PLUTUS IAS

CURRENT AFFAIRS

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ALPHA FOLD 3

THIS ARTICLE COVERS 'DAILY CURRENT AFFAIRS' AND THE TOPIC DETAILS OF "ALPHA FOLD 3 ". THIS TOPIC IS RELEVANT IN THE "SCIENCE AND TECHNOLOGY" SECTION OF THE UPSC CSE EXAM.

WHAT IS ALPHA FOLD?

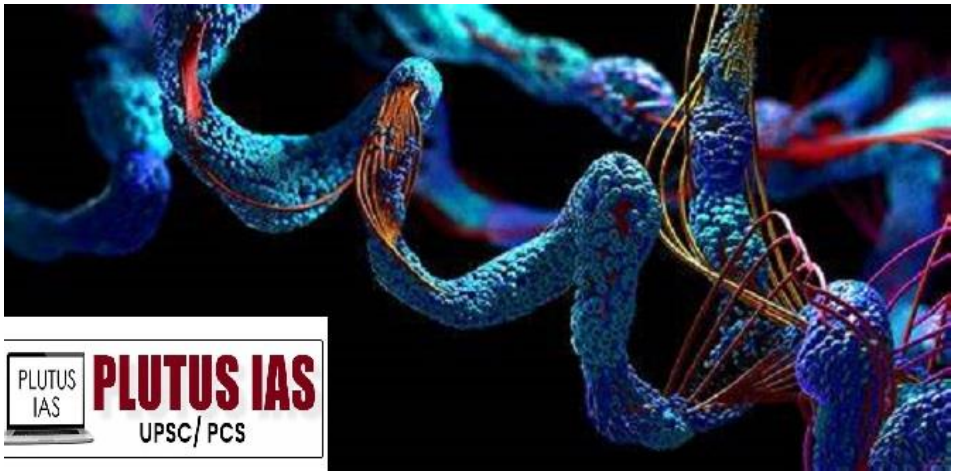
AlphaFold is an advanced AI system developed by DeepMind, a subsidiary of Alphabet Inc. AlphaFold is designed for protein folding prediction, which is a fundamental problem in biology. The primary goal of protein folding prediction is to determine the three-dimensional structure of a protein from its amino acid sequence.

Understanding the 3D structure of proteins is crucial for deciphering their functions, interactions with other molecules, and implications in diseases. Experimental methods for determining protein structures, such as X-ray crystallography and cryo-electron microscopy, can be time-consuming and expensive. Therefore, computational methods, such as those based on AI, offer a promising alternative for predicting protein structures quickly and accurately.

AlphaFold gained significant attention in the scientific community due to its remarkable performance in the Critical Assessment of Structure Prediction (CASP) competition. CASP is a biennial competition where research groups worldwide compete to predict the structures of proteins whose experimental structures have not yet been determined. In CASP14, held in 2020, AlphaFold achieved unprecedented accuracy, outperforming other methods by a significant margin.

AlphaFold's success is attributed to its novel deep learning architecture, which combines deep neural networks with novel attention mechanisms and advanced training strategies. These techniques allow AlphaFold to accurately predict the complex 3D structures of proteins based solely on their amino acid sequences, rivaling the accuracy of experimental methods in many cases.

The release of AlphaFold has the potential to revolutionize structural biology by accelerating the pace of protein structure determination and facilitating research in various fields, including drug discovery, enzyme engineering, and understanding the molecular basis of diseases.



HOW PROTEINS ARE FORMED IN NUCLEUS OF A CELL

The process of protein formation, also known as protein synthesis or translation, primarily occurs in the cytoplasm of the cell, not the nucleus. However, the nucleus plays a crucial role in the initial steps of protein synthesis, which involve transcription. Here are the steps involved in protein formation, with a focus on the role of the nucleus:

- **TRANSCRIPTION IN THE NUCLEUS:**
  - The process begins with the transcription of a gene from DNA to RNA within the cell nucleus.
  - RNA polymerase, along with other transcription factors, binds to the promoter region of the gene.
  - The DNA double helix unwinds, and RNA polymerase catalyzes the synthesis of a complementary RNA strand, using one of the DNA strands as a template.
  - The newly synthesized RNA molecule, called messenger RNA (mRNA), is complementary to the DNA template and carries the genetic information from the nucleus to the cytoplasm.
- **PROCESSING OF MRNA:**
  - In eukaryotic cells, the newly synthesized mRNA undergoes processing before it can leave the nucleus.
  - This processing involves the addition of a 5′ cap and a poly(A) tail to the mRNA molecule.
  - Additionally, introns (non-coding regions) are removed from the pre-mRNA through a process called splicing, leaving only the exons (coding regions) to form the mature mRNA.
- **EXPORT OF MRNA TO THE CYTOPLASM:**
  - Once processed, the mature mRNA molecule is transported out of the nucleus and into the cytoplasm through nuclear pores.
  - The mRNA carries the genetic information encoded in the DNA from the nucleus to the cytoplasm, where protein synthesis will occur.
- **TRANSLATION IN THE CYTOPLASM:**
  - In the cytoplasm, ribosomes, along with transfer RNA (tRNA) molecules and various protein factors, catalyze the synthesis of proteins from the mRNA template.
  - During translation, the ribosome reads the mRNA sequence in codons (groups of three nucleotides) and matches each codon to the corresponding amino acid carried by tRNA molecules.

