A Diet-stress-diathesis Model of Homosexuality

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Abstract

This paper aims to contribute with answers to the scientific question of how and why homosexuality develops. It identifies 6 phases of the heterosexual response cycle: spontaneous sexual arousal, attribution to emotional cue, courtship, thrusting/engulfing, orgasm and refractory period. It proposes that a disturbance in the phases of the sexual response may lead to homosexuality. Hormonal and neurotransmitter system imbalances involving testosterone, estrogen, progesterone, dopamine and serotonin, are identified as proximal causes of homosexuality. Diet and stress are identified as ultimate causes of homosexuality in genetically susceptible persons.

Key words: homosexuality, diet, stress, sleep

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1 Introduction

Homosexuality refers to the feeling of sexual attraction toward people of the same-sex. In this article homosexual will be considered a person who experiences homosexual attractions, even if he/she does not identify himself/herself as homosexual.

Until relatively recently in history homosexuality was considered a mental disorder. More specifically, in the United States, homosexuality was categorized as a mental disorder until 1974. In 1974 it was removed from the Diagnostic and Statistical Manual of Mental Disorders (DSM) and was replaced by “ego-dystonic homosexuality”. In 1987, ego-dystonic homosexuality was also removed from the DSM. The Chinese Psychiatric Association removed homosexuality from the Chinese Classification of Mental Disorders in 2001. It was followed by the Indian Psychiatric Society, which declared in 2014 that homosexuality is not a disease. Homosexuality is currently illegal in 72 countries [1].

Homosexuality has been observed in humans and in animals. Homosexual behavior has been noted in more than 450 animal species. Nevertheless, homosexuality as an enduring behavior has been documented in only a handful of animal species, like the Japanese macaques, the bonobos, the domesticated rams, etc. [2].

Different theories explaining homosexuality

There are different theories explaining homosexuality.

Psychological theories

Richard Von Crafft-Ebing, an Austro-German psychiatrist of the 19th century, proposed that homosexuality occurs when the young man or woman masturbates early in life or it is due to neurasthenia [3].

Sigmund Freud considered homosexuality to be the result of an arrest in development or a regress to an earlier phase of development. Other psychoanalysts, like Sandor Rado, considered homosexuality to be a symptom of neurosis, the result of anxiety from heterosexual relationships, or of problematic relationships within the family [4].

Joseph Nicolosi [5], clinical psychologist, held that a homosexual man does not have homosexual attractions when he is in an assertive state. He described assertion as a self-state (frame of mind, attitude, feelings about oneself, viewpoint) of being secure, confident, feeling good about oneself, feeling connected to others and to oneself. Even if homosexuals have homosexual thoughts, when in an assertive state they easily dismiss them. His therapy aimed to keep the client in an assertive state. He explained homosexual enactment as a different self-state from the assertive state. When something happens that causes the person to feel shame he is thrown into the gray zone. Nicolosi explained the gray zone as a kind of mood where the person is detached, zoned out, numb, disconnected, depressed, hopeless, helpless, in a generalized state of irritability, anger, frustration not directed anywhere. This state can last for different lengths of time. The gray zone, according to Nicolosi, always sets the homosexual person up for homosexual enactment.

Aldo Poiani [6] has proposed that stress may affect sexual orientation around the age of ten by increasing the activity of the adrenal glands. The adrenal glands release androgens, precursors of the sexual hormones estrogen and testosterone. Poiani proposed that adrenarche (which happens around the ages of six to ten) may be central to the prepubertal development of homosexuality.

Genetic and epigenetic theories

Genetic studies show that genes are a contributing factor to sexual orientation [7]. Twin studies have found that only in 6% to 32% of twins both members of an identical twin pair would be homosexual if at least one member is. [8]

The kin selection hypothesis proposes that genes predisposing to homosexuality confer some evolutionary advantage to the relatives of homosexuals. For example, species with high homosexuality rates have high sexual willingness [9,10,11,12], which can be an advantageous trait. Female kin of homosexuals have been found to have high fertility [13,14]. Increased altruism [15,16] has also been proposed to be associated with homosexuality.

Epigenetic theories of homosexuality explain development of homosexuality based on changes in gene expression or cellular phenotype caused by environment.

Neurohormonal theories

The neurohormonal theory proposes that hormones are a decisive factor in homosexuality. Experiments with animals support the neurohormonal theory. Homosexuality can be induced by several methods in laboratory animals: (a) direct perinatal manipulation of androgens, (b) pharmacologically blocking or enhancing the perinatal effects of androgens, (c) foetal and neonatal exposure to emotional stress, which suppresses androgen production by the male fetus or, in the case of the female fetus, exposes it to high level of androgens due to a high level of activity of the mother's adrenal glands, (d) the induction of immunity responses to sexual hormones involved in sexual differentiation [17].

Günter Dörner [18], formulated a "dual mating center" theory. The theory proposed that the medial preoptic-anterior hypothalamic region in the brain is mainly involved in the regulation of male sexual behavior (pelvic thrusting, ejaculation) and is the male mating center. The ventromedial nucleus is involved in the regulation of female sexual behavior (lordosis in the mammals) and is the female mating center. In homosexuals, the mating center is more similar to that of the opposite sex. The mating center is organized under the effect of sexual hormones.

Studies have found differences in different brain areas of homosexual males and females, showing structures similar to those of the opposite sex. [19] These brain differences are susceptible to sexual hormones.

Homosexuality in animals

Homosexuality in animals is observed in different situations. It is observed in populations with skewed sex ratios, where individuals unsuccessful at mating with the opposite sex, direct sexual behavior toward same-sex.

In the bonobos, homosexual behavior is thought to lower social tensions, for example during competition for food (a stressful situation) [20].

Ethologist Wolfgang Wickle suggested in 1967 that homosexual mounting in animals is a show of dominance. He observed that same-sex mounting commonly occurred in response to aggression [21]. In many animal species same-sex mounting is observed in dominance relationships mediated by aggressive/submissive interactions, which in many cases occur in captivity [22].

Homosexuality is observed more often in adolescent animals, which outgrow it [23].

In species with high sexual willingness homosexuality is more prevalent. For example, in promiscuous monkeys, like Old World monkeys, [24] homosexual mounting is much more commonly observed among them and apes than in other nonhuman primates [25].

Homosexuality as normal variation of sexuality

Another view on homosexuality, which has recently become the dominant view, is that it is normal sexuality [26]. The first authors to consider homosexuality natural were Alfred Kinsey and Evelyn Hooker. Kinsey pointed to homosexuality's ubiquity and suggested that homosexuality and heterosexuality may be learned behaviors [27].

Researcher Evelyn Hooker [28], based on psychological tests administered to homosexuals, suggested that they are as psychologically normal as heterosexuals.

History of the use of diet and other therapies to treat homosexuality

Although diet may seem totally unrelated to homosexuality, it has been used for centuries to treat it. According to historian Caroline Bynum [29]:

Many patristic [early Christian, from c. AD 100 to either AD 451 or to the 8-th century] writers associated food with lust and urged abstinence as a method of curbing sexual desire. John Cassian, writing for monks in the early fifth century, said: 'It is impossible to extinguish the fires of concupiscence (*strong sexual desire*) without restraining the desires of the stomach.' (p. 37)

Tertullian (c. 155 – c. 240 AD), Christian author from Carthage, saw a close connection between lust and gluttony [30]:

Lust without voracity would certainly be considered a monstrous phenomenon; since these two are so united and concrete, that, had there been any possibility of disjoining them, the pudenda would not have been affixed to the belly itself rather than elsewhere... First, the belly; and then immediately the materials of all other species of lasciviousness are laid subordinately to daintiness: through love of eating, love of impurity finds passage. (paragraph 1)

The Penitential of Cummean [31], an Irish penitential, which was much circulated in Europe during the eighth and ninth centuries, described different penances (punishments) for sexual misconduct, including homosexuality. The Penitential calls the penances "medicine for the salvation of the soul." It begins with a chapter on gluttony, followed by a chapter on fornication. It ordered a penance of 7 years for those who committed sodomy. It does not describe the penance, but in the previous paragraphs it describes the penance for fornication by a priest who has taken the vow of a monk:

...he shall perform a special fast during every week except in the fifty days (between Easter and Pentecost). After the special fast he shall use bread without limitation and a titbit spread with some butter [that is to say, a quarter-measure] and he shall live in this way on Sunday; on other days on a ration of dry bread [made from a twelve polentae vessel full of flour] and a dish enriched with a little fat, garden vegetables, a few eggs, British cheese, a Roman halfpint [the capacity of six hen's eggs] of milk on account of the weakness of bodies in this age; a Roman pint of whey or buttermilk [the capacity of twelve hen's eggs] for his thirst, and some water, if he is a worker; and he shall have his bed provided with a small amount of hay. Through the three forty-day periods of the year he shall add something, as far as his strength permits...(paragraph 29)

The penitential of Columban, which dates about the year 600, orders fasting for sodomy:

But if one commits fornication as the Sodomites did, he shall do penance for ten years, the first three on bread and water; but in the other seven years he shall abstain from wine and meat, and [he shall] not be housed with another person forever [32].

John The Faster, Patriarch of Constantinople (582-595 AD), in his canon XVIII, excludes the sodomist from communion for three years, with the additional penance of fasting and toward evening xerophagy. Xerophagy is a kind of Christian fast in which only bread, salt, water, vegetables may be eaten and meat, fish, milk, cheese, butter, oil, wine, and all seasonings or spices are excluded [33].

According to Stephen Morris [34], penance (*epitimia* in greek) in Byzantine Christianity was considered a therapeutic or medicinal tool-similar to surgery-that although painful in the short term was aimed at restoring the (spiritual) health of the patient.

Fasting has also been used in non-Christian cultures. *The Laws of Manu*, the most popular Hindu law book of medieval and ancient India, prescribed food restriction for homosexual acts: “If a man has shed his semen in non-human females, in a man, in a menstruating woman, in something other than a vagina, or in water, he should carry out the ‘painful heating’ vow.” [35] The Painful Heating vow is described as follows: “If one lives one day on cow’s urine, one day on cow-dung, one day on milk, one day on sour milk, one day on clarified butter, one day on a decoction of *Kuśa* grass, and during one day and night, on air” [36].

An early medical text where diet is mentioned as a remedy for homosexuality is a medieval medical treatise on passive homosexuality, *Treatise on the hidden Illness*, attributed to Abū Bakr Muhammad ibn Zakariyyā al-Rāzī (854 AD – 925 AD), a Persian polymath. Al-Rāzī mentions fasting and a special diet among other treatments for homosexuality:

The treatments mentioned by me are right for young and the affluent people. In connection with others, your aim in treating them should be to make them loose weight and diminish the blood. Thus they should be ordered to fast, to give up drinking wine, to use vinegar for seasoning....They should also stick to foods such as qarīs, masūs, hulām, hisrimiyah, with gourds and lentils, drink constantly oxymel... [37]

Avicenna (980-1037 AD), another Persian polymath, wrote regarding homosexuality: “Things that break the desire, such as worries, hunger, vigils, detention, and beatings, constitute useful treatment.” [37]

In China, sodomy was first punished in 1790 by the Qing Code. Sodomy with consent was penalized with one month in the cangue and 100 heavy blows. A cangue was a device used for corporal punishment and the person wearing the cangue could not eat, unless he was helped by others.

Herbert Shelton [38], an American naturopath, suggested fasting to aid in removing “abnormal sexual desire”:

Tolstoy pointed out the close connection between idleness and gluttony and unchastity and recommended fasting as a means of controlling strong sexual passions. This should be understood to mean that fasting is to be employed to aid in removing the surfeit that is responsible for the abnormal sexual desire that is a common result of nutritive redundancy, not that fasting should be employed to suppress normal sexual urges. (p. 102)

While religions have treated homosexuality with their own methods of prayer, fasting, etc., psychologists and psychiatrists have historically used conversion therapy (also called reparative therapy). Techniques used by them include counseling, visualization, social skills training, psychoanalytic therapy, spiritual interventions such as "prayer and group support and pressure" as well as avoidance of masturbation [39].

Before 1973, conversion therapy employed aversive conditioning techniques, involving electric shock and nausea-inducing drugs during presentation of same-sex erotic images. Cessation of the aversive stimuli was accompanied by the presentation of opposite-sex erotic images, with the objective of strengthening heterosexual feelings. Another method used was the covert sensitization method, which involved instructing patients to imagine vomiting or receiving electric shocks. Behavioral conditioning tended to decrease homosexual feelings.

Psychoanalytic treatment of homosexuals is based on the work of Irving Bieber and his colleagues published in the book "Homosexuality: A Psychoanalytic Study of Male Homosexuals." They advocated for long-term therapy aimed at resolving the unconscious childhood conflicts that they considered responsible for homosexuality. Bieber reported a 27% success rate from long-term therapy, including success in exclusive homosexuals.

Reparative therapy is associated with Elizabeth Moberly and Joseph Nicolosi. Nicolosi's therapy aims to keep the homosexual man in an "assertive state," to condition him to a traditional masculine gender role by increasing participation in sports, increasing time spent with heterosexual men, etc. His therapy includes attending church.

