



# Genome Sequencing

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## Why in News?

Recently, a report published in the journal Nature revealed that a team of archaeologists and scientists from Germany, Mexico, Spain, the U.K. and the US has **sequenced genetic material** obtained from the **human remains found from an ancient burial place**.

## What is Genome Sequencing?

### ▪ About:

- **Genome sequencing** is a process of determining the complete **DNA** sequence of an organism's genome.
  - A genome is a complete set of **DNA** that contains all of the genes of an organism.
- It involves figuring out the order of bases (**Adenine, Cytosine, Guanines, and Thymine**) that make up an organism's DNA. It is supported by automated DNA sequencing methods and computer software to assemble the massive sequence data.

## Gene Editing

- Gene editing, also known as genome editing, is a technology that **allows for the precise modification** of the **genetic material (DNA or RNA)** of an organism.
- It involves the **use of specialised tools** to add, remove, or alter specific DNA sequences within a genome.
- **Methods:**
  - CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats):
    - It is the most widely used and versatile gene editing tool.
    - It uses a guide RNA (gRNA) to direct the Cas9 enzyme to the target DNA sequence, where it can make a double-strand break. The cell's natural DNA repair mechanisms are then used to either disrupt the target gene or insert a desired DNA sequence.
  - **Zinc Finger Nucleases (ZFNs):**
    - ZFNs are composed of a DNA-binding domain (zinc finger proteins) and a DNA-cleaving domain (FokI endonuclease).
    - The zinc finger proteins are designed to recognize and bind to specific DNA sequences, and the FokI domain then cleaves the DNA. ZFNs can be engineered to target and edit specific genomic regions.

### • **Difference Between Gene Editing and Gene Sequencing:**

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Characteristics	Gene Sequencing	Gene Editing
<b>Definition</b>	The process of determining the precise order of nucleotides (A, T, C, G) in a DNA or RNA molecule.	The process of making targeted modifications to the DNA sequence of a gene or genes.
<b>Purpose</b>	To obtain the complete or partial sequence of a gene, a set of genes, or an entire genome.	To introduce desired changes, such as correcting genetic defects, modifying gene expression, or introducing new genetic traits.
<b>Techniques</b>	Sanger sequencing, Next-Generation Sequencing (NGS), and others.	<b>CRISPR-Cas9</b> , zinc finger nucleases, TALENs, and other specialised tools.
<b>Outcome</b>	Provides information about the genetic makeup and composition of an organism.	Allows for the direct manipulation and alteration of the genetic code.
<b>Modification</b>	Does not directly modify the genetic material.	Enables the addition, removal, or alteration of specific DNA sequences.

### ▪ Methods of Genome Sequencing:

#### ◦ Clone-by-Clone Approach:

- In this approach, the genome is first broken up into relatively large segments called clones, which are typically around 150,000 base pairs (bp) in length. Genome mapping techniques are then used to determine the location of each clone within the overall genome.
  - Next, each clone is further fragmented into smaller, overlapping pieces of around 500 bp in size, which are suitable for sequencing.
  - Finally, the individual sequenced pieces are assembled using the overlapping regions to reconstruct the complete sequence of the entire clone.

#### ◦ Whole-Genome Shotgun Approach:

- This method involves randomly fragmenting the entire genome into small pieces.
  - These small fragments are then **sequenced**, without any prior knowledge of their genomic location.
  - The sequenced fragments are then **computationally reassembled** into the full genome sequence by identifying and aligning the overlapping regions between the fragments.
- The **clone-by-clone approach** is often used for **large and complex genomes**, while the **whole-genome shotgun** method is **more suitable for smaller** and less complex genomes.

