BI-10 The modern endocrine environment

The human endocrine system evolved to navigate the specific ecological and social conditions of the Pleistocene. This ancestral environment was characterized by seasonal fluctuations in caloric availability, high pathogenic and parasitic loads, physical exertion tied directly to subsistence, photoperiods strictly regulated by solar and lunar cycles, and continuous reproductive cycles for females that were heavily interspersed with prolonged lactational amenorrhea. In stark contrast, the modern endocrine environment—the Anthropocene—represents a profound evolutionary mismatch. It is defined by hyper-caloric diets, pervasive artificial blue light, exposure to thousands of novel synthetic endocrine-disrupting chemicals (EDCs), widespread pharmacological interventions in reproduction, and chronic, low-grade psychosocial stressors.

To systematically analyze the implications of these novel inputs on human life, and specifically to construct a foundational understanding for how men and women live together, this report distinguishes between three interacting layers: **physiology** (the measurable hormonal, anatomical, and metabolic substrate), **behaviour** (the statistical, overlapping distributions of human action, psychology, and pair-bonding), and **culture** (the variable, constructed environments, and normative frameworks that modulate these biological inputs). A rigorous evaluation of the literature—prioritising systematic reviews, meta-analyses, and peer-reviewed primary research—reveals a rapidly shifting physiological landscape with profound downstream implications for couples, families, and societies.

Layer 1: Physiology (The Measurable Substrate)

Physiology provides the foundational, quantifiable metrics of the modern endocrine shift. Over the past five decades, large-scale epidemiological data have documented highly significant secular trends in reproductive, metabolic, and neurological parameters across both sexes.

The Decline of Male Reproductive Parameters: Sperm Count and Testosterone

Male reproductive health has emerged as a critical, global public health concern, characterised by significant, population-level declines in both sperm parameters and circulating endogenous testosterone.

Sperm Concentration and Total Sperm Count The most comprehensive, methodologically rigorous evidence for declining sperm counts derives from the systematic reviews and meta-regression analyses conducted by Hagai Levine, Shanna Swan, and colleagues. In 2017, Levine et al. published a landmark meta-analysis in *Human Reproduction Update* comprising 185 studies and capturing data from 42,935 men who provided semen samples between 1973 and 2011[1]. Among "unselected Western" men (populations from North America, Europe, Australia, and New Zealand not selected for known fertility issues), sperm concentration (SC) declined by 1.4% per year, resulting in a total decline of 52.4% over the 38-year study period. Total sperm count (TSC) declined even more dramatically at 1.6% per year, representing an

overall decrease of 59.3%[2].

In 2022, Levine et al. updated this analysis in the same journal, expanding the dataset to 223 studies containing 288 estimates from 53 countries. This iteration, which included 7,518 new men, incorporated samples from South and Central America, Asia, and Africa[1]. The updated findings demonstrated a global decline in SC of 51.6% between 1973 and 2018. The overall slope of the decline was –1.17 million/mL per year ($p < 0.001$)[1]. Crucially, the rate of decline has not leveled off; rather, it has accelerated in the 21st century. Prior to the year 2000, the decline was 1.16% per year; post-2000, it accelerated to 2.64% per year[1]. This finding of a precipitous drop has been replicated across multiple independent cohorts, though substantial geographic heterogeneity exists. For example, steep declines have been robustly replicated in France (a Parisian study of 1,351 men showed a 2.6% yearly decrease), Denmark, and Scotland, whereas some large Chinese regional cohorts (a systematic review comprising 327,373 healthy Chinese men from 1981 to 2019) exhibit complex, sometimes stable temporal patterns[1].

Controversy and Critics: While the Levine meta-analyses are widely considered the gold standard and rely on conservative meta-regression models, they have faced rigorous academic pushback. The strongest evidence against the "looming crisis" narrative comes from researchers at the Harvard GenderSci Lab (led by Boulicault et al., 2021) and Allan Pacey (University of Sheffield). Boulicault et al. proposed the "Sperm Count Biovariability (SCB) hypothesis," arguing that sperm counts naturally fluctuate within a wide, non-pathological range across populations, and that interpreting these fluctuations as a continuous, catastrophic decline is a misapplication of the data[7]. Furthermore, Pacey and others argue that the apparent decline may be a statistical artifact of changing measurement methodologies. They suggest that laboratory techniques, such as the gold standard haemocytometry, have improved significantly over time through rigorous quality control programs, which may have artificially shifted the baseline of historical data upwards[8].

