African Journal of
Biochemistry and Molecular Biology Research

ISSN : 0000-0000
Index: Harvard, Boston, Sydney University, Dimensions, Lens, ResearchGet Scilit, Semantic, Google Scholar, Base etc

https://doi.org/10.58578/AJBMBR.v1i1.3355

REVIEW: THE BIOCHEMISTRY OF LOVE AND LOVING

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Article Info:

Submitted:	Revised:	Accepted:	Published:
Jun 22, 2024	Jul 9, 2024	Jul 12, 2024	Jul 15, 2024

Abstract

Human love is more complex than simple feedback mechanisms. Love create its own reality. The biology of love originates in primitive parts of the brain; the emotional core the human nervous system, that evolved long before the cerebral cortex. The brain of human 'in love' is flooded with sensations, often transmitted by the vagus nerve, creating much of what we experience as emotion. The modern cortex struggles to interpret the primal messages of love, and weaves a narrative around incoming visceral experiences, potentially reacting to that narrative rather than reality. The four functions of love include; Romantic love (erotic) love, Friendly love or Platonic love (Philia), Familial love (Storge) and Unconditional love (Agape). Glutamate is an excitatory neurotransmitter released by the nerve cell. It's mostly referred to as the master switch of the brain. Lust: Characterized by a strong desire for sexual gratification and is primarily driven by testosterone and oestrogen. Attraction: This stage involves intense romantic and sexual feelings, associated with dopamine, norepinephrine, and serotonin. Attachment: The final stage, involving long-term commitment and bonding, is influenced by oxytocin and vasopressin. The hypothalamus of the brain plays a big role in stimulating the production of sex hormones testosterones and oestrogen from the testes and

ovaries. These chemicals are often stereotyped as being 'male' and 'female' respectively, both plays a role in men and women. Males produce forty to sixty times more of the testosterones. Testosterones increases the libido in male and female. The effect is less pronounced with oestrogen, but some woman report being more sexually motivated around the time the ovulate, when oestrogen levels are highest. Conclusions: Love is a complex neurobiological phenomenon, relying on trust and belief as well as brain reward activity,

Keywords: Biochemistry, Love, Neurotransmitter, Dopamine, Norepinephrine, and Serotonin

INTRODUCTION

Firstly, love can be said to be a quality or feeling of strong or constant affection for and dedication to another. It's also a set of emotions, behaviours and beliefs with strong feelings of affection. (Ingham et.al, 2008).

Love is an intangible feeling that makes us vulnerable to danger, pain and suffering, however love is the foundation of friendship; it brings us together and promotes cooperation. Love is a powerful emotion which suits every person differently whether love is between family, friends or lovers. It's an overwhelming emotion that can be experienced in different ways, people experience love for the first time by being part of the family.

A close-knit loving bond between two people can begin with a friendship, whether it is a friendship between two males, two females, or one male and one female, these friendships will develop into love.

Romantic love is a love that not every person will experience, it is a type of love that is not there at the beginning, but it grows within the individual. When one finds the love, they have been looking for, one cannot imagine life with anyone else (Zhu et.al., 2015).

Love is deeply biological .it pervades every aspect of our lives and has inspired countless works of art and several lives. love also has a profound effect on our mental and physical state. (Woodward et.al, 2011).

Love is clearly not 'just' an emotion; it is a biological process that is both dynamic and bidirectional in several dimensions.

Human love is more complex than simple feedback mechanisms. Love create its own reality. The biology of love originates in primitive parts of the brain; the emotional core the

human nervous system, that evolved long before the cerebral cortex. The brain of human 'in love' is flooded with sensations, often transmitted by the vagus nerve, creating much of what we experience as emotion. The modern cortex struggles to interpret the primal messages of love, and weaves a narrative around incoming visceral experiences, potentially reacting to that narrative rather than reality (McManamy, 2008).

It also helpful to realize that human social behaviour is supported by biological components that were co-opted over the course of human evolution eventually allowing lasting relationships between adults.

The biochemistry of love can be defined as the process in which high level of Dopamine and a related hormone, Norepinephrine, are released during attraction. The biochemistry of love has some element that repeatedly features in loving process is the Neuropeptide Oxytocin. These chemicals make us giddy, energetic, and even leading to loss of appetite and insomnia.

The equation below explains the biochemical process of love;

Testosterone + Estrogen + Dopamine + Norepinephrine + Serotonin + Oxytocin + Pheromones + Vasopressin = LOVE (Boadu A et al.,2016)

WHAT IS LOVE

Love encompasses a range of strong and positive emotional and mental states, from the most sublime virtue or good habit, the deepest interpersonal affection, to the simplest pleasure. An example of this range of meanings is that the love of a mother differs from the love of a spouse, which differs from the love of food. Most commonly, love refers to a feeling of a strong attraction and emotional attachment.

