

Tracing The Evolution of Philosophical and Neurohormonal Origins of the Expression of Love in Vertebrates From Fish to Human: A Review

Dr. Sofronios E. Papoutsoglou

Emeritus Professor of Applied Hydrobiology
Agricultural University of Athens
Greece

Abstract

Basing on humans' gradually development and understanding the existence of Love as well as on the theory of evolution of animal species, the aim of the present study, has been focused on the neurohormonal origins of Love as they arise in vertebrates' origin (fish) and in their present stage (humans). Starting from the most ancient humans' approach, related to the way of the creation of feelings and meanings of Love, the development of its philosophical-historical and religion expressions and definitions have been outlined and highlighted. However, more specifically, the biological sequence and the language of Love, defined by the presently available data concerning the involvement of molecules of neuroendocrinological action in both fish and humans, have been examined from the mating-reproduction, friendship-social behavior and altruism points of view.

Key Words: Love, Emotions, Feelings, Meanings, Development, Vertebrates.

1. Introduction

Who is able to say how many people have uttered the words, "I love my parents", or "I love my sons, my brother, my sister, some body else" and so on, literally endlessly? How many are voicing suchlike thoughts and emotions at this very moment? More importantly, does anyone truly know precisely what he or she means, regardless of the recipient of this affection, when he or she speaks these words? It is common knowledge that Love is an issue about which everybody knows something and nobody knows everything. Yet, despite this elusiveness surrounding the precise meaning of Love, it is surely universally agreed that Love, offered to other beings of our world, is that which above all things is capable of creating unity among all people on this Planet, harmony on Earth. Amongst humans, it is that outpouring of the heart that nurtures and nourishes and that may be expressed regardless of sex, age, profession, social position, physical condition, financial situation, cultural level. Love, along with all that is connected with it, has eternally been and will surely always be a subject of allure and fascination for all people. Countless philosophers have mulled over its origin and denotation. Numberless poets and writers, inspired by this captivating theme, have written glorious words about it. Innumerable songs have been penned recounting the 'ups and downs' of Love.

The issue of Love, in other words, lends itself to myriad definitions, denotations, descriptions, since Love means something different to each and every one of us and one particular concept to no one. One might ask why people have for so long and so ardently sought to 'pin down' Love, to which one could simply reply: because the urge is overwhelming. In other words, people instinctively feel the need to communicate to others an internal and eternal impulse, and this in a limitless number of ways, and to muse and to meditate on it. An impulse and a sentiment capable of being extended, after all, to all other beings and things that surround us—other people, animals, objects, ideas (religious, political, social, etc.), to science, to art (Harlow, 1958). Bearing in mind the universality of Love and the incalculable multiplicity of the manners of its expression, the moment comes to more intricately analyze it, and this will here be undertaken from the point of view of biology, i.e. examining the phenomenon according to its biological/neuroendocrinological sources. Scrutinizing it in this fashion we may see that its expression is extremely closely related with the strict mechanisms and regulations of Physiology, Neuroendocrinology, Biochemistry and Genetics (Heredity), most of these, however, lying beyond the realm of total comprehension, so mysterious and inscrutable are the myriad 'processes' of living beings (Cambell and Ellis, 2005; Shepherd, 1988; Slater, 2009; Zeki, 2007).

Reflecting on Aristotle's statement that "nothing that nature does is odd or in vain" while also basing it on the theory of evolution of animal species, the aim of the present study is to draw essential knowledge via examination of the neurohormonal origins of Love as they arise mainly in vertebrates' origin (fish) and in their present stage (humans) as well as through inspection of the "language" that is employed to express it (Platt, 2007; Shields, 2007; 2008).

2. The existence of Love and its expression in vertebrates

2.1. Definitions and meanings

In this quest to analyse the biological origins and the "language" of Love, the very first requirement is to arrive at some commonly accepted denotation of this word. As already mentioned, this is no easy task, this stemming from two vital issues: firstly, that, as stated above, many kinds or types of Love prevail among humans and animals; and secondly, that enumeration of the expressions via which Love is "expressed", mainly by humans, would lead to a continuous adding to a virtually endless list. Nevertheless, if one is to pursue this worthy quest, some commonly accepted definition of Love and the forms of its "language" need initially to be determined. Proceeding to a definition of Love is truly a challenging enterprise. Nonetheless, the search for terms that attempt to pinpoint the meaning of this extraordinary attribute is necessary to our investigation. This perforce will require a semasiological approach that will permit inspection of some of the words used by various peoples and as studied via the writings that they have left behind. The people here studied are the ancient Greeks.

The first written statements about Love as evidenced in the western world are to be found in Homer's texts, The Iliad and The Odyssey. As is well known, the three principle words used in ancient Greek to define Love are: 'Αγάπη, Έρως and Φιλία. In Homer's works, however, the specific term "Αγάπη/Agapi--love" is not to be found. Instead, the verb "Αγαπώ-Αγαπάω/Agapo-Agapao--I love" is employed with the meaning of "I am friendly" to somebody. (Let it be noted in passing that Homer's poetic account of the Trojan War attributes its cause to the passion between Paris and Helen.) The word "Έρως-Eros", is also used by the ancient poet in these same texts, where its meaning is related to both sexual pleasures (directly) and reproduction (indirectly), as well as to friendliness (Bakalis, 2005; Malaspina, 2001).

Obviously, the great importance of Eros, as interpreted according to the above senses, is, from the biological standpoint, its fundamental connection with the natural urge for propagation/reproduction as it exists among species (perpetuation of life), the materialization of this urge being both prompted and energized by way of stimulation of the nervous system of the specific animal species resulting in a sexual 'drive' that will provide the mating pairs with utmost gratification within a strictly limited space of time. It is thus an expression of the wisdom of nature for achievement of the maintenance of mankind and of animal species. This urge for self-propagation is, as is well known, paralleled by the urge for self-preservation, manifesting, among other ways, via satisfaction of nutritional needs through the pleasures of eating and of taste (Bancroft, 2005, Gazzaniga, 1998; Haufe, 2007; Mayer, 1982; Miller, 2001; Ord and Garcia-Porta, 2012; Zohar et al., 2010).

Because of the abovementioned primal need, Eros has been described in Greek mythology and by certain of the ancient Greek philosophers as the primordial god. Hesiod in his "Theogonia – The Theogony, Origins of the Gods" describes the god Eros as the son of Chaos, this latter denoting the primeval void or formless state from which all things sprang and which embodies the continuous dynamic of being and of the Earth, the primal condition into which all things are to be placed. Thus, according to Hesiod, "Eros, fairest of the immortals (gods), not only represents the outcome of power and beauty but is also ranked third, after Chaos and Gaia, as a cosmogonic Element". He is also the first Element underlying the origin of all living species as well as the origin of the environment in which they will live. Because of him, all immortal and mortal Elements of Life have been created, as Aristophanes writes in his "Ornithes – Birds": "...nothing existed before Eros brought everything together. The result of his involvement was the creation of Sky, Ocean and Earth, as well as all the immortal and imperishable gods". This concept has also been communicated by Empedocles, who, in his poems "About nature" and "Expiations", seeks to define Love in its more physiological dimensions. He states that Eros is the prime cause of the definitive unification of the four principal Elements of the: Κόσμος-Cosmos: Earth, Water, Air and Fire (Inwood, 2001; Lamberton, 1988; Most, 2007; Stoddard, 2003; White, 1914; Wright, 1995).