Secular Declines in Testosterone Concurrently, population-level testosterone levels have fallen independent of the normal chronological aging process. In 2007, Thomas Travison and colleagues published a pivotal study in the *Journal of Clinical Endocrinology & Metabolism* using data from the Massachusetts Male Aging Study (MMAS). Analyzing 2,769 longitudinal observations from 1,532 randomly selected American men (aged 45–79), they found a substantial, age-independent decline in serum total testosterone of approximately 1.2% per year, and a 1.3% decline in bioavailable testosterone, between the periods of 1987–1989 and 2002–2004[13]. This denotes a strong birth cohort effect: a 65-year-old man in 2003 had significantly lower testosterone (average 423 ng/dL) than a 65-year-old man in 1988 (average 503 ng/dL)[13].

This age-independent secular decline has been robustly replicated in Danish (N=5,350), Finnish, and Israeli population studies[1]. For instance, an Israeli study analyzing men between 2006 and 2019 showed that at age 21, testosterone levels declined from 19.68 nmol/L to 17.76 nmol/L ($p < 0.001$)[1]. Similarly, Lokeshwar et al. (2020) demonstrated in *European Urology Focus* that this trend extends to adolescent and young adult (AYA) men (aged 15–39) in the USA. Using a large, nationally representative sample, they observed a significant decline in serum testosterone levels from 1999 to 2016 ($p < 0.001$)[17]. While increasing body mass index (BMI) partially explains

this variance, the decline remained statistically significant even among men with a normal BMI, pointing to unidentified environmental, dietary, or stress-related factors not captured by body composition alone[17].

The Evolutionary Context of Testosterone: The Tsimane Benchmark To assess whether modern testosterone levels are "abnormal," they must be evaluated against an evolutionary benchmark. Benjamin Trumble, Michael Gurven, and colleagues (2012, 2019) published comparative studies in the *Proceedings of the Royal Society B* and *Adaptive Human Behavior and Physiology* examining the Tsimane (a forager-horticulturalist population in the Bolivian Amazon), the Datoga (N=70), Hadza (N=29), and Qom (N=43)[21]. The researchers found that Tsimane men have baseline salivary testosterone levels approximately 33% lower than age-matched American men[21].

In ancestral environments with high parasite and pathogen loads, maintaining continuously high circulating testosterone is evolutionarily disadvantageous due to its profound immunosuppressive effects[21]. Crucially, however, Tsimane men do not exhibit the steep age-related decline in testosterone universally seen in Western populations; their levels remain remarkably stable across the lifespan, and they do not suffer from the modern diseases of affluence (obesity, metabolic syndrome) associated with late-life testosterone decline in the West[21]. Furthermore, despite low baselines, Tsimane men mount robust acute endocrine responses to physical competition (e.g., a sample of N=63 men showed a 30% surge in testosterone immediately following a soccer match, remaining 15% elevated an hour later)[21]. This suggests that the high peak testosterone of young Western men is an "evolutionarily novel spike" permitted by surplus energy and artificially low pathogen loads. The subsequent age-related decline observed in industrialized nations is likely an artifact of metabolic dysfunction and accumulated allostatic load, rather than an intrinsic feature of biological male aging[21].

Female Reproductive Maturation and Cycling

The modern female endocrine environment has diverged radically from ancestral norms, manifesting changes at the onset of puberty and radically altering the hormonal architecture of the entire reproductive lifespan.

Earlier Pubertal Onset Secular trends indicate an increasingly early onset of puberty in girls, theorized to be driven by improved childhood nutrition, rising prepubertal BMI, and widespread exposure to environmental chemical estrogens. A comprehensive 2020 systematic review and meta-analysis by Eckert-Lind et al. in *JAMA Pediatrics* synthesized data from 30 eligible studies to evaluate global trends in thelarche (the onset of breast development, clinically defined as Tanner stage 2)[24]. The meta-analysis found a robust, statistically significant global decrease in the age at thelarche of 0.24 years (approximately 3 months) per decade between 1977 and 2013 ($p = 0.02$)[25].