A peer-reviewed study of 202 respondents published in 2002 found that 88% of participants in sexual orientation conversion interventions failed to achieve a sustained change in their sexual behavior and 3% reported changing their orientation to heterosexual. The remainder reported either losing all sexual drive or attempting to remain celibate, with no change in attraction [40].

Some studies show that conversion therapies can be harmful. Douglas Haldeman [41], based on his clinical work with homosexuals, reported that following an unsuccessful therapeutic attempt to change sexual orientation, the patients had various psychological problems like poor self-esteem, depression, social withdrawal and sexual dysfunction.

Increase in the prevalence of homosexuality

Many surveys show an increase in the prevalence of homosexuality in modern societies.

A study by Twenge et al. [42] on the prevalence and acceptance of homosexuality concluded that homosexuality has increased in the last decades in the United States. The number of U.S. adults who had at least one same-sex partner since age 18 doubled between the early 1990s and early 2010s. Bisexual behavior in the United States increased from 3.1% to 7.7%. Controlling for acceptance reduced, but did not eliminate, the increase in same-sex behavior over time.

Between 1990 and 2000, homosexuality in Great Britain also increased. Mercer et al. [43] used data from two large, national probability sample surveys of sexual attitudes and lifestyles carried out in 1990 and 2000 to assess homosexual behavior prevalence among men. Homosexual experience was reported by 8.4% of men in 2000 compared to 6.0% of men in 1990.

Two surveys using the same methodology in Australia, in 2001-2002 and 2012-2013, show an increase in homosexuality. In the first study, among men 1.6% identified as gay and 0.9% as bisexual. Among women, 0.8% identified as lesbian and 1.4% as bisexual. In the second study, 1.9% of men identified as gay and 1.3% as bisexual; and 1.2% of women identified as lesbian and 2.2% as bisexual [44,45]. The 2003-2014 Canadian Community Health Survey also showed an increase in prevalence of homosexuality during that period [46,47].

Tolerance toward homosexual behavior has increased considerably during the 20th century. This has allowed more freedom in reporting homosexual attraction and behavior in different surveys. The increased prevalence of homosexuality in surveys cannot be explained solely by increased freedom of reporting, because even studies conducted on different age groups conclude that homosexuality is more frequent in younger generations. In such a study in Australia, women born in the 1960s were more than four times more likely to report female-female contact than women born in the 1930s or earlier [48]. The study did not find a difference in homosexuality rates in males by age group, however. A study of age groups in the United States found that the prevalence of female-female contact may have increased three to four fold for cohorts of women born between the 1930s and 1960s. It found no increase in male-male contact [49].

R. Von Krafft-Ebing [3], in the 19th century in Germany, mentioned that a contemporary colleague, Ulrichs, had stated that 0.5% to 0.12% of adult males were homosexuals. A homosexual patient of Krafft-Ebing personally knew 14 homosexuals in his home town of 13,000 inhabitants and 80 homosexuals in another city with 60,000 inhabitants. If we presume that ~30% of the population is made of males over 18, the prevalence of homosexuality in these 2 cities would be 0.3% and 0.4% respectively. Such prevalence is much lower than the prevalence of homosexuality in modern Germany. Today, by some estimates, 7.4% of Germans identify as lesbian, gay, bisexual and transgender [50].

The increase in homosexuality rates is interesting. During the 20th century people have been increasingly exposed to stress sources like pollution, artificial light, noise, electromagnetic fields, drugs etc., while consuming increasingly unhealthy diets. There may be a causal link between diet, stress and homosexuality. Before investigating the role of diet and stress, let's examine from the psychological and physiological perspective how homosexuality develops.

2 Materials and methods

Thorough literature search was done in PubMed with key words: "homosexuality", "sexual orientation." Other key words related to the study were also searched in Google.

3 Development of sexual partner preference

This chapter will discuss the sexual response cycle in heterosexual and homosexual sex and the proximate causes of the homosexual response: imbalanced sexual hormone and/or neurotransmitter systems.

3.1 The phases of the sexual response cycle in heterosexual and in homosexual sex

In early adolescence, spontaneous erections in males are common. Similarly to males, females have periods of increased sexual interest driven by hormonal changes during the ovulation part of the menstrual cycle [51]. The spontaneous erections and increased sexual interest usually precede the first sexual experiences.

According to the two-factor theory of emotion [52], when physiological arousal occurs, the person uses the immediate environment to search for emotional cues to label the physiological arousal. Similarly, the individual experiencing sexual arousal would search for such cues in the immediate environment. According to Daryl Bem's theory [53] the opposite sex person is usually different in appearance, behavior, from the person experiencing the sexual arousal, hence the former's presence would further increase arousal and would be the more prominent emotional cue to attach arousal to. This would lead to heterosexual attraction.

Another factor influencing the attribution to emotional cue may lie in the nature of the sexual arousal. In males, when sexual arousal becomes intensive, initially there is an urge to thrust followed later by pelvic thrusting which becomes faster and more frequent with the approach of orgasm. This is a stereotyped, almost instinctive, involuntary movement. Its biological function is to ensure insemination of the female.

In women, there are vaginal contractions when sexual arousal becomes intense. Research shows that contractions appear during stimulation of the clitoris and/or vagina, [54,55,56] but they may also appear, although less noticeably, without physical stimulation. Researcher Shafik Ahmed calls it the clitorovaginal reflex. Similar vaginal contractions have been identified in the female rat, rabbit and cat [57,58,59]. Their biological function is to stimulate the thrusting reflex in the male.

The females may feel an urge to engulf/clasp associated with the vaginal contractions. The urge could be present early on during sexual arousal, when it has not yet been attached to an emotional cue. Having the urge, and recalling similar acts, which are common in nature, would orient the male toward females and females toward males.

Once the sexual cue is identified, courtship begins. Humans have diversified courtship behaviors. Nevertheless, the typical courtship ritual in most cultures is one where the male plays the initiating, assertive role, whereas the female plays the proceptive and, later, the receptive role. The term proceptive refers to behavior enacted by a female to initiate, maintain, or escalate a sexual interaction. The female displays coy behavior during courtship: she is shy, but subtly inviting. Playing the hard-to-get increases sexual desire in the male [60].

Mammals have courtship rituals, which are almost identical in all members, thus strongly genetically determined. Subhuman primates have courtship rituals, which are much more diverse than those of the other mammals, but less diverse than courtship rituals in humans.

If the courtship ritual is successful, the person comes into physical contact with the partner, further increasing sexual arousal. During physical contact more oxytocin is released (the social bonding hormone, which is also increased during sexual activity and has a role in sexual arousal) [61,62]. Physical contact is followed by intercourse, during which the male shows stereotyped,

almost reflexive thrusting movements, while the female has vaginal contractions. These movements further increase arousal to orgasm. Orgasm plays an important role in the creation of partner preference, acting as an unconditioned stimulus, while partner preference is the conditioned stimulus [63]. In females, the role of orgasm is less prominent and sexual arousal during vaginal stimulation is often enough rewarding to condition partner preference. About 10% of heterosexual women never experience orgasm.

After orgasm there is a refractory period, when there is no sexual desire, neither the ability to perform.

The heterosexual response cycle is as follows:

Figure 1. The heterosexual response cycle in sexually inexperienced individuals

When successful, each of the phases increases sexual arousal. In males, after several successful experiences with an emotional cue leading to orgasm, the emotional cue turns into a sexual cue and consistently elicits a sexual response.

Figure 2. The phases of heterosexual response in sexually experienced individuals

Homosexuality may arise when there is a disruption of one or several phases of the sexual response cycle.

Disruption of phase-2: Attribution to emotional cue

Disruption of this phase may happen under several scenarios.

Gender nonconformity

The theory “Exotic becomes erotic” of sexual development argues that gender nonconforming children feel different from their same-sex peers. Therefore, they experience increased physiological arousal in the presence of same-sex peers and attribute their spontaneous sexual arousals to them.

Gender is used to denote the public lived role as boy or girl, man or woman. There are differences in gender behavior. Males in general are more independent, assertive and competitive, while females are more passive, sensitive and supportive.

Gender nonconformity refers to somatic features or behaviors that are not typical (in a statistical sense) of individuals with the same gender in a given society and historical era [64].

Gender nonconforming individuals are heterogeneous as a group. Depending on the cause of the gender nonconformity, they can be divided into these categories:

- a) Individuals with disturbances in sexual hormones;
- c) Individuals with psychological disorders. Gender nonconformity in this subgroup may be the result of cognitive problems. Individuals with autism spectrum disorders or autistic traits have increased rates of gender nonconformity [65,66]. Schizophrenia is also more prevalent among individuals with gender dysphoria [67].
- b) Males who begin to show gender nonconforming behavior during puberty or adulthood and who cross-dress. Most of these males feel sexually aroused when fantasizing of being a woman [68]. Their behavior is called “autogynephilia” and is categorized as a paraphilia in DSM-5. Paraphilias are compulsive behaviors similar to substance and behavioral addictions.
- c) Individuals with gender nonconformity of unknown cause.

Gender nonconformity has different degrees. Genetic males with androgen insensitivity syndrome are at the extreme end of male gender nonconformity scale. They feel and look female. Most of them are androphilic (sexually attracted to men).

The theory of Bem is well supported by the data [53] [69] but it can't explain cases when gender conforming youth become homosexual and when gender non-conforming youth become heterosexual. Most youth in the top 10% of gender nonconformity scale are heterosexual, and only a small percentage of gays and lesbians are gender nonconforming [70,71].

The thrusting/engulfing urge

At this phase of the sexual response cycle, the individual may already feel an unconscious urge to thrust/engulf when sexually aroused. The presence of this thrusting /engulfing urge may explain why some gender nonconforming individuals prefer opposite sex persons although they don't find them different, exotic. In gender conforming males and females, a lack of the thrusting urge may cause sexual partner preference to be more fluid. Some insight can be gained from research on genetic males with complete androgen insensitivity syndrome. They are genetic males with female physical appearance and behavior, who probably lack the thrusting urge because they have male levels of female sexual hormones and no sensitivity to testosterone. They have higher rates of nonheterosexuality [72].

High sexual drive

High sexual drive may be another factor disturbing attribution to emotional cue. The attribution of arousal to an emotional cue is facilitated by dopamine, the neurotransmitter of wanting (or incentive salience) [73]. Serotonin, the neurotransmitter regulating satiety, is also involved in sexual behavior. Its role is to inhibit dopamine in a negative feedback fashion after the cue has fulfilled its physiological role [74].

Sexual arousal has at least three components: the wanting component which manifests as sexual drive/mental arousal (facilitated by dopamine [73]), the physiological component, which manifests as erection in males and engorgement of the genitalia in women (facilitated by sexual hormones) and the bonding component, which manifests as attachment to the object of desire (facilitated by oxytocin) [75].

These three components can get decoupled like in the Persistent Genital Arousal Syndrome [76], where there is physiological arousal but no mental arousal, in erectile dysfunction where there is mental arousal but no physiological arousal; and in platonic love, where there is attachment but little physiological and mental arousal.

When the wanting aspect of sexual arousal is overactive, there may be homosexual behavior. Several experiments on animals show that substances stimulating dopamine receptors in the brain cause homosexuality. In experiments on rats by Triana Del-Rio et al. [77], when sexually naive male rats, living in cages with only same-sex rats, were administered quinpirole (a dopamine receptor D2 agonist that acts similarly to alcohol and cocaine), and/or oxytocin, the rats developed sexual preference for the male cohabitant over the female.

In a study with fruit flies, which have similar reaction to alcohol as humans, male flies that regularly consumed alcohol began to have sexual encounters with males and females. When the researchers lowered the level of dopamine in the brain, their homosexual behavior decreased [78].

Psychoactive substances are often used by adolescents. Cocaine, opiates have a stimulant effect on sexuality [79]. The effect of cocaine on erections is stronger when combined with sleep deprivation [80]. Alcohol causes increased sexual interest upon withdrawal. Increased sexual interest during alcohol withdrawal is called "hangover horn" in urban slang [81].

REM sleep deprivation potentiates the effect of drugs on sexuality. It causes hypersensitivity of dopamine receptors in the brain and increases sexual drive [82,83]. Being in stress (like in a state of REM sleep deprivation and/or during withdrawal from psychoactive substances), the

individual's reward system may be sensitized to potential rewards and, upon early signs of spontaneous sexual arousal may misattribute the sexual arousal to emotional cues present at the moment. These frequently present emotional cues more often than not are same-sex peers.

Drugs may have a more pronounced effect on sexuality during adolescence, when the brain becomes more sensitive to rewards [84].

The stimulating effect of sleep deprivation on sexual arousal is observed in women with high testosterone levels but not in those with low testosterone levels [85]. In men as well, testosterone increases sensitivity to rewards in general [86] and sexual drive in particular. For example, castrated animals respond with less spontaneous erections to dopamine agonists [87]. So, men and women exposed to high testosterone levels may respond more readily with an increase in sexual drive when sleep deprived and after drug use.

In some genetic and pharmacological experiments with animals, low serotonin levels cause both male and female mice to prefer same-sex over opposite sex partners [88,89]. In other experiments, low serotonin levels do not change sexual partner preference, but they negatively affect sexual behavior. Low serotonin levels tend to increase sexual drive [90].

