

# **The Biochemistry of Attraction**

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## **Abstract**

The biochemistry of attraction is complex and multifaceted; it is affected by specific neurological pathways, neurotransmitters, hormones, and fertility levels, as well as influenced by olfaction. This paper reviews different aspects of attraction, including the neurology and biochemistry driving humans to seek love. Love is a motivation that helps facilitate mate choice. Research into love distinctions, dopaminergic reward pathways, and neurotransmitters have provided clear evidence that romantic love specifically uses multiple neural systems and is a biological process. Olfaction is another critical component of human attraction and love. Differences in scent and the major histocompatibility complex (MHC) strongly influence the mate selection of humans. Human leukocyte antigen (HLA) links between females and their parents have also been strongly linked to the influences of the MHC. Additionally, the use of perfumes by humans is also directly linked to amplification of their own MHC-related body odors. Fertility levels of women also affect mate attraction and scent preferences. Research on pheromones in humans has been limited, but research on secretions from Montgomery's glands shows the potential to identify a human pheromone.

## **Keywords**

attraction, biochemistry, human leukocyte antigen (HLA), olfaction, major histocompatibility complex (MHC)

## Introduction

Love affects all human beings, but how are humans drawn to love? Why do humans love? Research has shown that human romantic love is universal; it is a cross-cultural phenomenon (Aron et al., 2005; Fisher et al., 2006; Jankowiak & Fischer, 1992; Seshadri, 2016). Love is biological and our bodies physically pursue it (Carter & Porges, 2012). Humans have evolved to have long-lasting relationships, and without them, humans would fail to thrive (Carter & Porges, 2012). If love is known to be a multi-cultural, universal experience in humans, then what is the neuroscience behind the drive that pushes humans to seek love? The biochemistry of attraction and love is complex and includes specific neural pathways, neurotransmitters, and olfaction. Human pheromones are another area with huge potential to affect attraction and love.

Love biologically originates in the primitive area of the brain, which is the emotional core of the human nervous system (Carter & Porges, 2012). The modern cerebral cortex receives this information, the primal messages of love, via the vagus nerve and then interprets it (Carter & Porges, 2012). Some researchers argue that romantic love is not an emotion, but rather a motivation and drive that has evolved to govern reproduction in humans (Aron et al., 2005; Fisher et al., 2005; Fisher et al., 2006). Love is comprised of three specific components: lust, attraction, and attachment. A developed form of attraction, early-stage romantic love, is separate from lust (i.e., the sex drive) and likely a highly developed form of courtship among humans (Aron et al., 2005; Fisher et al., 2005). Romantic attraction is a neural mechanism in humans that plays a key role in directing humans to focus their energy for courtship on courting others to find a suitable mate. This helps conserve metabolic energy as well as time, which in turn helps facilitate human mate choice (Fisher et al., 2006). This primary brain system may have evolved to direct reproduction: lust motivates humans to look for mates, attraction motivates humans to pursue specific mates, and attachment motivates humans to be with their partners long enough to raise children. This means romantic love is a unique drive and motivation that evolved to stimulate mate choice, thereby conserving courtship energy and time (Aron et al., 2005; Fisher et al., 2005).

## Dopaminergic Award Pathways

Romantic love activates specific brain pathways. Evidence has shown that dopaminergic reward pathways in the brain are associated with the behavioral *attraction system* along with mate choice in mammals (Fisher et al., 2006). A developed form of this attraction system has been proposed to be intense romantic love, which is a cross-cultural universal need in humans (Fisher et al., 2006). Functional Magnetic Resonance Imaging (fMRI) has shown that early-stage romantic love uses specific neural systems – specifically those associated with reward and motivation, such as the subcortical regions including the ventral tegmental area and ventral striatum/nucleus accumbens (Aron et al., 2005). Other goal and reward systems were also found to be used, such as the anterior caudate nucleus. These systems all converge onto regions of the caudate (Aron et al., 2005). Bartels and Zeki (2000) performed a similar study, but it focused on participants in longer-term relationships. Both studies suggest that cortical regions, caudate localization, and the ventral tegmental area are critical components in romantic love (Aron et al., 2005; Bartels & Zeki, 2000).

Fisher et al. (2005) examined 17 people who were in this intense, early stage of romantic love and found activation in the brainstem right ventral tegmental area and right postero-dorsal body of the caudate nucleus. Greater activation in the right anteromedial caudate body was shown in participants who reported higher levels of romantic love ( $r = 0.60, p = 0.012$ ) (Fisher et al., 2005). Individuals in love for longer time periods showed more cortical, ventral tegmental area, and caudate localization, which further suggests these regions are critical in romantic love (Aron et al., 2005). The left mid-insular cortex (a region similar to where Bartels and Zeki (2000) reported activation) was correlated with the affect intensity measure (AIM) scores of participants ( $r = 0.58; p < 0.01$ ), showing this region to be stimulated by how strongly in general the participants experience affect (Aron et al., 2005). Regional effects were related to the number of months a participant reported being in love, including a correlation with several limbic cortical regions (Aron et al., 2005). Results of this study suggest that early-stage romantic love is

not a specific emotion, but a motivation that leads to emotions, such as anxiety or euphoria (Aron et al., 2005).