It should also be mentioned that Hesiod calls Eros the “*λυσιμελή*” power (that is, that power which can loosen the parts of a body), as well as he who “can dominate the soul of all gods and humans”, but also he who is capable of driving both gods and humans to a state of dementia, depriving them of the capacity for logical thought (Most, 2007; White, 1914).

Socrates, expressing his own wisdom about life, action, will and knowledge, which, as he stresses, must be united, believes that the only way to achieve goodness and thus happiness is via the power of Eros signifying, by its particular use, “to inquire, to ask questions” and, more specifically, to investigate the great questions of life. Thus, through perpetual questioning and self-questioning via Philosophy (meaning Love of Wisdom), the highest knowledge and insight may be acquired this inevitably bestowing goodness, harmony, joy and contentment. There is, however, another view, which is the clearly philosophical position here entertained by Plato, one which closely echoes the profound wisdom of his master Socrates, namely that Eros is that desire to attain an inner vision of eternal and transcendental reality, which is the source of all knowledge and which elevates man to his highest state. In his “*Symbosio – Symposium*”, he asserts: “Eros is the most unconquerable power, which can turn mortal to immortal, or in other words to turn mortal to God” (Bakalis, 2005; Dover, 2010; Wilson, 2007).

Later, Aristotle upholds the view that Love is *Φιλία* (filia-friendship). It is of great importance to mention that Aristotle in his “*Ithika Nikomachia – Nicomachian Ethics*” and “*Ritoriki – Rhetoric*” strongly emphasizes that friendship is the only power that can establish Sociality and Solidarity, both between individuals and within human communities. Within the framework of efforts made today to establish unity and brotherhood among peoples and nations, this perspective concerning the dimension of sociality appears as a most important step towards the attainment of this ideal, embracing as it does the importance of Love from both the philosophical and the practical/biological point of view (Bartlett et al., 2011; Broadie and Rowe, 2002; Crisp, 2000; Gill, 2005; Taylor, 2006).

It is noteworthy that the fundamental significance of the Chinese term “*yen*” closely approaches the western denotation of Love. In defining its meaning, Confucius urges us to love everybody, indiscriminately and with joy, from the depths of our soul (Rainey, 2010; Riegel, 2012). An all-understanding and all-embracing “reverence” for Life, attained through internal vision of it, is the very broad and comprehensive dimension given to Love by Hinduism (Williams, 2003). Similarly, one of the ten principles of Buddhism concerns the idea of “general love”: this means that, through understanding of life’s fundamental unity, compassion (i.e. absolute and empathetic identity with all other forms of life) will arise (Armstrong, 2004). Of a more emotional nature is the meaning of Love that has been given to it by Christianity, according to which concept, however, there exists an essential differentiation between Eros and Love: Eros is described as characterizing humans, while Love defines the relationship between humans and God and vice versa. This latter dimension of Love is thus considered of divine origin and offered to all creatures. It is a concept of Love that is seen, moreover, to contain within it the sense of sociality, its main features being Altruism and Selflessness, which lead to a peaceful manner of living. The altruistic dimension of Love, characterized by a continuous effort of humans to overcome their weaknesses, is outlined by the apostle Paul in his first Letter to the Corinthians (Holt, 2005; MacCulloch, 2010). In addition, a wide-ranging meaning of Love, and especially that of Godly origin, characterizes the principles of Islamism (Cook, 2000).

The spiritual meaning of Love is also given later by Augustine. He seeks to demonstrate the divine concept of Love, based on constraining of negative human traits via the power of the human mind, the attainment of transcending knowledge and the power of Eros (Matthews, 2005). During the Middle Ages, there developed what has been called “courtly love”, generally defined as a high-minded and gallant mode of expressing love and respect. However, modern historical studies of contemporary literary sources have shown it to be much more fascinating and complex. An additional vital aspect characterizing that age is the fact that especial emphasis was laid on Mysticism and Vision, with the concept of Love being closely allied to this. This approach—one fully embraced historically by the world’s leading religions as well as by its highest philosophical systems—is especially evident via the preaching and acts of the 13th century saint Francis of Assisi, who declared his “secret vision of love”, and Bernard of Clairveau and Peter Abelard both of whom spoke about their expression of a “pure love to God” that awaits no reward (Robinson, 2009; Evans, 2000; Mews, 2001; Marenbon, 2010).

It is Rene Descartes who made the great break between ‘ancient’ and ‘modern’ views of life: by defining the physical world as mechanistic and completely separate from mind, he establishes the ‘dualistic’ notion of nature. He thus describes Love as a touching of the soul caused by mental functions connecting love with the “most fitting object” to be loved, thereby attributing to Love a clearly biological sense and dimension (Naaman-Zauderer, 2010). Three hundred years later, Freud assigned to Love its possibly most biological dimension, connecting it as he does directly with the sexual instinct (Duffy-Hutcheon, 1995). The above brief overview of the historical inquiry into Love has shown that man at all stages of his development has carried out multiple analyses of this universal phenomenon. It has also been made evident that this persevering study of Love and the attendant determination to define Love have sprung from man’s yearning to discover the optimal means of expressing Love while also identifying the causes for its existence. In the previous paragraphs, it has been thus undertaken a short discussion of the ancient Greek approach to the concept and that of the world’s highest religions, a consideration of the unitary, the reconciliatory and the mystic aspects of Love, as well as of the universally entertained dimension of Love as sympathy for and sharing in others’ problems and adversities. It may safely assumed that this ageless search, comprising as it does investigation into such concepts as virtue, pleasure, desire, as well as the human being’s relation to God, has ever been carried out for enhancement of the human condition. In summary, it may be stated that Love or Eros (physical or divine), friendship, desire, sympathy, passion, sociality, solidarity and altruism are the most dominant definitions and denotations of Love. They cover its significance both broadly (intellectually, philosophically and religiously) and specifically in terms of satisfying the enduring as well as the more temporary of human desires.

2. 2. The existence of Love

With regard to the physiological/biological dimension of Love, it is apparent that it possesses two main features. One concerns the instinctive desire for propagation/reproduction (desire, passion and mating). The other (friendship, sociality) relates to the inborn urge for self-preservation. Both of these (but especially the first) are of instinctual origin which, however, takes numerous forms depending on an individual’s character, age, sex and the existing religious, financial and social circumstances. However, one must additionally consider yet other more ‘refined’ manifestations of Love, including solicitude for others (parents, siblings, friends, etc.), or for people in general, or for the natural or artificial environment (animals, plants, objects), or for all of them. Within the framework of this concept it is also necessary to emphasize a basic desire among humans to live in peace with others—though this is often frustrated by a conflicting contrary compulsion for competition, rivalry, selfishness, jealousy, etc. which must be constrained. With regard to humans’ desire to communicate with God, this is especially intense when there is belief in the afterlife, but it also arises by virtue of the abovementioned quest for internal knowledge. The aforementioned differentiation between the various expressions of Love is related both to heredity and to the fact that each person has the ability to reflect and reason in his or her own way. It is uncertain whether the same applies, to a certain degree, to animals, especially when they live in groups.