Love is considered to be both positive and negative, with its virtue representing human kindness, compassion and affection, as "the unselfish loyal and benevolent concern for the good of another" and its vice representing human moral flaws.

The colour wheel theory of love defines three primary, three secondary and nice tertiary love styles, describing them in terms of the traditional colour wheel. The triangular theory of love suggests "intimacy, passion and commitment" are core components of love. Love has additional religious or spiritual meaning. This diversity of uses and meanings combined

with the complexity of the feelings involved makes love unusually difficult to consistently define, compared to other emotional states.

Attachment, commitment, intimacy, passion, grief upon separation, and jealousy are but a few of the emotionally-loaded terms used to describe that which love represents. In science, however, love appears to be a hypothetical and multi-dimensional construct with many interpretations and implications.

Love and its various emotional states and behaviours are rarely investigated by scientific means. In part, this may be due to the fact that love has always been the domain of poets and artists, maybe psychologists and clinicians, but has certainly not been considered to be right within the scope of common experimental science, i.e., neurobiology research. Emotions and feelings such as attachment, couple and parental bonding, and even love – presumably typical of higher mammals and neglected for centuries by the experimental sciences – have now come into the focus of neuroscientific research in order to elucidate their biological mechanisms and pathways. Thus, knowledge on the neurobiology of love has yet to evolve, and only recently, exciting research has brought to surface detailed information on molecular and physiological "ingredients" of the love phenomenon, as described later on. The concept of love involves having an emotional bond to someone for whom one yearns, as well as having sensory stimulation that one desires. The word "love," however, derives etymologically from words meaning "desire," "yearning" and "satisfaction" and shares a common root with "libido". Thus, the psychological sense of love can be interpreted as referring to the satisfaction of a yearning, which may be associated with the obtaining of certain sensory stimulation. Love therefore possesses a close connection not only with reward and pleasure phenomena, but also with appetitive and addictive behaviours. Naturally rewarding activities like love boost a flood of stimulating signalling molecules. However, this stimulation may not be as strong or enduring as that achievable by addictive drugs – natural rewards may not, like some artificial drugs, completely surpass normal physiology. The distinction between natural and artificial rewards can also be made by the build-up of appetence. Natural rewards, i.e., pleasurable experiences like eating or sex, usually depend on a preceding build-up of appetence (e.g., sexual desire) to fully develop their pleasure potential. Thus, love can be viewed as a dynamic process that represents the result of different components probably sub served by distinct neural substrates at different times. As such, some steps can be

identified, e.g., its beginning ("falling in love"), which is the process of attraction, followed by the attachment process that, in some cases, can last forever. Selective social attachments and the propensity to develop social bonds are necessary features of the love concept.

Importance of Love

Love is a source of motivation and strength. It reforms bad character, improves one's self-worth and esteem and it builds trust among people. Love also creates a healthy working environment and strengthens family ties. One of the most important parts of a relationship is to trust one another completely. You have to be able to trust that they won't stray and you trust them with your feelings. You have to trust each other enough to be vulnerable on an emotional and physical level too.

Why Love is the Most Important Value

When we value love, not only are we willing to sacrifice for others and support them through thick and thin, but we also realize there's nothing wrong with being vulnerable. Those bonds are unique; society tends to associate with family.

The Four Functions of Love

The four functions of love include; Romantic love (erotic) love, Friendly love or Platonic love (Philia), Familial love (Storge) and Unconditional love (Agape).

1.Romantic love/Eros (erotic): Eroticism is a quality that causes sexual feelings, as well as a philosophical contemplation concerning the aesthetics of sexual desire, sensuality and romantic love.

2.Friendly love/Platonic love (Philia): it can also be called "affectionate love" and this is said to be the love without romantic attraction and occurs between friends or family members. It occurs when both people share the same values and respect each other – its commonly referred to as "brotherly love".

3.Familial love (Storge): this can be said to be the natural or instinctual affection, such as the love of a parent towards offspring and vice versa.

4.Unconditional love/Agape: In Christianity, agape is "the highest form of love, charity" and "the love of God for man and of man for God". This is widely referred to as the love of mankind and humanity.

GLUTAMATE AS A LOVE NEUROTRANSMITTER

Glutamate is an excitatory neurotransmitter released by the nerve cell. It's mostly referred to as the master switch of the brain.

It is the precursor of Gramma-aminobutyric Acid (GABA), They are produced in by the nerve cells and stored in walls of vesicles called the Synaptic vesicles. It plays a major role in regulating activity of dopamine neurons. The glutamate release in brain and excitatory influences and enhance dopamine release. McCutcheon (2015).

