

# Anisogamy as the Universal Criterion of Human Sex

## A Causal-Hierarchical Definition and Triage

*A falsifiable, life-cycle-consistent classification grounded in gamete organization*

### Abstract

Sex in *Homo sapiens* is defined here as a binary reproductive category grounded in anisogamy—the production of two markedly dissimilar gamete types—within a sexually reproducing, gonochoric mammalian species. An organism is classified by the developmental pathway around which its body is organized: the pathway oriented toward small gametes (sperm) or the pathway oriented toward large gametes (ova). We operationalize this definition as a hierarchical triage—chromosomal constitution, embryonic genital differentiation, and gamete presence or developmental capacity—resolving the large majority of cases at the first decisive step and the remainder through subsequent steps with clinical context. We argue that this formulation is causal rather than correlational, species-wide rather than population-average, consistent across the life cycle, empirically measurable, and falsifiable. We state explicitly the conditions under which the framework would be refuted, and distinguish those legitimate refutation conditions from claims that, while sometimes raised in opposition, do not bear on a definition anchored in gamete organization. Differences of sex development (DSDs) are treated as disorders of male or female development rather than as addition of sexes or as a continuum; no documented human produces a third functional gamete type or both functional gamete types simultaneously.

## 1 Introduction

Definitions of biological sex are sometimes treated as though they were lists of correlated characteristics—chromosomes, hormones, genitalia, secondary traits—each of which admits exceptions, from which it is inferred that the category itself dissolves into a continuum. This inference mistakes the explanatory structure of sex. The characteristics commonly invoked are not co-equal criteria but a causal sequence with a single terminus. In an anisogamous species, sex is defined by gamete type, and the developmental machinery—chromosomal, gonadal, hormonal, anatomical—exists in service of producing one of two gamete classes. A definition anchored at the terminus is not a checklist and is not refuted by variation in the upstream steps.

This paper sets out that anchored definition for *Homo sapiens*, operationalizes it as a clinical triage, and specifies the conditions of its falsification. The aim is a formulation precise enough to be applied to any human at any life stage and explicit enough that the difference between a legitimate refutation and a category error is unambiguous.

## 2 Definition

*Homo sapiens* is a sexually reproducing, gonochoric (separate-sexed) mammal. Sexual reproduction in the species proceeds by anisogamy: the fusion of two gamete types that differ markedly in size

and number—a small, motile gamete produced in large quantity (sperm), and a large, nutrient-provisioned gamete produced in small quantity (ovum). These two gamete classes exhaust the reproductive types in the species. There is no third gamete class, and no individual produces both functional classes simultaneously.

From this the definition follows directly:

- A human is **male** if the body is organized around the developmental pathway that produces, or has the developmental capacity to produce, small gametes (sperm).
- A human is **female** if the body is organized around the developmental pathway that produces, or has the developmental capacity to produce, large gametes (ova).

There are no other sexes in humans because there are no other gamete types. The definition is fixed across the life cycle, from conception onward, and applies to the species universally— independent of secondary sexual characteristics, self-perception, medical intervention, or developmental variation. “Organized around” carries the explanatory weight: it refers to the developmental program the organism instantiates, not to whether that program has reached functional completion. Sterility, immaturity, senescence, and injury bear on whether gametes are *currently produced*; they do not bear on which pathway the organism is built along.

## 2.1 Why the definition is causal, not correlational

The upstream features track sex because they are stages in a single causal chain whose endpoint is gamete type:

SRY status → gonadal differentiation → hormonal milieu → genital morphogenesis → gametogenesis.

Because the chain is causal and convergent, a disruption at one link does not generate a new endpoint; it generates a recognizable disorder of one of the two existing pathways. This is the structural reason the binary is not dissolved by exceptions: the exceptions are perturbations *within* pathway, not evidence of a third.

## 3 Triage: An Operational Identification Method

The definition is applied through a hierarchical triage. The order reflects both decisiveness and cost: the earliest step resolves the large majority of cases, and ambiguity is escalated to later steps together with clinical context.