Finally, when discussing the question of logic among animals, it is common to dismiss contemplation of this possibility and ascribe to them only ‘base instinct’. However, while animals do not have the tremendous intellectual and mental skills possessed by ‘homo sapiens’, one can certainly say that they possess a ‘sense of nature’ and of their place in it. In parallel, despite man’s enormous capacity for intellectualization, instinct will also be implicated in human reaction, particularly when an individual has limited time to reflect, as for example in an encounter with sudden danger (Aron et al., 2005).

2. 3. The biological sequence of Love

For the purposes of achieving a better approach to and study of the existence and expression of the instincts of reproduction and sociality of mankind and of animals, it needs to be stressed that instincts are, in fact, the expression of specific genes. The expression of instinct genes within the entire animal kingdom as well as in humans has a common origin and is modified according to the systematic level of each species. It is therefore obvious that its investigation involves an examination of the evolutionary progress of instinct gene expression extending from the lowest to the highest species, one that is intimately bound up with perpetuation of the species and the social behavior of individuals in their communities. The general assumption is that this progress represents a sequence of three steps that are of vital importance for animal and human life, steps which govern not only the origination and continuation of life but also its quality, this especially applying to human pairing.

Among humans, this sequence normally starts from the step of Friendship (social behavior), goes through the step of Mating (potential for desire to be satisfied as well as for reproduction) and is capable of further ascending to the step of Altruism. However, among animals, this sequence frequently commences from the 'second' step (mating) and is followed by the friendship step. The last step, as applied to animals, is termed "biological altruism" (i.e. manifested without conscious intent) and is a well documented phenomenon among numerous animal species - e.g. ants, bees, bats, birds, monkeys (Buller, 2005; Dudai, 1994; Dunbar, 2012; Mayer, 1982).

Basing our investigation upon the information available, examination of the expressions of the genes responsible for mating, friendship and altruism among the systematically different animal/vertebrate species reveals the fact that commonality of biological data between mankind and animal species decreases going along the scale from mating to altruism. In other words, the similarities of the expression of these common origin genes in all living beings are numerous in the case of the first step of this evolutionary sequence, mating, fewer in the case of friendship, and still fewer in the case of altruism, though, as noted above, by no means absent (Fisher et al., 2006; Patterson, 1978; Sandroni, 2001). It can thus be seen that biological involvement is expressed via biochemical mechanisms belonging to the nervous/neuroendocrinological system and which are characterised by specific actions of chemical substances that participate in the above described three steps.

2. 4. Mating (reproduction)

Commonalities of sexual behaviour shared by mankind and animals/vertebrates are extremely abundant. These are mainly associated with the physiology of this procedure and especially with the functions of the nervous, hormonal and enzymatic systems, functions that demonstrate the involvement in both human and animals of molecules of almost identical chemical composition along with an almost identical regulation of their activity. Substances that have been detected in fish and humans, these two species representing respectively the lowest and the highest levels of living vertebrates, and that are involved before (infatuation-attraction), during (orgasm) and after lovemaking, mainly belong to hormones or hormone-like (neurohormones - neurotransmitters, chemical transmitters/messengers, neuroregulators) groups (Akazome et al., 2010; Broglio et al., 2005; Le Page et al., 2010; Mueller and Wullimann, 2009; Munakata and Kobayashi, 2010).

2. 4. 1. The stage of attraction (infatuation)

Neurochemicals of the adrenaline (epinephrine) group express the result of infatuation, which is transmitted to almost all nerve cells by phenylethylamine. Amphetamines, or molecules similar to them such as catecholamines (dopamine and noradrenalin or norepinephrine), are involved, triggering the release of adrenaline, which is closely related to the release of cortisol. What transpires in humans (and probably in animals) when these chemicals are in action is well known. Common descriptions of the sensations are the impression of "seeing stars" and of "flying". Heart beats become strikingly noticeable and "life appears like a dream". Men and women are feeling like they are "mixing up" or "changing their souls" by mouth to mouth kisses and, usually, they "offer their hearts" to each other. A sense of spilling over with euphoric energy stimulates the couple further towards the act of love, during which 'preliminaries' enjoyment and pleasure abound. At this stage, and especially when the bonding is chiefly prompted by sexual attraction, such noble values as respect, honesty, loyalty are rarely implicated. Emotively prompted reactions as humour, wit and various demonstrations of pleasure and gratification are, on the other hand, very usual. This is the stage of sexual appeal in which charm, or "chemistry", plays a large role, though it can also be accompanied by a certain degree of insecurity in front of the 'unknown'. Unfortunately, or perhaps fortunately, this is a stage that usually does not last long, according to the data available, normally concerning a period lasting a few weeks or months (Aron et al., 2005; Bartels and Zeki, 2000; Fisher et al., 2006; Lewis et al., 2000).

In fish, the presence of neurohormones-neurotrophins-neure growth factors, like adrenaline, noradrenalin serotonin and dopamine as well as their metabolites (3,4 - dihydroxyphenylacetic acid DOPAC, homovanillic acid HVA, 5-hydroxyindoleacetic acid 5-HIAA), cortisol, several blood parameters (e.g. haematocrit, electrolytes, pH, pO₂, p CO₂, glucose, fatty acid), digestive enzymes, and growth rate, has been closely related to the maintenance of their homeostasis and, importantly, to their genital maturation (Ala-Honkotala et al., 2010; Bass and Ledich, 2008; Broglio et al., 2010; Brown and Laland, 2008; Cerda-Reverter and Canosa, 2009; Guevara-Fiore et al., 2010; Liu et al., 2010; Maruska et al., 2011; Papoutsoglou et al., 2010; Papoutsoglou, 2012b; Pottinger, 2007).

2. 4. 2. The stage of orgasm and after lovemaking

The stage of infatuation brings the individuals to the ultimate outcome, which is orgasm. The substances that are involved in this act belong to a group known as the oxytocin-vasopressin group. However some of them (oxytocin) are also involved just before and after lovemaking. In humans, such emotional and physical factors as tone of the voice and fantasizing commonly trigger the production and the release of oxytocin in humans. It is of note that vasopressin has been called the ‘monogamy substance’. Also interesting is the fact that a very limited proportion (about 3%) of mammals, excluding humans, is naturally monogamous. In fish, these substances have been shown to be involved in mechanisms that, through the nerve cells, control, their reproduction procedure. It is additionally noteworthy that vasopressin may be related to the male jealousy syndrome, as experiments on voles have shown. Equally important similarities are found in biochemical and neurohormonal pathways that are involved in the production of the genetic material. In both fish and humans, these mechanisms are initiated via the action of external/environmental factors registered by the nervous system, and most particularly by the mechanisms of smell, taste and sight. These cause stimulation of internal factors which are mostly related to species (in fish), age and sex (in both fish and humans). The final result of these procedures is related to the stimulation of cells of the hypothalamus and is transmitted to the hypophysis, which causes the production of gonadotropins, steroids, prostaglandins, etc. (Agulleiro et al., 2006; Akazome et al., 2010; Daniel, 2004; Papoutsoglou, 2010; 2012b). It can therefore be deduced that the similarities in molecules and biochemical pathways involved both in human beings and in vertebrates higher on the scale than fish (i.e. terrestrial and aquatic mammals) are remarkably numerous and striking.