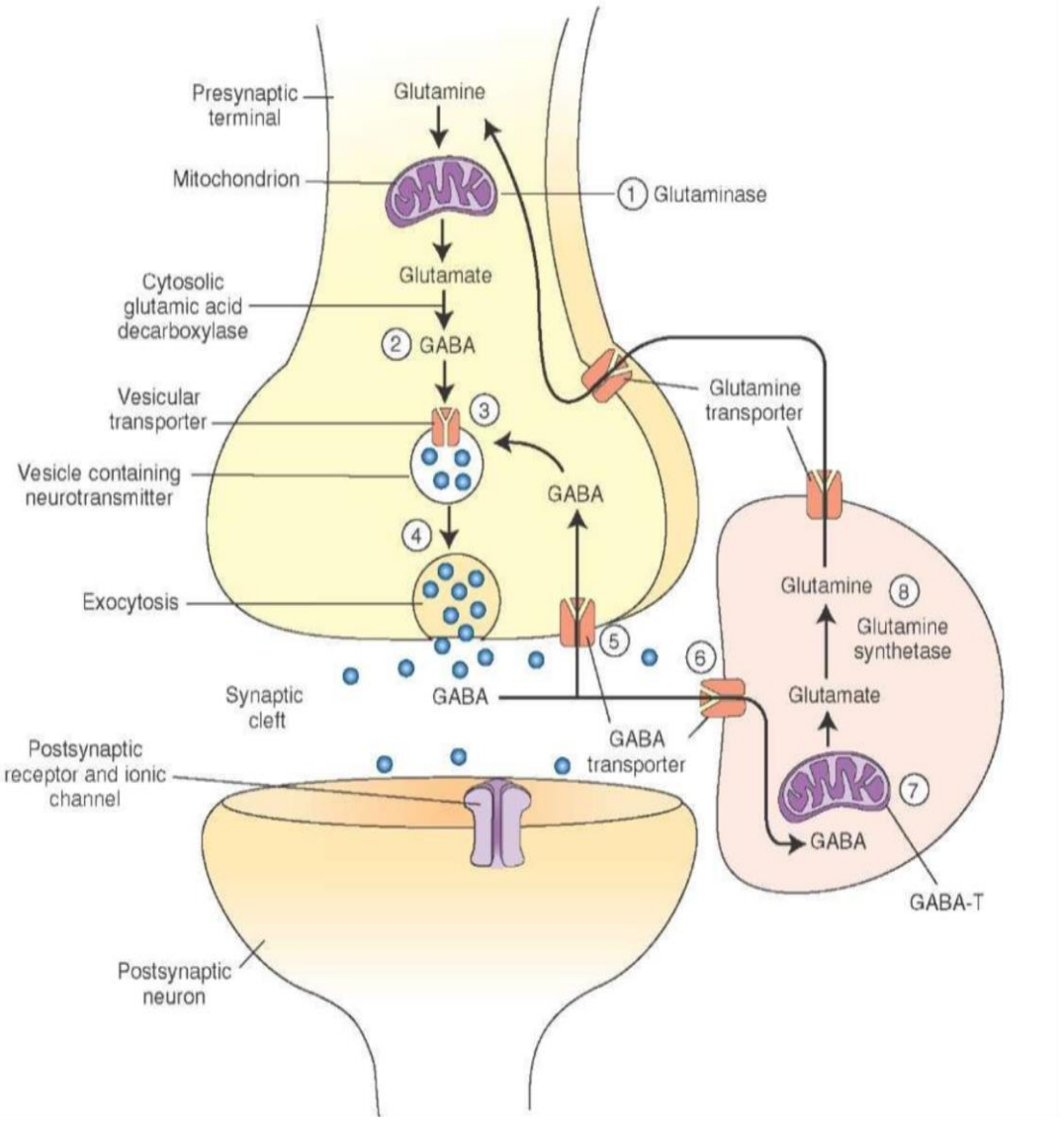

Figure 1: The pathway of glutamate

Testosterones and Estrogens

The hypothalamus of the brain plays a big role in stimulating the production of sex hormones testosterones and oestrogen from the testes and ovaries. These chemicals are often stereotyped as being 'male' and 'female' respectively, both plays a role in men and women. Males produce forty to sixty times more of the testosterones. Testosterones increases the libido in male and female. The effect is less pronounced with oestrogen, but some woman report being more sexually motivated around the time the ovulate, when oestrogen levels are highest.