1. **Chromosomal constitution (primary genetic determinant).** Presence or absence of the *SRY* gene—typically carried on the Y chromosome—initiates the male pathway (testis determination) or, in its absence, the pathway that proceeds to ovarian development. Standard constitutions: 46,XY → male trajectory; 46,XX → female trajectory. Mosaics and aneuploidies (e.g., 45,X, Turner; 47,XXY, Klinefelter) are evaluated by their predominant gonadal and reproductive orientation rather than treated as further categories.
2. **Embryonic genital differentiation (the urogenital pathway, ~weeks 7–12).** In the male pathway, testosterone and dihydrotestosterone drive elongation and fusion: genital tubercle to penis, urogenital folds to penile urethra and scrotum. In the absence of that androgenic drive, the pathway proceeds to clitoris and separate urethral and vaginal openings. This bifurcation is assessable by physical examination, imaging, or histology and reflects an early, irreversible developmental commitment.

3. **Gamete presence or developmental capacity (the definitional anchor).** Functional or potential production of sperm versus ova. Pre-pubertally, this is inferred from gonadal type (testicular versus ovarian tissue); post-pubertally it may be assessed directly (semen analysis; ovarian histology). Sterility does not reassign the category, because the category is set by which pathway the organism is organized along, not by current fertility.

**Application rule.** Resolve at the earliest decisive step. Most individuals resolve at Step 1. Where a step is ambiguous, advance to the next, and where the steps diverge, the gamete anchor (Step 3) governs, because it is the criterion the definition names; the prior steps are diagnostic predictors of it.

## 4 Handling of Variation

### 4.1 Differences of sex development (DSDs)

DSDs are disorders of male or female development. They disrupt one of the two pathways; they do not constitute additional sexes or points on a continuum. Congenital adrenal hyperplasia in a 46,XX individual produces virilized external genitalia on an ovum-oriented developmental program. Complete androgen insensitivity in a 46,XY individual produces female-appearing external genitalia on a sperm-oriented program with testicular tissue that the somatic tissues cannot respond to. In each instance the underlying organization assigns the case within the binary. No DSD yields a third functional gamete class, and ovotesticular DSD—the rarest configuration in which both ovarian and testicular tissue are present—does not yield simultaneous functional production of both gamete classes in a documented human.

### 4.2 Post-developmental intervention

Cross-sex hormones and surgery do not alter chromosomal constitution, do not reverse the embryonic genital commitment, and do not switch gamete type or capacity. They produce a phenotypically altered typically female version of the original developmental sex. Changes induced are overlays on the original trajectory rather than a transition between the two pathways.

### 4.3 Life stage

Pre-pubertal individuals are classified by Steps 1 and 2, both established by birth. Puberty activates full gamete capacity (Step 3) but does not alter the underlying organization; pubertal suppression or cross-sex hormones interrupt expression without redefining the pathway. Infertility, menopause, and injury bear on current gamete production, not on developmental organization, and so do not reassign category.

## 5 Falsifiability

A definition worth the name specifies what would refute it. The present framework is refuted by either of the following, demonstrated in a single documented human:

1. the production of a **third functional gamete class**, distinct from sperm and ovum; or
2. the simultaneous production of **both functional gamete classes** by one individual.

Either observation would falsify the claim that human sex is binary and gamete-anchored, because both contradict the anisogamy on which the definition rests. No such case is documented.

It is equally important to state what does *not* bear on the framework, because a definition

anchored in gamete organization is not addressed by claims about other things. The following do not constitute refutations, not because they are dismissed, but because they are not claims about gamete organization:

- **Self-perception and self-report**, which concern psychological identity, not the developmental pathway the body instantiates;
- **Secondary sexual characteristics**, which are downstream, variable expressions of the pathway and not its definitional anchor;
- **Medical or surgical intervention**, which alters phenotype without altering chromosomal constitution, embryonic commitment, or gamete class;
- **Chromosomal anomalies that resolve to a pathway** (mosaics, aneuploidies), which are evaluated by predominant orientation and remain within the binary.

The distinction is not rhetorical. A legitimate challenge to a gamete-anchored definition must be a claim about gametes. A claim about identity, appearance, or intervention engages a different question and leaves the definition untouched. Stating this boundary is what makes the framework falsifiable in the strict sense: it can be refuted, and the form a refutation must take is specified in advance.

## 6 Discussion

The formulation is offered as the most precise and definable because it is causal and hierarchical rather than a list of averaged correlates; species-wide and constant across the life cycle; empirically measurable at each step by karyotype examination or imaging, and histology; non-circular, in that it is anchored in reproductive function rather than in stereotypes or self-report; and falsifiable with its refutation conditions stated explicitly. It coincides with standard usage in evolutionary biology—where anisogamy is the cross-species criterion of sex—and with the developmental and reproductive medicine of the human case. No known human case escapes it, and the form that an escaping case would have to take has been named.