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Biochemistry of the Human Orgasm

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Abstract

Recent research suggests that there is substantial evidence that specific hormones and neurotransmitters directly influence the various aspects of human orgasm. Clinical and experimental studies have linked a number of hormones and neurotransmitters to specific features of the orgasm, including chemicals of orgasmic excitement, peak, and pleasure, as well as those that inhibit sexual desire. With this knowledge, insights into the origin and solution of sexual problems and disorders may be gained. Unfortunately, a detailed map of the biochemistry of the orgasm is still far away. However, researchers have begun to explain the basic ingredients of the intricate series of hormonal and neuronal events that produce one of the most pleasurable experiences in the world, orgasm.

The human orgasm is an intricate ballet of hormonal and neuronal chemistry producing what is arguably one of the most pleasurable experiences available to human beings. While people have been fascinated by orgasms for about as long as they have been a species, it is only in recent years that researchers have begun to learn what this phenomenon is all about at a biochemical level. Today, there is substantial evidence that specific hormones and neurotransmitters directly influence the various aspects of orgasm. For example, oxytocin, which has recently been touted by the popular media as the 'love hormone,' is released during orgasm and appears to be an essential factor modifying the intensity experienced. Similarly, endorphins, the endogenous brain opiates, are also thought to contribute to the pleasurable sensations. On the other hand, prolactin, which is released right after orgasm, acts to inhibit the desire for additional sexual engagement. Examples such as these are the beginning of a very crude biochemical map that will add to the understanding of normal sexual performance as well as shed light onto sexual dysfunction.

What is an Orgasm?

Webster defines an orgasm as 'the climax of sexual excitement that is usually accompanied by the ejaculation of semen in the male and vaginal contractions in the

female.' From that simple definition it would seem that Webster distinguishes orgasm from the physiological processes that often come with it. This distinction is sometimes difficult to take into account when attempting to figure out the complexities of orgasm, because many studies rely solely on the physical characteristics of the phenomenon, not to mention the difficulty in asking a mouse, "Was it good for you?"

However, dividing orgasm into experiential and physiological components precedes an even greater division between orgasm and the general sexual response. According to Masters and Johnson, the typical sexual response includes phases of excitement, plateau, orgasm and resolution, usually in that order (alternative systems use the terms desire, arousal, and orgasm) (Meston & Frohlich, 2000). With the understanding that orgasm, as defined above, rarely exists without the preceding stages of sexual response, dissecting influences of sexual excitement from those of climax becomes very difficult. However, there are times when the sexual response is halted right before orgasm and similarly there are cases of orgasm occurring spontaneously, suggesting that the orgasm is a distinct event. Nonetheless, it is a relatively short event that is complicated to pin point. As a result, this paper focuses on hormones and neurotransmitters influencing the rising action, the climax and the resolution of the orgasm and attempts to focus on the experiential side of the process, but sometimes these are imprecise distinctions.

Hormone Specificity

The other major introductory note that has to be made is that every hormone and neurotransmitter plays a very complex role, which requires the interaction of many other components. Reducing a substance to one characteristic, such as referring to oxytocin as the 'love hormone,' inaccurately simplifies the elaborate situation. Furthermore, many hormones will produce different effects depending on many subtle changes, such that the difference between too little, too much and just right may not be linear. Having said this, it should also be noted that the complex biochemical pathways and interactions of orgasm have not been fully developed and for simplifying purposes, many hormones and neurotransmitters will be referred to as though they each have a separate role.

Background Influences: Sex Hormones and Viagra

Most of the early sex research revolved around the so-called sex hormones, androgens and estrogens. Back then, the primary interest was focused on hormonal influence of sexual desire rather than orgasm. Androgens such as testosterone appear to be influential and important factors in sexual desire, behavior and performance (Bancroft, 1983; Meston & Frohlich, 2000; Sherwin et al., 1985). However, androgen levels do not change dramatically during the various stages of sex and orgasm, indicating they are not the primary factors involved in orgasm (Exton et al., 1998, 1999). In contrast, estrogens and progesterone are thought to have only minor effects on sexual desire and activity (Meston & Frohlich, 2000) and levels of these hormones also do not change much during sex (Exton et al., 1999; Kruger et al., 1998).