## **Neurotransmitters**

Love is a biological process (Carter & Porges, 2012). In addition to activation of subcortical dopaminergic pathways, neurotransmitters, including glutamate, are also likely involved because of their role in the release of dopamine, and norepinephrine may be associated with courtship attraction (Fisher et al., 2006). The intertwined components of lust, attachment, and attraction are also separate systems. Each process has its own circuits and neurotransmitters that mediate it. Lust is centered around the amygdala and is mediated by testosterone and estrogen, whereas attraction is focused around the nucleus accumbens and the ventral tegmental area and is moderated by dopamine, norepinephrine, and cortisol. Attachment behaviors are connected to pleasure pathways involving hippocampal mechanisms (Fisher et al., 2006). Sex hormones also play a role in attraction. For instance, men with high levels of testosterone are more attracted to more feminine women, further demonstrating the range of neurotransmitters that affect attraction and love (Welling et al., 2008).

Vasopressin, oxytocin, and dopamine are important neurotransmitters in regulating social behavior in terms of sexual behavior, aggression, and parental care (Seshadri, 2016). Oxytocin acts with other neurochemicals such as opioids, dopamine, and, of particular importance to social bonding, vasopressin, and is found repeatedly in the biochemistry of love and attraction (Carter & Porges, 2012). For instance, from the process of birth to milk production to the formation of a lasting bond between mother and child, oxytocin is a central component in the love and reproduction of humans (Carter & Porges, 2012). Oxytocin is important in love and bonding in all adults, not just women; it has even been suggested that oxytocin is released in an adult simply by being in the presence of an infant. The body also uses oxytocin to protect against acute stress (Carter & Porges, 2012). Oxytocin reduces stress during social interactions by inhibiting amygdala activity, thereby decreasing anxiety (Seshadri, 2016). Moreover, social behaviors important for love and

attraction, such as social cognition and eye contact, have been shown to be facilitated through oxytocin delivered through the nose (Meyer-Lindenberg et al., 2011).

## **Olfaction**

Olfaction, or the sense of smell, also has important consequences on attraction and human sexual behavior (Rikowski & Grammar, 1999). In many species, body odors regulate sexual, social, and endocrine responses (Yamazaki & Beauchamp, 2005). More than 10,000 odors can be recognized by humans (Prasad & Reed, 1999). Odors play a complex role in human attraction and mating choice, and are an important part of emotional life (Wedekind et al., 2007). Body odor often communicates the individual identity of a person and can affect mate choice, helps humans avoid incest, and influences parental care (Yamazaki & Beauchamp, 2005).

## **Dissimilar Major Histocompatibility Complex Genotypes**

It is important to note that there is not one single smell that is attractive to all humans. What smell is considered attractive varies from person to person and is linked to their respective major histocompatibility complex (MHC) (Wedekind & Furi, 1997). The MHC is a group of genes that is important in the human immune system (Wedekind et al., 2007; Wedekind & Furi, 1997). Human leukocyte antigen (HLA) is the human MHC genotype (Mililnski & Wedekind, 2001). By 2018, MHC social signaling has been discovered in over 20 vertebrate species and is a likely basis for a chemosensory communication system among vertebrates (Wedekind, 2018). The MHC has been found to also influence body odors, preferences for body odors, and human mating choices (Mililnski & Wedekind, 2001; Wedekind, et al., 2007; Wedekind & Furi, 1997; Wedekind et al., 1995).

A double-blind study by Wedekind et al. (1995) showed that women preferred the scents of men who had dissimilar MHC-genotypes. Wedekind

and Furi (1997) used the same methods to type participants for their HLA, and had 121 participant smellers (average age 25.7,  $SD = 2.90$ ) to score the odors of six T-shirts; the six odors were scored differently with respect to pleasantness as well as with respect to intensity. Similarly to Wedekind et al. (1995), Wedekind and Furi (1997) found a negative correlation between the degree of similarity of MHC in a potential mate and whether that person prefers his/her body odor (with the best correlation being in non-contraceptive using women). These studies suggest that the human sense of smell has evolved to prefer mates with different MHC or immune systems. One interpretation is that this preference evolved to increase genetic variation in offspring (Wedekind & Furi, 1997). Milinski and Wedekind (2001) also suggest that preference for MHC-dissimilar mates would increase MHC heterozygosity, which could lead to increased resistance to infections, increased resistance to disease, and reduction in inbreeding.

