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Why human evolution should be a basic science for medicine and psychology students

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Summary - *Based on our teaching experience in medicine and psychology degree programs, we examine different aspects of human evolution that can help students to understand how the human body and mind work and why they are vulnerable to certain diseases. Three main issues are discussed: 1) the necessity to consider not only the mechanisms, i.e. the "proximate causations", implicated in biological processes but also why these mechanisms have evolved, i.e. the "ultimate causations" or "adaptive significance", to understand the functioning and malfunctioning of human body and mind; 2) examples of how human vulnerabilities to disease are caused by phylogenetic constraints, evolutionary tradeoffs reflecting the combined actions of natural and sexual selection, and/or mismatch between past and present environment (i.e., evolution of the eye, teeth and diets, erect posture and their consequences); 3) human pair-bonding and parent-offspring relationships as the result of socio-sexual selection and evolutionary compromises between cooperation and conflict. These psychobiological mechanisms are interwoven with our brain developmental plasticity and the effects of culture in shaping our behavior and mind, and allow a better understanding of functional (normal) and dysfunctional (pathological) behaviors. Thus, because the study of human evolution offers a powerful framework for clinical practice and research, the curriculum studiorum of medical and psychology students should include evolutionary biology and human phylogeny.*

Keywords - *Science education, Natural selection, Sexual selection, Ultimate causation, Human health, Darwinian medicine.*

Introduction

Since publication of Darwin's book "*the descent of man and sexual selection*" in 1871 overwhelming evidence from different disciplines, ranging from paleontology to molecular biology, genetics, comparative anatomy, embryology, neuroscience and behaviour, clearly shows that what made us human is the process of evolution by natural and sexual selection, which operated to increase individual's reproductive fitness. It follows that human body and mind are a product of biological evolution. Although this concept should be obvious for all biological disciplines it is foreign to many physicians and psychologists. Commonly, in these disciplines the focus is on understanding how the body or the mind works and on detailed descriptions of pathophysiology. This proximate approach is the prevalent conceptual and cognitive framework for the current models of learning, practice and research in medicine (including psychiatry) and psychology. From an evolutionary perspective for understanding the functioning and malfunctioning of human body and mind, it is necessary to consider not only the mechanisms, i.e. the "proximate causations", implicated in the processes but also why these mechanisms have evolved, i.e. the "ultimate causations" or "adaptive significance". These so-called "how and why questions" were originally proposed by the ethologist Niko Tinbergen, recipient of the 1973

Nobel Prize for Physiology and Medicine, as the four questions that need to be answered to fully understand a behavioral trait (Tinbergen, 1963), namely: 1. How does a behavior come to be expressed (i.e., the mechanisms underlying a certain behavior)? 2. Why does a certain behavior come to be expressed (i.e., adaptive significance)? 3. How does the behavior develop in individuals (i.e., ontogeny)? 4. What is the evolutionary history of the behavior in related species (i.e., phylogeny)? This classic ethological approach on proximal (questions 1 and 3) and ultimate (questions 2 and 4) causations of animal behavior, which can and should be applied to the study of any biological trait (a protein, a cell, an organ, a system, a behaviour), radically changed the way in which biologists ask questions about any phenotype, including disease (Mayr, 1982).

Evolution is the foundation for biology and biology the foundation for medicine, it follows that evolution ought to be a foundation for medicine. In 1991 George Williams and Randolph Nesse published a seminal paper, and few years later a book, that defined the new science of Darwinian Medicine (Nesse & Williams, 1991, 1994). Darwinian medicine explains the importance of asking: why in order to understand how, e.g., asking why the body is designed in a way that makes us vulnerable to infections, cancer, choking, depression, hypertension, ulcers, diarrhea, back pain, prenatal complications, etc. It recognizes that the body is a bundle of compromises and is far from perfect and provides explanations for the body's flaws and vulnerabilities that fall into just a few categories, and explains how discriminating between them can help the understanding of health and disease. Understanding the evolutionary origins of disease vulnerability is not alternative to understanding proximate causes of disease; both levels of analysis offer synergetic explanations that together can ameliorate the search for causes and cures. Although medicine uses some evolutionary concepts, such as the evolution of antibiotic resistance in bacteria or the phylogeny of viral infections, evolution is poorly studied in medical school. Nesse & Shiffman (2000) have shown that few courses include evolutionary topics in their curriculum in the USA. In our experience, the same holds for Italy and other European country.