2. 5. Friendship (social behaviour)

Most of the substances as well as the biochemical systems related to social behavior (friendship) that are either directly or indirectly involved in both human and animal behavior are as yet unknown, those that have been identified being chiefly detected in animal species that live in groups. One interesting example of these substances is that particular type of molecules known as pheromones and, more specifically, as alarm pheromones and pheromones of social behavior, which are to be found even at the level of fish (Barsagade et al., 2010; Campos et al., 2012; Papoutsoglou, 2012a; Salas et al., 2006). In humans, and particularly in the case of a happy couple, specific substances called endorphins that act like opiates have been correlated with affection, dependability, deep intimacy, thoughtfulness and serenity. It should be mentioned that long-married human couples are characterised by a certain level of endorphins which becomes decreased when they are apart, a reduction which produces yearning for the mate (Bancroft, 2005; Bartels and Zeki, 2000; Chretien et al., 1981; Funkelstein et al., 2008; 2010). In fish, endorphins have been found in several parts of their body, including the brain and gonads. It is assumed that they are implicated in fish reproduction, some indications also linking them to relief of stress (Batten et al., 1999; Flik et al., 2006; Jamiesen, 1991; Northcutt, 2008; Papoutsoglou, 2010; 2012b).

It may thus be established, firstly, that endorphins nourish the growth of friendship and, secondly, that friendship, which, among humans, means the will for the creation of an ambience of calm, peace and dependability as well as the wish for shared life experiences, is strongly linked to our need for loving and being loved. By contrast, catecholamines tend to be linked with possessiveness and aggressiveness. In this context, special attention should be paid to a substance called serotonin. According to the results of several studies, serotonin has been closely related to the feeling of happiness in humans (Cortez et al., 2012; Young and Leyton, 2002). In some fish species, serotonin has been shown to be involved in mechanisms of suppression of aggressiveness. In other words, serotonin makes these fish more “civilized” (Huntingford and Kadri, 2008; Kandel et al., 2000; Papoutsoglou, 2010; 2012b; Pottinger, 2007).

2. 6. Altruism

According to commonly accepted knowledge, substances directly related to the expression of altruistic behavior in animals and in humans have not so far been reported. However, it could be assumed that they belong to the group of substances possessing specific hormonal or/and neurotransmitting action. Most of them will likely be of chemical composition similar to those involved in friendship behavior. It could also be possible that friendship substances are involved in altruistic behavior, most probably in combination with several others. Regarding the biochemical pathways involved in altruism, it could also be assumed that they mainly include functions of the nervous, endocrine and enzymatic systems, additionally influenced by personality, circumstances and environmental conditions.

However, of great importance is the genetic origin of altruism manifesting within members of the same family—as well as possibly within human communities—as has been demonstrated by Hamilton's rule (Hamilton, 1964; 1996; Stark and Wang, 2004).

3. The expression/“language” of Love

3. 1. Mating (reproduction)

The “language” that a human uses to express his/her sexual intentions obviously differs from individual to individual. However, it is of note that there are certain rules governing its manifestation, the rules operating according to specific signals transmitted and received by the individuals. This fact points to the involvement of the nervous system by means of the sense of sight (gaze, “body language”, smiles, laughter, etc.), hearing (conversation, music), smell (natural or artificial scent), touch (all parts of the body are involved) and taste (Achaibou et al., 2008; Bass and Ladich, 2008; Dritsas et al., 2006; Emanuele et al., 2006; Fisher et al., 2006; Fitch, 2005; Kandel, 2007; McDermott and Hauser, 2005; Miller, 2000; 2001; Mithen, 2007).

Approximately the same situation may be seen to exist amongst animals, and especially as regards the vertebrates. The “language” used by male fish of many species during their reproductive period involves courtship, sound production, production of electricity, production of mucus substances, increase of the diameters of the eyes, elongation of the fins, modification of the jaws, colour changes and increase of the width of the epidermis. Females are characterised by an increase in their receptivity of acoustic, chemical and optical stimuli, increase of the width of their epidermis, modification of their fins and body size, courtship behaviour, building of a nest and, most important, choice of a partner (Ala-Honkota et al., 2010; Desjardins and Fernald, 2009; Papoutsoglou et al., 2010; Papoutsoglou, 2012b; Rocha and Rocha, 2006; Witte, 2006; Zohar et al., 2010). Even more stunning is courtship behaviour among certain bird species which may include intricate dances, displays of superb colours and extraordinary calls signalling their search for a match. As one ascends to the higher vertebrates and particularly to mammals, one identifies behaviour ever closer to that of humans as concerns the “language” and expression of their sexual intentions (Haufe, 2007; Zeki, 2007).

3. 2. Friendship (social behaviour)

Given the fact that nobody can live alone, it is obvious that companionship, friendship and sociality are a *sine qua non* for humans' wellbeing. With reference to the “language” that a human will use to convey his/her social/friendship behaviour, needless to say, this concerns an issue that is virtually impossible to express in either numbers or even examples, since there is no individual that is identical to any other. Nor are they even to their own selves, since the type and level of friendship behavior expression undergoes constant change, even within one and the same day, this being dependent on numberless factors, a differentiation due to the widely varying temperaments, desires and expectations characterizing human beings. Nevertheless, one could summarize the most common aspects of this behaviour as being provision of assistance to a needy person or persons, participation in common entertainment, working and living together. In the case the development of friendship between two individuals, their friendship behaviour typically follows a period of acquaintanceship and of growing harmoniousness experienced in the company of one another. The end result is the achievement of deep appreciation and respect between the two individuals. It may be added that appreciation and respect as conferred and received among greater numbers of individuals will be achieved, in a civilized community or society, with a minimum of person-to-person communication.

It has been scientifically established that “language” or expression of friendship behavior exists among certain species of animals, including elephants, chimpanzees, dolphins and bats, with this expression being quite similar to that of man. Of particular interest are those expressions related to the protection of the individuals of a community from natural enemies. Also of note are manifestations of parental care which, in some cases, involves a continuous surveillance of the young during the first stages of their life. There is also the remarkable ‘solidarity’ manifested among creatures that are inseparably integrated into strictly organized communities, as for instance among such invertebrates as certain insect species (ants, bees). Among the lowest vertebrates (fish), friendship may be expressed in a number of ways. Amphibians, reptiles and birds represent intermediate stages (Bester-Meredith et al., 1999; Moreau et al., 2011).

3. 3. Altruism

In humans, altruistic behaviour, meaning dedication to the welfare of others, is typically expressed by acts of selflessness and even by self-sacrifice. Clear examples of the expression of altruistic behaviour in animal species have been widely documented, though, because it naturally excludes conscious choice, it is named, as mentioned above, “biological altruism”. A striking manifestation of altruism among animals is the remarkable expressions of parental care manifested by some animal species, including some fish species (Bshary, 2002) that have been known literally to reach the level of self-sacrifice. Such expressions of selfless behaviour are also richly documented among animals that form emotional relationships with humans: dogs, cats, horses and many other animals form strong emotional attachments to their owners and many dogs have been known to spring to the defence of their master or mistress. This may be explained by the fact that such animals not only possess elevated mental capacities but are also characterized by the existence of special parts in their brain able to express emotional feelings and behaviour (Hamilton, 1964; 1996).

