

Secondary Sex Characteristics

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1. Core Definition

Secondary sex characteristics are the non-reproductive physical features that distinguish the sexes of a species. These traits emerge typically during **puberty**, catalyzed by the significant surge in sex hormones, primarily androgens and estrogens. Functionally, these characteristics are external markers of sexual maturity and reproductive competence. While they are not directly involved in the production of gametes or the sustaining of gestation--the functions reserved for primary sex characteristics--secondary traits play an indispensable role in processes such as mate recognition, sexual signaling, and facilitating sexual dimorphism across the species. The array of characteristics is broad, encompassing skeletal, muscular, integumentary, and vocal changes, all serving as honest, often elaborate, indicators of an individual's hormonal status and genetic fitness.

The development trajectory of secondary sex characteristics is a predictable, stage-wise progression defined by the sequential activation of specific target tissues in response to circulating steroids. This development is managed by the intricate feedback loop of the hypothalamic-pituitary-gonadal (HPG) axis. The eventual adult phenotype, characterized by these features, provides critical information regarding the reproductive potential of an individual to potential mates and rivals within the social or ecological environment. Consequently, these traits are often the focus of intense selective pressure, leading to pronounced differences in morphology and behavior between adult males and females in many sexually reproducing species, including humans.

2. Distinction from Primary Sex Characteristics

The defining criterion separating secondary from primary sex characteristics lies in their fundamental biological function. Primary sex characteristics are the essential reproductive organs--the gonads (ovaries and testes) and the external and internal genitalia (uterus, penis, vagina, etc.). These organs are necessary for the formation and transport of gametes (sperm and ova) and, in females, for carrying the developing fetus. Primary characteristics are largely determined during embryonic development, often dictated by the presence or absence of the SRY gene and subsequent early hormonal exposure, establishing the fundamental sex determination of the individual.

In contrast, secondary characteristics arise later in life, during adolescence, and are ancillary to the core reproductive process. They contribute to reproductive success indirectly, typically by making the bearer more attractive to the opposite sex or more formidable to same-sex rivals. For example, in human males, the testes are primary; the growth of the larynx (Adam's apple) and increased

muscle bulk are secondary. In human females, the ovaries are primary; the deposition of fat on the hips and the development of breasts are secondary. This functional distinction means that while the loss of primary characteristics usually results in sterility, the loss or alteration of secondary characteristics (e.g., through injury or surgery) does not negate the underlying reproductive capacity, reinforcing their role as signaling mechanisms rather than reproductive machinery.

3. Development and Hormonal Basis

The onset of secondary sexual development is intrinsically linked to the cascade of hormonal events initiating puberty. The process is centrally regulated by the hypothalamus, which begins releasing pulsatile **Gonadotropin-Releasing Hormone (GnRH)**. This hormone stimulates the anterior pituitary gland to secrete Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH), which subsequently act on the gonads to dramatically increase the production of sex steroids. It is the differential activity of these steroids--testosterone and dihydrotestosterone (androgens) in males, and estradiol (estrogen) in females--that directs the specific patterns of tissue development characteristic of each sex.

In males, testosterone and its highly potent derivative, DHT, are responsible for the vast majority of secondary characteristics. DHT drives the growth of terminal, or androgenic, hair (facial, axillary, and pubic), and contributes to the changes in skin thickness and sebaceous gland activity. Testosterone itself mediates the growth spurt, the substantial increase in lean muscle mass, and the transformation of the vocal cords and larynx, resulting in a deeper voice. Conversely, in females, elevated estradiol levels are the predominant factor. Estradiol stimulates **thelarche** (breast development) and governs the characteristic gynoid pattern of fat deposition around the hips and thighs. The precise timing and intensity of these hormonal surges determine the pace and extent of secondary sexual maturation, which is clinically assessed using standardized tools like the Tanner staging system.

4. Specific Examples in Human Males

Male secondary sex characteristics often emphasize traits useful for aggressive competition and physical defense, resulting in pronounced sexual dimorphism. Musculoskeletal development is paramount; males experience greater bone density and a proportionally larger increase in muscle mass than females during puberty. This leads to the typical male physique defined by broader shoulders and a greater upper body strength ratio. These changes are crucial for signaling competitive fitness, historically relevant for both hunting and defending territory or mates.