We are behavioral biologists who teach biology at the schools of Medicine, Dentistry, Obstetrics, and Psychology, both for undergraduate and graduate students. The longer we teach, the more our programs focus on evolutionary biology and, more specifically, vertebrate and human evolution. Human evolution deals with all aspects of evolutionary change in *Homo sapiens* and its descent from other hominins, as well as with vertebrate evolution and the concept of the common ancestry of living beings. It also concerns the evolutionary changes in human physiology and morphology and has important implications for understanding human behavior, health and disease. In this paper we describe some practical examples that illustrate why medical and psychology students have much to gain including evolution and human phylogeny in their curriculum studiorum and understanding how evolutionary principles affects human health and disease (Nesse *et al.,* 2010).

Human evolution and medicine

The study of pathologies has often been key for understanding the underlying normal physiology of organs and systems. Despite the obvious human vulnerability to pathologies, during the first years of medical school students focus on basic sciences and learn how perfect the association is between structure and function of various parts of the healthy human body, including the skeleton and muscles, the eye, the nephron, the heart, the teeth, the brain, etc. In the last 3 years of medical school students study clinical sciences and suddenly learn how the human body is tremendously imperfect, flawed, and prone to diseases, such as backache, pain of the neck, fragility of hips, knees and ankles, myopia, presbyopia and cataract, heart failure, dental cavities, obesity and diabetes, depression, and so on (Fig. 1).

This apparent contradiction reveals a lack of knowledge about biological and human

