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Q5(d)

Mitochondrial DNA and human evolution.

UPSC Civil Services Mains 2025 · Anthropology GS 1 · 10 marks · The biological basis of Life

1.7 The biological basis of Life: The Cell, DNA structure and replication, Protein Synthesis, Gene, Mutation, Chromosomes, and Cell Division.

Core demand of the question

- State why mitochondrial DNA is a special genetic system
- Show how it has been used to reconstruct human evolution
- Give the main findings and the main limits
- Keep the argument on evolution rather than clinical mitochondria alone

Revision summary

mtDNA is inherited from the mother and does not recombine like nuclear DNA.

Cann, Stoneking and Wilson used it to place the common maternal ancestor of living humans in Africa.

Mitochondrial Eve is a node in a tree, not the only woman of her generation.

Haplogroups map later dispersals. They are not races.

Neanderthal mtDNA and nuclear admixture show that one locus is not the whole story.

Join mtDNA to Y-chromosome and autosomal evidence.

Introduction

Mitochondrial DNA is a small circular genome inside mitochondria. It is inherited almost only from the mother and does not recombine in the way nuclear chromosomes do. Those two facts made it an early clock and tree for human evolution.

Body**Why mtDNA is useful**

Because it comes down the maternal line, a tree of mtDNA types is a tree of mothers. Mutation accumulates fast enough, relative to many nuclear regions, to separate human groups on a recent timescale. **Allan Wilson's** laboratory used this logic. In 1987 **Rebecca Cann, Mark Stoneking** and Wilson published the famous mitochondrial work that placed the common maternal ancestor of living humans in Africa.

Popular writing called her "**mitochondrial Eve**". That name misleads if it sounds like the only woman of her time. She is the most recent woman from whom all living mtDNA lines descend. Many other women lived then; their mtDNA lines later died out.

What it showed about evolution

- **Recent African origin:** Living human mtDNA diversity is greatest in Africa, and non-African lineages sit inside African variation. This supported an Out-of-Africa model against a simple multiregional story of separate ancient origins.
- **Haplogroups:** Later work labelled maternal **haplogroups** that map dispersal into Eurasia, Australia and the Americas. They are tools for migration history, not races.
- **Archaic cousins:** Neanderthal and Denisovan mtDNA, when recovered, did not match living human mtDNA as a simple continuation. Nuclear DNA later showed some interbreeding. One locus is not the whole species tree.

Svante Pääbo's ancient-DNA programme sits beside this note even though much of it is nuclear. It is the next chapter, not a substitute for the 1987 argument.

Limits

mtDNA is one locus. Selection, population size and drift can warp the tree. Time estimates depend on mutation-rate assumptions. Paternal leakage is rare. The bigger caution is that a maternal tree is not the full history of peoples. Y-chromosome and autosomal DNA must join it.

Commercial "maternal ancestry" tests report a haplogroup, not a caste or a civilisation.

Flow diagram

mtDNA -> Maternal / no recombination
mtDNA -> African diversity deepest
African diversity deepest -> Out of Africa
mtDNA -> One locus only

Conclusion

Mitochondrial DNA gave anthropology a maternal clock and a strong African-origin argument. **Cann, Stoneking and Wilson** established the maternal African-origin case. Eve is a node in a tree, not a lone first woman, and mtDNA is one line beside nuclear genomes.

Facts & figures

Cann, Stoneking and Wilson

Their 1987 mitochondrial DNA study argued that the maternal ancestor of living humans lived in Africa and that living diversity is structured by a recent African origin.

Mitochondrial Eve

The most recent common maternal ancestor of living humans' mtDNA. Other women lived at the same time; their mtDNA lines did not survive.

Maternal inheritance

Children receive mtDNA from the mother. Affected fathers do not transmit their mtDNA lineage.

Haplogroups

Named branches of the human mtDNA tree used to study migration. They are genealogical labels, not biological races.

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