Testosterone: is a steroidal hormone, with cholesterol as the pre-cursor, it is found in both male and female which is vital to the health and well-being as well as sexual function, it is also a steroid sex hormone with an important role in the physiology in both sexes. It is involved in the development of morphological and functional parameters of the body via multiple molecular mechanisms. Intensive research focused on testosterone reveals associations with cognitive abilities and behaviour and its causative role in sex differences in cognition. Testosterone modulates brain structure and the differentiation of neurons during intrauterine development with profound effects on brain functions during postnatal life. In this review we summarize the effects of testosterone on brain physiology and cognition with respect to the underlying molecular mechanisms. (Feldman et al., 2012)

Estrogen: the hormone estrogen is involved in both female and male reproduction, as well as numerous other biological systems including the neuroendocrine, vascular, skeletal and immune systems. Therefore, is it also implicated in many different diseases and conditions such as infertility, obesity, osteoporosis, endometriosis and a variety of cancers. Oestrogen is a well-known female steroid hormone synthesized from the ovary that controls the oestrous or menstrual cycle in females, therefore oestrogen is imperative for female reproduction. Oestrogen is not only important in female reproduction but also in male reproduction and in numerous other systems including the neuroendocrine, skeletal and immune systems in males and females. Along with the influence of oestrogen of many physiological processes, it is also implicated in many different diseases including, obesity, metabolic disorder, cancer, osteoporosis, endometriosis and fibroids. (Wang, 2009)

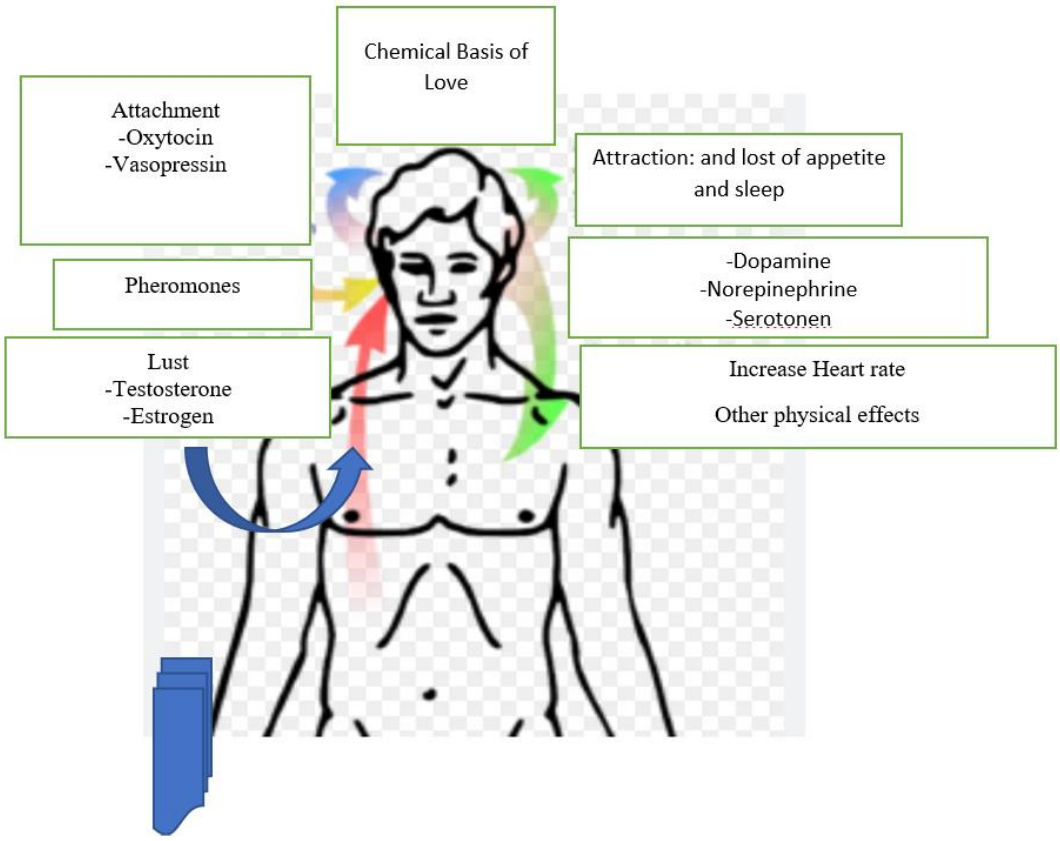

Figure 2: The biochemical stages of love

Stages of Love

Lust: Characterized by a strong desire for sexual gratification and is primarily driven by testosterone and oestrogen.

Attraction: This stage involves intense romantic and sexual feelings, associated with dopamine, norepinephrine, and serotonin.