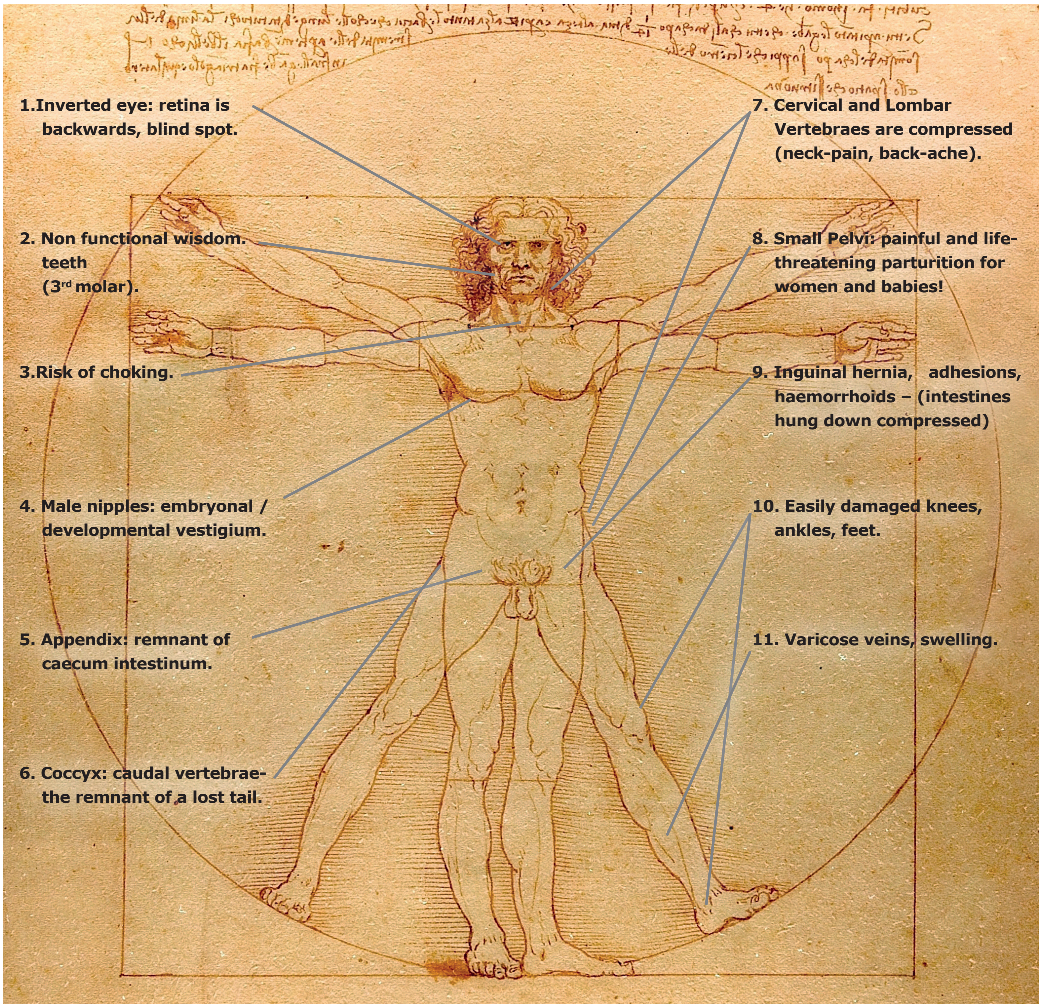

Fig. 1 - **Homo vitruvianus*****, the "perfect human body"…or not ? N. 1, 3: trade offs and evolutionary constraints; n. 2,4,5,6: vestigial stuctures; n. 7-11: consequences of erect, bipedal posture. Image credit: Luc Viatour (www.Lucnix.be). The colour version of this figure is available at the JASs website.***

evolution because attention is focused on proximal mechanisms of normal and pathological function. Physicians in training and in their subsequent professional practice learn to identify illnesses by recognizing patterns of signs and symptoms. However, vulnerability to disease can partly be explained by common ancestry, phylogenetic relationships, constraints and selection. Understanding how human vulnerabilities to disease are caused by evolutionary tradeoffs reflecting the combined actions of natural and sexual selection offers a powerful framework for clinical practice and research. This means that physicians should know when and how the species of *Homo sapiens* developed from other species and spread over the world in order to understand that the anatomy, physiology and behavior of humans is constrained by evolution and that the human evolutionary past and present are mismatched.

Below we provide specific examples of such apparent contradictions and flaws of the human body which can only be understood by taking our evolutionary history into account.

A 'perfect' eye

"To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest possible degree…"

C. Darwin 1859, chapter VI, The origin of species by means of natural selection.

The eye is often reported as a great example of a human organ that has been exquisitely shaped; Darwin himself confessed that it was *absurd* to propose that the human eye must have evolved through spontaneous mutation and natural selection because of its perfection. However, he then explained how this was possible, through a gradation of changes from "an optic nerve merely coated with pigment " to "a moderately high stage of perfection" (Darwin, 1859, chapter VI). Darwin's hypothesis has been demonstrated to be correct by recent scientific evidence; for instance, comparative analysis indicates that the vertebrate eye most likely evolved from ancient population of light-sensitive cells that were initially located in the brain, as now can be observed in the living fossil worm, *Platynereis dumerilii* (Urbilateria; Arendt *et al.,* 2004). The *inimitable* human eye is, however, far from perfect, and has a suboptimal design. In the vertebrate eye, including ours, the nerves and blood vessels run across the top of the retina and cast a network of shadowed areas across it. Furthermore, where the optic nerve passes through the retina there is a blind spot (students can experience it by closing one eye and watching a point on a piece of paper that is moving forward). The Vertebrate retina is therefore inverted, in that cones and rods sit at the back of the retina and light must pass through the layers of the supply systems to reach them. By contrast, the Cephalopod eye is extremely sophisticated. It looks and works like the vertebrate eye (cornea, lens, iris, and retina) but the retina is not inverted. Instead the photoreceptors are at the front of the retina and the supply systems are stored beneath the visual cells, i.e. there is no blind spot. The flawed structure shared by all vertebrates is most likely the result of evolutionary developmental constraints and/or trade offs between costs and benefits. Thus the evolution of an inverted retina depended on contingencies and on possible selective advantages outweighing the costs of having a blind spot, such as the need of increased oxygen supply and/or long lasting functionality of the retina photoreceptors (Nesse & Williams, 1994). An evolutionary approach not only allows one to understand why these "flaws" exist, it also allows us to understand the frequent eye pathologies we suffer today, such as: myopia, presbyopia, cataracts, glaucoma, iritis, retinal detachment etc. According to the Darwinian medicine perspective, all these diseases arise from a mismatch between evolved eye functionality during phylogenesis and modern environments. Our eyes did not evolve to read books, watch TV or look at smartphone screens. Neither were we supposed to age and thus develop cataracts or presbyopia, as we live much longer today than in the past. Many modern diseases are indeed related to aging and the consequent senescence of structures and organs (Nesse & Williams, 1994).

Teeth and diets

"Tell me what you eat, and I will tell you who you are"

Jean Anthelme Brillat-Savarin.