Summarizing, the attribution of sexual arousal to an emotional cue is affected by:

1. Gender conformity;
2. Sexual drive;
3. The thrusting/engulfing urge.

A person may have exclusively heterosexual attractions, or exclusively homosexual attractions, or both heterosexual and homosexual attractions. (S)he has to go through the following phases of the sexual response to have a conditioned and stable partner preference.

Disruption of phase-3: Courtship

Once the individual identifies (s)he is attracted to someone, the behavior will proceed to the next step, courtship. Gender nonconforming behavior negatively impacts the appropriate courtship by the male and acceptance of courtship by the female. Non-masculine males are less assertive in the courtship game and lose in the competition with more assertive males [91].

Excessive anxiety also negatively impacts courtship. Unsuccessful courtship attempts may increase anxiety in the individual attempting them. In successive attempts increased anxiety can decrease sexual arousal, [92] thus contributing to failure of the courtship attempt. Masturbation during this phase may also negatively affect the motivation to engage in courtship.

Failing several heterosexual courtship attempts, the individual may lose all sexual interest, becoming asexual, or (s)he may act on homosexual attractions (s)he may have, becoming homosexual. Alternatively, the individual may engage in masturbation. Masturbation may disrupt phase-4 (thrusting/engulfing) and phase-5 (orgasm).

In countries where marriages are arranged and there is a strict segregation of sexes, courtship is a phase which is significantly reduced.

Disruption of phase-4: Thrusting/engulfing

Pelvic thrusting appears to be weak or missing during most homosexual acts, like masturbation, oral sex, receptive anal sex. Giving anal sex is practiced by a minority of homosexual men. Interestingly in different cultures, like in ancient Greece, but also in some modern cultures, real homosexuals are considered those who are receptive during anal sex (who do not engage in pelvic

thrusting during sex). Among lesbians, vaginal stimulation does not seem to be a preferred activity. Only one quarter of lesbians report to have used a vibrator in the last month [93].

An important role in the pelvic thrusting in males is played by the medial preoptic area (MPOA) in the brain, and specifically a structure within it, the sexually dimorphic nucleus in the preoptic area (SDN-POA), or INAH3. I will use the term 'thrusting center' instead of MPOA, or SDN-POA, or INAH3, for an easier reading and understanding.

In females, the activation of the medial preoptic area and other brain areas, like the ventromedial hypothalamus, is involved in the motor responses during sex. The thrusting center in female rats is significantly more activated during intromissions than before them [94]. Female rats with lesioned thrusting center show an aversion to intromissions, although they do not seem to change their partner preference [95].

When the thrusting center is lesioned in male animals, the pelvic thrusting is lacking or impaired [96], but masturbation is not affected [97]. In some studies with male rats and ferrets, lesions of the thrusting center modify partner preference to same-sex partners [98,99].

In humans, the thrusting center is 2.2 times larger and has 2 times more neurons in males than females [100]. It is larger in heterosexual rams than in homosexual ones [101]. A decrease in the size of the thrusting center in male rats has been associated with same-sex preference [102]. In a study by LeVay [19] homosexual men had a thrusting center that was smaller than that of heterosexual men and almost as large as that of women. In another study, the magnitude of the difference was lower, not statistically significant, and homosexual men had a similar total number of neurons in the thrusting center as heterosexual men [103].

According to Hofman and Swaab, the thrusting center at birth has only 20% of the cells found at 2- to 4-year-olds. It achieves its full development in males and females around the age of three. After that age, it gradually becomes smaller through the years in females [100]. The authors state that "This postnatal period of hypothalamic differentiation indicates that, in addition to genetic factors, a multitude of environmental and psychosocial factors may have profound influence on the sexual differentiation of the brain."

Ahmed et al. [104] challenge the view that the thrusting center does not change during puberty in males. They have shown that it is enlarged with new cells during puberty in male rats and that in male rats castrated before puberty it gets smaller. Schulz et al. [105] have proposed that all the postnatal period up to late adolescence is a window of opportunity for the sexual differentiation of the brain structures, including the thrusting center implicated in homosexuality.

The thrusting center is organized into a male form under the long-term influence of testosterone. Prenatal and/or postnatal high levels of testosterone negatively affect the female motor responses (vaginal contractions), increase male typical motor responses in females, while prenatal and/or postnatal low testosterone levels in males decrease or abolish pelvic thrusts. In females, estrogen and progesterone as well have an impact on the thrusting center. More detailed information on the effect of sexual hormones will be given in the coming sections.

During adolescence, the thrusting center is still under development. The urge to thrust may not be present in the early sexual arousals of adolescents, but it appears later, under the influence of increasing levels of hormones and experience. Physical appearance and behavior of adolescents also changes and becomes more gender conforming under the effect of hormones. Therefore, most of the human male adolescents who experience homosexual attractions and behaviors outgrow them [106]. This is the case in modern cultures, but also in primitive ones, like in the Bisaasi-tedi or the Samba tribes [107]. Homosexuality is widespread among animal adolescents in some species and they outgrow it as well [23].

Regular masturbation during adolescence may negatively affect the development of the thrusting/engulfing reflex.

The thrusting/engulfing reflex during masturbation is not stimulated by the thrusting/engulfing of the sexual partner. Physical contact of the vagina with the penis stimulates the vaginal contractions in females and the pelvic thrusting in males. Vaginal contractions in females and pelvic thrusting in males, if present, may achieve little increase in the sexual arousal of the masturbator. Given the lack of physical stimulation from intercourse, the thrusting reflex may be weak or not even present during masturbation. If time after time orgasm is achieved without thrusting/engulfing, the brain may not develop this ability fully.

Experience is important in sexual development. This is the case for most mental and physical faculties. After the first several matings, the male becomes more efficient at pelvic thrusting, but the reverse may be true after the first several masturbations: the male becomes less efficient at pelvic thrusting, while the female at vaginal contractions. This effect of masturbation on the thrusting reflex may contribute to the inability of many heterosexual porn users to have intercourse [108].

The thrusting reflex may be weak also for anatomical reasons. Whereas the thrusting center centrally controls the thrusting instinct, the anatomy of the penis and of the vagina facilitates it. Research of urologist Ahmed Shafik suggests that physical stimulation of the clitoris and/or the G spot (suggested to be the internal extension of the clitoris) causes vaginal contractions. In females exposed to high androgen levels prenatally, the G spot may be located so high in the vagina that the penis cannot effectively stimulate it [109]. As a result, the vaginal contractions may be too weak or not appear at all during intercourse. This negatively affects sexual arousal of both partners.

In males, pelvic thrusting is thought to be stimulated by the action of dopamine on the D1 type dopamine receptors in the thrusting center. In mice without the D5 dopamine receptor (a D1 like receptor), in contrast to the normal mice, the males do not show preference for a place when only intromissions are paired to it. That is, male mice without the D5 dopamine receptor find intromissions (pelvic thrusting) not rewarding. Female mice without the D5 dopamine receptor are not receptive to male mice when stimulated with dopamine like substances [110]. These behavioral traits are similar to those of homosexuals, who find intromissions not rewarding. The D5 dopamine receptors in the thrusting center and their activation may thus have a role in homosexuality.

When the thrusting/engulfing reflex is missing or weak during intercourse, the individual may fail to achieve orgasm due to inadequate physical stimulation and may find heterosexual partnered sex unrewarding. As a result, (s)he may lose interest in future heterosexual relationships. The individual may become asexual, or if (s)he has homosexual attractions may act on them, becoming homosexual, or (s)he may resort to masturbation, which may disrupt phase-5 (orgasm).

Disruption of phase-5. Orgasm

Persons with high sexual drive and those with high testosterone may be prone to homosexuality due to the disruption of this phase. Heterosexuals with high sexual drive may become addicted to sex, hypersexual. Persons with sexual addiction have increased odds of having homosexuality [111].

Addicted persons prefer stimuli which are fast rewards over stimuli which are slow at rewarding (although the latter may give higher satisfaction when achieved). Many people will not engage in masturbation because partnered sex is much more satisfying, although more demanding. But

masturbation is a fast reward, and addictive personalities may prefer masturbation over partnered sex when they face even slight challenges in courtship.

The sex addict usually masturbates to sexual fantasies or to porn. The endless supply of porn images increases the risk of addiction. Experiments with rats show that rats exposed to new female partners continue mating despite having reduced or stopped it with the familiar partner [112].

With the progression of the sexual addiction the individual is desensitized (creates tolerance) to the female characters of porn/fantasies (the rewarding stimulus). He has a diminished orgasmic response to the usual porn images/fantasies. In porn images/sexual fantasies, both women and men characters are present usually, and during or following desensitization, sexual arousal may get transferred through conditioning from the main stimulus (the woman character) to the stimulus associated cue (the man character). The new cue (the man character), is perceived as new, exotic and this facilitates the transfer of arousal. In sexual fantasies, the man character is often the sexual addict himself.

This phenomenon is known in drug addiction, where the drug-associated cues may elicit even more arousal than the drug itself [113]. The negative impact masturbation has on thrusting/engulfing reflex facilitates the re-attribution of the sexual arousal to same-sex cues.

Many heterosexuals view (and masturbate to) gay porn, transsexual porn, while many gays view heterosexual porn and this shows the fluidity in the attachment of sexual arousal to stimuli during porn use [114,115].

The porn user would have to enact his fantasies with same-sex persons in order to become real life homosexual. Some porn users don't find the real life experience satisfying and return to heterosexual identity, while others progress into partnered homosexuality.

The effect of sexual addiction may be more pronounced in individuals inexperienced in partnered sex.

Males with high testosterone levels are more sensitive to rewards and may be more vulnerable to the disruption of this phase [84]. Addicted persons (who have high sexual drive) may already have homosexual attractions due to disruption of phase-2 (attribution to emotional cue). For them, the shift of sexual arousal from heterosexual cues to homosexual cues would be easier.

What if someone is homosexually addicted? Can a homosexually addicted person become heterosexual as a result of his addiction? As I mentioned previously, some gay men view heterosexual porn. I don't think homosexual addiction can lead to heterosexuality. A complete heterosexual response cycle requires a developed thrusting/engulfing reflex and sexual addiction negatively affects this reflex. Heterosexual porn users are often unable to have heterosexual relationships.

Addiction is thought to be caused by an imbalance in dopaminergic circuits in the brain.

This phase of the sexual response cycle may also get disrupted in females prenatally exposed to high levels of testosterone. In them, the long distance of the G spot from the entry of the vagina may decrease the likelihood of experiencing orgasm during intercourse [109]. Such women experience orgasm more easily through direct stimulation of the clitoris. If they have gender nonconformity as well, which is highly probable due to exposure to high testosterone levels, they may have homosexual attractions from phase-2 (attribution to emotional cue). In these women homosexual orgasmic sex, which is mostly based on the stimulation of the clitoris, would be perceived as more rewarding than heterosexual orgasmless sex, which is mostly based on the stimulation of the vagina. Similarly to men, women who have high testosterone levels would preferentially condition to cues that elicit orgasm, that is, to homosexual cues.

The following four chapters will explore in depth the role of masturbation, sexual hormones, and brain inflammation in the disruption of the different phases of sexual response.

3.2 Masturbation

Masturbation occurs in 34 nonhuman primate species. It is more common in primates with a promiscuous mating system. Male masturbation in these species has been proposed to be a non-functional by-product of high sexual drive. In male rhesus macaques masturbation is linked to low mating opportunities: regardless of rank, males are most likely to be observed masturbating on days in which they are not observed mating. Lower-ranking males mate less and tend to masturbate more frequently than higher-ranking males [116].

Similarly, in the Japanese macaques (a primate), masturbation with or without ejaculation, is practiced by males mainly during the breeding season. In this species, both the rate of masturbation only and masturbatory ejaculations increase as male social status and male mating success decline [117].

Masturbation statistics have a similar trend as drugs' use data. In the last decades more youth practice masturbation. They begin to masturbate at an earlier age and continue to practice it even when living in satisfying relationships [118].

R. Von Krafft-Ebing, [3] in the nineteenth century, held that masturbation causes homosexuality:

Nothing is so prone to contaminate- under certain circumstances even to exhaust- the source of all noble and ideal sentiments, which arise of themselves from a normally developing sexual instinct, as the practice of masturbation in early years. It despoils the unfolding bud of perfume and beauty, and leaves behind only the coarse, animal desire for sexual satisfaction. If an individual, spoiled in this manner, reaches an age of maturity, there is wanting in him that aesthetic, ideal, pure, and free impulse which draws one toward the opposite sex. Thus the glow of sensual sensibility wanes, and the inclination toward the opposite sex becomes weakened. This defect influences the morals, character, fancy, feeling, and instinct of the youthful masturbator, male or female, in an unfavorable way, and, under certain circumstances, allows the desire for the opposite sex to sink to nil; so that masturbation is preferred to the natural mode of satisfaction. If the youthful sinner at last comes to make an attempt at coitus, he is either disappointed because enjoyment is wanting, on account of defective sensual feeling, or he is lacking in the mental strength necessary to accomplish the act. The fiasco has a fatal effect, and leads to absolute psychical impotence. A bad conscience and the memory of past failures prevent success in any further attempts (p. 188).