Within the classification of altruism is man’s self-sacrifice for an idea or ideology whereby he/she expresses profound Love for the preservation of Life itself via preservation of these elevated beliefs, such articulation being found, of course, only amongst humans. A very few examples of such self-sacrifice are to be seen in the lives of Socrates, Jesus and Gandhi. While normally not understood or appreciated by others of less lofty ideals—assuming that the ideals being defended with one’s life and being thus ‘rendered sacred’ (the etymological meaning of the English word “sacri-fice”) are, indeed, lofty and not founded upon a wrong understanding of life—such sacrifice may be categorized amongst the very highest manifested by the human being (Okasha, 2009). Love in this case has expanded to include the entirety of mankind and, in fact, the cosmos.

4. Epilogue

It is clear, that Love, however expressed, can be studied from the point of view of its hereditary origin, its expression in both mankind and animals capable of being traced, among other means, to the actions of specific molecules and biochemical pathways. It is further evident that the biological origins of this phenomenon implicate the involvement of genes that are common to both humans and animals. The laws of heredity have dominated the development of these genes within and among different animal species as well as among humans since their first appearance on earth. It is important to remember that a gap of some millions of years intervened between the first appearance of fish and that of man on earth. Fish appeared about 400 million years ago, amphibians 325, reptiles 255, birds 165, mammals 39, and the present stage of humans only about 200,000 years ago. This will account for the huge variability in the existence and expression or “language” of Love, both horizontally (different species) and vertically (mating, friendship and altruism). This is more obvious in the case of humans, and most particularly with regard to the expression of friendship and altruism. In other words, in this case, not only is there vivid physical expression of feelings (due to the function of specific brain centers) but in addition their broadest and most intricate articulation.

Today, although scientists are, without doubt, in possession of a considerable amount of knowledge about the phenomenon, they are still far from unraveling all its deep mystery and complexity. Two thousand four hundred years ago, Socrates pronounced the famous words “the only thing I know is that I know nothing”, signifying that man’s aching quest for knowledge is indeed an eternal one. Nevertheless, the quest continues, and we persevere in our continuous inquiry into nature, life, Love and their origins, the sum total being designated in religious terms as God, who, in the words of Thales, “has never been born and will never die”. Probably, functions of the **brain** (including the expression of Love) of vertebrates (from fish, and especially, to the present stage of humans) should be added to the already accepted list of mysteries consisting of **Space** and **God**.

5. Conclusions

Based upon the anatomical and functional evolution of the neurohormonal actions of vertebrates and, more specifically, that of their brain, from fish pallium to the present stages of the human being’s cortex/neocortex, the following points could be recapitulated with regard to the meaning of the “language” of Love:

- Bearing in mind the philogenetical “distance” between fish and humans and the practical/laboratory difficulties of determining fish hormone levels during their various physiological stages, it is evident that our data concerning the type, level, intensity and interactions of hormones and/or hormone-like molecules involved in their Love stages are as yet incomplete. This particular investigation is further impeded by the fact that fish are easily stressed.

- The molecules (hormones, neurotransmitters, enzymes, etc) so far known that are involved in mating expression in fish are almost the same as those of humans. The most notable difference between them is that in fish the action of these molecules is expressed automatically to cover their instinctual needs for reproduction, while in humans, this procedure may be, when desired, controlled via will power.
- Fish and humans are remarkably close as regards their attraction/infatuation behaviour between male and female individuals, this behaviour depending in fish exclusively upon identification of specimens of the same species. Meanwhile, in humans, despite many instances of contrary behaviour, the tendency is for attraction to a member of the opposite sex who will possess very similar characteristics, mainly those of their faces, this being especially prevalent among younger people.
- In general, in both fish and humans, the neurohormonal mechanisms related to their expression of Love are intimately related to the functions of their senses, although there are exceptions. In both, sight plays the most important role in the expression of the first stage of Love (attraction/mating), in combination (in many cases of fish and humans) with smell through involvement of the pheromones, although in some fish species the contribution of smell is stronger. In fish, the expression of what is for them the first stage of Love (friendship) involves, apart from sight, mainly smell, along with the neurohormonal functions of hearing and possibly touches. Fish behaviour is directly related to the naturally arising “feelings” pertaining to each fish species, namely, of aggressiveness mostly among species living individually and of friendliness characteristic of species living in groups. It is likely that the main biological contributors in the first case are neurohormonal mechanisms (e.g. high levels of blood cortisol), while in the second they are those which are present during relaxing conditions (e.g. high levels of blood serotonin). Although altruistic behaviour expressed by a fish species has occasionally been recorded, there are as yet no available data related to pertinent neurohormonal functions, due to laboratory – practical difficulties.
- Following the biological manifestation of Love behaviours (mating, friendship, altruism), these judged in terms of the neurohormonal functions involved, it is clear that they weaken (with advancing age?) in both fish and humans from the first to the last stage, due to different reasons. In fish they are completely based on their primitive evolutionary level as vertebrates, while in humans the refinement of Love is continuously under development thanks to the superior functional capacities of their brain/neuroendocrinological systems. Thus, when humans are able to control the expression of their feelings (even at the biological level, by “altering” the kind and the interactions of certain molecules), they are empowered to express the very highest forms of Love, while fish, needless to say, are not. This, however, does not mean that, via “biological” expression of friendship and altruism, animals, especially mammals, are incapable of extraordinary demonstration of “emotive” reactions.
- After millions of years of their exposure to the influence of evolutionary, mimetic and epigenetic mechanisms, it is evident that the level of fish hormonal interactions, ‘primitive’ as they might generally be considered, has nevertheless reached a remarkably high level of competence. Notably, fish can very effectively use their power of memory both to help them survive—via their feeding/nutrition and living ethology—and to enhance their reproductive abilities through choice of partner and care of offspring, both of these functions related to preservation of life and species. Apart from these two capabilities ensuring survival and reproduction, fish seem to be able, by using specific biochemical-neurohormonal pathways (almost identical to those of humans), to express their “romantic needs” by showing their preferences concerning the characteristics and quality of their living environment. This extends as far as to appreciation of music, in combination with “liking” for specific environmental colours (in combination with specific photoperiod characteristics) and fish and/or human company. Since the fact that, to a considerable degree, fish are able to communicate with, or “speak” to, humans, it is evidently the responsibility of humans to seek to understand their “language” so as to enhance to the greatest possible extent their living conditions. Today, this aspiration may be supported by carrying out experimental studies on fish for the purposes of basic neuroendocrinological research.
- Humans, being the only creatures on this planet who are able to conceptualize both the ideological/abstract and the biological/neurohormonal differences of meaning between I love, I am in love and I make love, are responsible for the control and modification of their behaviour according, for example, to the teaching of Κλεόβουλος - Cleovoulos (c. 600 BC), namely “Μέτρον Ἀριστόν” (Metron ariston = Moderation is best).