This famous quotation could be rephrased for mammals as "Show me your teeth, and I will tell you what you eat". Teeth of different forms and size (heterodontia) are a characteristic feature of mammals. Heterodontia is accompanied by the occlusion of teeth and the ability to chew that in turn affects the jaws joint and relative muscles. Mammalian teeth became differentiated during evolution to enable animals to obtain food more efficiently and to extract nutrients more quickly and thoroughly. Teeth are also used as weapons in defense against predators and in fighting conspecifics, usually of the same sex. Their diversity of uses is reflected in their morphology. One can look at the teeth of any unknown mammal and make a very good guess about what it eats and its lifestyle. It is thus not surprising that mammalogists are obsessed with teeth and that teeth are one of the most important taxonomic tools for mammalian classification, including primates and hominin fossils.

Some of the most noticeable changes in the evolution of the genus *Homo* and its antecedents (australopithecines) have indeed been in the dentition and the jaws which support them. More specifically, the overall constant trend in human evolution was toward smaller teeth and a reduced splacnocranium together with a parallel increase of the neurocranium and larger brain size (Jones *et al.,* 1992). From *Australopithecus spp*. to *Homo habilis*, *H. erectus*, *H. neanderthalensis* and finally *H. sapiens*, the architecture of the head has changed dramatically. The australopithecines had large molars and premolars, prominent jaws and receding mandibular symphysis, but slightly reduced canines and a chimpanzee-size brain. Since about 2.5 million years ago, successive species of the genus *Homo* reduced the size of their jaws and teeth and the mandibular symphysis became more vertical and eventually protruded as a chin in *H. sapiens*. Such a reduction of the prognatic face resulted in a regular curved shape of the dental arcade typical of our species and in crowded teeth, with no space between them and not enough space for the eruption of the third molars. Indeed most modern humans have non-functional wisdom teeth, which are easily impacted in about 70% of people. Wisdom teeth are the third permanent molars, which emerge between 17-25 years of age and have lost their function. This is clearly a flaw, because we maintain a structure that not only is not functional anymore but also creates medical problems that need odontoiatric treatment.

The main causes for such a decrease in the masticatory complex appear to be changes in the human diet, food preparation, and technology. The combined effects of improved cutting, pounding, and grinding tools and techniques, the use of fire for cooking and an increased consumption of meat surely have contributed to the process (Wrangham, 2009). In addition, brain volume constantly increased during hominin evolution and a large brain needs energy. The human brain consumes 25% of our energy when resting and thus there is need for energy-rich food (Wrangham, 2009). Humans have indeed evolved a strong preference – a craving - for sweet and fat food but we move less than our ancestors. Consequently, in our modern environment, many adults (and children) suffer from obesity and related diseases, such as cardiovascular diseases and diabetes mellitus. According to Darwinian medicine, the mismatch between our evolved dietary needs and modern diet explains many modern diseases.

The evolution of the masticatory complex is related to other anatomical features such as bipedal posture and brain size, which led to important anatomical modifications that facilitated the emergence of speech and language. In association with the emergence of spoken language, a reduced prognatic face and the relative reduced oral cavity were accompanied by a re-organization of the throat with an elongated pharynx and a lower larynx. This creates a resonating chamber in which the tongue can move and articulate sounds. The low position of the larynx, however, does not allow the epiglottis to lock behind the soft palate, which makes it possible to choke while eating or drinking. This adaptation of the human throat for speech is, thus, a flaw, resulting from a trade off between the selective advantage of a complex language for social communication (see the paper by Liebermann in this issue) and the need of swallowing. From an evolutionary point of view, the advantages of talking outweighted the risk of choking. This is a good example of the concept of changing morphologies and changing behavior over time and the close link between behavioral and morphological changes in evolutionary processes (Mayr, 1982).

The importance of being erect

> *"Man alone has become a biped; and we can, I think, partly see how he has come to assume his erect attitude, which forms one of his most conspicuous characters"*
>
> Darwin 1872, p.434.

