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GENOME INDIA PROJECT

THIS ARTICLE COVERS 'DAILY CURRENT AFFAIRS' AND THE TOPIC DETAILS OF THE "GENOME INDIA PROJECT".THIS TOPIC IS RELEVANT IN THE "SCIENCE & TECHNOLOGY" SECTION OF THE UPSC CSE EXAM.

WHY IN THE NEWS?

The Department of Biotechnology (DBT) formally declared the completion of the '10,000 genome' project, which aimed to develop a reference library of whole-genome sequences outside of India.

DEMYSTIFYING THE INDIAN GENOME: THE GENOME INDIA PROJECT (GIP)

- **India's Mosaic of Genomes**: With over 1.3 billion people belonging to 4,600 distinct groups, India boasts remarkable population diversity. This intricate tapestry translates into unique genetic variations and disease-causing mutations within the population, many stemming from endogamous practices within specific groups.
- **A Collaborative Endeavor**: **Launched in 2020**, the ambitious GIP, **led by the Indian Institute of Science (IISc)** and the **Centre for Cellular and Molecular Biology (CCMB),** is a testament to collaborative spirit. Around 20 institutions across the country are actively contributing their expertise to this groundbreaking initiative.
- GIP **aims to sequence and analyze the genomes of 10,000 individuals by the end of 2023.** This data will be **instrumental in understanding the intricate variations in the Indian population's genetic makeup, including disease-causing mutations**. As of now, close to 7,000 genomes have been sequenced, with 3,000 already publicly accessible.

UNLOCKING THE POTENTIAL: THE PROJECT HOLDS IMMENSE PROMISE FOR VARIOUS APPLICATIONS

- **Personalized Medicine**: By deciphering the genetic code, GIP can pave the way for precision medicine, tailoring treatments and therapies to individual patients' unique genetic profiles. This personalized approach has the potential to significantly improve treatment efficacy and patient outcomes.
- **Enhanced Diagnostics**: Understanding genetic predispositions to diseases can revolutionize diagnostic methods, allowing for early detection and intervention. This can significantly improve disease management and patient prognosis.

- **Biotechnological Advancements**: The wealth of genetic data generated by GIP can serve as a springboard for advancements in biotechnology. This data can fuel the development of novel drugs, diagnostics, and other innovative technologies.
- **Sustainable Agriculture**: Understanding the genetic makeup of diverse plant and animal populations can aid in developing new agricultural practices and crop varieties specifically suited to the unique environmental conditions across India. This can contribute to increased agricultural productivity and sustainability.

ABOUT GENOMES

Definition: A genome constitutes the entire genetic content within an organism, encompassing the essential information for its development, functioning, and reproduction.

Genetic Material: In most organisms, genomes are constructed from DNA (deoxyribonucleic acid), although certain viruses may employ RNA (ribonucleic acid) as their genetic material.
Significance: Grasping the intricacies of genomes is imperative for unravelling the foundational mechanisms of life, spanning from evolutionary processes to disease dynamics.

STRUCTURE OF GENOMES

- **DNA Molecules:**
  DNA comprises two lengthy strands forming a double helix.
  Nucleotides: The basic constituents of DNA, comprising a sugar molecule (deoxyribose), a phosphate group, and one of four nitrogenous bases (adenine, thymine, cytosine, and guanine).
- **Genes:**
  Functional segments of DNA are tasked with encoding proteins or RNA molecules. Genes carry instructions for the synthesis of specific molecules, such as enzymes or structural proteins.
- **Chromosomes:**
  DNA is organized into chromosomes, thread-like structures containing extensive DNA molecules and associated proteins. Humans possess 46 chromosomes, organized into 23 pairs, inclusive of one pair of sex chromosomes.
- **Genome Size and Complexity:**
  Genome sizes exhibit considerable variation among organisms, ranging from a few thousand base pairs in certain viruses to billions of base pairs in complex organisms like humans.

UNVEILING THE BLUEPRINT OF LIFE: A LOOK AT GENOME SEQUENCING

- **Cracking the Code**: Genome sequencing is essentially the process of deciphering the exact order of building blocks, called nucleotides, that make up an organism's DNA. This information is akin to the instruction manual for life, holding the key to understanding an organism's characteristics and functionalities.

- **A Journey Through Time**: Our ability to read the genetic code has not always been so sophisticated. The 1970s marked a significant era with the development of Sanger sequencing, a method laying the foundation for future advancements. However, the turn of the millennium ushered in a revolution with the arrival of Next-Generation Sequencing (NGS) technologies, offering faster and more efficient ways to sequence genomes.

- **Unlocking the Power of Genetics**: Genome sequencing holds immense value in various areas. By analyzing the variations within the genetic code, scientists can gain insights into how individuals differ from each other, both in terms of health and other traits. This knowledge allows them to explore the evolutionary connections between species and sheds light on the intricate dance of life on Earth. Additionally, genome sequencing plays a crucial role in diagnosing diseases with greater accuracy, paving the way for personalized treatment strategies tailored to individual patient's genetic makeup.

DELVING DEEPER: A GLIMPSE INTO THE TECHNIQUES FOR GENOME SEQUENCING

- **Sanger Sequencing**: This pioneering method, devised by Fred Sanger, involves copying DNA strands with the help of special nucleotides that halt the replication process at specific points. By analyzing the lengths of the resulting fragments, scientists can determine the original sequence.
- **Next-Generation Sequencing (NGS)**: This umbrella term encompasses a range of high-throughput techniques that significantly accelerate the sequencing process compared to Sanger sequencing. These methods allow for parallel sequencing of numerous DNA fragments simultaneously, making them faster and more cost-effective. Some prominent examples of NGS technologies include Illumina sequencing, Ion Torrent sequencing, and Roche 454 sequencing.
- **Third-Generation Sequencing**: This cutting-edge approach pushes the boundaries even further by enabling the sequencing of individual DNA molecules in real time. This eliminates the need for amplification, which can introduce errors, and offers a more direct approach to reading the genetic code. Prominent players in this field include PacBio (Pacific Biosciences) and Oxford Nanopore sequencing.

PRELIMS PRACTICE QUESTION

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? (UPSC PRELIMS-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

Answer: (d)

MAINS PRACTICE QUESTION

Q1. Explore the applications of genome sequencing in personalized medicine, emphasizing how it can be utilized to tailor medical treatments to individual genetic profiles

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