Attachment: The final stage, involving long-term commitment and bonding, is influenced by oxytocin and vasopressin (Vijay, 2013)

Oxytocin as a Love Hormone

Oxytocin is a peptide hormone and neuropeptide normally produced in the hypothalamus and released by the posterior pituitary. Oxytocin is present in animals since early stages of evolution, in humans it plays a vital role in behaviour that include social bonding, love, reproduction, childbirth and the period after the childbirth. (Fisher 2006). Oxytocin is

released into the bloodstream as a hormone is response to sexual activity and during labour. It is also available in pharmaceutical form, in either form, oxytocin stimulates uterine contractions to speed up the process of childbirth. In its natural form, it also plays a role in bonding with the baby and milk production. Production and secretion of oxytocin is controlled by a positive feedback mechanism, where its initial release stimulates production and release of more oxytocin and an increase in the intensity and frequency of contractions. This process compounds in intensity and frequency and continues until the triggering activity ceases. A similar process takes place during lactation and during sexual activity. Feldman (2012)

Pheromone as a Love Hormone

This hormone is a secreted or excreted chemical factor that triggers a social response in members of the same species. Pheromones are chemicals capable of acting like pheromones outside the body of the secreting individual, to affect the behaviour of the receiving individuals. There are alarm pheromones, food trail pheromones (in the case of ants), sex pheromones and many others that affect behaviour or physiology. Pheromones are used by many organisms, from basic unicellular prokaryotes to complex multicellular eukaryotes, their use among insects has been particularly well documented. In addition, some vertebrates, plants and ciliates communicate by using pheromones. The ecological functions and evolution of pheromones are a major topic of research in the field of chemical ecology. (Karelina et al., 2011)

Alarm pheromone: alarm pheromones are chemical substances that are synthesized and released in response to predators to reduce predation risk. Alarm pheromones can also be perceived by predators, who take advantage of alarm cues to locate prey.

Trail pheromone: these are semio-chemicals secreted from the body of an individual to affect the behaviour of another individual receiving it. Trail pheromones often serve as a multipurpose chemical secretion that leads members of its own species towards a food source, while representing a territorial mark in the form of an allomone to organisms outside of their species. Specifically, trail pheromones are often incorporated with secretions of more than one exocrine gland to produce a higher degree of specificity. Considered one of the primary chemical signalling methods in which many social insects depend on, trail pheromone deposition can be considered one of the main facets to explain

the success of social insect communication today. Many species of ants, including those in the genus Crematogaster use trail pheromones.

Sex pheromone: sex pheromones are defined as odours, produced by either males or females that stimulate one or more behavioural reactions in the opposite sex, bringing the males and females together for the purpose of mating. In the blue crab, C. sapidus, these chemical signals are present in the pre and post pubertal molt females, inciting courtship and mate-carrying behaviour in males Gleeson et al., (1991).

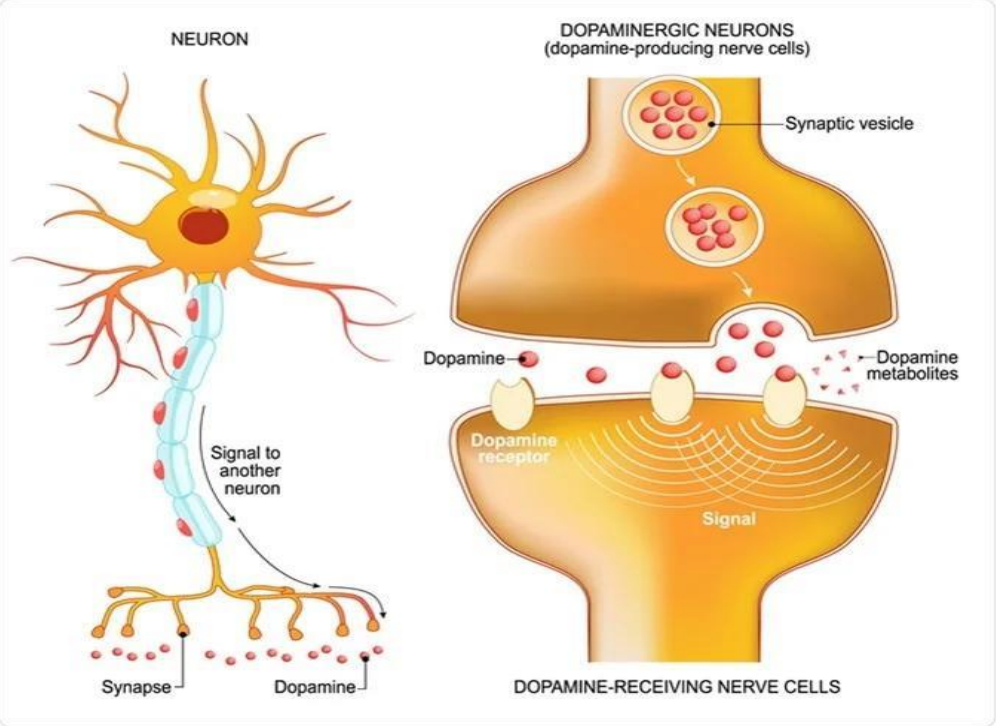

Figure 3: Generation of dopamine from neuron.