Human beings walk upright as the only living bipedal mammals. Erect posture and locomotion require small changes to turn a tetrapod four-footed animal into a two-footed animal walking upright. This process entails adaptations in the entire skeleton from head to toe for taking the weight on the hind legs and balancing it on one leg when each stride is taken. The head becomes balanced on the spinal column with the foramen magnum opening centrally at the base of the skull; the vertebral column, which was originally designed as a weight bearing arch with one backward thoracic curve (kyphosis), evolved a series of S curves (i.e., two lordosis and two kyphosis) to bring the body's centre of gravity directly over the feet. The rib-cage becomes barrel shaped (rather that an inverted funnel-shape); the pelvis is remodelled into a bowled shape, which is lower and broader compared to apes and also its muscles are remodelled. Because of these changes, femurs elongate and are angled inwards, thus assuming a carrying angle that ensures that the knees are brought under the body and bear its weight. The feet are thus placed under the body and the allux is not opposed to the other toes (non-abductible), making the foot strong and suited for powerful push-offs during the last point of contact with the ground during the stride (Jones *et al.,* 1992).

Bipedalism was the initial adaptation, the first step in the long path to becoming human. This change took place at least four million years ago, probably much earlier. In fact, the pelvis and femurs of *Australopitecus afarensis*, "Lucy", together with the footprints embossed in a bed of volcanic ash found near Laetoli in Tanzania clearly indicate habitual bipedalism 3.0 to 3.5 mya (Jones *et al.,* 1992). However, the head (skull, brain size and the prognatic face) was still similar to that of apes. While the body was already human-like, the brain and most likely the behavior were ape-like. Bipedalism thus appeared far earlier than the large brains that we consider to be a crucial human characteristic. Many hypotheses about why bipedal locomotion evolved are debated, from the "patchy environment" hypothesis to the energetic advantage for running (Jones *et al.,* 1992).

Many of the recognized flaws in our body design arise primarily from the evolutionary compromises that occurred when our ancestors became biped (Fig. 1, n. 7-11). By standing upright the weight of the head and top of the body greatly compresses the vertebrae in the neck and in the lower spine, which necessitates more muscular effort to maintain a bipedal than a quadrupedal stance. Pain of the neck and backache are highly common medical problems in our species, ranging from being a minor annoyance to becoming a serious disability. Knees, ankles and feet are fragile and easily injured as they bear all the action of body weight that was originally distributed on four legs. The abdominal viscera of mammals are enclosed in the peritoneum and hang loosely in the abdominal cavity. On the other hand, the upright posture in humans presses the viscera towards the vertical wall of the cavity thus causing problems such as digestive blockages, hemorroids, visceral adhesions, inguinal hernia. Also the mammalian circulatory system is affected by upright posture, which increases the hydrostatic pressure in the lower limbs and can cause varicose veins and swollen feet and ankles. On the opposite side, towards the brain, decreased blood pressure can result in dizziness and fainting, for instance when one abruptly stands up. None of these defects exist in other primate or mammalian species, all of which are quadruped. The flaws due to the evolution of biped locomotion have only recently become pathologies as indicated by the fact that they generally arise with senescence due to aging. But when bipedalism evolved, aging was not a problem because individuals died long before senescence. The same can be said for many contemporary diseases which are related to aging. Evolution is not about increasing longevity but reproduction, as stated by Nesse & Williams (1993): "*we did not evolve to live long but to reproduce*".

However, the most striking cost of becoming bipedal appears to be related to the consequences of a reduced pelvis for parturition. "*To the woman He said, «I will greatly multiply your pain in childbirth, in pain you will bring forth children»*" (Genesis 3,16).

In our species giving birth conveys a great health risk for mothers and newborns due to the evolutionary constraints imposed by having a small pelvis and a big brain. Reproduction is crucial in evolution and it is puzzling that such flawed features reducing reproductive success could have evolved in humans. As noted, however, the reduced pelvis was an early adaptation for upright walking that was established before 4 million years ago in australopithecines, when brains were relatively small and ape-sized (about 450 cc). It follows that bibedalism alone did not introduce into the process of childbirth enough difficulty for mothers to make it too disadvantageous (Rosenberg & Trevathan, 2002), but the expanding size of the hominin brain certainly did. The conflict of function between the size of the birth canal and the baby's head arose later with the rapid evolution of the brain size that started around 2.5 million years ago and more than tripled the brain volume in *H. sapiens*. The evolutionary result of this conflict was the remodelling of the female pelvis and the birth of a premature baby with an underdeveloped brain. The female pelvis has become larger and broader than the male pelvis to respond to the requirements of the diverse selective forces for efficient bipedalism and parturition (the so called "obstetrical dilemma" - Trevathan & Rosenberg, 2002). In addition, sexual selection has made this sexual dimorphism even more pronounced, with males being more attracted by females with larger hips and females preferring males with narrow hips (Buss, 1989). Despite these structural adjustments, childbirth is painful and dangerous and can result in significant infant and maternal mortality and morbidity. This helps to explain why assistance during labor and delivery is a common feature of human societies, as laboring women and their babies benefit by lower rates of mortality, injury and anxiety with the assistance of others, specifically of other women (Hrdy, 1999). The obstetrician is indeed one of the oldest jobs described in the first historical documents and social support during birth is a near universal feature of human cultures – a condition that is not considered enough in hospitals' delivery rooms (Trevathan & Rosenberg, 2002).

