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Commands of Synthetic Biology to Modernize and Re-design the Biological Systems

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Abstract

The scope of synthetic biology continues to expand and has encompassed a huge number of biological features. Its scope starts from scratch, enabling the de novo synthesis of biological systems. It has re-designed the biological systems and empowered the production of synthetic genes, RNA, DNA and proteins by undertaking the control of pathways involved in genetic regulation. It has increased the production of nano-scale RNA architectures and synthetic biological circuits which either have therapeutic or other productive uses. Furthermore, advancements in synthetic biology have enabled the generation of diversity through methods such as epPCR and site-directed mutagenesis, allowing for the creation of complex genetic variations. Additionally, synthetic biology intersects with computer engineering to design functional biological devices and circuits, utilizing computational analysis to guide the design process. Moreover, ethical and regulatory considerations are paramount in synthetic biology, with careful examination required to address dual-use concerns, environmental impacts, and issues of social justice and equitable access to benefits. As synthetic biology continues to advance, it presents opportunities to address pressing challenges in fields ranging from medicine and agriculture to environmental conservation and beyond. Thus, the fusion of synthetic biology with other scientific disciplines holds promise for transformative innovation and societal benefit. The present discussion enlightened the core of generating complex biological systems and has given a brief overview on the fusion of synthetic biology with other fields of science.

Introduction

Synthetic biology welcomes to the world of opportunities. It is an attractive platform for chemists, biologists and bioengineers who seek interest in designing novel cellular behaviors' or redesigning the existing biological physiologies. This has been proven successful in certain areas and the outcomes are quite fruitful and encouraging. Synthetic biology finds various applications in the modern era of human daily life and society. Advancements in synthetic biology are made with the passage of time as in 1960 mathematical systems were introduced in gene regulation systems. In 1970 a new technique recombinant DNA technology was introduced [1].Synthetic biology has made tremendous key advancements at the molecular level. Researchers have developed decent RNA-Nano objects which are regulated by RNA binding proteins [2]. Synthetic RNA with different structural motifs has been harnessed to get the desired output. Mirror image peptides and proteins have been synthesized which are used as therapeutic agents and are seem to be resistant against harmful pathogens such as HIV and Ebola [3].The latest technique Chiral Synthesis Process (CSP) has been considered advantageous towards protein crystallography and synthesis of mirror image proteins is a key step towards the establishment of mirror image cells [4]. By the use of such synthetic approaches' novel proteins can be developed that can then be used for diagnostic purposes and different oligonucleotides can also be designed to be used as PCR primers or to probe DNA and RNA [2].

Synthetic engineering also plays a role in genetic engineering. Genetic engineering refers to alteration in genetic makeup for producing desired traits in organism. Various methods with specific repairs pathways that are advantage of synthetic biology used to modify genes [5]. Genetic engineering without synthetic approach has some disadvantages. It led to limit genetic diversity and produced defective genes [6,7]. New organisms formed by genetic engineering could create an environmental problem, also caused instability or accidental cases when genes modify. This could be fatal in human genetic engineering causing problems ranging from little medical complication to death [8]. Also, as defective genes are replaced with functional genes, it may reduce genetic diversity and if humans have similar genomes, the population as a whole will be susceptible to virus or any form of diseases [9]. The presence of antibiotic-resistance genes in foods could have harmful effects. If these gene transfer, then it causes severe health problem of antibiotic resistant disease [10]. Using synthetic method of Engineering this problem could be reduced.

Synthetic biology contributes to biotechnology, creating new products and tools, and removing plastic waste from oceans using biotechnological techniques. Oceans absorb CO2 and heat, preserving ecosystems[11]. Biotechnology enhances drug effectiveness in therapies like chemotherapy and immunotherapy by modifying target sites and actions, using modified antibodies, enzymes, and metabolizers [1]. Biotechnology involves synthetic biological methods, such as computer engineering, to modify organisms' genetic makeup, extend their DNA, RNA, and metabolites, and engineer multicellular systems for complex tasks [12].