- Love is an absolute need for every living creature—this certainly also including all manifestations of the natural environment—so that humans have the duty not only to preserve but also to enhance their manifestation of Love by every possible means. It is the only way for all of us to live in peace and in harmony, considering all people as our friends and brothers and, also most vitally, regarding our natural environment as our ‘mother’, she that forever nourishes and sustains us.
- Sadly yet inevitably, it is impossible for anybody to neatly sum up in a word, or even a ‘thousands words’, the true and deep meaning of Love. It means so much to so many: it is simple, it is complicated; it is peaceful, it is stressful; it is obscure, it is radiant; it is welcoming, it is elusive; it is delightful, it is painful; it is sweet, it is bitter; it is explicable, it is inexplicable, and on and on endlessly. The best that can be said, perhaps, is that Love is Love, the force and the hope of the world. That is why Love must be understood to be our very greatest wealth and our very highest ideal.

6. Acknowledgement

It is a great pleasure to express my thanks to Scarlett Gingell for her useful comments on this manuscript.

7. References

- Achaibou, A., Pourtois, G., Schwartz, G. S., and Vuilleumier P. (2008). Simultaneous recording of EEG and facial muscle reactions during spontaneous emotional mimicry. *Neuropsychologia*, 46 4, 1104–1113.
- Agulleiro, B., Garcia-Hernandez, M. P., and Ayala A. G. (2006). Pituitary: development, hormones and functions. Teleost adenohypophysis: morphofunctional and developmental aspects. In: Reinecke, M., G. Zaccone, and B. G. Kapoor, (Eds), *Fish Endocrinology*, Vol. 1. Science Publishers.
- Akazome, Y., Kanda, S., Okubo, K., and Oka Y. (2010). Functional and evolutionary insights into vertebrate kisspeptin systems from studies of fish brain. *Journal of Fish Biology*, 76 1, 161–182.
- Ala-Honkola, O., Saila, L., and Lindstrom K. (2010). Males prefer small females in a dichotomous choice test in the poeciliid fish *Heterandria formosa*. *Ethology*, 116 8, 736–743.
- Armstrong, K. (2004). *Buddha*. Penguin Press. ISBN 0-14-303436-7.
- Aron, A. H., Fisher, D. J. Mashek, G., Strong, H. Li. and Brown L. L. (2005). Reward, Motivation, and Emotion Systems Associated With Early-Stage Intense Romantic Love. *Journal of Neurophysiology*, 94, 327-337.
- Bakalis, N. (2005). *Handbook of Greek Philosophy: From Thales to the Stoics*. Victoria, B.C. Trafford Publishing. ISBN 1-4120-4843-5.
- Bancroft, J. (2005). The endocrinology of sexual arousal. *Journal of Endocrinology*, 186 3, 411–427. doi: 10.1677/joe.1.06233. PMID 16135662.
- Barsagade, V. G., Mazumdar, P. S., Singru, L., Thim, J. T. Clausen, and Subhedar N. (2010). Reproductive phase-related variations in cocaine and amphetamine-regulated transcript (CART) in the olfactory system, forebrain, and pituitary of the female catfish, *Clarias batrachus* (Linn.). *Journal of Comparative Neurology*, 518 13, 2503–2524.
- Bartels, A., and Zeki S. (2000). The Neural Basis of Romantic Love. *NeuroReport*, 11, 17:3829-3834. Retrieved 27 March 2012.
- Bartlett, R., Collins, C., and Susan D. (2011). *Nicomachean Ethics*. Chicago: University of Chicago Press. ISBN 978-0-226-02674-9. (Translation, with Interpretive Essay, Notes, Glossary).
- Bass, A. H., and Ladich F. (2008). Vocal–acoustic communication: from neurons to behavior. In: Webb, J. F., A. N. Popper, and R. R. Fay, (Eds), *Fish Bioacoustics*, 253–278. Springer Science, New York.
- Batten, T. F. C., Moons, L., and Vandesande F. (1999). Innervation and control of the adenohypophysis by hypothalamic peptidergic neurons in teleost fishes: EM immunohistochemical evidence. *Microscopy Research and Technique*. 44 1, 19– 35. doi: 10.1002/(SICI)1097-0029(19990101)44:1<19::AID-JEMT4>3.0.CO;2-L.
- Bester-Meredith, J. K., Young, L. J. and Marler C. A. (1999). Species Differences in Paternal Behavior and Aggression in *Peromyscus* and Their Associations with Vasopressin Immunoreactivity and Receptors. *Hormones and Behavior*. 36 1, 25–38.
- Broadie, S. and Rowe C. (2002). *Aristotle Nicomachean Ethics: Translation, Introduction, and Commentary*. Oxford: Oxford University Press.
- Broglio, C., Rodriguez, F., Gomez, A., Arias, J. L. and Salas C. (2010). Selective involvement of the goldfish lateral pallium in spatial memory. *Behavioural Brain Research*, 210 2, 191–201.