Dopamine as a Love Hormone

Dopamine (DA, a contraction of 3,4-dihydroxyphenethylamine) is a neuromodulatory molecule that plays several important roles in cell. It is an organic chemical of the catecholamine and phenethylamine families. Dopamine constitutes about 80% of the catecholamine content in the brain. It is an amine synthesized by removing a carboxyl group from a molecule of its precursor chemical, L-DOPA, which is synthesized in the brain and kidneys. Dopamine is also synthesized in plants and most animals. In the brain, dopamine functions as a neurotransmitter – a chemical released by neurons (nerve cells) send signals to other nerve cells. Neurotransmitter are synthesized in specific regions of the brain, but affect many regions systematically. The brain includes several distinct dopamine

pathways, one of which plays a major role in the motivational component of reward-motivated behaviour. The anticipation of the most types of rewards increases the level of dopamine in the brain and addictive drugs increase dopamine release or block its reuptake into neurons following release. Other brain dopamine pathways are involved in motor control and in controlling the release of various hormones. These pathways and cell groups form a dopamine system which is neuromodulatory. (Millor ,2011)

In popular culture and media, dopamine is often portrayed as the main chemical of pleasure but the current opinion in pharmacology is that dopamine instead confers motivational salience; in other words, dopamine signals the perceived motivational prominence (i.e., the desirability or aversiveness) of an outcome, which is turn propels the organism's behaviour toward or away from achieving that outcome. (Brown, 2023)

Outside the central nervous system, dopamine functions primarily as a local paracrine messenger. In blood vessels, it inhibits norepinephrine release and acts as a vasodilator (at normal concentrations); in the kidneys, it increases sodium excretion and urine output; in the pancreas, it reduces insulin production; in the digestive system, it reduces gastrointestinal motility and protects intestinal mucosa; and in the immune system, it reduces the activity sof lymphocytes. With the exception of the blood vessels, dopamine in each of these peripheral systems is synthesized locally and exerts its effects near the cells that release it. This hormone is released mostly when an individual sight the person he/she loves dearly.

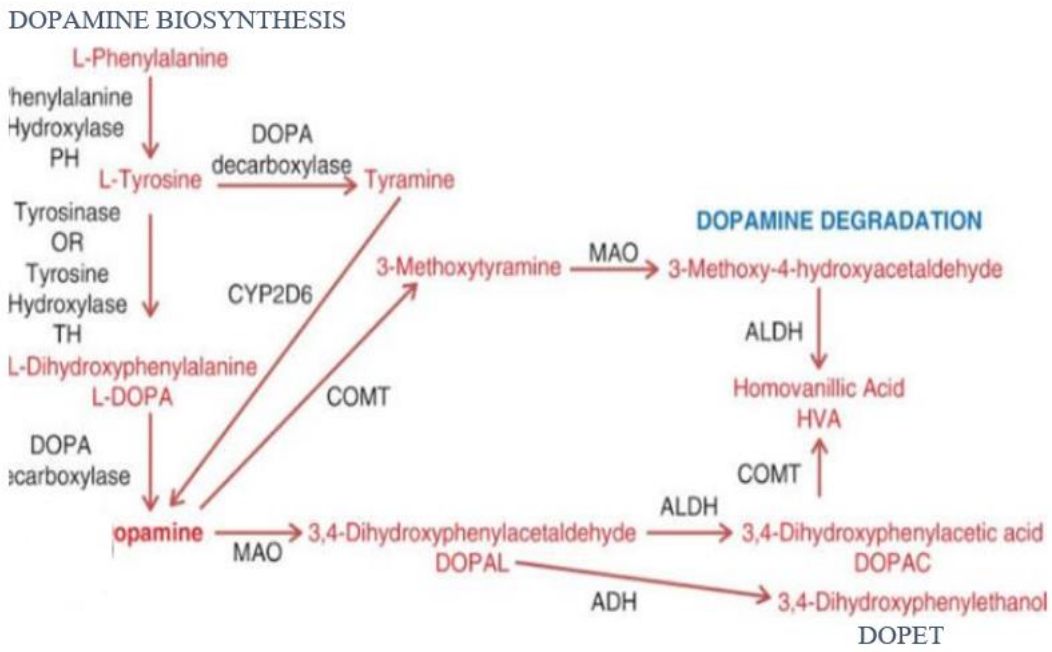

Figure 4: Biosynthesis of Dopamine

Norepinephrine as a Love Hormone

Norepinephrine is also known as noradrenaline, it is both a neurotransmitter and a hormone. It plays an important role in your body's "fight-or-flight" response. High levels of dopamine and a related hormone, norepinephrine are released during attraction. These chemicals make us giddy, energetic, and euphoric, even leading to decreased appetite and insomnia – which means you actually can be so "in love" that you can't eat and can't sleep. (Jennifer F. 2021).