This trend has been replicated across multiple regions, including a synthesized analysis of 16 studies involving 177,886 Chinese girls, which found that the median age of breast development in urban Chinese areas had dropped to 8.26 years[24]. Similarly, data from the US ECHO program cohort (N=7,495) demonstrated that early-life rapid gains in BMI are strongly associated with an

earlier age at peak height velocity and earlier time to menarche[28]. This accelerated maturation carries profound implications, as earlier menarche is an established risk factor for adverse psychological outcomes in adolescence and hormone-sensitive cancers later in life[27].

The Mismatch of Lifetime Menstrual Cycles Beyond the precocious onset of puberty, the architecture of the modern female reproductive lifespan is historically unprecedented. As detailed by Eaton et al. (1994) in the *Quarterly Review of Biology*, women in ancestral, natural-fertility hunter-gatherer populations experienced much later menarche (often mid-teens), earlier first births, frequent continuous pregnancies, and prolonged periods of lactational amenorrhea (nursing suppressing ovulation)[29]. Consequently, a paleolithic woman might have experienced roughly 100 to 160 ovulatory cycles in her entire lifetime.

In stark contrast, modern Western women experience earlier menarche, drastically delayed first birth, and far fewer overall pregnancies, resulting in minimal time spent in lactational amenorrhea. As a result, a modern woman may undergo upwards of 400 menstrual cycles in her lifetime[30]. This equates to decades of uninterrupted, cyclical exposure to high levels of endogenous estrogens and progestins. This evolutionary mismatch is theorized by evolutionary biologists and oncologists to be a primary driver of the vastly increased rates of female reproductive cancers (breast, ovarian, and endometrial) in modern societies. These reproductive tissues are subjected to continuous cellular proliferation, apoptosis, and hormone exposure without the evolutionary expectation of frequent, prolonged reproductive pauses, effectively acting as an exaptation of wound healing functions that tip into oncogenesis[30].

Endocrine-Disrupting Chemicals (EDCs)

The pervasive integration of synthetic chemicals into the modern environment represents a fundamental alteration of the human endocrine landscape. In 2015, the Endocrine Society published its second Scientific Statement on EDCs (EDC-2), authored by Gore et al. (*Endocrine Reviews*), defining EDCs as exogenous substances that interfere with hormone synthesis, transport, metabolism, or action[32]. Because EDCs mimic or antagonize endogenous hormones—often acting via non-monotonic dose-response curves where low doses can have outsized physiological effects—they uniquely disrupt normal homeostatic control[33].

Phthalates and the Masculinisation Programming Window Phthalates, widely used as plasticizers in PVC and in personal care products, possess well-documented anti-androgenic properties. Experimental and epidemiological evidence highlights their capacity to disrupt the "masculinisation programming window" (MPW)—a highly critical period during early fetal development (approximately 8-14 weeks gestation in humans) when fetal Leydig cells produce the testosterone and insulin-like factor 3 (INSL-3) required for the differentiation of male external genitalia and testicular descent[36].

The primary morphometric biomarker for fetal androgen exposure is Anogenital Distance (AGD). In humans and animal models, male AGD is typically twice as long as female AGD[36]. Systematic reviews by van den Driesche and colleagues (2012, 2015, 2019) confirm that prenatal maternal exposure to specific phthalates (such as DEHP, DBP, and BBzP) disrupts androgen signaling, resulting in significantly shorter (feminized) AGD in male infants[36]. A shortened AGD at birth is highly predictive of adult reproductive disorders, including

cryptorchidism (undescended testes), hypospadias (abnormal urethral opening), and reduced adult semen quality, collectively referred to as Testicular Dysgenesis Syndrome[36].

Per- and Polyfluoroalkyl Substances (PFAS) PFAS, colloquially known as "forever chemicals" due to their virtually unbreakable carbon-fluorine bonds and extreme environmental persistence, have permeated global water supplies, food chains, and human biological tissues[41]. Rickard et al. (2022) and multiple systematic reviews have linked PFAS exposure to the disruption of the hypothalamic-pituitary-gonadal (HPG) axis in both sexes[41].