- Broglio, C., A. Gomez, E. Duran, F. M. Ocana, F. Jimenez-Moya, F. Rodriguez, and Salas C. (2005). Hallmarks of a common forebrain vertebrate plan: specialized pallial areas for spatial, temporal and emotional memory in actinopterygian fish. *Brain Research Bulletin*, 66, 4-6, 277-281. doi: 10.1016/j.brainresbull.2005.03.021.
- Brown, C., and Laland K. (2008). Social learning in fishes. In: Brown C, K. Laland, and J. Krause, (Eds), *Fish Cognition and Behavior*. Blackwell Publishing, Oxford.
- Bshary, R. (2002). Biting cleaner fish use altruism to deceive image-scoring client reef fish. *Proceedings of Biological Sciences*, 269, 1505, 2087–2093. doi: 10.1098/rspb.2002.2084.
- Buller, D. J. (2005). Evolutionary psychology: the emperor's new paradigm. *Trends in Cognitive Sciences*. 9 6: 277-283.
- Campbell, L., and Ellis B. J. (2005). Commitment, Love, and Mate Retention. In: D. M. Buss, (Ed.), *The Handbook of Evolutionary Psychology*. 419-442. Wiley & Sons, New Jersey.
- Campos, V. F., Robaldo, R. B., Deschamps, J. C., Seixas, F. K., McBride, A. J. A., Marins, L. F., Okamoto, M., Sampaio, L. A., and Collares T. (2012). Neuropeptide Y gene expression around meal time in the Brazilian flounder *Paralichthys orbignyanus*. *Journal of Biosciences*, 37 2, 227–232. doi: 10.1007/s12038-012- 9205-7.
- Cerda-Reverter, J. M., and Canosa L. F. (2009). Neuroendocrine Systems of the Fish Brain. In: Bernier, N. J., G. Van Der Kraak, A. P. Farrell, and C. J. Brauner, (Eds), *Fish Neuroendocrinology-Fish Physiology Vol.28*, 3-74. Academic Press. nd
- Chretien M, Seidah, N. G., and Scherrer H. (1981). Endorphins: structure, roles and biogenesis. *Canadian Journal of Physiology and Pharmacology*, 59 5, 413-431.
- Cook, M. (2000). *The Koran: A Very Short Introduction*, Oxford University Press.
- Cortez ,V., Santana, M., Marques, A. P., Mota, A., Rosmaninho-Salgado, J. And Cavadas C. (2012). Regulation of catecholamine release in human adrenal Chromaffin cells by α -adrenoceptors. *Neurochemistry International*, 60, 4, 387- 393.
- Crisp, R. (2000). *Aristotle: Nicomachean Ethics*. Cambridge University Press. ISBN 0- 521-63221-8.
- Daniel, P. (2004). *Darwin's Fishes. An Encyclopedia of ichthyology, Ecology and Evolution*. Cambridge University Press.
- Desjardins, J. K., and Fernald R. D. (2009). Fish sex: why so diverse? *Current. Opinion in Neurobiology*, 19, 1–16, doi:10.1016/j.conb.2009.09.015.
- Dover, K. J. (2010). Eros and nomos (Plato, Symposium) *Bulletin of the Institute of Classical Studies*, 11, 1, 1-109. doi:10.1111/j.20415370.1964.tb00003.x.
- Dritsas, A., Pothoulaki, M., MacDonald, R. A. R., Flowers, P., and Cokkinos D. V. (2006) Effects of music listening on anxiety and mood profile in cardiac patients undergoing exercise testing. *European Journal of Cardiovascular Prevention and Rehabilitation*, Vol 13 (suppl 1):S76.
- Dudai, Y. (1994). *The Neurobiology of Memory. Concepts, Findings, Trends*. Oxford University Press. York.
- Dunbar, R. I. M. (2012). Bridging the bonding gap: the transition from primates to humans. *Philosophical Transactions of the Royal Society of London*, 367B, 1837-1846.
- Duffy-Hutcheon, P. (1995). Through a Glass Darkly: Freud's Concept of Love. In: D. Goicoechea, (Ed), *The Nature and Pursuit of Love: The Philosophy of Irving Singer* (Amherst, NY: Prometheus Books, 1995).
- Emanuele, E., Politi, P., Bianchi, M., Minoretti, P., Bertona, M., and Geroldi D. (2006). Raised plasma nerve growth factor levels associated with early-stage romantic love. *Psychoneuroendocrinology*, 31 3, 288-294.
- Evans, G. (2000). *Bernard of Clairvaux (Great Medieval Thinkers)*. Oxford University Press. ISBN 0-19-512525-8.
- Fisher, H. E., Aron, A., and Brown L. L. (2006). Romantic love: a mammalian brain system for mate choice. *Philosophical Transactions of the Royal Society of London B Biological Sciences*, 361 1476, 2173–2186.
- Fitch, W. T. (2005). The evolution of music in comparative perspective. In: *The Neurosciences and Music II. From Perception to Performance*. Avanzini, G, L. Lopez, S. Koelsch, and M. Majno, (Eds). *Annals of N.Y. Academy of Science*, 1060, 29-49.
- Flik, G. P., Klaren, H. M., Van den Burg, H. E., Metz, J. R., and Huising M. O. (2006). CRF and stress in fish. *General and Comparative Endocrinology*, 146, 36–44.
- Funkelstein L., Toneff, T., Mosier, C., Hwang, S. R., Beuschlein, F., Lichtenauer, U. D., Reinheckel, T., Peters, C., and Hook V. (2008). Major role of cathepsin L for producing the peptide hormones ACTH, beta-endorphin, and alpha-MSH, illustrated by protease gene knockout and expression. *Journal Biological Chemistry*, 283, 51, 35652-35659.
- Funkelstein, L., Beinfeld, M., Minokadeh, A., Zadina, J., and Hook V. (2010). Unique biological function of cathepsin L in secretory vesicles for biosynthesis of neuropeptides. *Neuropeptides*, 44, 6, 457-466.
- Gazzaniga, M. S. (1998). *The mind's mind. The regents of the University of California*. Published by arrangement with the University California Press.
- Gill, M. L. (2005). Aristotle's Metaphysics Reconsidered, *Journal of the History of Philosophy* 43, 223–251.

- Guevara-Fiore, P., Stapley, J., Krause, J., Ramnarine, I. W., and Watt P. J. (2010). Male mate-searching strategies and female cues: how do male guppies find receptive females? *Animal behavior*, 79 6, 1191-1197.
- Hamilton, W. D. (1964). The genetical evolution of social behavior. Parts I and II. *Journal of Theoretical Biology*, 7, 1-52.
- Hamilton, W. D. (1996). *Narrow Roads of Gene Land*. Oxford University Press; ISBN:0878931880.
- Harlow, H. (1958). The Nature of Love. *American Psychologist*, 13, 573-685.
- Haufe, C. (2007). Sexual selection and mate choice in evolutionary psychology. *Biology and Philosophy*, doi: 10.1007/s10539-007-9071-0 Springer Science+Business Media B.V. 2007.
- Holt, B. (2005). *Thirsty for God: A Brief History of Christian Spirituality* (2nd ed.).
- Huntingford, F. A., and Kadri S. (2008). Welfare and Fish. *General Fish Welfare*. In: Branson, E. (Ed), *Fish Welfare*. Blackwell Publishing.
- Inwood, B. (2001). *The Poem of Empedocles* (rev. Ed.). Toronto: University of Toronto Press. ISBN 0-8020-4820-X. ISBN 1-85399-482-0.
- Jamieson, B. G. M. (1991). *Fish Evolution and Systematics: Evidence from Spermatozoa*. Cambridge University Press.
- Kandel, E.R., Schwartz, J H., and Jessell T. M. (2000). *Principles of Neural Science*. McGraw-Hill. New York. ISBN 0-8385-7701-6.
- Kandel, E. R. (2007). In search of memory. *The Emergence of a New Science of Mind*. W. W. Norton.
- Lamberton, R. (1988). *Hesiod*, New Haven. Yale University Press, 1988. ISBN 0-300-04068-7. Chapter II. The Theogony.
- Le Page, Y., Diotel, N., Vaillant, C., E. Pellegrini, E., Anglade, I., Merot, Y., and Kah O. (2010). Aromatase, brain sexualisation and plasticity: the fish paradigm. *European Journal of Neuroscience*, 32 12, 2105-2115. doi: 10.1111/j.1460-9568.2010.07519.x.
- Lewis, T., Lannon, R., and Amini F. (2000). *A General Theory of Love*. Vintage Books USA. ISBN-0-307-424340,9780307424341. <http://www.thomaslewis.com/writing.html>. U.K., USA, Australia.
- Liu, Y., Lu, D., Zhang, Y., Li, S., Liu, X., and Lin H. (2010). The evolution of somatostatin in vertebrates. *Gene*, 463, 1-2, 21-28.
- MacCulloch, D. (2010). *Christianity: The First Three Thousand Years*. Published by Allen Lane.
- Malaspina, I. J. (Translator). (2001). *Homer. The Iliad*. University College. Nanaimo, B. C. Canada.
- Marenbon, J. (2010). *The Oxford Dictionary of the Middle Ages*. Robert E. Bjork, (Ed.), Oxford, England. Oxford University Press. ISBN 978-0-19-866262-4.
- Maruska, K. P., Levavi-Sivan, B., Biran, J., and Fernald R. D. (2011). Plasticity of the reproductive axis caused by social status change in an African cichlid fish: I. Pituitary gonadotropins. *Endocrinology*, 152 1, 281-290.
- Matthews, G. (2005). *Augustine*. Blackwell. ISBN 0-631-23348-2.
- Mayer, E. (1982). *The Growth of Biological Thought-Diversity, Evolution, and Inheritance*. The Belknap Press of Harvard University Press, Cambridge, Mass.
- McDermott, J. and Hauser M. D. (2005). The origins of music: Innateness, uniqueness, and evolution. *Music Perception*, 23, 29-59.
- Mews, C. (2001). *The Lost Love Letters of Heloise and Abelard: Perceptions of Dialogue in Twelfth-Century France*. St. Martin's Press. New York.
- Miller, G. F. (2000). Evolution of human music through sexual selection. In: Wallin, N. L., B. Merker, and S. Brown, (Eds.), *The origins of music*. MIT Press.
- Miller, G. F. (2001). *The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature*. Doubleday/Heinemann, 2000, 503 pp. ISBN: 0-434-00741-2.
- Mithen, S. (2007). *The singing Neanderthals-The origin of music, language, mind, and body*. Harvard University Press.
- Moreau, D. T. R., Conway, C., and Fleming I. A. (2011). Reproductive performance of alternative male phenotypes of growth hormone transgenic Atlantic salmon (*Salmo salar*). *Evolutionary Applications*, 4 6, 736-748. doi: 10.1111/j.1752-4571.2011.00196.x.
- Most, G. W. (Translator) (2007). *Hesiod: Volume I, Theogony. Works and Days. Testimonia*.
- Mueller, T., and Wullimann M.F. (2009). An evolutionary interpretation of teleostean forebrain anatomy. *Brain, Behavior and Evolution*, 74, 1, 30-42.
- Munakata, A., and Kobayashi M. (2010). Endocrine control of sexual behavior in teleost fish. *General and Comparative Endocrinology*, 165 3, 456-468.
- Naaman-Zauderer, N. (2010). *Descartes' Deontological Turn: Reason, Will and Virtue in the Later Writings*. Cambridge University Press. ISBN 978-0-521-76330-1.