An interesting fact is the use of masturbation by the Native Americans of the southwestern United States to create feminine males (*mujerado*) for their traditional orgies. These feminine males were used as passive partners in homosexual orgies. The manner they were created is narrated by Hammond [119]:

For the making of a *mujerado* one of the most virile men is selected, and the act of masturbation is performed upon him many times every day. At the same time he is made to ride almost continuously on horseback.

The genital organs are thus brought at first, into a state of extreme erethism, so that the motion of the horse is sufficient to produce the discharge of seminal fluid, while at the same time the pressure of the body on the animal's back -- for the riding is done without a saddle -- interferes with their proper nutrition. It eventually happens that, though an orgasm may be caused, emissions can no longer be affected, even upon the most degree of excitation. Finally, the accomplishment of an orgasm becomes impossible; in the meantime the testicles and the penis begin to shrink, and in time reach their lowest plane of degradation. But the most decided changes are at the same time going on, little by little, in the instincts and proclivities of the subject. He loses his taste for those sports and occupations in which he formerly indulged, his courage disappears and he becomes timid to such an extent that, if he is a man occupying a prominent place in the council of the pueblo, he is at once relieved of all power and responsibility, and his influence is at an end (p. 168).

Hammond held that excessive masturbation (and horse riding without a saddle, which frequently leads to seminal emissions) can lead to feminization by first causing impotence. According to him, "this condition is accompanied with such moral and physical changes in the affected individuals as to cause them to look like women, and to acquire the mental characteristics and instincts of the female sex."

Masturbation may play an important role also in autogynephilia by reinforcing the paraphilic interest through orgasm. Transgender males are categorized in two groups by psychologist Michael Bailey: homosexual transgenders and autogynephilic transgenders. Autogynephilic transgenders want to be females because they feel or have previously felt sexually aroused from the thought of being a female. Autogynephilia is a paraphilia. Autogynephilic transgenders often perform sex reassignment surgery and have higher homosexuality rates than in the general population.

Masturbation and stress

Several studies show masturbation to be associated with stress [120,121]. Homosexuals on average masturbate and view porn more than heterosexuals [122]. Compared to heterosexuals they experience less sexual desire toward a partner and more sexual desire directed to non-partners or masturbation [123]. Masturbation itself, when done excessively, can be a source of stress, as porn users can attest. Persons with hypersexual disorder are more vulnerable to stress and have overactive stress systems [124,125].

3.3 Brain inflammation

The sexual response cycle could also be disrupted due to brain inflammation in the brain areas controlling sexual behavior.

A paper [126] published recently by Kathrin Lenz et al., found out through experiments on rats that mast cell activation in the brain pre-optical area (POA) during the prenatal period masculinizes sexual behavior of females and de-masculinizes the sexual behavior of males.

According to the study, the male POA during the sexual differentiation stage has more mast cells than the female POA. A gestational allergic challenge significantly increased the number of mast cells in the female POA to male-typical levels. Prenatal allergic challenge also increased the proportion of degranulated mast cells.

The females born to allergic challenged dams when adults, under treatment with testosterone, mounted more quickly and more often than control females, so that their overall performance was

equivalent to males. They also trended towards a preference for olfactory investigation of female versus male soiled bedding. Males gestated in an allergic challenged dam showed the opposite, a loss of female partner preference, suggesting demasculinization.

The authors of the study proposed that there may be an optimal threshold for inflammatory signaling in the male brain, beyond which there is dysregulated sociosexual development. In the experiment, the inflammation was induced prenatally. In humans, the brain continues to sexually differentiate during adolescence, hence it is possible that inflammation in the brain during adolescence could also affect its sexual differentiation and contribute to homosexuality.

Inflammation in the brain could impact not only sexual differentiation of the brain, but also its activation at whatever age.

Hypothalamic inflammation has been suggested by different studies to be a causal factor in obesity and anorexia and a diet rich in fat and sucrose has been suggested to further increase hypothalamic inflammation [127,128,129].

Hypothalamus is the key brain region regulating food intake, as well as sexuality. Inflammation in the hypothalamus or in other brain areas regulating sexual behavior could disturb sexual response similarly to how it disturbs eating behaviors. Hypersexuality is similar to obesity, whereas asexuality is similar to anorexia.

Brain inflammation has been suggested as contributing factor in drug addiction, depression, psychotic disorders and autism spectrum disorders [130,131,132]. Persons with depressive disorders, psychotic disorders, autism spectrum disorders have higher homosexuality rates [133,65]. The increased rate of mental health disorders among homosexuals has usually been explained with minority stress. While minority stress is a significant stress source, there is the possibility that mental disorders themselves are highly correlated with homosexuality due to sharing similar brain processes (inflammation) leading to different outcomes depending on which part of the brain the inflammation affects.

Answers to the following questions can clarify on how big (or small) a role minority stress has in the mental disorders of homosexuals:

1. Do mental health symptoms precede homosexuality?
2. Do relatives of homosexuals have increased odds of mental health symptoms?
3. Has the rate of mental disorders among homosexuals been proportionally affected by the decrease of homophobia in modern societies?
4. Do animals engaged in same-sex behavior show mental health symptoms?

Regarding question 1: Autism spectrum disorders precede homosexuality. Children who later become homosexual score higher on indicators of anxiety and depression [134].

Regarding question 4: Male rats with same-sex preference show higher anxiety than other rats [135]. Animals are probably not subject to minority stress, so the anxiety these rats have should not normally be the result of minority stress.

I am not aware of any study investigating question 2 and 3.

How may brain inflammation cause homosexuality?

A frequent symptom of manic and hypomanic phases in affective and schizoaffective disorders is excessive involvement in sexual activities, a marked increase in goal-oriented behavior in general, and in sexual drive in particular. The dopamine hypothesis of affective disorders holds that during manic episodes there is a hyperactive reward processing network, a state of hyperdopaminergia.

High sexual drive may disrupt phase-2 (attribution to emotional cue) and phase-5 (orgasm) of the sexual response cycle.

Brain inflammation during depression has been proposed to cause low serotonin levels in the brain [136]. Serotonin balances dopamine in the brain. As mentioned previously, low serotonin levels may cause high sexual drive and homosexuality.

When depression goes into remission, the homosexual attractions and behavior may cease. Different mental health forum users mention experiencing homosexual desires during depression:

Ceshire Kitty Cat [137], on CrazyBoards.org:

So I consider myself a straight female, but for the last few years I've noticed that I was sometimes attracted to certain girls....never acting on it, never been sexually involved with a girl. The last few year were very bad for me, as I reflect on that time I was displaying blatant bipolar disorder behaviors. I was officially diagnosed 8 months ago and so far so good.

....

I have no interest in a relationship with a women but I'm having these fantasies.

I noticed these fantasies and wants to act upon them are really intense during my manic phases.

Am I bisexual or bicurious bc o these?

Are these just a part of my manic episodes?

Does being bipolar play a role in my sexuality?

EarlyGreyDregs [138], on PsychForums.org:

...during the times when I've been extremely ill, I've fell for girls. They were the only ones that I was attracted to, men were like irritating flies that I tried to ignore. But now that I am stable, I am attracted to guys again, no thoughts towards girls anymore. & When I say I was ill, I meant rapid cycling between hypomania and depression, so the hyper-sexuality didn't play a part as I was falling for them when I was depressed as well.

SPQR user on the same discussion thread:

I have BP II, and the hyper sexuality has been one of my biggest problems. I consider myself straight. Undeniably incredibly straight. Always have been always will be (who the hell knows though!).

HOWEVER! When I am on a really high up-swing (like the tippy top of my moods) I will flirt with dudes. Gay dudes, straight dudes, whoever. During these times people that don't know me think I am gay.

Now that is all pretty common place but every once and a while I will consider having sex with a dude (again on an upswing). I will consider them along with all the other females that I think might have sex with me. I will find them attractive just like any other girl. It is actually quite hard to explain. Even while having these thoughts I still consider myself straight, I just want to have sex that badly.

I should note that I have never actually acted on any of my gay impulses.

Now when I am on a low that thought would even cross my mind. It is all girls and darkly romantic, no guys come to mind.

Hanktrick [139], on EmptyClosets forum:

My mother died this year in April, after that I went through grieving and I was able to pick myself up and move on. Throughout the months I went through periods where I thought I might have been schizophrenic, depressed, had OCD, had social anxiety, I was transsexual, homosexual, and other things.

I even came out in the internet forums as a "homosexual that isn't willing to live like a homosexual", in other words a gay man in the closet.

After I got treated with Prozac, I suddenly realized that I actually wasn't gay, and if I had actually come out in real life as gay, it woulda taken a hell of a ride to convince others that I was indeed straight.

Systemic inflammation, which can cause widespread activation of immune cells in the brain, is also thought to affect dopamine levels in the brain, thus increasing the risk for addiction [140].

In addition to neurotransmitters, inflammation may affect sexual hormones, which are important in sexual behavior. The hypothalamus, the pituitary gland (situated in the brain) and the gonads form the hypothalamic-pituitary-gonadal (HPG) axis. The HPG axis plays a critical part in the development and regulation of the reproductive system. Hypothalamic inflammation due to high-fat, high-glycemic index diet is suggested to be involved in low testosterone levels and hypogonadism associated with obesity [141]. In an experiment on mice, hypothalamic inflammation due to high-fat diet impairs the function of the hypothalamic neurons which stimulate the production of sexual hormones [142].

Cognitive problems associated with schizophrenia, autism spectrum disorder may contribute to gender nonconformity. Individuals with an autism spectrum disorder or autistic traits have increased rates of gender nonconformity [65,66]. Schizophrenia is more prevalent among individuals with gender dysphoria [67]. Gender dysphoria bears similarities to delusional disorder, a condition where the person has a belief maintained despite being contradicted by reality or rational argument.

In addition to inflammation, brain injuries like brain stroke [143], brain surgery [144] have been recorded to cause homosexuality in rare occasions.

Brain inflammation and stress

Factors that increase hypothalamic inflammation include sleep disruption combined with high-fat diet, excessive physical exercise [145,146]. Severe air pollution [147], heavy metals also induce brain inflammation.

3.4 High testosterone and estrogen dominance in females

High testosterone

Prenatal exposure of female fetuses to male hormones increases the likelihood of them being homosexual [148]. Postnatal exposure of females to testosterone has also been linked to an increased chance of homosexuality. High testosterone levels have been found in lesbians [149]. Gender nonconforming, masculine behavior is predictable of homosexuality in females [69].

Around half of transsexuals report a change in sexual orientation during transitioning and this has been partially attributed to treatment with hormones, especially testosterone [150,151].

High testosterone can affect several phases of the sexual response cycle.

The effect of high testosterone on phase-2 (attribution to emotional cue)

High testosterone levels affect physical appearance of women by increasing their facial hair, deepening their voice, reducing fat around the hips, increasing muscle mass, etc. They also affect behavior by increasing assertiveness. Women, who due to high testosterone levels are different from their female peers in physical appearance and behavior, may attribute spontaneous sexual arousals to their same-sex peers.

High testosterone levels also increase sexual drive, thus facilitating disruption of phase-2 when the woman is sleep deprived and/or under the effect of psychoactive substances.

The effect of high testosterone on phase-3 (courtship)

Masculine looking and behaving women have difficulties in attracting men and accepting their assertiveness during courtship. Unsuccessful courtship attempts may increase anxiety in the woman and in successive attempts such increased anxiety may decrease sexual arousal and may contribute to failure of the courtship.

The effect of high testosterone on phase-4 (thrusting/engulfing):

The thrusting/engulfing reflex in females is impacted by testosterone. In rams, exposure of female fetuses to increased levels of testosterone in the womb increases the size of the thrusting center, and as adults the females show more mounting behavior (male-typical behavior) [152]. In female rats, androgens are needed to keep the volume of the thrusting center from getting smaller [153], and its volume increases to the male size when the female rats are treated with testosterone prenatally and postnatally.

Research of urologist Ahmed Shafik shows that physical stimulation of the clitoris and/or the G spot (suggested to be the internal extension of the clitoris) causes vaginal contractions. In females exposed to high androgen levels prenatally, the G spot may be located so high in the vagina that the penis cannot effectively stimulate it [109], as a result the vaginal contractions may be too weak. This negatively affects sexual arousal of both partners.

The effect of high testosterone on phase-5 (orgasm):

High testosterone levels in women increase sexual drive, hence increase the risk for sexual addiction.

Testosterone also affects the anatomy of the vagina. A greater distance of the G spot from the entry of the vagina, due to high prenatal testosterone levels, may decrease the likelihood of experiencing orgasm during intercourse [109]. Such women experience orgasm more easily through direct stimulation of the clitoris. As a result, homosexual orgasmic sex, which is mostly based on the stimulation of the clitoris, could be perceived as more rewarding than heterosexual orgasmless sex, which is mostly based on the stimulation of the vagina. Similarly to men, women who have high testosterone levels would preferentially condition to cues that elicit orgasm, that is, to homosexual cues.