- The ribosome catalyzes the formation of peptide bonds between adjacent amino acids, resulting in the synthesis of a polypeptide chain.
- The process continues until a stop codon is reached, at which point translation terminates, and the newly synthesized protein is released.

WHAT IS PROTEIN FOLDING PROBLEM

The protein folding problem is one of the most important and challenging questions in molecular biology. It refers to the task of predicting the three-dimensional structure of a protein from its amino acid sequence.

Proteins are large, complex molecules made up of long chains of amino acids. The sequence of these amino acids dictates how the protein will fold into a specific three-dimensional shape. This shape, in turn, determines the protein's function. Proteins can perform a wide variety of functions in living organisms, including catalyzing biochemical reactions, serving as structural components, and acting as signaling molecules.

The protein folding problem arises from the fact that the number of possible ways in which a protein can fold into its native structure is astronomically large. Even a relatively small protein consisting of just a few dozen amino acids can have an enormous number of possible conformations. Finding the correct, biologically relevant conformation among this vast number of possibilities is a formidable computational challenge.

HOW AI CAN HELP IN STUDYING PROTEIN PREDICTION

AI can play a significant role in studying protein prediction from DNA sequences. Here's how:

1. **Sequence Analysis:** AI algorithms can analyze DNA sequences to identify potential protein-coding regions. This involves identifying open reading frames (ORFs) and predicting where genes start and stop.
2. **Gene Prediction:** AI models can predict genes within DNA sequences by recognizing patterns such as start and stop codons, splice sites, and regulatory elements. This helps in understanding the genetic code and locating genes responsible for specific traits or diseases.
3. **Protein Structure Prediction:** AI-powered algorithms can predict the three-dimensional structure of proteins based on their amino acid sequences. This is crucial for understanding protein function, interactions, and designing drugs targeting specific proteins.
4. **Function Annotation:** AI can help annotate proteins with known or predicted functions based on similarities to other proteins with known functions. This can provide insights into the role of proteins in biological processes and pathways.
5. **Variant Analysis:** AI algorithms can analyze DNA variations (mutations, SNPs) and predict their impact on protein structure and function. This is important for understanding the genetic basis of diseases and designing personalized treatments.
6. **Protein-Protein Interaction Prediction:** AI can predict protein-protein interactions by analyzing protein sequences and structures. This helps in understanding cellular processes and pathways, as well as in drug discovery by identifying potential targets and off-target effects.
7. **Drug Discovery**: AI can accelerate drug discovery by predicting how potential drug molecules interact with target proteins. This includes predicting binding affinity, specificity, and potential side effects, leading to the identification of promising drug candidates.

8. **Data Integration and Analysis:** AI algorithms can integrate and analyze large-scale genomic, transcriptomic, proteomic, and clinical data to identify patterns, correlations, and biomarkers associated with diseases or biological processes.

By combining deep learning with advanced optimization techniques, AlphaFold is able to predict protein structures with unprecedented accuracy, rivaling experimental methods in many cases. Its success in the Critical Assessment of Structure Prediction (CASP) competition demonstrates the effectiveness of its approach and its potential to revolutionize structural biology.

Ankit Kumar

FOOT ROT DISEASE OF BASMATI RICE

THIS ARTICLE COVERS 'DAILY CURRENT AFFAIRS' AND THE TOPIC DETAILS OF **"FOOT ROT DISEASE OF BASMATI RICE".** THIS TOPIC IS RELEVANT IN THE "**SCIENCE AND TECHNOLOGY**" SECTION OF THE UPSC CSE EXAM.

Why in the News?

The Punjab Agricultural University (PAU) has achieved a notable accomplishment by officially registering the biocontrol agent **Trichoderma asperellum 2% WP** with the Central Insecticides Board and Registration Committee (CIBRC). This registration targets the control of **Foot Rot or Bakane disease in Basmati rice**, a long-standing issue in the area that has led to substantial losses for farmers and jeopardized the state's export potential.

WHAT IS FOOT ROT DISEASE OF RICE?

- Foot rot or bakanae disease represents a severe **fungal infection** that targets Basmati rice cultivation, resulting in notable reductions in yield and compromising the quality of grains.
- Under field conditions, Bakanae disease has the potential to lead to a substantial reduction in Basmati rice yield, reaching up to 70%. This issue has become a significant worry for Basmati rice cultivation in India, particularly for the widely grown Pusa Basmati 1121 variety, which accounts for more than 65% of the Basmati-growing area.

SYMPTOMS IN CROPS

- Infected seedlings appear elongated and taller compared to healthy plants, featuring pale yellowish leaves.
- Surviving seedlings often display increased height and a wider flag leaf angle during the field stage, ultimately succumbing before grain formation.
- Symptoms in underground parts involve rotting and blackening of roots, along with the emergence of adventitious roots.