The second effect of this evolutionary compromise is that in order to pass through the pelvic canal, human babies are born underdeveloped compared with other primates; their brains are around 25 percent of their adult size at birth, compared with around 45 percent for chimpanzees, our closest living ape relative. In fact, it would take a gestation length of 18 to 21 months instead of nine months for human babies to reach a level of development comparable with that of a newborn chimpanzee (Portmann, 1990). Thus the human infant is the least neurologically mature primate at birth and experiences the longest delays in both social and biological maturation -a fact that can be appreciated only through a comparative analysis of primate evolution and development. As a consequence of its immaturity, the human infant is forced to rely on external regulation and support, especially in the first year of life (Trevathan, 2011). All of these lead to human infants depending on their mothers much more and for much longer than other primates. These needy babies and infants imply high energetic costs for the mothers and most likely constituted a selective pressure for the evolution of paternal support and care and the consequent change in the mating system during human evolution. Accordingly, sexual dimorphism, that is a strong index of the mating system of a species, decreased constantly during human evolution suggesting a constant trend towards reduced polygyny in favour of monogamy (Ridley, 1993). This also implies the evolution of strong emotional bonding between mother and child (even between father and child) and also between male and female (pair bonding), which can be considered the biological root of our enlarged social brain (Dunbar & Schultz, 2007), as discussed in the next section. Again, changes in morphology always cause (or are caused by) changes in behavior, but changing behavior implies changing the brain and thus the mind and the psyche.

Human evolution and psychology

"Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown on the origin of Man and his history"
Charles Darwin, 1859, p.458

The difference in the brain-size between our species and our closest living relatives, the chimpanzees, mostly reflects the evolutionary expansion of association cortex, a group of regions that supports human-specialized functions as language, tool making, reasoning, social cognition and self-awareness. Seventy-five percent of human brain growth occurs post-natally, more than any other placental mammal, and this fact probably accounts for the developmental complexity of its neuronal connections and high plasticity. During human evolution patterns of gene expression in the brain have changed, in association with higher brain metabolism and greater levels of neuronal activity and plasticity across much of the lifespan. These changes may account for our increased cognitive capacity but may also have influenced the unique human susceptibility to neurodegenerative disease, such as Alzheimer's disease, and to neuropsychiatric diseases such as autism and schizophrenia (Preuss, 2012).

The puzzle is why primates, the hominin lineage and, in particular, *Homo sapiens* evolved such a large, highly wired brain? The traditional hypothesis focused on the importance of technical skills and ecological problem-solving, while the more recent evidence emphasizes the role of complex social relationships as the main selective force for the evolution of a large brain, the so called "social brain hypothesis" (reviewed in Dunbar & Schultz, 2007). Sharing food, caring for infants, developing pair bonds and building social networks helped our ancestors to meet the daily challenges of their environments and increased individuals' reproductive success (Fletcher *et al.,* 2015). In this view, maternal care and pair bonding seem to have played a crucial role in setting the social capability of a species and, indeed, they share the same neuro-endocrine substrates, i.e. oxytocin and vasopressin in association with dopaminergic system, that are also involved in social empathy (Insel & Young, 2001). This strongly suggests that the biological substrates of the social brain (i.e., pairbonding, altruism, cooperation, empathy) most likely originated as an exaptation of the maternal-infant attachment process. It is noteworthy that the understanding of the importance of a critical period in social behavior development started with the discovery of the imprinting phenomenon in geese by K. Lorenz (Lorenz, 1935), was subsequently reinforced by Harlow's studies on long-term effects of maternal deprivation in macaques (Harlow, 1958), and finally led to the fundamental psychological Theory of Attachment that emphasizes the importance of early experiences on the development of social behavior in humans (Bowlby, 1969). It follows that the comparative analysis of brain and behavior in an evolutionary perspective is essential to understand human social behavior and that these prosocial mechanisms belong to all mammals and existed long before the appearance of primates, including *Homo sapiens*. Understanding evolution would help psychologists to understand the human mind and behavior, because evolutionary processes forged the brain that controls human behavior, just as they forged the brain of other species.