Lesbian women with masculinized appearance and behavior are referred to as butch in the LGBT community. Lesbians who behave in a feminine way and whose appearance is feminine are referred to as femme. Let's talk about the femme lesbians. Estrogen dominance may be the hormonal imbalance affecting their sexuality.

Estrogen dominance, progesterone

Estrogen dominance in women is the condition of having too much estrogen relative to progesterone Luoto et al. [154]. have proposed that femme homosexuality happens due to exposure of the female to high levels of estrogen in the womb in contrast to butch homosexuality, which happens due to a testosterone imbalance. Several studies support a role for estrogen in female homosexuality. Exposure of rodents to high levels of estrogen in the womb causes masculinization of the thrusting center [155]. Exposure of female monkeys to synthetic estrogen in the womb causes an increase in mounting behavior [156]. In males and in females, testosterone masculinizes the thrusting center by first converting to estrogen. In contrast to testosterone, estrogen does not cause virilization of physical appearance.

Some studies have shown that women prenatally exposed to synthetic estrogen diethylstilbestrol (DES) have increased incidence of homosexuality [157,158]. A larger study nevertheless has concluded that DES has no effect on sexual orientation [159]. DES was widely prescribed to millions of pregnant women in the 1940s, 1950s and 1960s.

In animals, estrogen followed by progesterone release is necessary for receptive (copulation facilitating) behavior by the female. In women, progesterone may play a role in stimulating the vaginal contractions during sex and the engulfing urge that precedes them. This urge would make the woman more receptive to heterosexual sex. While progesterone facilitates receptivity during ovulation, its continued release in the days following ovulation decreases receptivity.

A reddit transgender user recounts her experience of how synthetic progesterone would change her sexual partner preference:

So basically about a month ago I had pretty much decided I was a lesbian. I was off of the progesterone at the time because I realized I didn't have much left. Then I decided to just start taking the progesterone again every day and after about a week I felt only attracted to males, I even hooked up with a guy. But now I have been off the progesterone for a couple of weeks and I am only interested in women and identifying as a lesbian...
...when I am full of progesterone I want to be dominated, and at that stage some big and strong is arousing for me [160].

Reddit user Iyzie, transgender, responds:

I've been on and off progesterone and my orientation has gone through cycles like you describe pretty much the whole time since I've been on HRT [hormone replacement therapy] (+2 years).

Another Reddit user recounts in the same discussion thread:

She said around ovulation and afterward (peak progesterone levels) she was more attracted to dominance, physical attractiveness, leadership, adventurous guys, while before and during her period (lowest progesterone levels) she was more attracted to empathetic, calm, organized, kind and caring kind of guys.
That kind of matches your experience if you are seeing men as more dominant and being attracted to them at peak progesterone levels while seeing women as more nurturing, kind and empathetic at your lowest progesterone levels.

To the question on Quora, “Can your sexual orientation change due to gender transition?”, a male to female transgender responds:

Yes.... as a MtF [male to female] person I have experienced it. What seemed to do it for me was the hormone therapy, specifically the progesterone which I started later on in the therapy itself. When I did, men became MUCH more attractive to me [161].

Researchers have found that women with consistent lesbian identity show an increase in same-sex motivation around ovulation, while bisexual women who grant a role for choice in their sexuality show a decline in same-sex motivation around ovulation [162]. Half of femme lesbians are bisexual, while almost all butch lesbians see themselves as exclusively homosexual [154]. So, the women who saw a decline in same-sex motivation during ovulation are probably femme. This study supports a role for progesterone in homosexuality.

Women with polycystic ovary syndrome (PCOS) have estrogen imbalance and increased testosterone levels,. Several studies have shown that women with PCOS have reduced progesterone levels. In PCOS, the ovarian follicles fail to release the egg and become cysts that do not produce progesterone. Women with PCOS have higher homosexuality rates [163].

Kingsberg argues that when women go through menopause they no longer have a biological imperative to mate with a male, and so their body becomes attuned to same-sex attraction.

An interesting case is that of genetic males with complete androgen insensitivity syndrome (CAIS). Genetic males with CAIS produce testosterone, but their cells are unable to utilize it. Their physical appearance is typical female, but they do not have ovaries and uterus. Genetic men with CAIS produce estrogen and progesterone at male levels. Most of them get hormonal replacement therapy, mainly estrogen. So what is their sexual orientation? They are mainly androphilic (sexually attracted to males), but they have a high percentage of non-heterosexual orientation, of issues with vaginal penetration, and of dissatisfaction with their sexual life [72,164,165]. The studies with CAIS genetic men are with small samples, so there may be significant differences in conclusions between studies.

The studies mentioned herein support a role for low progesterone levels in female homosexuality. Another hypothesis is that high progesterone levels in women and men promote homosexuality. The affiliation hypothesis of homoerotic motivation in humans asserts that affiliation is one of the main drivers of homoerotic behavior. Fleischman et al. [166] have argued that in women and men, progesterone, a hormone shown to promote affiliative bonding, is positively associated with homoerotic motivation. Nevertheless they found that during ovulation progesterone is negatively correlated with homoerotic motivation. Outside of the ovulatory days there is a positive, although small ($r(90) = .27$) correlation between high progesterone levels and homoerotic motivation.

A study on progesterone levels in homosexual and heterosexual women found higher levels of progesterone in homosexual women [167]. The study was with a small sample (20 homosexual women). Another study with homosexual women found no differences in progesterone levels [168].

Use of progesterone during pregnancy has been associated with increased homosexuality rates in the offspring [169].

Estrogen imbalance, progesterone and stress

Progesterone is produced by the ovary, testis, but also the adrenal gland, and is a precursor to the stress hormone cortisol. In healthy women, during the first phase of the menstrual cycle (when the ovary produces minimal progesterone) progesterone levels increase during stress [170]. During ovulation and the second phase of the menstrual cycle, when progesterone should be high to stimulate ovulation and receptive behavior, stress lowers progesterone levels because the adrenal glands ‘steal’ the progesterone to produce cortisol. Author Stefani Ruper calls this ‘pregnenolone steal’.

Estrogen levels in the blood may be vulnerable to pollution, a physiological kind of stress. Xeno-estrogens and other endocrine-disrupting chemicals flooding the environment expose human fetuses to excessive estrogen levels (for more details read the chapter on pollution).

While half of femme lesbians are bisexual, almost all butch lesbians see themselves as exclusively homosexual. The difference is probably due to testosterone affecting more phases of the sexual response cycle than estrogen and progesterone. Testosterone affects phase-2 (attribution to emotional cue), phase-3 (courtship), phase-4 (thrusting/engulfing) and phase-5 (orgasm). Estrogen imbalance does not affect gender conformity of the femme lesbian.

Some conditions associated with disturbed sexual hormones in females

Androgens in the female are produced mainly by the ovary and the adrenal gland. One of the most common reasons for high androgen production among women is polycystic ovary syndrome (PCOS). Polycystic ovaries are found in 32% to 88% of untreated female-to-male transsexuals [171,172,173].

A study by Agrawal et al. [163] with 254 lesbians and 364 heterosexual women found that 80% of lesbian women compared to 32% of heterosexual women had polycystic ovaries on pelvic ultrasound examination. There were no significant differences in the androgen concentrations between lesbian and heterosexual women with normal ovaries. However, lesbian women with polycystic ovary/PCOS had a significantly higher free androgen index compared with heterosexual women with PCO/PCOS. Agrawal et al. suggest that high androgen levels may contribute to homosexuality in women. PCOS is the most common endocrine disorder in women of childbearing age, affecting up to 20% of women in this age group [174]. In a study by Manlove et al. [175] with 34 women with PCOS, the women reported less feminine childhood behavior, less gender-typical behavior and there was a tendency toward bisexuality and fluid sexual orientation.

Female children of women with PCOS have increased levels of androgens upon birth [176]. Therefore the effect of PCOS on sexual orientation may extend beyond the mother to her female offspring.

The adrenal glands are another source of increased androgen production in women and in prepubertal men (whose testicles do not yet produce testosterone). In prepubertal boys the excess of adrenal androgens leads to virilization and precocious puberty, while in prepubertal girls, it leads to inappropriate virilization [177]. Girls with increased androgen production due to congenital or non-classical adrenal hyperplasia, have increased homosexuality rates [178]. Such increased rates are attributed to the prenatal effect and masculinization of childhood behavior due to the increased androgen production by the adrenal glands. Non-classical adrenal hyperplasia begins during childhood or adulthood. About 25-30% of Polycystic Ovary Syndrome cases are due to excess production of androgens by the adrenal glands [179].

Thyroid dysfunctions also have been associated with higher homosexuality rates. Thyroid dysfunction in the mother increases the probability for homosexuality in the daughter [180]. Lesbians have higher rates of Hashimoto’s Thyroiditis, (a kind of hypothyroidism) [181].

Hashimoto's Thyroiditis is an autoimmune disease. The thyroid regulates sexual hormone levels. The thyroid hormones stimulate progesterone release and severe hypothyroidism is associated with failure of ovulation.

3.5 The role of sexual hormones in males

Low testosterone

Testosterone is responsible for the masculinization of the brain, of physical appearance and behavior of males. Anti-androgens and estrogens are given during hormonal replacement therapy to male-to-female transgender patients in order to demasculinize and feminize them [182]. Prenatal low testosterone levels in males have been associated with increased homosexuality in adulthood [148]. Postnatal testosterone levels can also affect sexual orientation. Some studies have been done with eunuchs (castrated males). Testosterone levels are very low in eunuchs. In a study with eunuchs who were not transsexuals, 22% of the eunuchs reported a change in sexual orientation after castration [183]. In another study, 20-30% of eunuchs reported a change after castration in the preferred gender of attraction, fantasies or relationships. The average age at castration was 43 years old [184]. Most of the eunuchs in both studies were taking supplemental testosterone and/or estrogen.

A considerable percentage of male-to-female transsexuals report a change in their sexual orientation during the transition process, and some of them attribute the change to the sexual hormone therapy [185]. Male-to-female transsexuals report a shift in sexual orientation after sex reassignment surgery (from 54% predominantly attracted to women to 25% after sex reassignment surgery) [186].

Low testosterone levels may be more prevalent among homosexual men than is evident from different studies. Studies often compare testosterone levels between contemporaneous males. Testosterone levels of homosexuals compared to today's heterosexuals may not be considerably lower, but testosterone levels in young men in general seem to have decreased (or their action has gotten weaker) through the last century. Data from the 1940s show that the majority of young men had sperm counts with averages higher than 100 million/ml. Recent studies of young men in Northern Europe show that in Denmark approximately 40 percent of the men nowadays have sperm counts below 40 mill/mL [187]. Testosterone levels greatly influence sperm count, therefore they also have probably decreased (or their action has been impaired) during the last century.

Low testosterone levels can impact several phases of the sexual response cycle.

The effect of low testosterone on phase-2 (attribution to emotional cue):

In studies on gender nonconformity, men with feminized, gender nonconforming behavior have an increased probability of becoming homosexual [69,188,189].

At the extreme end of the testosterone scale are genetic males with complete androgen insensitivity syndrome, whose cells are completely resistant to the action of testosterone. They have a female appearance and are mostly androphilic.

The effect of low testosterone on phase-3 (courtship)

Gender nonconforming behavior would negatively impact appropriate courtship by the male. Non-masculine males would be less assertive in the courtship game and would lose in the competition with more assertive males [91]. Low testosterone levels are associated with low self-confidence, timidity and fearfulness in males [190].

Unsuccessful courtship attempts may increase anxiety and in successive attempts this may decrease sexual arousal and contribute to failure of the courtship attempt.

The effect of testosterone on phase-4 (thrusting/engulfing)

In females the thrusting center gradually gets smaller after the ages of three to four, while in males it remains unchanged, but it gets smaller with lower testosterone levels (in castrated males). In a study by Garcia-Falgueras [191], the volume and neuron number of the thrusting center in castrated men was intermediate between that of males and females, but higher than in castrated, hormone-treated male-to-female transsexuals, who had a structure similar in size to that of females. In a female-to-male transsexual its volume and number of neurons was within the male range, even though the treatment with testosterone had been stopped three years before.

These data show that testosterone levels affect the size of the thrusting center prenatally as well as postnatally, in both females and males. Thus, males who have low testosterone levels through their childhood and adolescent years could have a smaller/more feminine thrusting center due to chronically low testosterone levels. Testosterone not only organizes the thrusting center but also facilitates its activation by acting on dopamine. In male animals, recent presence of testosterone is necessary for both dopamine release and copulation. Dopamine acts on the Dopamine D5 receptors in the medial preoptic area to stimulate the pelvic thrusts [192].

High testosterone levels

Different studies show different testosterone levels in homosexuals: some show low levels, [193,194], some show high testosterone levels [195,196] and other studies show normal testosterone levels [197,198]. Different facts support the idea that high testosterone levels may facilitate development of homosexuality:

- Penis size of homosexuals is bigger on average than that of heterosexuals [199]. Penis grows under the effect of testosterone.
- Anti-androgen therapy was used in the past to treat homosexuality and is used today to treat homosexual pedophilia, male hypersexuality [200].
- More men identify as gay than women identify as lesbian and men have higher testosterone levels.
- In animals, homosexual activity is often noticed in situations of competition for resources, territory or mates between same sex individuals. In such situation, the mounting male shows his dominance to the other male. The aggressive male has probably high testosterone levels, which mediate both aggression and physiological arousal [201,202]. Extraverted males may be more prone to such a behavior [203].
- In primitive cultures, like the tribes of Melanesia, where warfare was common and masculinity very esteemed, ritualized homosexuality was widely practiced.
- As mentioned earlier, “one of the most virile men” was selected to create feminine males (mujerado) for the traditional orgies of the Native Americans.