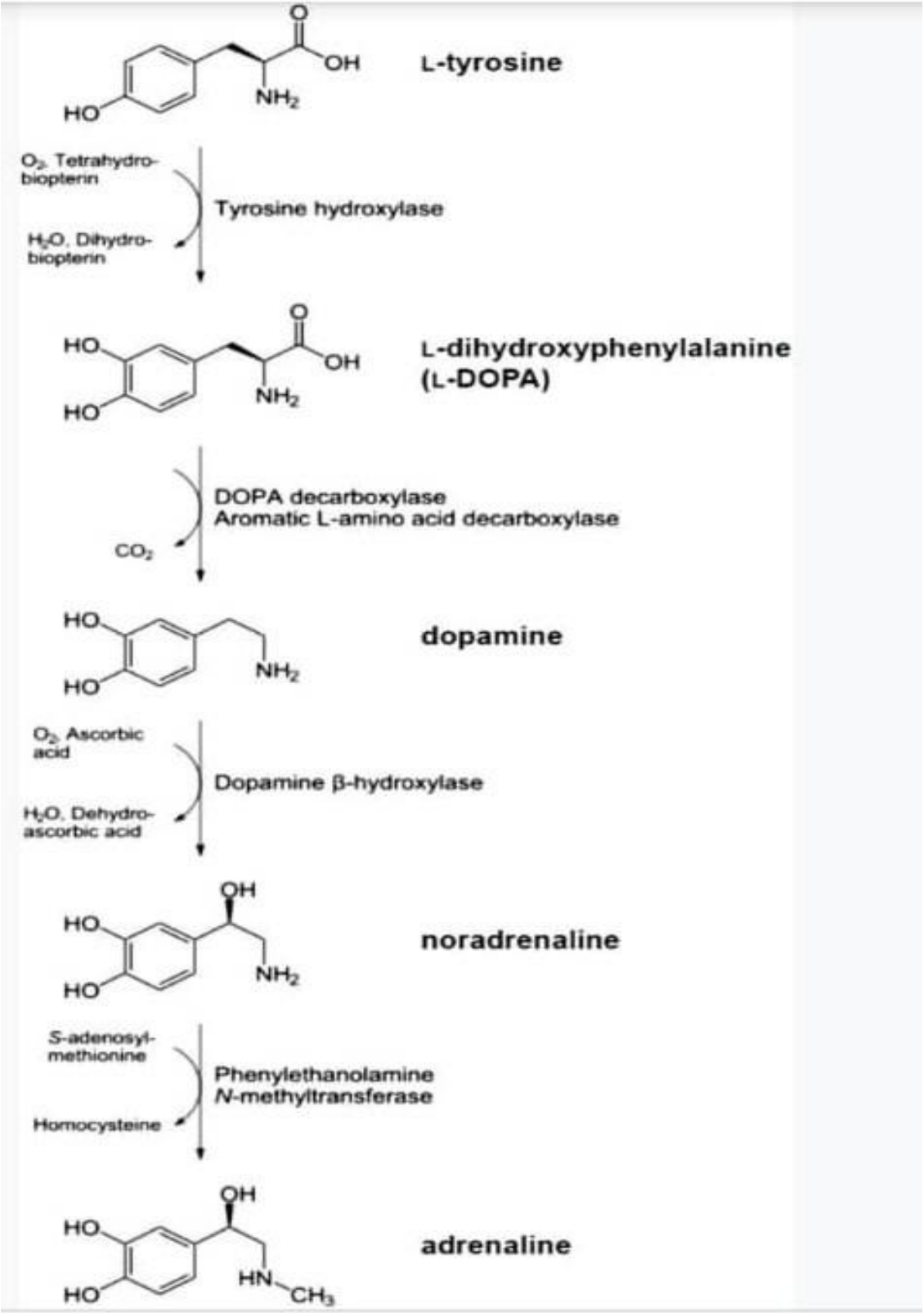

Figure 5: Biosynthesis of adrenaline.