An evolutionary perspective can help psychologists to understand, for instance, the ambivalence of feelings and behavior in mother-child relationships and male-female pairbonding, which although crucial for individual fitness, are far from the harmonious ideals celebrated by our symbolic brain in poetries, romances, arts and songs. Instead, these behaviors are a compromise between cooperation and conflict as explained by the theory of Sexual selection and Parental Investment (Darwin, 1871; Trivers, 1972). Parental investment is "*any investment by the parent in an individual offspring that increases the offspring's chance of surviving (and hence reproductive success) at the cost of the parent's ability to invest in other offspring*" (Trivers, 1972, p.138). As a general rule, males and females have divergent reproductive strategies that originate from the asymmetric investment in the production of gametes (many tiny sperms and few large eggs) and the care of offspring, with females sustaining higher costs than males in most cases. In humans, this asymmetry is extremely pronounced because the females sustain all the physical costs of pregnancy, delivery and lactation for a long period of time due to their immature and underdeveloped infants. A clear implication of this asymmetry is that men and women have different mating strategies and men are notoriously less choosy than women (Buss, 1989), as demonstrated by cross-cultural studies that show that sex differences in sociosexual behavior are consistent and universal (Buss, 1989; Schmitt, 2005). Although cultural variations exist in human socio-sexual behaviors, these studies show that biological sex is the largest and strongest predictor of human mating strategies across different cultures (Schmitt, 2005). Additionally, the most harmonious relation of all, the mother-child bond, suffers the burden of potential conflict. In a seminal paper on the evolution of parent–offspring conflict, Trivers (1974) argued that offspring are selected to demand more investment than parents are selected to give. This genetic conflict starts in utero (mother-fetus conflict: Haig, 1993) and then continues over the termination of parental investment with offspring demanding a longer investment period and/or a larger amount of investment at any time during the period of offspring dependence.

As seen for the bundle of compromises and flaws in design of the human body, the same is true for human behavior and mind. To acknowledge that human social behaviors, such as sexual and parent-offspring relationships, are a result of evolutionary compromises between cooperation and conflict allows a better understanding of functional (normal) and dysfunctional (pathological) psychological mechanisms.

This evolutionary approach to psychology does not mean to underestimate the plasticity of our brain and the effects of culture in shaping human behaviour and mind. The recent epigenetics revolution has clearly revealed how genes combine with environment in determining the development of brain, neural mechanisms and behavior. Nature is expressed via nurture (Ridley, 2006). Most likely our brain structure has not changed too much since the appearance of *Homo sapiens* (Barash, 1986). However, because of long postnatal brain development, plasticity and culture, this is not entirely true. This concept is well expressed by David Barash (1986): "*There would be little if any difficulty exchanging a Cro-Magnon and a modern infant, but great incongruity in making the same switch amongst adults of both cultures*" .

Conclusions

> *"Origin of man now proved. – Metaphysics must flourish. – He who understands baboon would do more towards metaphysics than Locke"*
> Charles Darwin, M Notebook, 16 August 1838.

We have reviewed different aspects of human evolution that help to understand how human bodies and minds work and why they are vulnerable to certain diseases. There are, of course, many more examples of evolutionary principles of medical and psychological significance, but the point is that an evolutionary perspective is necessary to understand vulnerability to diseases and behavioral disorders. Based on a long teaching experience in medicine and psychology, we are convinced that the *curriculum studiorum* of medical and psychology students should include evolutionary biology and human phylogeny. In addition to the fact that a humanistic culture is important for scientists, understanding how natural and sexual selection and other evolutionary processes shaped the human species is indeed relevant for all of the academic disciplines that are concerned with human beings (i.e., medicine, psychology, social sciences and even the humanities).

References

Arendt D., Tessmar-Raible K., Snyman H., Dorresteijn A.W. & Wittbrodt J. 2004. Ciliary photoreceptors with a vertebrate-type opsin in an invertebrate brain. *Science*, 306: 869-871.

Barash D. 1986. *The Hare and the Tortoise: Biology, culture and human nature*. Viking Penguin, New York.

