SYNTHETIC HUMAN GENOME PROJECT: SCIENCE & TECHNOLOGY

NEWS: Work begins to create artificial human DNA from scratch

WHAT'S IN THE NEWS?

The Synthetic Human Genome Project (SynHG) launched in the UK aims to construct a human genome from scratch using chemically synthesized DNA, marking a shift from reading to writing genetic material. The project has vast scientific potential but also raises ethical, regulatory, and dual-use concerns.

Synthetic Human Genome Project (SynHG)

1. Objective and Vision

- The project aims to **design and construct an entire human genome** from scratch using **chemically synthesized DNA**.
- It marks a major shift from **reading (sequencing)** human DNA to **writing (constructing)** it.

2. Core Activities

- Initially focused on building a **fully synthetic human chromosome**, which will serve as a proof-of-concept for the larger goal.
- Employs advanced chemical synthesis and genome assembly technologies.

3. Leading Institutions Involved

- Led by prominent UK-based institutions including:
    1. **Ellison Institute of Technology**
    2. **University of Oxford**
    3. **University of Cambridge**
    4. **University of Kent**
    5. **University of Manchester**
    6. **Imperial College London**

4. Funding and Support

- Backed by the **Wellcome Trust**, a major health research charity.
- An initial funding of **£10 million** has been allocated to start the project.

5. Ethical and Societal Engagement

- A program called **"Care-full Synthesis"** is embedded within the project to:

- Involve social scientists and ethicists
- Engage public and policy stakeholders
- Explore ethical, legal, and societal implications

Scientific and Technological Significance

1. Advancement in Genomic Science

- Enables scientists to **create customized DNA sequences** that can help study the structure and function of genes in new ways.
- Goes beyond traditional genome editing (e.g., CRISPR) by enabling **entire genome synthesis**.