### ▪ Applications:

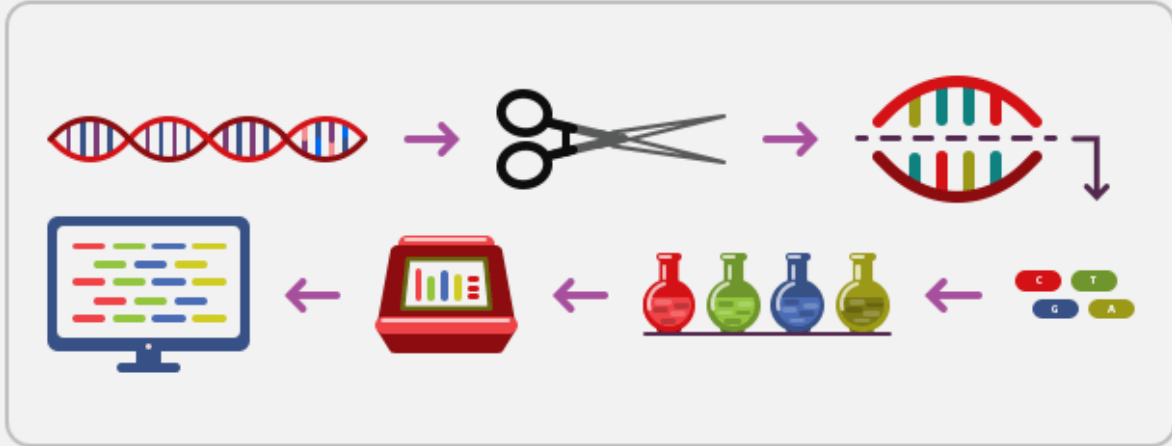
- **Finding origin of Epidemics:** Genome sequencing helps researchers understand the genetic makeup of pathogens, tracing the source and spread of outbreaks like SARS-CoV-2.
- **Controlling Disease Spread:** Genome analysis allows monitoring pathogen evolution and identifying mutation patterns, incubation periods, and transmission rates to inform prevention strategies.
- **Healthcare Applications:** It enables personalised treatments, guides targeted public health interventions, reveals genetic underpinnings of diseases like cancer, and informs drug efficacy and safety for diverse populations.

- **Agricultural Advancements:** Crop genome sequencing can enhance understanding of genetic susceptibility to pests and environmental stressors.
- **Evolutionary Studies:** Genome data can contribute to mapping species' migrations and evolution, furthering our knowledge of human origins and life's history.

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## GENOMIC SEQUENCING

What is Genomic Sequencing?



## GENOMIC SEQUENCING

Genomic sequencing refers to methods of determining the entire DNA sequence of an organism's genome. In simpler terms, it determines the order of As, Ts, Cs and Gs that make up an organism's DNA. A genomic sequence is depicted by a very long line of these letters arranged in a specific order.

### Important genome sequencing initiatives

#### ▪ Human Genome Project:

- The [Human Genome Project \(HGP\)](#) from **1990 to 2003**, was a landmark international effort to **map and sequence the entire human genome**.
  - It was coordinated by the US National Institute of Health (NIH) and the U.S. Department of Energy.
- The project revolutionised medicine and advanced DNA sequencing technology.
- Developments like Her2/neu for breast cancer treatment and CYP450 for antidepressant response resulted from the project.

#### ▪ [Genome India Project:](#)

- It was launched in **2020** as a flagship initiative aimed at comprehensively **deciphering the genetic makeup of the Indian population**.
- It is funded and coordinated by the Department of Biotechnology (DBT), Government of India.

#### ▪ IndiGen Project

- It was undertaken by CSIR in April 2019.
- It aims to undertake whole genome sequencing of diverse ethnic groups from India.
- The objective is to **enable genetic epidemiology** and **develop public health**

**technologies applications** using population genome data.

### UPSC Civil Services Examination, Previous Year Questions (PYQs)

**Q1. With reference to agriculture in India, how can the technique of 'genome sequencing', often seen in the news, be used in the immediate future? (2017)**

1. Genome sequencing can be used to identify genetic markers for disease resistance and drought tolerance in various crop plants.
2. This technique helps in reducing the time required to develop new varieties of crop plants.
3. It can be used to decipher the host-pathogen relationships in crops.

**Select the correct answer using the code given below:**

- (a) 1 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

**Ans: (d)**

PDF Reference URL: <https://www.drishtiias.com/printpdf/genome-sequencing-4>