## **Genetic Links in Human Leukocyte Antigen Alleles**

The MHC influences body odor preferences of humans, therefore influencing human attraction and mate choice. Another double-blind study found a different relation, a genetic link, between odor preference and the MHC. Jacob et al. (2002) is the first study on any species to find that odor selection is determined by paternal HLA alleles. In this experimental study, women preferred particular odors based on the HLA alleles inherited from their fathers, but not from their mothers (Jacob et al., 2002). Furthermore, results suggest women are especially sensitive to HLA allele differences. This further suggests that odor preference is relative and unique to each individual, but especially sensitive for females. The HLA alleles from parents that a woman does not inherit show no relationship to preference of smell, even though she is exposed to these smells throughout her life (Jacob et al., 2002). The preference for MHC-based odors has also been interpreted as an evolutionary mechanism in human mate selection; additionally, these odor choices could also influence more general aspects of social behavior (Jacob et al., 2002).

## **Influences of Perfumes and Artificial Scents**

Many people utilize perfume to increase sexual attractiveness, consequently affecting human mate attraction and choice. For thousands of years, humans have selected and used artificial scents, yet it is still undecided why individual differences exist in perfume preferences. Milinski and Wedekind (2001) found a significant correlation between the MHC and what their participants scored for “self” scents, but not a significant correlation for “partner” scents (the pleasantness of 18 scents were evaluated for “self” and for “partner”). This suggests that humans select perfumes for themselves, not their partners, in order to amplify their own MHC-related body odor (Mililnski & Wedekind, 2001). It has been shown that humans can even identify gender by smelling natural axillary odors alone. It is unclear, though, if this capability depends more on the perceptible amount of odor as opposed to qualitative aspects of the odor. Nonetheless, the greater amount of odor detected, the more likely the person will be considered male (Mililnski & Wedekind, 2001; Wedekind & Furi, 1997).

Perfumes fundamentally contain the same ingredients for both male and female genders; it is the quantity of those specific ingredients that makes it differ between the genders (Mililnski & Wedekind, 2001). Wedekind et al. (2006) examined if variation in body odor intensity could be influenced by the MHC; however, a link between MHC alleles and body odor intensities could not be demonstrated. Wedekind et al. (2007) tested if MHC could be linked to verbal descriptions of human body odors by creating a study that consisted of 45 males wearing a t-shirt for two consecutive nights and living as odor neutral as possible. These t-shirts were then described by five evaluators (consisting of three laymen and two professional perfumers). Wedekind et al. (2007) found that some humans do have the ability to describe body odor components correlated with significant allelic specificity of the MHC.

## **Influences of Fertility and Pregnancy in Women**

Mililnski and Wedekind (2001) also found that taking oral contraceptives significantly affects the interaction between HLA type and scent rat-

ing, such as reversing scent preference and sensitizing scent preference. This reversed scent preference coincides with the findings by Wedekind and Furi (1997) and Wedekind et al. (1995) where women taking oral contraceptives similarly displayed a reversed preference for body odors correlated with the MHC. Pregnant women have been known to have an increased sensitivity to scents (Gilber & Wysocki, 1991), which agrees with the results of Mililnski and Wedekind (2001).

Body symmetry, facial symmetry, and overall physical attractiveness have been found to affect mating choices in humans, as they are thought to be indicators of good genes. Sexual selection for good genes is important in many animal species (Gangestad & Thornhill, 1998). Wedekind and Furi (1997) have shown that body odor influences mate choice depending on the immune system. Unlike symmetry and attractiveness, however, smell has not yet been proven to be able to show good genes (i.e., good potential mate qualities) (Rikowski & Grammar, 1999). Rikowski and Grammar (1999) attempted to test this by conducting an experimental study that contrasted body odor with facial attractiveness as well as body and facial asymmetry of 25 individuals. The results suggested that body odor is in fact a conditional-dependent trait of the value of a mate. Unfortunately, there was not a control for menstrual cycle phases of the women. An interesting finding, however, was that women were able to best distinguish odors when in their most fertile phase (Rikowski & Grammar, 1999).

It has been shown that preferences in sexual partners change for a woman depending on her point in her menstrual cycle (Gangestad & Thornhill, 1998); just before and during ovulation (at the peak of fertility), women prefer men with certain phenotypic markers of genetic benefits. Gangestad and Thornhill (1998) examined if a woman would prefer the scent of a man with more symmetrical features as well, depending on her place in the menstrual cycle. Results showed that (normal cycling; non-pill using) women preferred the scent of shirts worn by more symmetrical men when they were near the peak of their fertility. When the normal cycling women were not near the peak of their fertility, they

did not show a significant preference for the more symmetrical men. Contraceptive-using women also did not show a significant preference for symmetrical men. One complicated question is that, if a woman during the high-fertility portion of her cycle finds the scent of a symmetrical man less repulsive, perhaps the woman prefers symmetry, not because of the presence of a pleasant smell, but rather the lack of an unpleasant one? This would suggest a possible biological signal of importance, which could be the absence or presence of an unappealing smell (Gangestad & Thornhill, 1998). It should be noted that not all relevant factors (such as HLA similarity) were measured in this study, meaning it could have been a combination of factors (e.g., symmetry with HLA-dissimilarity and good hygiene) that cannot be addressed nor show causation, and should be analyzed in future research. Moreover, future research should investigate if these effects translate to same sex relationships.