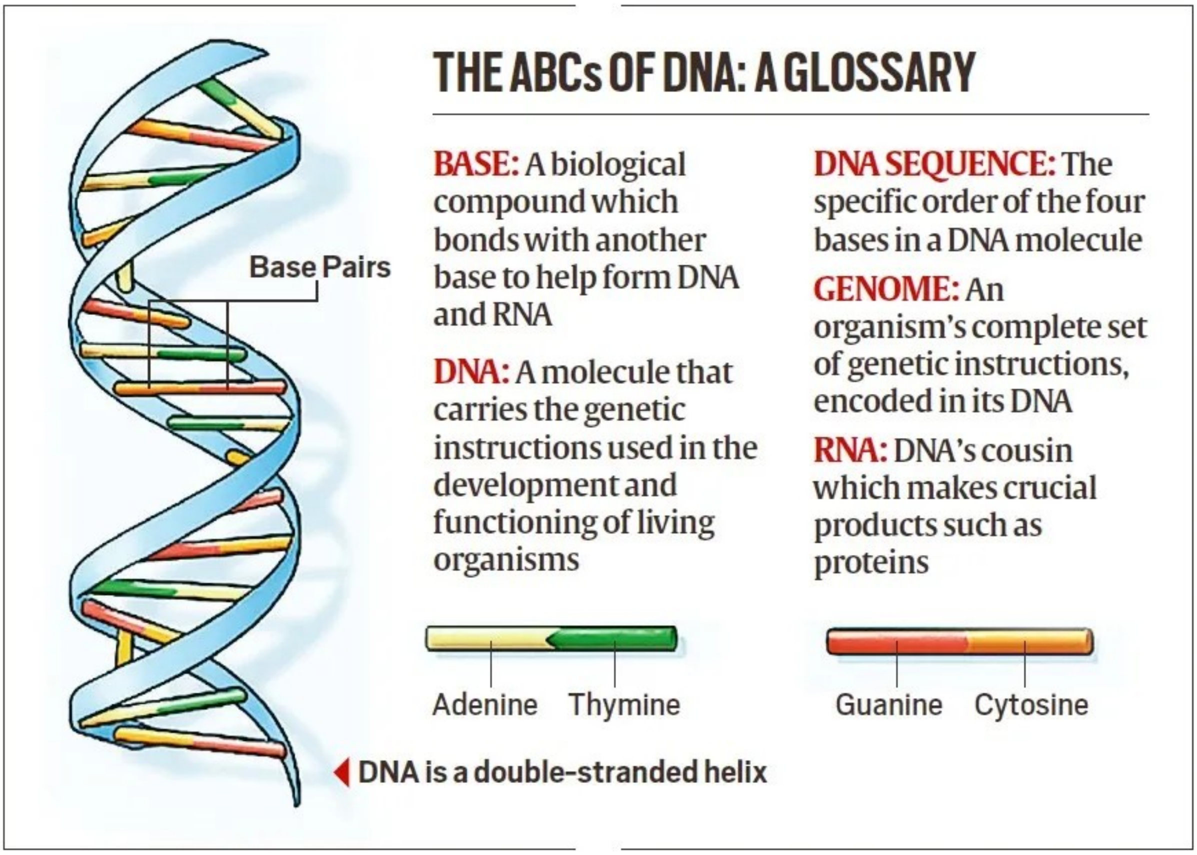
2. Medical and Therapeutic Potential

- Creation of **disease-resistant cells and tissues**
- Potential for **organ regeneration** and **repair of immune systems**
- May revolutionize **organ transplantation** by creating organs that won't be rejected by the body
- Opens doors to **healthy ageing**, by eliminating inherited disease risks and enhancing cellular repair mechanisms

3. Applications in Other Sectors

- **Agriculture**: Engineering crops with synthetic genomes to resist pests, drought, and climate stress
- **Biotechnology**: Synthetic organisms for industrial enzyme production, drug synthesis, or waste treatment

- **Global Food Security**: Bioengineered plants with better nutrition and yield



Risks and Ethical Concerns

1. Ethical Dilemmas

- Questions on **human dignity, identity, and life manipulation**
- Fears about scientists **"playing God"** or crossing moral boundaries

2. Oversight and Regulation Challenges

- Rapid commercialization may outpace legal and ethical frameworks
- Difficulty in controlling the use of synthetic biology by private entities or rogue actors

3. Dual-Use Risk

- While the technology is intended for good, it could be misused for:
  - **Bioweapons**
  - **Genetic manipulation for unethical purposes**
  - **Designer babies** or socio-genetic discrimination

What is a Synthetic Genome?

1. Definition

- A synthetic genome is a **man-made sequence of DNA** that imitates or enhances natural genetic code.
- It is **built entirely from scratch** using chemical synthesis, not just edited from existing DNA.

2. Key Differences from Gene Editing

- **Gene Editing**: Modifies existing DNA (e.g., CRISPR-Cas9)
- **Synthetic Genomics**: Creates new DNA entirely, including **new genes and chromosomes**

Techniques Used in Synthetic Genome Construction

1. Chemical DNA Synthesis

- Short sequences of DNA called **oligonucleotides** are chemically created in labs.
- These fragments are **combined and extended** to form longer DNA strands.

2. Gene Assembly Techniques

- **Polymerase Cycling Assembly (PCA)** and **Gibson Assembly** are used to stitch together overlapping fragments.
- These methods allow the **step-by-step construction** of entire genes or chromosomes.

3. In Vitro and In Vivo Assembly

- **In Vitro**: DNA is assembled in test tubes outside living cells.
- **In Vivo**: DNA fragments are inserted into host organisms (commonly **yeast**) that naturally replicate and assemble the genome.

4. Error Correction and Validation

- Synthetic DNA is **prone to errors**, so extensive validation is done using **DNA sequencing** and **correction tools**.

5. Functional Testing

- Final genome is introduced into **cellular systems** to check if it behaves like natural DNA:
    - Produces proteins
    - Controls gene regulation
    - Supports cellular replication and metabolism

Historical Context: First Artificial Genome

- The **first synthetic genome** was made for a virus named **Phi X 174** by Craig Venter's team.
- Used **Polymerase Chain Assembly (PCA)** to chemically build the viral DNA.
- This achievement **paved the way** for synthetic biology research globally.

Comparison with Earlier Genome Projects

1. Human Genome Project (HGP)

- **Timeline**: 1990–2003
- **Aim**: Decode the **entire human DNA sequence** and map all genes (~20,000–25,000 genes)
- **Outcome**:
    - Transformed biological sciences and medicine
    - Enabled **genomic medicine** and disease gene identification

2. India Genome Project

- **Launched by**: Department of Biotechnology (DBT), Govt. of India
- **Purpose**: Sequence genomes of diverse Indian populations
- **Objectives**:
    - Understand **genetic diversity** among Indians
    - Support **personalized medicine** and better **drug response** prediction
    - Boost **indigenous research capabilities** in genomics