Testosterone increases sensitivity to rewards in general and sexual drive in particular. High sexual drive may disturb phase-2 (attribution to emotional cue) and phase-5 (orgasm). Hypermasculine men may be vulnerable to situational homosexuality in populations with sex-skewed ratios (in prisons, during war etc.) and to porn use.

High progesterone, high estrogen

Men produce estrogen and progesterone, although in lower levels than women.

The affiliation hypothesis of homoerotic motivation in humans asserts that affiliation is one of the main drivers of homoerotic behavior. Fleischman et al. [166] argue that in men, progesterone, a hormone shown to promote affiliative bonding, is positively associated with homoerotic motivation. They tested progesterone levels in 56 exclusively heterosexual men and 4 mostly heterosexual men and found that homoerotic motivation positively correlated with higher progesterone levels.

Estrogen is a hormone that feminizes both physical appearance and behavior of the male when it is in high levels. High levels of estrogen in the male cause growth of breast tissue, distribution of the body fat in a feminine fashion, loss of muscular mass etc. Transgender users of hormone treatment therapy report of estrogen making them more emotional and more interested in social relations. Thus, estrogen may affect phase-2 (attribution to emotional cue) and phase-3 (courtship) of the sexual response cycle.

Stress affects both progesterone and estrogen levels in men (for more read the chapter on stress).

4 The role of diet

4.1 Epidemiological evidence

The Western diet is typically made of high-sugar, high-fat food. Consumption of sugar doubled in the United States and the United Kingdom between 1900 and 1967 [204]. Obesity rates also increased in the 20th century [205].

Homosexuals have more eating disorders than heterosexuals, [206,207,208] which usually involve eating large amounts of high glycemic index foods and fat, or eating an imbalanced diet, leaning toward carbohydrates. A study on eating behaviors in sexual minority adolescents in the UK by Calzo et al., [209] found that:

At age 14, gay and bisexual boys and mostly heterosexual girls reported greater body dissatisfaction than their same-gender heterosexual peers. All sexual minority boys and mostly heterosexual girls reported greater mean dysfunctional eating behaviors than their same-gender heterosexual peers. At age 16, gay and bisexual boys had 12.5 times the odds of heterosexual boys of binge eating; mostly heterosexual boys had over three times the odds of reporting binge eating. Sexual minority girls had over twice the odds of heterosexual girls of purging and binge eating.

Access to a high calorie diet and alcoholic drinks was limited to the social elite circles in the past. Homosexuality as well appears to have been more frequent among the elite. In ancient Greece, homosexuality was widespread. According to Robert Flaceliere, as cited by Larry Houston:

It appears extremely likely that homosexuality of any kind was confined to prosperous and aristocratic levels of ancient society. The masses of peasants and artisans were probably scarcely affected by habits of this kind [210].

The notion of homosexuality as a distinctively aristocratic vice has a considerable history [211]:

In the first century AD, the Jewish writer Philo of Alexandria wrote about sodomy (a term usually used for anal sex, which included homosexual acts):

The inhabitants owed this extreme license to the never-failing lavishness of their sources of wealth ... Incapable of bearing such satiety, plunging like cattle, they threw off their necks the law of nature and applied themselves to deep drinking of strong liquor and dainty feeding and forbidden forms of intercourse.

.....

The theologian Albertus Magnus (1280) held that the vice of sodomy was more common in persons of high status than in those of humble backgrounds. In the 17th century, Sir

.....

Edward Coke, a noted English jurist, attributed the origin of sodomy to “pride, excess of diet, idleness and contempt of the poor.”

In Florence, in the 15th century, sodomy cases often involved members of the social elite,

indicating a proclivity for it among the Florentine aristocracy [212].

The number of societies with a presence of homosexuality increases with the intensity of agriculture [213]. Intensive agriculture typically involves a better food supply, especially to the social elite, with high calorie food (fat, honey, sugar) and alcoholic drinks.

Francis Pottenger, noticed an effect of diet on homosexual activity in experiments with 900 cats and raw food versus cooked food diet, done in the 1932-1942 period. In cats fed cooked food:

...there is evidence of a role reversal with the female cats becoming the aggressors and the male cats becoming passive as well as evidence of increasing abnormal activities between the same sexes. Such sexual deviations are not observed among the raw food cats [214].

According to Stephen Arlin and David Wolfe, authors of the book “The First Law of Nature: Raw Food Diet” [215], raw food diet changes the sexual orientation of homosexuals.

Adherents to the raw food diet (low-calorie, sugar-free, low fat) seem to better conserve the physical gender differences than those consuming the mainstream diet. Tonya Zavasta, the author of five books on raw food diet, notes that aging chronic raw foodists do not begin to resemble the opposite sex, common in their peers who eat the mainstream diet [216].

Different religions have historically used fasting to treat homosexuality, as detailed previously.

4.2 The effect of diet on sexual hormone levels

Calorie concentrated foods

In females

As explained in the chapter on development of sexual partner preference, too high testosterone levels in females and males and too low testosterone levels in males increase the frequency of homosexuality.

Disorders linked with sexual hormonal imbalances and homosexuality include PCOS, CAH (nonclassical adrenal hyperplasia), Hashimoto’s Thyroiditis (a kind of autoimmune thyroiditis) in females and non-alcoholic liver disease, Graves’ disease (a kind of autoimmune thyroiditis) in males [181].

In a systematic review of studies on diets and PCOS, high-carbohydrate diets were associated with an increased free androgen index, while low-glycemic index diets with improved menstrual regularity, reductions in insulin resistance. Weight loss improved the presentation of PCOS regardless of dietary composition in the majority of studies [217].

Insulin resistance and compensatory hyperinsulinemia have been recognized as a key factor in the pathogenesis of PCOS, and a diet with no high glycemic index food (no sugar and similar foods), low in fat, is recommended for PCOS [218].

Nonclassical adrenal hyperplasia is a form of adrenal insufficiency and although there are no formal studies (that I am aware of) of the effect of diet on this condition in humans, in alternative medicine, a healthy diet is considered important for the health of the adrenal glands. According to Dr. Daniel Kalish, the standard American diet is “a perfect recipe for destroying your adrenal glands.” He recommends eating a diet low in sugar and carbs for adrenal health [219].

In experiments on mice, high-fat diets cause adrenal hyperplasia [220].

In males

Obesity and excess weight are associated with lower testosterone, higher estrogen levels in males and low calorie diets can improve testosterone deficiency in males [221,222,223].

A study by Simon et al. [224] with 1,292 healthy men found that as total plasma testosterone decreased with each decade of age, insulin increased with each decade of age. The inverse association between testosterone and insulin was independent of age. The association remained even when obesity was accounted for. That is, even men who were not obese had higher odds of having low testosterone if they had high insulin levels. Consumption of high-index glycemic foods, especially when combined with fats, causes increased insulin levels.

A high-calorie diet has been implicated in lower testosterone levels for up to two subsequent generations in rats [225].

Low testosterone levels can be noticeable in obese males. Cases of transsexualism, with extremely low testosterone levels have been noted in obese men [226]. Hammond [119] narrates about tribes where obesity as well as feminization of males was rampant:

The most remarkable of all the nomadic tribes of the Kuban is that called the Nogays or Mongutays. The members of this are distinguished from the others by the Mongolian features, which characterize their entire physical structure. The men are obese, large and swollen, the cheek bones very prominent, the eyes deep sunken, and the beard sparse. When they are reduced by disease, or when they have attained to an advanced age, the skin of the whole body becomes wrinkled, the beard disappears altogether, and in this state they present a great resemblance to women. They become incapable of the procreative act, and their feelings as well as their actions cease to be like those of the sex to which they belong. Obligated to fly from the society of men, they seek that of women, whose dress they adopt (p. 160-161).

Males with a problematic liver may be more susceptible to a decrease in testosterone levels and to an increase in estrogen. Chronic liver diseases have been associated with feminization, hypo-androgenization and hyper-estrogenization in males [227]. Cirrhosis, a severe liver disease, is associated with testicular atrophy, female pattern distribution of hair, gynecomastia (development of the mammary gland). Non-alcoholic fatty liver disease is widespread in the population, including children [228]. Insulin resistance is thought to contribute to it [229]. Poor diet is considered the leading cause of non-alcoholic fatty liver, with the biggest offenders being sugar and fruit juices. A diet low in high-glycemic index carbohydrates, fat and alcohol is recommended for it.

The thyroid is another gland important in the control of sexual hormone levels and function. Grave's disease, an autoimmune disease that makes the thyroid overactive, is a disease that is more frequent among homosexual than heterosexual men [181]. Polymorphisms of a gene, TSHR, that codes for the major autoantigen in the Graves' disease, have been found to be relevant for the development of homosexuality [230].

An overactive thyroid gland may explain why many homosexual men have lower body weight than heterosexual men (independent of diet or exercise) [181,231].

Thyroid hormones affect sexual hormone levels and action. Hypothyroid males have increased rates of hypogonadism, while hyperthyroid males have high estradiol (a kind of estrogen) levels, gynecomastia [232].

The Western Diet may promote autoimmune diseases [233] like the Graves' disease.

Whereas in some males a high calorie diet lowers testosterone, in others it may increase it

above normal levels. It has been proposed that a syndrome similar to PCOS exists in males and is associated with high levels of free androgens and high insulin resistance [234]. Both low testosterone and high testosterone in males increase the frequency of homosexuality. Low testosterone affects phase-2 (attribution to emotional cue), phase-3 (courtship) and phase-4 (thrusting) of the sexual response cycle, whereas high testosterone affects phase-2 (attribution to emotional cue) and phase-5 (orgasm).

Vitamin and mineral deficiency

Several studies show an association between low vitamin D levels and low testosterone levels [235]. Vitamin D deficiency is associated with impaired male and female sexual function [236,237]. In some studies, after vitamin D supplementation testosterone levels in men increase and their sexual function improves [238]. Vitamin D supplementation may be beneficial for lowering testosterone levels in women with hyperandrogenism due to PCOS [239].

Vitamin A is another vitamin shown to be beneficial for healthy sexual hormone levels. Male children with delayed puberty treated with vitamin A and iron supplement for several months achieved puberty similarly to children treated with testosterone [240]. Male rats with vitamin A deficiency have low testosterone levels [241]. Vitamin A is abundant in organ meats, green leaves, carrots, etc. These foods are scarce in today's children's menus.

Among minerals, zinc is important for reproduction. Severe zinc deficiency causes delayed sexual maturation and hypogonadism in males. Zinc deficient animals (rats, sheep) have low testosterone levels due to the decreased capacity of the testicles to produce testosterone [242].

Some zinc is lost with semen emissions, [243] so sexual addiction contributes to zinc deficiency.

Climate change may be contributing to depletion of nutrients. Higher CO₂ levels may be significantly reducing the levels of zinc, iron in staple grains. Before the industrial revolution the level of CO₂ in the atmosphere was 280 ppm. Today the level of CO₂ is ~400 ppm. In an experiment, an increase of CO₂ levels from 380-390 ppm to 545-585 ppm caused a decrease in zinc levels of 9% in wheat, of 3% in rice and similar decrease in maize and soybeans, as well as a decrease in iron levels of 5% in wheat, 3% in rice [244].

One study on zinc levels in homosexuals found low levels of zinc, while another study found normal levels [245,246].

4.3 The effect of diet on sexual drive

In mammals and humans, sexual desire is impacted by food intake. Food deprivation suppresses estrous behavior in female mammals [247]. Women with eating disorders, especially those with anorexia, have decreased sexual desire and increased sexual anxiety [248]. Ketogenic diet, a diet with almost no carbs, low in protein and high in fat, causes menstrual dysfunction, and probably low desire, in 45% of adolescent women [249].

Long water fasts are associated with lower sexual desire. Robert Shelton [38] writes about water fasts:

To add to the religious power of the fast, sexual desires disappear and thoughts of sex cease to obtrude upon the mind. ... In these days when the fallacies of psychology and psychoanalysis are on the lips of everyone and when feminine leaders declare chastity and continence to be neither desirable nor practicable and insist that they would be harmful if put into effect, methods of attaining self-control in matters of sex are frowned upon. This

feature of fasting may not, therefore, appeal to many who read these lines. Fasting does increase one's control over all his appetites and passions and this will account in some measure for its use by high priests and others in the religions of old" (p. 82).

Foods high in glycemic index, like chocolate, honey, bananas, figs etc. have historically been used as aphrodisiacs (although there are no scientific studies to support their use). [250]

While a normal calorie diet is needed to be sexually active, chronic consumption of high glycemic index foods, like sugar, may send sexuality into overdrive.