In vitro models demonstrate that PFAS exposure actively inhibits key steroidogenic enzymes. Specifically, PFOA and PFOS inhibit 3β-HSD and 17β-HSD in human testes microsomes with highly potent IC50 values of 1.35 μM and 6.02 μM, respectively[45]. In human epidemiological cohorts, this enzymatic disruption translates to altered hormone profiles. In the UPSIDE pregnancy cohort study (N=285), maternal serum concentrations of PFHxS were associated with a 20% increase in total testosterone in women carrying male fetuses, indicating a severe disruption of fetal androgenic pathways[47]. In adult populations, meta-analyses confirm that elevated PFAS burdens are associated with increased total testosterone in men and altered estradiol levels in women[44]. Furthermore, developmental exposure to PFAS is linked to morphological changes in the gonads, reduced sperm progressive motility (impairing the sperm's ability to reach the oocyte), and compromised endometrial receptivity[43].

Analgesics and NSAIDs in Utero Emerging, though contested, research also points to common over-the-counter medications acting as mild EDCs. Cohort studies by Jensen et al. (2010, N=47,400) and Snijder et al. (2012, N=3,184) have associated the prolonged use of acetaminophen (APAP) during the first and second trimesters with an increased risk of congenital cryptorchidism in male neonates[49]. However, this finding remains controversial; other large cohorts, such as the German Embryotox cohort (N>1,000), found no significant increase in major birth defects associated with first-trimester ibuprofen or APAP use, highlighting the difficulty in isolating mild endocrine disruptors from confounding lifestyle factors[49].

Obesity, Insulin, and the Metabolic Interplay

The modern endocrine environment cannot be evaluated without addressing the metabolic syndrome and obesity, which act in a bidirectional feedback loop with reproductive hormones. EDCs such as PFOA act directly as "obesogens" by binding to and activating Peroxisome Proliferator-Activated Receptors (PPARs)[42]. PPAR activation alters lipid and fatty acid metabolism, promoting adipogenesis and weight gain even in the absence of increased caloric intake[42].

Visceral adiposity, in turn, acts as an active endocrine organ. Adipose tissue contains high levels of the enzyme aromatase, which converts endogenous testosterone into estradiol[44]. In men, this creates a vicious cycle: obesity lowers testosterone and raises estrogen, which promotes further visceral fat deposition and insulin resistance. The resulting hyperinsulinemia suppresses sex hormone-binding globulin (SHBG) and disrupts the hypothalamic-pituitary-gonadal (HPG) axis, creating a state of functional hypogonadism that heavily contributes to the population-level testosterone declines observed by Travison and others[13].

Artificial Light and Circadian Disruption

The modern endocrine environment is uniquely shaped by the eradication of ancestral photoperiods. The human circadian pacemaker, located in the suprachiasmatic nucleus (SCN) of the hypothalamus, is synchronized to the 24-hour solar cycle via the retinohypothalamic tract[51]. The afferent limb of this pathway relies on intrinsically photosensitive retinal ganglion cells (ipRGCs) that express the photopigment melanopsin[51].

Melanopsin has a peak spectral absorption sensitivity near 480 nm, a wavelength corresponding precisely to the blue light emitted by modern LED screens, smartphones, and artificial lighting[51]. Exposure to 480 nm light during evening hours directly photoactivates these melanopsin-containing ipRGCs, which transmit inhibitory signals via the SCN to the paraventricular nucleus, effectively and rapidly suppressing the release of melatonin from the pineal gland via the sympathetic nervous system[51]. Furthermore, the SCN and the subparaventricular zone (SPZ) project directly to the ventrolateral preoptic nucleus (VLPO), which contains sleep-inducing neurons[51]. The artificial stimulation of this pathway fundamentally alters sleep architecture, disrupts metabolic homeostasis, and desynchronizes peripheral cellular clocks (in the liver, pancreas, and gonads) from the central pacemaker.

Chronic Psychosocial Stress and Allostatic Load

While the ancestral environment featured acute stressors (predation, inter-tribal conflict, physical trauma), modern society is characterized by chronic, low-grade psychosocial stress. Bruce McEwen's (1998) seminal framework in the *New England Journal of Medicine* details the "protective and damaging effects of stress mediators"[54]. In the short term, stress mediators like cortisol, adrenaline, and pro-inflammatory cytokines are highly adaptive, promoting survival via allostasis (maintaining physiological stability through change)[57].

However, chronic activation leads to "allostatic load"—the physiological wear and tear resulting from prolonged neuroendocrine, metabolic, and immune dysregulation[57]. This chronic hyper-activation shifts metabolic resources away from reproduction and tissue repair. The continuous elevation of cortisol actively suppresses the HPG axis, further contributing to the hypogonadal states, impaired spermatogenesis, and anovulation observed in modern populations facing high psychological stress.