TRANSMISSION OF DISEASE

- **Seed Transmission:** The primary mode of transmission for Bakanae disease is through contaminated seeds from the preceding growing season. Infected seeds carry the pathogen into fresh fields, initiating disease development in subsequent crop cycles.

- **Soil Transmission:** Fusarium fujikuroi, the causative agent of Bakanae disease, can endure in overwintering plant remains or soil, acting as a reservoir of infection for new rice plants. Soil-borne pathogens contribute to the dissemination of the disease within agricultural fields.

CONTEMPORARY MANAGEMENT STRATEGIES

- Contemporary strategies for managing bakanae disease in Basmati rice cultivation involve multiple approaches, such as **treating seeds with fungicides, employing biocontrol agents, and implementing integrated management tactics** that encompass seed and seedling treatment, as well as foliar sprays.
- These methods are designed to curtail disease dissemination, lessen its impact, and promote the sustainable production of high-quality rice grains.
- Furthermore, the utilization of antagonistic bacteria, biological control agents like Trichoderma-S7, and the assessment of resistant rice varieties are pivotal in the management of bakanae disease.
- Effective management of the nursery phase is essential, with specialists advising the planting of seeds in the initial two weeks of June and transplantation in July to circumvent the disease's peak occurrence during hot months such as May.

NEW SOLUTION BY PUNJAB AGRICULTURE UNIVERSITY

- The innovation by PAU in utilizing Trichoderma asperellum marks a substantial progress in addressing foot rot. This biocontrol agent has received registration from the Central Insecticides Board and Registration Committee (CIBRC), guaranteeing its effectiveness and safety.
- Trichoderma asperellum is environmentally friendly, emphasizing its contribution as a non-chemical substitute to conventional pesticides, thereby reducing environmental impact.

IMPACT OF FOOT ROT DISEASE

Environmental impact:

- **Chemical Usage:** Disease control frequently relies on fungicides such as carbendazim, which may leave behind detrimental residues and have adverse repercussions on soil health and biodiversity, thereby impacting the overall ecosystem.

- **Soil Health:** The presence of the foot rot pathogen in soil can instigate soil-borne diseases, jeopardizing soil health and potentially diminishing its fertility and productivity over time.
- **Environmental Sustainability:** Dependence on chemical interventions for disease management can present obstacles to environmental sustainability.

Economic Impacts:

- Foot rot disease in Basmati rice cultivation can exert a substantial influence on the export of Basmati rice. It can cause diminished yields and compromise the quality of rice grains, potentially resulting in reduced availability of high-quality Basmati rice for export.
- This decline in both yield and quality attributable to foot rot disease can directly impede the export potential of Basmati rice, as it may result in a decrease in the volume of rice meeting the stringent quality criteria necessary for export markets.
- **India holds the top position as the primary exporter of Basmati Rice** worldwide. In the fiscal year 2022-23, the country exported 4558972.23 metric tons of Basmati Rice, valued at Rs. 38524.11 Crores (or 4787.50 million US dollars).
- **Major export destinations** during this period included **Saudi Arabia, Iran, Iraq, the United Arab Emirates, and Yemen Republic.**
- Basmati Rice is predominantly cultivated in several states across India, including **Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Delhi, Uttarakhand, and western Uttar Pradesh.**

HOW DOES TRICHODERMA ASPERELLUM HOLD SIGNIFICANCE?

- **Strategic Significance:** This advancement holds strategic importance for Punjab and Haryana, the primary Basmati rice-producing states in India, by offering an eco-friendly alternative to conventional pesticides while mitigating environmental damage.
- **Potential for Extensive Adoption:** The introduction of Trichoderma asperellum has received approval from the **Central Insecticides Board and Registration Committee (CIBRC),** ensuring its effectiveness and safety. Moreover, an agreement between PAU and a private firm for large-scale production and distribution of **Trichoderma asperellum** aims to make it easily accessible to farmers in Punjab and beyond, starting from the upcoming growing season.
- **Holistic Management:** The biocontrol agent presents a comprehensive approach to combating foot rot disease, encompassing seed and seedling treatments. This approach empowers farmers to effectively manage the disease and minimize crop losses.
- **Future Prospects:** The introduction of **Trichoderma asperellum** opens up new avenues for research and development in the realm of biocontrol agents, potentially paving the way for more innovative and sustainable solutions in crop disease management.

PRELIMS BASED QUESTION

Q1. Consider the following statements regarding Foot Rot disease of Rice:

1. Foot Rot disease is a Fungal disease that affects the root of the crops.
2. India is the largest exporter of Basmati Rice worldwide.

Choose the correct answer using the codes given below:

(a). 1 Only
(b). 2 Only
(c). Both 1 and 2
(d). Neither 1 nor 2

ANSWER: C

MAINS BASED QUESTION

Q1. How does the prevalence of foot rot disease in Basmati rice cultivation impact India's position as the leading exporter of Basmati Rice? What are the potential economic consequences of reduced yield and quality due to foot rot disease on India's export potential in the global market?

Vikas Agarwal