Serotonin as a Love Hormone

Love affects serotonin, a neurotransmitter primarily responsible for regulating behavior and mood. Interestingly, love's impact on serotonin largely depends on gender. For men, serotonin levels decrease in response to romantic relationships, which women experience a significant increase in serotonin (Jerome M .2011). Serotonin is an indoleamine molecule that functions as a neurotransmitter.it is produced in the raphenuclei of the midbrain and modulates various functions (Vijay k. 2013).

Vasopressin as a Love Hormone

Vasopressin is another hormone that is involved in romantic love. (McGinn et al., 2017) reported that the interaction between oxytocin and vasopressin is necessary for certain complex behaviours, including parenting, social bonding and sexual attraction and behaviour.

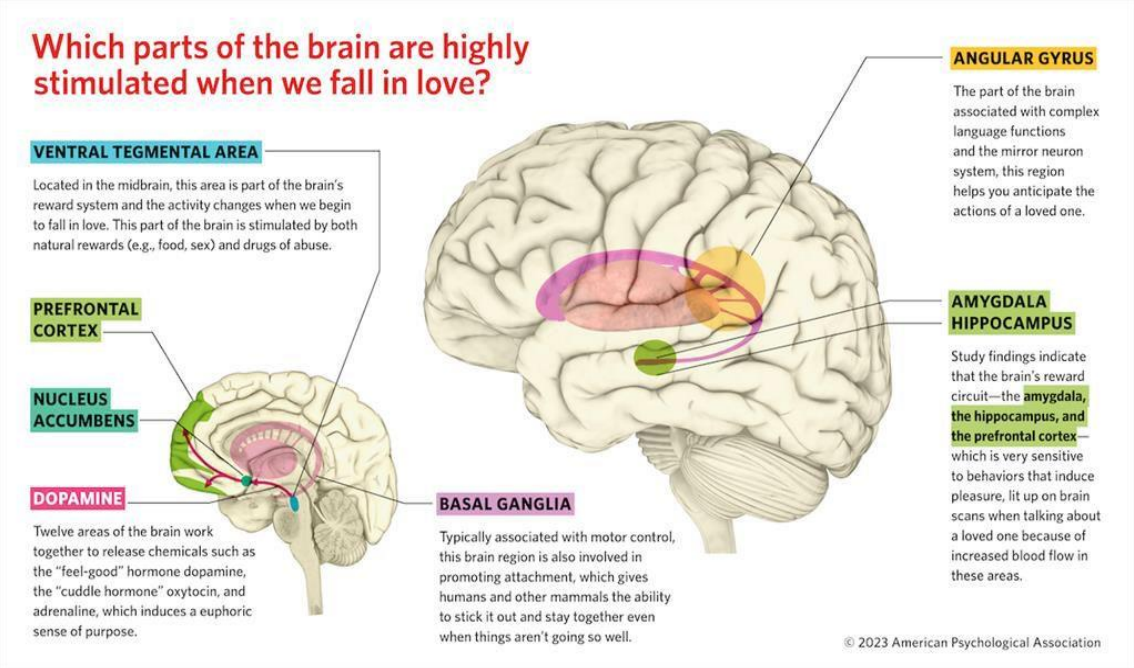

Figure 6: The biochemical processes of love.

CONCLUSION

Love is a complex neurobiological phenomenon, relying on trust and belief as well as brain reward activity, i.e., limbic processes. These processes critically involve oxytocin, vasopressin, dopamine, and serotoninergic signalling. Moreover, endorphin and

endogenous morphinergic mechanisms, coupled to nitric oxide auto regulatory pathways, play a role. Naturally rewarding or pleasurable activities are necessary for survival and appetitive motivation, usually governing beneficial biological behaviours like eating, sex, and reproduction. h us, love and its rewarding pleasure are much needed. Love and social bonding employ a push-pull mechanism that activates reward and motivation pathways. Simultaneously, brain circuits that facilitate critical social assessment and negative emotions, as well as physical and mental stress, or "cognitive dwelling" (i.e., 'cognitive constipation'), get down regulated. This down regulating property of love may also include further physiological phenomena. However, early phases of love, such as falling in love and its related arousal and more pronounced behaviours and molecular signalling activities, are distinct from later stages or even long-lasting relationships. Nonetheless, a broad basis of common signalling and beneficial neurobiological features exist with connection to the love concept, thereby combining physiological aspects related to maternal, romantic or sexual love, and attachment, with other healthy activities and neurobiological states. Medicine can make use of this concept, i.e., mind/body or integrative medicine. Many questions remain open. For example, would acute exposure to oxytocin promote a search for social contact, while chronic exposure might trigger social satiety or safety and reduce social motivation? What about the other signalling pathways and neuropeptides? We attempted to answer some of these questions on possible solutions for related medical problems or applications. Undoubtedly, love, pleasure and lust, have a stress-reducing and health-promoting potential.

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