Another chemical that is necessary for the earlier stages of sexual response is nitric oxide, which is secreted into the penis (and clitoris) in response to sexual stimulation. Nitric oxide signals the release of the enzyme guanylate cylase that converts guanosine triphophate into cyclic guanosine monophosphate (cGMP). cGMP is responsible for the smooth muscle relaxation that allows greater blood flow to the penis producing an erection (a similar pathway has been suggested in the clitoris). Viagra, a medication for erectile dysfunction, works by inhibiting cGMP metabolism (Meston & Frohlich, 2000).

The steroid hormones along with nitric oxide are clearly important ingredients for moving one through the excitement and plateau phases that usually precede orgasm. While these background influences might even be necessary for orgasm, they are not the direct contributors. Other substances, including serotonin, catecholamines, oxytocin, endorphins etc., also influence these early stages, but these chemicals appear to have a direct role in producing orgasm.

The Rising Action: Catecholamines, Serotonin and Premature Ejaculation

At some point in the plateau stage, the heartbeat quickens, blood pressure rises, and the sympathetic nervous system turns up its level of intensity. The peak of orgasm is on its way. This heightening state of arousal might be comparable to the experience of stress or anxiety commonly referred to as the fight or flight response. Not surprisingly, it appears that the same hormones involved during stress, namely the catecholamines epinephrine (adrenaline) and norepinephrine, also are involved in the exciting quality of orgasm.

Catecholamines

Some studies have shown that epinephrine levels increase during the excitement and plateau phases and peak at orgasm and then return to baseline (Exton et al., 1999; Meston & Frohlich, 2000). However these changes in epinephrine are not as great as the changes in norepinephrine levels around the orgasm, which can be up to a 12-fold increase (Exton et al., 1999,200O; Kruger et al., 1998; Meston & Frohlich, 2000; Wiedeking et al., 1979). One study demonstrated how sympathetic arousal via exercise beforehand would not only increase norepinephrine levels, but also increase vaginal pulse amplitude and vaginal blood volume (Meston & Gorzalka, 1996). Furthermore, drugs that increase norepinephrine activity, such as yohimbine and the antidepressant mirtazapine, have been shown to decrease sexual problems (Meston & Frohlich, 2000). Norepinephrine appears to directly influence the exciting quality of orgasm.

Serotonin

Serotonin's role in orgasm is much more complicated. Increased serotonin activity has long been known to cause sexual side effects such as reduced desire and inhibited orgasm in people using selective serotonin reuptake inhibitors. However, these same

drugs have been used to prevent premature ejaculation. Some researchers suggest that two different serotonin receptors affect sexual function in opposing ways. This indicates that there is a delicate balance of serotonin necessary for normal sexual functioning, too little or too much in the wrong place leads to problems (Meston & Frohlich, 2000).

The Climax: Oxytocin, Opiates, Dopamine and Bliss

As norepinephrine levels continue to rise increasing the intensity of the sexual , experience to a peak, there then comes a blissful release of tension and a rush of pleasure. In men, seminal vessels often begin to contract at orgasm, ejaculating semen from the penis. Women display a similar series of contractions in the uterus. At the same time, oxytocin molecules are released into the blood along with endorphins, creating a distinct feeling of euphoria.

Oxytocin

An orgasm would probably not be very enjoyable if it were not for oxytocin, the so-called love hormone. Oxytocin has been shown to be involved with most positive social interactions such as pair bonding and attachment (Carter, 1998; Uvnas-Moberg, 1998). It is also well known for its role in birth and breastfeeding (Odent, 2000). Loving touches, massage and sexual arousal also raise blood levels of oxytocin above baseline (Turner et al., 1999), but this is nothing compared to the levels reached at orgasm (Blaicher et al., 1999; Carmichael et al., 1987; Odent, 2000; Riley, 1988).

Oxytocin is released from the posterior pituitary into the blood at orgasm where it exerts a sedative, relaxing and positive effect. Catecholamine levels and blood pressure drop in response to it (Uvnas-Mohberg, 1998). The effect of raising excitement and arousal via increased levels of catecholamines and then flooding the system with the anti-stress hormone oxytocin produces a rapid and exaggerated feeling of euphoric contrast, and some researchers have linked oxytocin levels with the perceived intensity of orgasm (Meston & Frohlich, 2000). However, oxytocin does much more than just create exaggerated relaxation; it also affects the endorphin system producing an opiate like high.