Sugar acts on the reward circuit of the brain similarly to psychoactive substances (drugs) and sex. It has been proposed to be considered a drug with similarities to stimulant substances as well as opiates. It releases dopamine in the brain upon consumption [251,252]. Sugar use has been found to cross-sensitize with alcohol [253], amphetamine [254] and cocaine use [255]. Children who consume a lot of sugar are more prone to consume alcohol as adults [256]. Alcoholics prefer drinks with the highest concentration of sugar [257].

Psychoactive drugs increase sexual drive and in the laboratory cause rats to become homosexual. Sugar (similarly to psychoactive substances) may increase sexual drive several hours after its consumption. Jones et al. [258] have done a study on sugar with healthy children aged from eight to 16. Children had a twofold increase of epinephrine (adrenaline) compared to adults several hours after sugar consumption on an empty stomach. Increased epinephrine levels cause increased physiological arousal [259] and individuals in an increased physiological arousal may misattribute the arousal to sexual feelings toward the person present [52,260].

Studies show that the stimulating effect of dopaminergic drugs on sexual arousal is dependent on testosterone, [261] hence the effect of sugar on sexual drive may begin with adrenarche (from 6 to 10 year old), when there is an increase of production of androgens by the adrenal glands. This is the age when many children report first having sexual attractions.

High fructose corn syrup and honey are similar to sugar in sweetness and in glycemic index. The preference for sweet foods is an evolutionary trait, because they are high in calories needed for survival.

4.4 The effect of diet on brain inflammation

Brain inflammation may contribute to homosexuality, as mentioned before. High-fat and high-sugar feeding increase hypothalamic inflammation in experiments with rats and the combination of both is more detrimental than each of them alone [262,263].

Food allergies also may trigger brain inflammation [264,265].

Most common food allergens are usually difficult to digest proteins, like egg white, peanuts, gluten etc. Food allergies increase the risk for the development of autoimmune and inflammatory diseases, [266] including diseases like autoimmune thyroiditis, Graves' disease etc., which are associated with disturbed sexual hormone levels and increased homosexuality rates.

In animal models of food allergy, researchers combine a food protein with a heavy metal (usually aluminum) to induce an allergic reaction. Once the individual is sensitized to a food, the food allergy may become permanent.

5 The role of stress

There are different sources of stress. They are categorized in physiological and emotional stressors. Physiological stressors include sleep deprivation or insomnia, extreme hyper- or hypothermia, drug withdrawal states, hunger or food deprivation. High-fat, high-sugar diet may also be considered a source of physiological stress.

Emotional stressors include interpersonal conflict, loss of a relationship, death of a close family member, loss of a child, etc.

5.1 The effect of stress on proximate causes of homosexuality

The information already contained in the previous chapters on the relationship between stress and the proximal causes of homosexuality is summarized under this heading.

Stress and sexual hormone disturbance in women

Stress contributes to estrogen dominance in women by affecting progesterone levels. Progesterone is produced by the ovary, testis, but also the adrenal gland and is a precursor to the stress hormone cortisol. In healthy women, during the first phase of the menstrual cycle (when the ovary produces minimal progesterone) progesterone levels increase during stress [170]. During ovulation and the second phase of the menstrual cycle, when progesterone levels should be high, stress lowers progesterone because the adrenal glands ‘steal’ progesterone to produce cortisol. Cortisol is a hormone released in response to different sources of stress (physiological as well as emotional).

Stress exposure causes increased adrenal size in experiments with animals [267] [268]. Therefore stress may increase androgen production from the adrenal glands in susceptible women. Stress increases testosterone production in some females [269,270].

Melatonin, the anti-stress hormone that is produced during the night, decreases high testosterone levels in women suffering from PCOS [271].

Stress is a trigger in autoimmune diseases, like Hashimoto’s thyroiditis, which is associated with disturbed sexual hormone levels and increased homosexuality rates in women.

Stress and brain inflammation

Hypothalamic inflammation is known to be increased by sleep deprivation, excessive physical exercise [145,146]. Severe air pollution, [147] heavy metals can induce brain inflammation.

Stress and sexual hormones in men, brain development

Stress may increase testosterone production in aggressive, extrovert males [272], decrease it in other males [273], or affect the action of testosterone. In a study by Mehta and Josephs [274], cortisol, the hormone that is released by the adrenal glands during stressful situations, blocks the action of testosterone on dominant behaviors.

Sleep deprivation may negatively impact testosterone levels in males as well as development of the brain areas relevant for sexual behavior. Testosterone in males peaks during sleep [275] and homosexuals have more disturbed sleep than heterosexuals [276,277]. The sleep related rise in testosterone is linked with the first REM sleep during the night [278]. Interestingly, during REM sleep, males experience night-time erections [279]. Females also experience sexual arousal episodes during sleep [280]. REM sleep has an important role in the maturation of the brain in the young [281]. The thrusting center, or other brain areas important for sexual functioning, probably develop during these REM sleeps associated with sexual arousals.

Testosterone levels may also be impacted by masturbation, a behavior more frequent in stressed persons. Higher testosterone levels have been found in males after abstinence from masturbation [282].

Progesterone is another relevant sexual hormone in men. The affiliation hypothesis of homosexuality holds that progesterone in men increases homoerotic motivations. In men progesterone levels increase during stress [283].

Stress, pollution are known to trigger autoimmune diseases, which include Grave's disease, associated with disturbed sexual hormone levels and higher homosexuality rates in men. Chronic stress is also associated with non-alcoholic fatty liver disease [284]. Melatonin, the anti-stress hormone that is produced during the night, has been proposed as treatment for nonalcoholic fatty liver disease [285].

Pollution (another form of stress) from xeno-estrogens is causing mass feminization in obesity patterns in men in western countries [286].

Stress and high sexual drive

Drugs and sleep deprivation are the stress sources most affecting sexual drive. Drugs act on the reward system of the brain, similarly to sex and food. Neurotransmitters affected by substance use and sex include dopamine and serotonin. Dopamine is the neurotransmitter that signals motivation, facilitates sexual drive [287]. Serotonin signals satiation, is released after sex [288], during food, substance use [289] and lowers dopamine levels in the reward circuit.

In experiments on rats by Triana Del-Rio et al. [77], when sexually naive male rats living in cages with only same-sex rats were administered quinpirole (a dopamine receptor D2 agonist, that acts similar to alcohol and cocaine), and/or oxytocin, the rats developed sexual preference for the male cohabitant over the female.

In a study by Kyung An-Han [78], with fruit flies, which have similar reaction to alcohol as humans, male flies that regularly consumed alcohol began to have sexual encounters with males and females. When the researchers lowered the level of dopamine in the brain, their homosexual behavior decreased.

Cocaine, opiates, alcohol cause increased sexual arousal and drive in humans and animals [79,290,291,81]. The effect is stronger when combined with sleep deprivation [80]. REM sleep deprivation causes hypersensitivity of dopamine receptors in the brain, increases sexual drive and potentiates the effect of drugs on sexuality [82,83].

In genetic and pharmacological experiments with animals, low serotonin levels cause both male and female mice to prefer same-sex over opposite sex partners [88,89]. Low serotonin levels would cause a dopamine imbalance in the sexual response system. Low serotonin levels are found in persons suffering from depression and in those using drugs.

An increased sexual drive due to sleep deprivation is observed in women with high testosterone levels but not in those with low testosterone levels [85]. In men as well, testosterone increases sensitivity to sexual rewards.

Frequent masturbation and sexual addiction (usually involving masturbation to porn) are contributing factors in homosexuality. Many studies show masturbation to be associated with stress [120,121]. Homosexuals on average masturbate and view porn more than heterosexuals [122]. Compared to heterosexuals they experience less sexual desire toward a partner and more sexual desire directed to non-partners or masturbation [123]. Persons addicted to sex are more vulnerable to stress and have overactive stress systems [124,125].

Excessive masturbation itself can be a source of stress.

5.2 Artificial light, electromagnetic fields, noise and sleep deprivation

Sleep deprivation is a method used to induce a stress response in experimental animals. Total sleep deprivation causes death in laboratory animals [292] and in humans (like in Fatal Familial Insomnia).

Sleep deprivation has become a public health concern in the United States [293] and in many other developed countries. The average sleep duration of Americans is thought to have fallen from 8-8.9 hours, to 6.9-7 hours, mainly due to the use of artificial light [294].

The sleep-wake activity, feeding, hormones and neurotransmitter production have a daily (circadian) rhythm. The rhythm has a master clock in the brain (suprachiasmatic nucleus), which is entrained by light. Artificial light has the potential to disrupt such rhythms and cause circadian disruption. Circadian disruption can be a stressor and enhancer of other stressors [295].

Artificial light

There has been a steady increase in light pollution during the last century [296]. It has been estimated that light pollution is increasing on average by 6% every year [297]. People are using more artificial light indoors [298]. Adolescents in particular are prone to delay sleep and be more exposed to artificial light [299].

Exposure to constant light has been suggested to increase stress [300] and melatonin, the hormone that is produced during the night, has been shown in different animals to have an anti-stress effect [301]. Persons who experiment with no artificial light use, report considerable calming effect [302].

Light may also affect sexuality directly. In many mammals increased day lengths during spring signal the breeding season and cause increased sexual activity. There is still some seasonality in human sexuality as well. During spring, when the days get longer, sexual activity increases [303,304]. Ancient scholars acknowledge such seasonality. Master Liu Ching, a Han Dynasty adept, advised [305]:

In spring man may permit himself to ejaculate once every three days, but in summer and autumn he should limit his ejaculations to twice a month. During the cold of winter, a man should preserve his semen and avoid ejaculation altogether. The Way of Heaven is to accumulate Yang essence in winter. One ejaculation in winter is one hundred times more harmful than an ejaculation in the spring. (p. 256)

Artificial light, extending the daylength, may exert a stimulant effect on sexual drive. The suprachiasmatic nucleus, which regulates circadian rhythms in response to the environmental light/dark cycle, has been found to be enlarged in homosexuals [306].

Electromagnetic fields

Epidemiological studies have reported that electromagnetic fields can lower the secretion of melatonin. Increased mobile phone use has been found to correlate with decreased levels of melatonin [307,308]. The potential effect of electromagnetic fields on melatonin has been termed “the melatonin hypothesis.”

Electromagnetic fields may also increase inflammation [309]. Since inflammatory disorders (brain inflammation, PCOS, Graves disease, Hashimoto’s thyroiditis etc.) may increase the frequency of homosexuality due to the disturbance they cause in sexual hormones and neurotransmitters, electromagnetic fields could further add to the total burden of stress the brain-body is exposed to.

Noise

Noise, which usually accompanies light pollution, is stressful in high levels [310]. It has a disrupting effect on sleep, and decreases REM sleep [311]. Noise causes the release of stress hormones even when it does not disrupt sleep [312]. Noise pollution has also been on the rise [313].

Urban inhabitants are more exposed to artificial light and noise, less exposed to natural light and less involved in physical activities during the day. They sleep later and have more sleep disruption than the inhabitants in rural areas [314]. Homosexuality rates are also higher in the cities.

In Australia, according to the Second Australian Study of Health and Relationships, homosexuality is related to living in a big city [315]. In Denmark, persons born in the capital had higher probability of having a gay marriage, than their peers in the rural areas [316]. In large American cities there is a higher prevalence of homosexuality than the national average [317]. A factor contributing to this is migration of homosexuals into more accepting environments, but homosexuality is positively correlated with urbanization of the place of residence even at age 14-16 [318]. This age group does not usually take independent decisions to migrate for sexual orientation reasons.

In experiments on mice, when the mice population became overcrowded to stressful levels and probably sleep deprived, an increase in homosexuality was observed [319].

A study by Chen and Shiu [320] found “substantial disparities in sleep disturbances between sexual minorities and non-sexual minorities.” Nevertheless sexual orientation was not associated with an increased risk of short or long sleep duration.

A study by Fricke and Sironi [277] had similar findings.

Another study by Galinsky et al. [321] found that:

... there were no differences by sexual orientation in the likelihood of meeting National Sleep Foundation recommendations for sleep duration. For sleep quality, gay men were more likely to have trouble falling asleep, to use medication to help fall/stay asleep, and to wake up not feeling well rested relative to both straight and bisexual men. Gay/lesbian women were more likely to have trouble staying asleep and to use medication to help fall/stay asleep relative to straight women. Finally, bisexual women were more likely to have trouble falling and staying asleep relative to straight women.

Sleep deprivation may affect sexuality even prenatally. In experiments on rats, sleep deprivation in the pregnant mother increases demasculinization in offspring [322].

5.3 Substance use

A psychoactive substance (drug) is a chemical substance that temporarily changes brain function and is consumed purposely for this effect. Psychoactive substances include alcohol, nicotine, caffeine, cocaine, amphetamine, cannabis, opioids (including prescription opioids), etc.

Circadian disruption has been found to increase substance use: night shift-workers have a higher likelihood of alcohol use [323,324], rats raised in constant light increase consumption and preference for morphine [325]. Through a 12-year study on children, Maria Wong et al. [326] showed that children with sleep disorders had a twofold increase in substance use compared to the other children.