Vocal alteration is another key male trait. The thickening and lengthening of the vocal cords, driven by androgenic hormones, permanently lowers the voice pitch, a change often accompanied by the outward projection of the thyroid cartilage, commonly known as the Adam's apple. Furthermore,

the development of facial hair (beard and mustache) and the distinct male pattern of body hair (hirsutism), along with changes in scalp hair distribution that often lead to temporal recession or future baldness, are clear visual indicators of male maturity and high androgen exposure. The collective impact of these characteristics is to create a physically robust and distinctive appearance that serves as a visual signal of reproductive capacity and hormonal health.

5. Specific Examples in Human Females

Female secondary sex characteristics are primarily oriented towards signaling fertility and preparing the body for the metabolic demands of pregnancy and lactation. The most prominent characteristic is the development of the breasts (mammary glands), which involves the proliferation of glandular tissue and the accumulation of adipose tissue. This development is not merely an aesthetic feature but represents a functional capacity crucial for post-natal nourishment.

Furthermore, body fat distribution shifts dramatically from a centralized, pre-pubertal pattern to a peripheral, gynoid distribution. Fat is preferentially stored in the subcutaneous layers of the hips, buttocks, and thighs. This characteristic fat storage provides energy reserves vital for sustaining pregnancy and lactation, and the resulting low waist-to-hip ratio (WHR) is a frequently cited biological signal of high fertility in anthropological and psychological studies. Simultaneously, the bony structure of the pelvis widens significantly, forming the gynecoid shape optimized for accommodating fetal passage during childbirth. Though females also develop pubic and axillary hair (adrenarche being partly responsible), these traits typically remain less extensive than in males.

6. Evolutionary Significance and Sexual Selection

The exaggeration and maintenance of secondary sex characteristics are powerful evidence of their role in **sexual selection**. These traits often function as "honest signals" of genetic quality because they are metabolically costly to produce and maintain. Only individuals with superior health, strong immune systems, and robust genetics can afford to display highly developed characteristics without succumbing to disease or resource depletion.

Evolutionarily, male traits often emphasize strength (e.g., muscle mass, large body size) to facilitate intra-sexual competition--rivalry among males for access to females. Conversely, female traits frequently emphasize fertility (e.g., specific WHR, robust breast development) to attract males based on reproductive viability, a process known as inter-sexual choice. The degree of sexual dimorphism (the extent of difference in secondary characteristics between the sexes) in a species is often correlated with the intensity of sexual selection; species with high levels of competition or strong mate preferences typically exhibit more pronounced secondary characteristics. These signals are therefore crucial for ensuring the selection of the most reproductively successful mates.

7. Medical and Developmental Contexts

The study of secondary sex characteristics is central to pediatric endocrinology and developmental medicine. The standard progression of these characteristics is used clinically to assess pubertal timing and diagnose endocrine disorders. Healthcare providers rely on the **Tanner Scale** (or Sexual Maturity Rating) to track the sequential appearance and maturation of pubic hair, breast development in girls, and external genitalia in boys. Deviations from the normal range can indicate serious medical concerns.

For instance, the early appearance of secondary characteristics before the typical age thresholds signals precocious puberty, which requires investigation to rule out conditions like adrenal hyperplasia or hormone-secreting tumors. Conversely, delayed puberty, the lack of secondary characteristic development by a certain age, may point toward hypogonadism resulting from issues either at the gonadal level (primary hypogonadism) or defects in the pituitary or hypothalamus (secondary hypogonadism). Furthermore, genetic conditions, such as Androgen Insensitivity Syndrome (AIS), demonstrate the mechanistic dependence of these characteristics on receptor functionality: individuals with AIS produce testosterone but lack the functional receptors necessary for tissues to respond, resulting in an external female phenotype despite a male (XY) genotype, highlighting the critical role of tissue responsiveness in the manifestation of secondary characteristics.

8. Further Reading

[Secondary sex characteristic - Wikipedia](#)

[Puberty - Wikipedia](#)

[Sexual selection - Wikipedia](#)

[Tanner Scale - Wikipedia](#)