Endorphins

Heroin users often compare the opiate high to an orgasm, and it would not be surprising if endogenous opioids were involved. However, the level of involvement is not clear. Some researchers have found no significant increase in endorphin levels in the blood during orgasm (Exton et al., 1999, Kruger et al., 1998), but this does not necessarily mean they are not involved in the central nervous system. Heroin users often experience **serious** sexual side effects including inability to achieve orgasm, while opiate withdrawal has been known to cause spontaneous orgasms (Meston & Frohlich, 2000). This suggests that disruption of the endorphin system clearly affects orgasm, indicating that endorphins are involved.

Evidence suggests that endorphin involvement in orgasm is linked to oxytocin release, but it is uncertain how the two interact. One study demonstrated that naloxone, an endorphin antagonist, prevented oxytocin release at orgasm (Murphy et al., 1990). While other studies have shown oxytocin injections increase endogenous opioid production (Uvnas-Moberg, 1998). Another study has revealed that oxytocin can inhibit tolerance formation to morphine, meaning that the same amount continues to gives the same response (Kovacs et al., 1998). Clearly, there is some complex interaction between these two hormones.

Dopamine and Reinforcement

In order to get a better understanding of the probable role of oxytocin and endorphins, it is helpful to consider current models of reinforcement and learning concerning opiate addiction. Ingesting drugs or performing any action that facilitates dopamine secretion from the ventral tegmental nucleus into the nucleus accumbens is said to be a reinforcing act (Carlson, 1998). From a Darwinian perspective it would make sense that orgasm would be such a reinforcing act, because it promotes continuation of the species. (Also, from a behaviorist perspective the fact that orgasms are not always achieved makes them one of the most effective reward systems for increasing sexual behavior.) In animal studies, a place preference experiment is often used to determine reinforcement, the idea being that if the animal moves from his preferred location in order to perform some act, that act is reinforcing. Researchers have shown that ejaculation in rats produces reinforcement in the place preference paradigm. Furthermore, they have shown that naloxone, the endorphin antagonist, blocks the reinforcing properties of ejaculation (Agmo & Berenfeld, 1990). This evidence further demonstrates that endorphins play an important role in orgasm.

Resolution: After the Fireworks comes Prolactin

Right after the release of tension and the pleasure of climax, the heartbeat slows, blood drains from the genitals and a period of relaxation begins. Some people might want to go for another round, but most find it difficult. This is probably because high levels of prolactin have been secreted into their blood. .

Prolactin

If oxytocin is the 'love hormone,' prolactin is the "not now, honey" hormone. Prolactin has been shown to be associated with decreased sexual desire and function (Meston & Frohlich, 2000; Mulvihill, 2000). Prolactin has also been shown to be released in great quantity after orgasm (Exton et al., 1999, 2000; Kruger et al., 1998).

Researcher Michael Exton and colleges recently made the popular press with the announcement that a prolactin surge released after orgasm diminishes the desire for sex. In multiple studies (Exton et al., 1999,200O; Kruger et al., 1998), they have found that one of the biggest hormonal changes is the dramatic increase in prolactin after orgasm. One study (Exton, 2000) brought men and women close to orgasm,

but this was not enough to induce the prolactin surge, indicating prolactin release is orgasm dependent. However, as was pointed out in *Psychology Today,* this surge, which is seen in both men and women, does not explain the sexually asymmetrical tendency or ability towards multiple orgasms, especially because women produce more prolactin than men (Pirisi, 2000). Obviously, more research is needed.

Conclusion

The intricacies of orgasm remain somewhat of a mystery, but science is getting closer to understanding the underlying biochemistry that produces this wonderful phenomenon. The paradoxical excitement/pleasure/relaxation experience is beginning to make some sense when we investigate the hormones and neurotransmitters involved. Exciting adrenaline gives way to pleasurable oxytocin that stimulates endogenous opioids, creating an intense and life-creating event and before the dust settles prolactin comes in to make sure people do not overdo it. Of course, it is not at all that simple, but these basic concepts will eventually lead to a more complete understanding of the orgasm and sexual function.

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