## **Pheromones**

Similar to scents, pheromones also communicate messages between a species. Pheromones are compounds released through body secretions and perceived by members of the same species (Piccinni et al., 2018). Pheromones then trigger hormonal and behavioral responses, as well as modulate endocrine development and states in other members of the same species. Specialized structures have evolved to produce and detect odorous signals (Yamazaki & Beauchamp, 2005). The vomeronasal organ (VNO) is a specialized region of the olfactory system that detects pheromones (Piccinni et al., 2018). Humans also have a VNO as well as a gene that is presumed to be a pheromone receptor. The main sources of human pheromones seem to be apocrine glands in the pubic region and axillae, with the main ones structurally resembling sex hormones (Piccinni et al., 2018). Research on human pheromones has been substantially more limited compared to research on the pheromones found in insects and other mammals. Some of the first evidence in support of pheromones influencing human behaviors was research by McClintock (1971) that showed that women living together ended up with their menstrual cycles synchronized. Similarly, the duration of the menstrual cycle

was shown to be influenced by odorless compounds from the armpits of women (Stern & McClintock, 1998).

## **Secretions from Montgomery's Glands**

Newborns have the ability to smell the breasts of their mothers from across a room. Doucet et al. (2009) researched areolar glands to explore the communicative meaning of human areolar (Montgomery's) glands in three-day-old infants using a test with seven additional scents (including other human stimuli and artificial stimuli) to see if the babies could differentiate between the smells. Doucet et al. (2009) found that the secretions from this human gland caused newborns to increase (autonomic and behavioral) responses, as demonstrated by the increase in suckling response. Not only can babies detect these secretions, but they are even more attracted to these secretions than any other stimuli, and these responses are developed independently of the previous experience of the baby with breasts or milk. Furthermore, the secretions from the areolar glands used to test the responses were not secreted by the biological mother of the baby; they were donated by non-familiar and non-related lactating women (Doucet et al., 2009).

The newborns were stimulated by areolar secretions of *any* lactating mother, not just the biological mother of the baby. These secretions are vital to milk production and transfer, and consequently, attachment and the ability of a baby to survive. Evidence that newborn infants have a selective sensitivity to this specific human glandular secretion is paramount. This could lead to the discovery of the first human pheromone as the secretion affects all human babies, not just one. This could significantly influence future medical possibilities for the world. If we were able to identify that specific molecule, it could be synthesized and used to help improve the crucial suckling response of all children upon birth, thereby stimulating their eating. Therefore, this research has incredible potential to improve the chances of survival for all future babies, with special importance to premature babies.

## **Ideas for Future Research**

Although Doucet et al. (2009) were able to show that secretions from the areolar glands caused newborns to increase autonomic and behavioral responses; further research is still needed to fully understand this relationship. An important aspect would be examining how infant responsiveness is affected by the different rates of areolar gland secretions by mothers. Furthermore, these glandular secretions need to be chemically investigated to determine the formulary components of the secretions as well as how the messages are communicated through these secretions. Once this molecule is properly identified, the next step in research would be to find out how to synthesize it in a way to provide it to babies upon birth. Also, these researchers are solely focusing on these specific glands. More research needs to be done to find other possible human pheromones as this could greatly influence human attraction, bonding, and love.

## **Conclusion**

Love spans across cultures and is necessary for humans to flourish. Love is a highly evolved mammalian mechanism that helps facilitate mate choices in humans. Hormones are one biochemical aspect that affects love. Attraction, attachment, and lust all have their own functions and primary hormones; even though they are separate systems, they are still interwoven with each other. Romantic love is a drive and motivation, and an important step in mate selection. Specific brain regions, including subcortical reward and motivation systems as well as limbic cortical regions, have been found to be activated by early-stage intense romantic love. Likewise, mate selection is influenced by olfaction, which has been shown to be influenced by the major histocompatibility complex. Scent preferences, and therefore mate selections, can even change depending on the fertility levels of a woman. Although more research is needed on identifying human pheromones, an important step has been the research on secretions from the areolar glands of women that affect all babies. The study on areolar glands is just the beginning of research into human pheromones, and this upcoming field is going to provide much more information about human attraction, attachment behaviors, and love.

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