Layer 2: Behaviour (Statistical, Overlapping Distributions)

Endocrine physiology is inextricably linked to human behaviour. While hormones do not dictate behaviour deterministically, they fundamentally alter the probability of specific psychological and behavioral responses. These effects are best understood as statistical shifts in overlapping population distributions.

Hormonal Contraception and Mental Health

Hormonal contraception (HC) is one of the most widespread, sustained pharmacological interventions in human history. By overriding the endogenous HPG axis to prevent ovulation, HC fundamentally alters the neuroendocrine milieu.

A landmark 2016 nationwide prospective cohort study by Skovlund et al. in *JAMA Psychiatry*

analyzed 1,061,997 Danish women (aged 15-34, followed for an average of 6.4 years) to evaluate the association between HC and depression[58]. The study utilized a rigorous "new user" design and controlled for multiple confounders including educational level, endometriosis, and polycystic ovary syndrome (PCOS)[58]. The results demonstrated a robust, statistically significant association between HC use and the subsequent first-time use of antidepressants or a first diagnosis of depression at a psychiatric hospital[60].

Contraceptive Method	Risk Ratio (RR) for Antidepressant Use	95% Confidence Interval (CI)
Combined Oral Contraceptives (COC)	1.23	1.22 – 1.25
Progestogen-Only Pills (POP)	1.34	1.27 – 1.40
Levonorgestrel IUS (e.g., Mirena)	1.40	1.31 – 1.42
Vaginal Ring	1.60	1.55 – 1.69
Transdermal Patch	2.00	1.76 – 2.18
Data from Skovlund et al., 2016[60].		

The risk was most pronounced among adolescents (aged 15-19), with RRs of 1.8 for COC and 2.2 for POP[60]. The risk peaked approximately six months after initiation and declined over several years of continuous use[59].

The Neurosteroid Mechanism: The biological plausibility for the behavioural side effects of HC is heavily mediated by alterations to endogenous neurosteroids, particularly allopregnanolone (ALLO). ALLO is a 3α,5α-reduced metabolite of endogenous progesterone, synthesized in the nervous system via the enzymes 5α-reductase and 3α-hydroxysteroid oxidoreductase[62]. ALLO acts as a highly potent positive allosteric modulator (PAM) of the GABA-A receptor[62]. By binding to specific sites on the GABA-A receptor and enhancing chloride ion influx, ALLO exerts powerful anxiolytic, sedative, and anti-stress effects, effectively acting as the brain's endogenous mood stabilizer[64].

Synthetic progestins used in HC formulations do not metabolize into allopregnanolone. Concurrently, the suppression of endogenous ovulation eliminates the natural luteal surge of progesterone[63]. Consequently, women on HC experience a stark reduction in endogenous

ALLO, altering GABA-A receptor tone and leaving a subset of women highly vulnerable to mood disorders, depression, and stress-induced anxiety[63]. The therapeutic relevance of this pathway was recently validated by the FDA approval of brexanolone (an intravenous formulation of allopregnanolone) and zuranolone (an oral synthetic analog) for the rapid treatment of postpartum depression[62].

Controversy: While Skovlund et al. represent the highest-quality cohort data available, the finding remains contested in the literature. Some previous observational studies (using "prevalent user" designs) found no association, or even a protective effect, of HC against depression[58]. However, pharmacovigilance experts point out that the "prevalent user" design suffers from severe survivorship bias—women who experience severe mood disturbances quickly discontinue the drug, leaving a study cohort composed entirely of women who tolerate the hormones well[58].

Mate Choice and Relationship Dynamics: The Congruency Hypothesis

Beyond mood and anxiety, hormonal contraceptives subtly but significantly alter the statistical distributions of female mating psychology. In naturally cycling women, shifts in mate preference occur across the menstrual cycle, with women displaying a heightened preference for indicators of male genetic quality (e.g., facial masculinity, scent symmetry, deeper voices) during the highly fertile follicular phase[71]. Because HC eliminates the ovulatory peak in estrogen and establishes an endocrine state resembling the luteal phase (or early pregnancy), women on HC do not exhibit these cyclical shifts in attraction[71]. One striking study even demonstrated that normally cycling exotic lap-dancers earned significantly more tips during their fertile phase compared to other phases, a cyclical peak in attractiveness and male attention that was entirely absent in dancers using the pill[72].