- Northcutt, R. G. (2008). Forebrain evolution in bony fishes. *Brain Research Bulletin*, 75, 2-4, 191-205.
- Okasha, S. (2009). Biological Altruism. *The Stanford Encyclopedia of Philosophy*. Zalta, E. N. (Ed). URL = <<http://plato.stanford.edu/archives/win2009/entries/altruism-biological/>>.
- Ord, T. J., and Garcia-Porta J. (2012). Is sociality required for the evolution of communicative complexity? Evidence weighed against alternative hypotheses in diverse taxonomic groups. *Philosophical Transactions of the Royal Society B*, 316, 1811-1828.
- Papoutsoglou, S. E. (2010). The importance of fish neurohormonal response reared under recirculating water systems: A review. XVII World Congress of the International Commission of Agricultural Biosystems (CIGR). June 13-17. Canadian Society for Bioengineering Publications. Paper ID: CSBE 10033 (2010). Quebec City.
- Papoutsoglou, S. E. (2012a). The role of the brain in farmed fish. *Reviews in Aquaculture*. 4, 1-10.
- Papoutsoglou, S. E., N. Karakatsouli, N., Papoutsoglou, E. S., and Vasilikos G. (2010). Common carp (*Cyprinus carpio*) response to two music pieces (Eine Kleine Nachtmusik and Romanza) combined with light intensity using a recirculating water system. *Fish Physiology and Biochemistry*, 36, 539-554. doi: 10.1007/s10695-009-9324-8.
- Papoutsoglou, S. E. (2012b). *Textbook of Fish Endocrinology*. Nova Science Publishers, Inc. New York.
- Patterson, C. (1978). *Evolution*. Trustees of the British Museum (Natural history) Publication n.783. London.
- Platt, A. (Translator) (2007). *On the Generation of Animals by Aristotle* eBooks@Adelaide 2007.
- Pottinger, T. G. (2007). Stress response in fish—mechanisms, effects and measurement. *General fish welfare*. In: Branson E. (Ed.) *Fish Welfare*, 32–48. Blackwell Publishing, Oxford.
- Rainey, D. (2010). *Confucius & Confucianism: The essentials*. Oxford. Wiley- Blackwell. ISBN 9781405188418.
- Riegel, J. (2012). "Confucius". *The Stanford Encyclopedia of Philosophy*. Stanford University. <http://plato.stanford.edu/archives/spr2012/entries/confucius>.
- Robinson, P. (2009). St. Francis of Assisi. In: *The Catholic Encyclopedia*. New York: Robert Appleton Company. Retrieved on: 2011-10-17 from New Advent.
- Rocha, M. J., and Rocha E. (2006). Aspects of Reproduction from Synchronous to Asynchronous Fishes-An Overview. In: Reinecke M, Zaccane G, Kapoor B. G. (Eds.) *Fish Endocrinology*, 1, 571-624. Science Publishers.
- Salas, C., Broglio, C., Duran, E., Gomez, A., Ocana, F. M., Jimenez-Moya, F. And Rodriguez F. (2006). Neuropsychology of learning and memory in teleost fish. *Zebrafish*, 3 2, 157–171.
- Sandroni, P. (2001). Aphrodisiacs past and present: a historical review. *Clinical Autonomic Research*, 11 5, 303–307. DOI:10.1007/BF02332975. PMID 11758796.
- Shepherd, G. M. (1988). *Neurobiology*. Oxford University Press, Inc.
- Shields, C. (2007). *Aristotle*. (Routledge Philosophers). London: Routledge, 2007.
- Shields, C. (2008). *The Oxford Handbook on Aristotle*. Oxford University Press.
- Slater, L. (2009). True Love, *National Geographic Magazine* 2006 Retrieved 22 May 2009.
- Stark, O. and Wang Y. Q. (2004). On the evolutionary edge of altruism: a game- theoretic proof of Hamilton's rule for a simple case of siblings. *Journal of Evolutionary Economics*, 14, 37-42. doi: 10.1007/s00191-003-0168-6.
- Stoddard, K. (2003). The Programmatic Message of the "Kings and Singers" Passage: Hesiod, 'Theogony'. *Transactions of the American Philological Association*.
- Taylor, C. (2006). *Nicomachean Ethics, Books II-IV*, Translated with an introduction and commentary, Oxford: Oxford University Press.
- White, H G. E. (1914). *The Theogony of Hesiod*. Translation H.G. Evelyn White.
- Williams, G. (2003). *Handbook of Hindu mythology*. ABC-Clio Inc. ISBN 1-57607- 106-5. <http://books.google.com/books?id=SzLTWow0EgwC&>).
- Wilson, E. (2007). *The death of Socrates*. Profile Books London.
- Witte, K. (2006). Learning and Mate Choice. In; *Fish Cognition and Behavior*. Brown, C., K. Laland, and J. Krause, (Eds.).
- Wright, M. R. (1995). *Empedocles: The Extant Fragments*. London: Bristol Classical Press.
- Young, S. N., and Leyton M. (2002) The role of serotonin in human mood and social interaction. Insight from altered tryptophan levels. *Pharmacology Biochemistry and Behavior*, 714, 857-865.
- Zeki, S. (2007). The neurobiology of love by S. Zeki In: *FEBS Lett*. 581. 14. 2575-2579.
- Zohar, Y., Munoz-Cueto, J. A., Elizur, A. and Kah O. (2010). Neuroendocrinology of reproduction in teleost fish. *General and Comparative Endocrinology*, 165, 3, 438– 455.