probably a consequence of the evolution of feelings, in that some sort of awareness is required to experience good and bad.
5. Happiness is a question of positive feelings. It is presumably available for all mammals, and to a lesser extent the other amniotes, i.e. reptiles and birds.
6. Humans may have the capacity to be both the most happy and the most unhappy of any species.
7. Social relations are a major factor in determining quality of life.
8. Human feelings, including the system of rewards and punishment, evolved in a Stone Age setting—in an industrialised society they are likely to cause problems.

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