Drugs are often used to aid in sleep and arousal (for example alcohol for sleep, coffee for awakening), but in the long term they disrupt the circadian rhythms and sleep [327]. Alcohol, cocaine, marijuana etc. reduce REM sleep [328]. Drug withdrawal is a known physiological stressor [329].

Consumption of alcohol increased in the 20th century in the United States and Great Britain [330]. According to the World Health Organization [331], studies have shown a trend towards more drunkenness among youths in many countries, even in those where alcohol consumption per capita has decreased. Death rates from drugs per 100,000 people have increased since at least the 1970s [332] in the United States.

Many studies have shown that substance use is higher among homosexuals than the general population. According to a meta-analysis of such studies on adolescents, done by Marshal et al. [333], the odds of substance use for adolescent lesbians were 400% higher than those of heterosexuals; for adolescent bisexuals they were 340% higher and in general for the LGB (lesbian, gay and bisexual) adolescent group, the odds of substance use were 190% higher than for heterosexuals.

Homosexuals often live in a hostile social environment, and this may account for some of their substance use, but some studies conclude that their minority status does not explain all the difference. Substance use is high even among mostly heterosexuals, who do not suffer a sexual minority status [334,335]. Mostly heterosexuals may suffer from internalized homophobia, which could also increase their substance use.

Several prominent professionals have noticed a connection between substance use and homosexuality. Psychoanalyst Karl Abraham [336] noted: “The homosexual components which have been repressed and sublimated by the influence of education become unmistakably evident under the influence of alcohol” (p. 83).

The British physician Read noted in 1920 that when alcohol is taken to excess it brings “into active conflict with the personality different impulses and desires previously more or less successfully repressed. Of these, the homosexual impulse is found by analysis to be the most frequent” [337].

Several German clinicians (Hans Maier, Norbert Marx, Ernst Joel, F. Frankel) observed in the 1920’s that use of cocaine could cause homosexual behavior in previously heterosexuals [338].

In the 1950s and 1960s, Lawrence Hatterer, a physician, identified the use of drugs and alcohol among the triggers and perpetrators of homosexuality [339]. He claimed a 45% success rate in increasing heterosexual functioning of his clients [340]. He treated more than 600 homosexuals.

Substance use has been linked with repeated change of sexual orientation [341].

There are reports of ex-gays who claim to have reversed homosexuality due to religious faith. Ex-gay ministries offer support for homosexuals wanting to change their homosexuality. A common requirement by religious groups is that their members, regardless of sexual orientation, refrain from using drugs and alcohol. Religious rituals and requirements often have a calming and anti-stress effect.

Psychoactive substances may affect sexuality prenatally as well. Prenatal ethanol exposure lowers testosterone levels in the fetus male rats, and in one experiment exposed rats showed feminization as adults [342,343]. A study of 7,500 offspring and their mother found that nicotine use, but not alcohol use, during pregnancy significantly increased probability of lesbianism among female offspring [344].

5.4 Emotional stress and sexual abuse

Adverse events during childhood, physical and sexual abuse, have been correlated with homosexuality in different studies [345,346].

Homosexual/bisexual men report higher rates of childhood emotional and physical maltreatment by their mothers and major physical maltreatment by their fathers than heterosexual men. Homosexual/bisexual women report higher rates of major physical maltreatment by both mothers and fathers [347].

It has been observed in different studies that sexual orientation correlates with an individual's number of older brothers, each additional older brother increasing the odds of homosexuality. Increasing autoimmunity of the mother to the fetus is thought to contribute to this [348], but another factor may also be the stress involved with being the younger brother. Rough play is common among male siblings and the youngest brother would be the loser in most of the power plays, suffering emotional stress. In addition, losing the power struggles negatively affects testosterone levels in the youngest brother.

Emotional stress experienced by the mother may also affect sexual orientation of the child. In a study by Dörner et al. [349], males born during World War II and the early postwar period (1941-1947) had increased rates of homosexuality. The authors of the study suggested that prenatal or perinatal stress may be a causative factor for homosexuality. Mothers of effeminate male children report more stress-proneness than other mothers [350]. They may experience more emotional stress during pregnancy.

Homosexuality in itself is an emotional stress source due to minority stress. Homosexuals may find homosexual feelings unwanted because of social pressure or because of having heterosexual identity and may get anxious when experiencing them. Such anxiety and stress would further add to the total stress load. Psychiatrist Edward J. Kempf in 1920 coined such anxiety as “homosexual panic” [351].

Sexual abuse

Sexual abuse victims make a high proportion of homosexual clients seeking reparative therapy. 72% of sexually molested homosexual males and 57% of sexually molested homosexual females reported experiencing pleasure during sexual molestation in a study by Steed and Templer [352]. 68% of the gay men and 67% of the lesbian women who had been homosexually molested maintained it had an impact on their sexual orientation.

When sexual abuse happens at an age when the child is old enough to experience spontaneous sexual arousals, but is still too young to have experienced the higher phases of sexual response, the abuser can become the emotional cue to whom the arousal is attached to. This may be the case especially when the abuser is in a position of authority or is friends with the victim, and/or when the victim is cue sensitive.

Therefore, sexual abuse may disrupt phase-2 (attribution to emotional cue). The victim of sexual abuse may also become aversive to sexual relationships with persons of the same sex as the abuser, if (s)he experienced the abuse as traumatic.

Situational homosexuality

Lack of sexual partners can also be a source of emotional stress and can lead to situational homosexuality. Sex is associated with increased wellbeing. Intercourse lowers blood pressure reactivity to stress [353]. Situational homosexuality is known to happen in single gender environments like prisons, among sailors, in harems, boarding schools, etc. [354]. The lack of sex

may be most stressful for persons who have some sexual experience, or who have a high sexual drive. An unfulfilled desire, like in the early stage of love, has been associated with decreased sleep [355]. Persons with a high sexual drive who react to lack of sex with a decrease in sleep could be more vulnerable to the development of situational homosexuality.

Situational homosexuality is also widely observed in tribes where institutionalized homosexuality is practiced. For example, ten to 20% of all tribes in Melanesia – a region in Oceania stretching 3,000 miles from Irian Jaya to Fiji – had ritualized homosexual practices, where boys 6 to 10 years old were involved in homosexual rites with adolescents [356,357].

Situational homosexuality is sometimes called pseudo-homosexuality because once the situation is resolved the person returns to heterosexual behavior.

5.5 Chemical pollution, use of pharmaceutical products

Since the industrial revolution humans are being exposed to increasing levels of pollution, like smog, different pesticides, chemicals used in the manufacturing of plastics etc. [358,359].

Different chemicals that disrupt the endocrine system have been associated with gender nonconforming behavior, which may lead to homosexuality, or with homosexual behavior. The chemicals act prenatally as well as after birth.

Some of these chemicals are atrazine (a herbicide), mercury, polychlorinated biphenyls, bisphenol A, non-steroidal anti-inflammatory drugs (NSAID) etc.

The effect of atrazine on reproductive function has been studied extensively by Tyrone Hayes et al., who have reported that it causes demasculinized, hermaphroditic frogs, at low ecologically relevant doses [360].

In a study by Frederick and Jayasena [361] on male white ibises, male birds that ate mercury-contaminated food had higher rates of homosexual behavior. In the male groups with the highest exposure, up to 55% of the males showed homosexual behavior. Wild white ibises are exposed to mercury through their diet of crustaceans and other small invertebrates. Mercury is an endocrine disruptor. The exposed male birds in the study produced more estrogen than testosterone compared with control birds.

Exposure to xenoestrogens is thought to have contributed to the obesity epidemic in men in developed countries. Obesity rates in males and females of developed nations are similar, while in poorer nations obesity is much more prevalent in females. That is, males in developed countries are having obesity at rates seen among women [286].

Exposure to iodine, which is used in the water supply and is added to salt in some western countries, increases the risk for thyroid dysfunctions, [362] which are associated with disturbed sexual hormone levels and increased homosexuality rates.

Studies show that acetaminophen (paracetamol) use during pregnancy impairs masculinization of sexual behavior of male offspring and testosterone production by the fetus [363,364].

Heavy metals, pesticides, air pollution, infections, radiation can induce autoimmune diseases as well as brain inflammation. Antibiotics, which wipe out the gut microflora, further increase the risks for autoimmune diseases and inflammation. The literature in this area is vast, so I am not referring to specific studies.

6 The interaction of diet with stress

A high-sugar, high-fat, low nutrient diet increases stress, lowers resistance to stress. Stress, on the other side, increases consumption of high-sugar and high-fat foods.

Six weeks of a high-fat diet elicited anxiety-like behavior and hypothalamic-pituitary-adrenocortical axis (HPA) hypersensitivity to stress in mice. Withdrawal from the high-fat diet increased anxiety and basal corticosterone (stress hormone) levels and enhanced motivation for sugar and high-fat food rewards [365].

In mice who binge daily on sugar, withdrawal from sugar causes increased anxiety and decreased dopamine release in the reward circuit in the brain, similarly to opiate withdrawal [366].

Higher sugar and fat intakes can also contribute to sleep disruption (a source of stress). Twenty-six normal weight adults, habitually sleeping 7-9 hour/night, participated in a randomized-crossover inpatient study with 2 phases of 5 nights: short (4 hours in bed) or habitual (9 hours in bed) sleep. During the first 4 days, participants consumed a controlled diet; on day five, food intake was self-selected. When self-selected, food intake was higher, with more fat and sugar. Sleep duration was not affected by the ad libitum (eating with no restrictions) day, but it was less restorative and with more arousals. The study authors concluded that high saturated fat and sugar intake is associated with lighter, less restorative sleep with more arousals [367].

Sugar and fat are foods high in calories and empty in micronutrients. They usually displace from the diet the less calorific foods like leaves, tubers, vegetables, fruits, etc. These are also foods high in micronutrients. Hence the high-sugar, high-fat diet is usually deficient in micronutrients that help the mind-body to cope with stress sources.

While a high-sugar, high-fat diet increases stress, stress also increases the consumption of such a diet. Increased anxiety may contribute to high-fat, high-sugar eating [368]. Acute psychological stress can lead to insulin resistance and increased appetite for carbs [369].

Sleep deprivation is a common stressor in modern life. It increases appetite for high calorie foods, like sugary and fatty foods.

In a laboratory study of 44 healthy adults, the adults slept normally for two nights (10-12 hours in bed), followed by five consecutive sleep-restricted nights (4 hours of sleep). During sleep restriction, subjects increased daily caloric intake, sugar and fat intake, including obtaining more calories from desserts, and salty snacks [370]. In a similar study with healthy 225 subjects, in a laboratory, sleep restriction promoted weight gain, with increased fat intake during the night [371].

In a study with eleven healthy volunteers, the participants completed in random order two 14 day stays in a sleep laboratory with free access to palatable food and 5.5-hour or 8.5-hour bedtimes. The scientists measured the calories from meals and snacks consumed during each bedtime condition. Sleep was reduced by about two hours in the 5.5-hour bedtime condition. Although meal intake remained similar, sleep restriction was accompanied by increased consumption of calories from snacks, with higher carbohydrate content, particularly during the night [372].

Circadian disruption, common in modern societies due to artificial light use, is a source of stress. It causes decreased insulin sensitivity (insulin resistance) regardless of sleep loss [373]. Insulin resistance causes increased appetite for sugar and carbohydrates in general.

Physical activity is a third variable, with interactions with both stress and diet. In healthy levels, physical activity lowers stress, diminishes the negative effects of a high-sugar, high-fat diet and helps normalize the sexual hormone levels.

In different societies access to high calorie diets was often combined with exposure to high levels of stress, especially with increased social stratification. In societies with social stratification

there are increased rates of homosexuality. The probability of observing homosexuality was 0.28, 0.75 and 0.91 for non-stratified, moderately stratified and strongly stratified societies, respectively, in a sample of 89 societies from prehistoric and early historic times [107]. Stratified societies have usually a well-developed food supply to the elite, high population pressure and resulting stress sources (increased competition, less available individual space, more environmental pollution etc.)

Developed countries like the United States, Canada, Australia, European Union have among the highest rates of light, noise, and chemical pollution as well as high levels of alcohol [374] & drug consumption [375], and among the highest obesity rates [376]. These developed countries also have the highest acceptance of homosexuality in society [377] compared to Africa [378], the continent where there is the least light pollution, substance use and obesity. In some African tribes, like the Aka and Ngantu in central Africa, which live in the tropical forest, homosexuality and masturbation are not known, there are no words for them, although the tribe members are sexually very active [379].

Ancient Rome and Greece were civilizations where homosexuality was practiced and tolerated [380]. Wine was also widely consumed [381]. It had an aristocracy, which had the means to indulge in dietary excesses. Although an ancient city, Rome had noise pollution during the night, disrupting sleep of its citizens. To lower noise, the chariots were later banned during the night [313]. Rome also waged endless wars. These factors may have contributed to the relatively high presence of homosexuality in Rome. With the fall of the Roman Empire, over-indulgence in foods and alcoholic beverages became rarer, the city became smaller, probably with less noise pollution, the wars declined, and so did homosexuality and tolerance to it.

7 Summary

The following scheme summarizes what was discussed in the previous chapters:

Figure 3 Proximal and ultimate causes of homosexuality

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