Researchers Kelly Cobey, S. Craig Roberts, and colleagues formulated the **"Congruency Hypothesis"** to explain how this pharmacological suppression impacts long-term relationship stability[74]. According to this hypothesis, if a woman's HC use status changes between the time she chooses a partner and later in the relationship (e.g., meeting while on the pill, then discontinuing it to attempt conception), her mate preferences will shift. This creates an incongruency between her current hormonal state and the state in which she selected her mate[74].

In a 2014 study of 365 established couples, Roberts et al. demonstrated that women whose current HC use was *incongruent* with their use at the relationship's onset reported significantly lower sexual satisfaction and higher sexual jealousy than women whose status remained congruent[71]. Furthermore, women who met their partners while using HC tended to choose men with objectively less masculine facial features; if they subsequently stopped taking HC, their sexual attraction to their partner diminished compared to women whose hormonal state remained congruent[73]. These findings have replicated across several longitudinal and cross-sectional models, indicating that the pharmacological suppression of fertility has downstream consequences for long-term pair-bonding and intrapair dynamics[71].

Layer 3: Culture (Variable Responses and Feedback

Loops)

Culture operates as the critical interface between the ancestral human genome and the modern environment, actively constructing the exposures that alter physiology and behavior, while simultaneously generating norms to cope with those alterations.

1. **The Medicalization of Reproduction:** Cultural norms have shifted human reproduction from an early, continuous biological process to a delayed, highly regulated medical event. The reliance on hormonal contraceptives to achieve educational, financial, and career milestones is a cultural imperative that results in the physiological mismatch of hundreds of continuous ovulatory cycles[30] and the widespread disruption of neurosteroid-mediated mood regulation[63].
2. **The Chemical Environment:** The ubiquity of EDCs (phthalates, PFAS) is a direct byproduct of cultural and macroeconomic priorities emphasizing manufacturing efficiency, convenience (plastics, non-stick surfaces, fast fashion), and industrial agriculture over biological safety[33]. Regulatory frameworks (e.g., the more stringent EU REACH guidelines versus US EPA guidelines) dictate the severity of population-level EDC exposure, directly modulating fetal AGD and adult testosterone at the societal level[78].
3. **Chronobiology and Work Culture:** The normalization of 24/7 connectivity, shift work, and evening screen time represents a cultural suppression of chronobiology. Society's structural demand for evening productivity ensures the continuous activation of melanopsin, eroding sleep quality, increasing stress mediators, and driving the metabolic dysfunctions that accelerate testosterone decline and allostatic load[51].

Distinguishing Averages from Individuals

When interpreting endocrine and epidemiological data, it is crucial to avoid the ecological fallacy—the assumption that population-level averages apply deterministically to every specific individual.

The physiological and behavioral traits discussed in this report exist as broad, overlapping statistical distributions. For example, while the *average* sperm count in Western men has halved since 1973[1], millions of Western men maintain robust, highly fertile parameters that exceed the historical average. Conversely, the acceleration of the decline means that the *tail* of the distribution is shifting, resulting in a statistically much larger cohort of men crossing the clinical threshold for subfertility (<40 million/mL)[8].

Similarly, the behavioral effects of hormonal contraception reveal stark individual heterogeneity. While Skovlund et al. (2016) found a 23% increased *relative* risk (RR = 1.23) for antidepressant use among adult women on combined oral contraceptives[59], the *absolute* risk remains small. The incidence rate increased from 1.7 per 100 woman-years in non-users to 2.2 per 100 woman-years in users—meaning only one additional woman out of every 200 was prescribed antidepressants[61]. The vast majority of women tolerate hormonal contraceptives without developing clinical depression. Individual vulnerability is likely modulated by underlying genetic predispositions regarding GABA-A receptor subunit composition, baseline neurosteroid synthesis capacity, and pre-existing allostatic load[58].

In mate choice, the congruency hypothesis operates on the margins. A woman discontinuing the pill will not inevitably leave her partner; rather, she may experience a statistically measurable but modest shift in her subjective assessment of sexual satisfaction or jealousy. Whether this translates into macroscopic marital distress depends heavily on the couple's broader relationship quality, communication, and shared values[74].