Bowlby J. 1969. *Attachment and Loss: Attachment* . Vol. 1. Basic Books, New York.

Buss D. 1989. Sex differences in human mate preferences: evolutionary hypothesis tested in 37 cultures. *Behav. Brain. Sci.,* 12: 1-49.

Darwin C. 1859. *On the origins of Species*. Murray, London

Darwin C. 1871. *The descent of man and sexual selection*. Murray, London.

Dunbar R.I. & Shultz S. 2007. Evolution in the social brain. *Science*, 317:1344-1347.

Fletcher G.J.O., Simpson J.A., Campbell L. & Overall N.C. 2015. Pair-bonding, romantic love, and evolution: the curious case of *Homo sapiens*. *Perspect. Psychol. Sci*., 1: 20-36.

Haig D. 1993. Genetic conflicts in human pregnancy. *Quart. Rev. Biol*., 68: 495–532.

Harlow H. & Suomi S. 1970. The nature of love - Simplified. *Am. Psychol*. 25: 161–168.

Harlow H.F. & Zimmermann R.R. 1958. The development of affective responsiveness in infant monkeys. *Proc. Am. Philos. Soc.*, 102: 501 -509.

Hrdy S.B. 1999. *Mother Nature: A History of Mothers, Infants and Natural Selection*. Pantheon, New York.

Insel T.R. & Young L.J. 2001. The neurobiology of love. *Nature Rev. Neurosci.*, 2: 129-136.

Jones S., Martin R. & Pilbeam D. 1999. *The Cambridge encyclopedia of human evolution*. Cambridge University Press, Cambridge.

Lorenz K. 1935. Der Kumpan in der Umwelt des Vogels. Der Artgenosse als auslösendes Moment sozialer Verhaltensweisen. *J. Ornithol.*, 83: 137–215, 289–413.

Mayr E. 1982. *The Growth of Biological Thought*. The Belknap Press of Harvard University Press, Cambridge, Massachusetts.

Nesse R.M., Bergstrom C.T., Ellison P.T., Flier J.S., Gluckman P., Govindaraju D.R., Niethammer D., Omenn G.S., Perlman R.L., Schwartz M.D. *et al.* 2010. Making evolutionary biology a basic science for medicine. *Proc. Natl. Acad. Sci. USA,* 107: 1800-1807.

Nesse R.M. & Schiffman J.D. 2003. Evolutionary biology in the medical school curriculum. *Bioscience*, 6: 585-587.

Nesse R.M. & Williams G.C. 1994. *Why We Get Sick: The New Science of Darwinian Medicine*. Times Books, New York.

Portmann A. 1990. *A Zoologist Looks at Humankind*. Columbia University Press, New York.

Preuss T.M. 2012. Human brain evolution: From gene discovery to phenotype discovery. *Proc. Natl. Acad. Sci. USA*, 109: 10709-10716.

Ridely M. 1993. *The Red Queen: Sex and the evolution of human nature*. Viking Books, London.

Ridley M. 2003. *Nature Via Nurture: Genes, Experience, and What Makes Us Human*. Harper Collins Publ., London.

Rosenberg K. & Trevathan W. 2002 Birth, obstetrics and human evolution. *B.J.O.G.,*109: 1199-206.

Schmitt D.P. 2005. Sociosexuality from Argentina to Zimbabwe: a 48 nation study of sex, culture and strategies of human mating. *Behav. Brain. Sci.,* 28: 247-311.

Shipman P. 2013. Why is human childbirth so painful? *Am. Sci.,* 101: 426-429.

Tinbergen N. 1963. On aims and methods of ethology. *Z. Tierpsychol.,* 20: 410 433.

Trevathan W.R. 2011. *Human Birth: An Evolutionary Perspective*. Transaction Publishers

Trivers R.L. 1972. Parental investment and sexual selection. In B. Campbell (ed): *Sexual Selection and the Descent of Man, 1871-1971,* pp. 136-179. Aldine-Atherton, Chicago.

Trivers R.L. 1974. Parent-offspring conflict. *Am. Zool.*, 14: 247-262.

Williams G.C. & Nesse R.M. 1991. The dawn of Darwinian medicine. *Q. Rev. Biol.*, 66: 1-22.

Wrangham R. 2009. *Catching Fire: How Cooking Made Us Human.* Perseus, Philadelphia.