

# The Processes of Human Evolution: Natural Selection

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## Introduction

Human evolution is the gradual change in the inherited characteristics of hominin populations over successive generations. Several processes contribute to this change, but the primary mechanism of adaptive evolution is natural selection.

This report explains how natural selection works, the raw material it acts on, how it has shaped human anatomy and physiology, and how it interacts with other evolutionary processes.



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## The Mechanism of Natural Selection

Natural selection follows from four conditions:

- Overproduction — populations produce more offspring than the environment can support.
- Variation — individuals in a population differ in their inherited traits.

- Heritability — some of that variation is passed from parents to offspring.
- Differential survival and reproduction — individuals whose traits suit the local environment tend to survive and reproduce more successfully.

Over generations, the alleles associated with advantageous traits become more common, and the population becomes better adapted to its environment.

An important qualification: selection acts on individuals, but the change itself occurs in the population.

## The Source of Variation

Natural selection cannot create variation; it can only sort it. Variation arises from:

- Mutation, the ultimate source of new alleles.
- Recombination during meiosis.
- Independent assortment of chromosomes.

Sexual reproduction reshuffles existing alleles into new combinations each generation, so that offspring present novel trait combinations for selection to act upon.

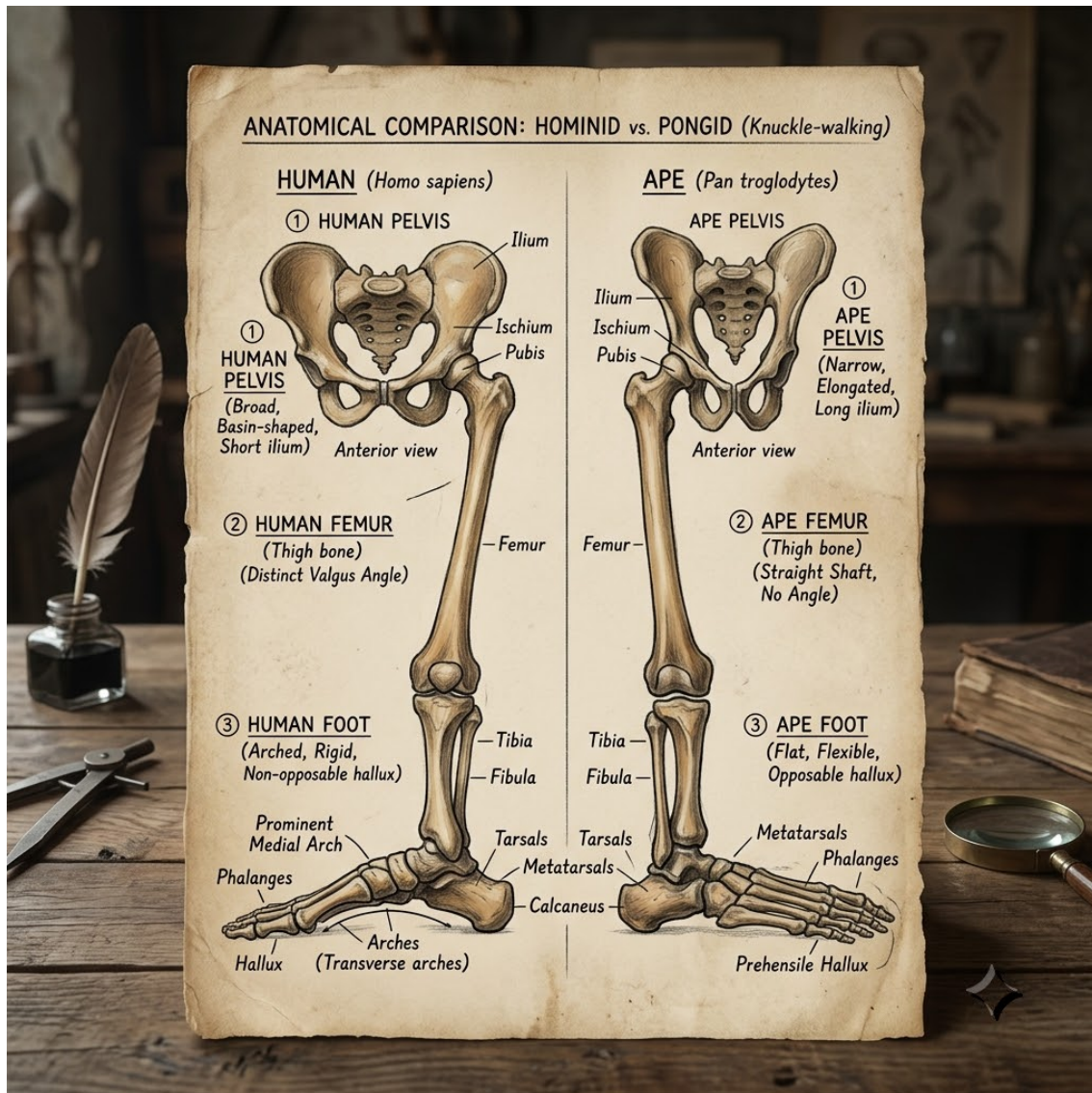
## Types of Selection

| Type        | Effect on the trait                              | Example cited                                        |
|-------------|--------------------------------------------------|------------------------------------------------------|
| Directional | Shifts a trait toward one extreme                | Trends such as increasing brain size across hominins |
| Stabilising | Favours intermediate values and removes extremes | Human birth weight, the standard example             |
| Disruptive  | Favours both extremes over the intermediate      | —                                                    |

## Natural Selection in Human Evolution

Selective pressures acting on hominin populations have been linked to a number of derived traits.

- Bipedalism — changes to the pelvis, spinal curvature, femur angle and foot arch, associated with efficient walking and with freeing the hands.
- Encephalisation — an increase in brain size relative to body size, associated with tool use, social complexity and dietary change.
- Changes in dentition and jaw structure — reduced molar size and jaw robustness, linked to dietary shifts and to food processing.
- Thermoregulation — reduced body hair and a high density of sweat glands, linked to activity in open, hot environments.
- Skin pigmentation — a cline associated with ultraviolet exposure, balancing protection of folate against vitamin D synthesis.
- Lactase persistence — the continued production of lactase into adulthood in some populations, associated with dairying.
- The sickle-cell allele — heterozygote advantage in regions where malaria is present, a classic example of balancing selection.



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## Other Processes Acting Alongside Selection

Not all evolutionary change is adaptive. Alongside natural selection:

- Genetic drift produces random change in allele frequencies, and is strongest in small populations.
- Founder effects and bottlenecks reduce the variation carried forward when a population is established by few individuals or sharply reduced in size.
- Gene flow moves alleles between populations.
- Sexual selection acts on traits affecting mating success.

Distinguishing adaptation from drift is an important part of interpreting the evidence.

# Evidence

| Line of evidence    | What it contributes                                                                                                    |
|---------------------|------------------------------------------------------------------------------------------------------------------------|
| The fossil record   | Shows the sequence of anatomical change                                                                                |
| Comparative anatomy | Shows homologous structures shared with other primates                                                                 |
| Molecular evidence  | From DNA and protein comparisons, allows relationships and divergence patterns to be inferred independently of fossils |



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# Conclusion

Natural selection explains how heritable variation is converted into adaptation. Acting on mutations and recombination, and alongside drift and gene flow, it accounts for the derived features that distinguish modern humans from other primates.

## References

*To be completed once the permitted sources are confirmed.*