Conclusion

10-Line Summary of Robust Findings

1. Global sperm concentration and total sperm counts have declined by over 50% since 1973, with the rate accelerating to 2.64% per year post-2000.
2. Western men are experiencing a secular, age-independent decline in serum testosterone of approximately 1-1.2% per year.
3. Populations living in ancestral conditions (e.g., Tsimane) have 33% lower baseline testosterone but do not experience the age-related decline seen in industrialized nations.
4. The age of pubertal onset (thelarche) in girls is advancing globally by approximately 3 months per decade.
5. Modern women experience ~400 menstrual cycles compared to the ancestral ~100, driving evolutionary mismatches linked to reproductive cancer risks.
6. Prenatal exposure to phthalates acts as an anti-androgen in the masculinisation programming window, shortening male anogenital distance (AGD) and predicting adult reproductive dysfunction.
7. Pervasive PFAS exposure disrupts the HPG axis, altering steroidogenesis (inhibiting 3β-HSD and 17β-HSD) and contributing to gonadal toxicity in both sexes.
8. Blue light (~480 nm) activates melanopsin-containing ipRGCs, powerfully suppressing melatonin and circadian synchronization via the SCN.
9. Hormonal contraception significantly increases the relative risk of depression, particularly in adolescents, likely by stripping the brain of the anxiolytic neurosteroid allopregnanolone.
10. Hormonal contraceptive congruency between mate selection and later relationship stages significantly impacts female sexual satisfaction and jealousy.

Contested or Open Questions

- **The Sperm Count Decline Hypothesis:** Is the global drop in sperm count a true biological crisis caused by EDCs and lifestyle factors, or primarily an artifact of the "Sperm Count Biovariability" hypothesis and changing laboratory haemocytometry techniques over time?
- **HC and Mood Causality:** While large-scale cohorts show a strong link between hormonal contraception and depression, the exact biological mechanism remains debated, complicated by "survivorship bias" in earlier prevalent-user studies that found no such link.
- **Transgenerational EDC Effects:** To what extent do epigenetic changes induced by EDCs (like PFAS and phthalates) in the fetal masculinisation programming window permanently alter the germline of future generations?

- **Analgesics as EDCs:** Do mild, over-the-counter analgesics like acetaminophen truly increase the risk of congenital cryptorchidism, or are these epidemiological findings confounded by the underlying maternal conditions prompting analgesic use?

5 to 10 Most Important Sources to Read in Full

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Implications for Living Together

Note: The following observations are strictly descriptive and analytical; they do not invoke the naturalistic fallacy. To state that the human body evolved for a specific ancestral environment is a biological reality, but it does not dictate that ancestral conditions are morally, socially, or practically "good" or superior to modern life.

The modern endocrine environment requires active, conscious management for men and women striving to live together successfully in couples, families, and organizations. For couples, recognizing that pharmacological interventions like hormonal contraception can subtly alter mating psychology, sexual satisfaction, and mental health allows partners to contextualize sudden shifts in relationship dynamics rather than attributing them solely to interpersonal failure. Understanding the neurosteroid-depleting effects of synthetic progestins should encourage patience, robust communication, and clinical vigilance regarding mood changes in female partners, particularly during adolescence, transitions off the pill, or the postpartum period.

For families, the robust data on the "masculinisation programming window" dictates that pregnant women must be rigorously shielded from EDCs (such as phthalates and PFAS in plastics, non-stick cookware, and cosmetics) to protect the long-term reproductive viability of their children. Furthermore, families should actively curate their home environments to mitigate allostatic load—prioritizing the reduction of 480 nm blue light after sunset to protect the circadian rhythm, and establishing dietary and behavioral habits that counter the obesogenic environment that drives the age-independent metabolic decline of testosterone.
At the organizational and societal level, modern life demands sustained attention and structural stress-management against an environment actively hostile to endocrine homeostasis. Policymakers and organizations must recognize that declining male fertility, precocious puberty, and rising rates of female hormone-sensitive cancers are structural crises rooted in chemical exposure, prolonged hyper-caloric stress, and delayed reproduction. Addressing these challenges requires systemic environmental regulation, workplace policies that respect human chronobiology, and public health frameworks that move beyond individual medicalization.

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