Synthetic biology is the engineering of biology, aiming to create novel bimolecular components, networks, and pathways to rewire and reprogram organisms, exposing design principles of complex natural systems [13]. Synthetic biology plays a crucial role in computer engineering, enabling the creation of synthetic circuits, sensors, and switches, as it aids in the detection of chemical signals in cells [14]. It has contributed a lot towards providing solutions for a number of hazardous environmental problems such as health problems and environmental sustainability [14].Synthetic biology combines engineering principles with biology, developing functional biological designer devices by reassembling and systemizing biological elements in a rational and standard process[15]. As it plays role in understanding the expression of protein or genes [16].

This review article explores recent advancements in synthetic biology, focusing on its relationship with molecular biology, genetic engineering, biotechnology, system biology, and evolutionary biology. It highlights future cutting-edge techniques like genome editing and computer-aided design, which could lead to the creation of biopharmaceutical and cell-based therapies using synthetic gene circuits and pathways, ensuring accurate drug manufacturing and patient care [17].

Methods

Literature Strategy and Selection Criteria

In order to gather relevant information, a comprehensive literature search was conducted using Google Scholar, PubMed, Science Direct and Web of Science. Key terms such as "synthetic biology role," "biological systems," "genetic regulation," "synthetic biology circuits," "enzymes engineering," "antibody engineering," "synthetic fluorescent sensors," "ethical and regulatory considerations" etc., were utilized. From the initial pool of literature, a total of 50 peer-reviewed research articles were selected for inclusion in this study.

Discussion

Synthetic biology role in Gene and Protein designing in molecular engineering

Synthetic gene designs create nucleotide sequences based on desired specifications, modifying their expression. Proteins are reverse translated into non-degenerative amino acid sequences using high-frequency codons. Restrictions are introduced evenly, some deleted or silenced, and the sequence is diced into small oligonucleotides for PCR assembly. Resite finder creates novel restriction sites using a library, generating silent mutations. Gene2Oligo and DNA are computer-based programs that produce oligonucleotide designs, resulting in 30 kb of synthetic DNA. A general schema of synthetic gene design is provided [2]. Atomic level preparation of proteins is possible by Chemical Protein Synthesis (CPS) that employs two strategies, solid phase peptide synthesis (spps) and chemo selective ligation strategy for the production of peptide segments and for the assembly of peptide segments into longer synthetic products respectively [4].Overview of steps involved in SPPS is given below in Fig 1.

The SPPS process involves attaching a C-terminus amino acid to a resin, preventing polymerization, and washing the resin to remove excess reagents. Activator is used to increase reaction specificity, and the resin is detached, forming a peptide. Different blocking agents are used to prevent unnecessary competing reactions. The steps are repeated to get a desired length of polypeptide as shown in Figure 1 [18]. But SPPS does not make lengthy peptides.

Chemo-selective ligation of peptides involves a highly selective reaction between C-terminal thioester and N-terminal cysteine. Native Chemical Ligation (NCL) is a significant advancement in this field, forming a native amide bond. Other chemical ligation processes include KAHA ligation, which generates unprotected peptide segments, and various other ligation processes for different peptide segments [4].

CPS allows site-specific protein modification and genesis of semisynthetic proteins, including histones, ubiquitin, and membrane proteins. Proteins of about 100 residues can be prepared using CPS methods. Challenges include poor solubility and inefficient gene design. Solutions include clever chemicals or pH-sensitive compounds. Automated Ligator (Aligator) is a computational tool that constructs large targets using CPS [4].

Generation of Mirror Image Proteins and Cells by synthetic approach

Synthetic biology has made significant progress in creating mirror image proteins, which are right-handed proteins that are resistant to protease degradation, making them effective therapeutic agents. These proteins are produced by selecting amino acid sequences and assembling them into a 3D yarn. Scientists are also working on creating mirror image organisms from these proteins, which can be used to produce useful peptides and drugs, and study dangerous pathogens without causing harm to humans. Examples include the synthesis of D. coli, which is the mirror image of *E. coli* and Ebola virus [3].

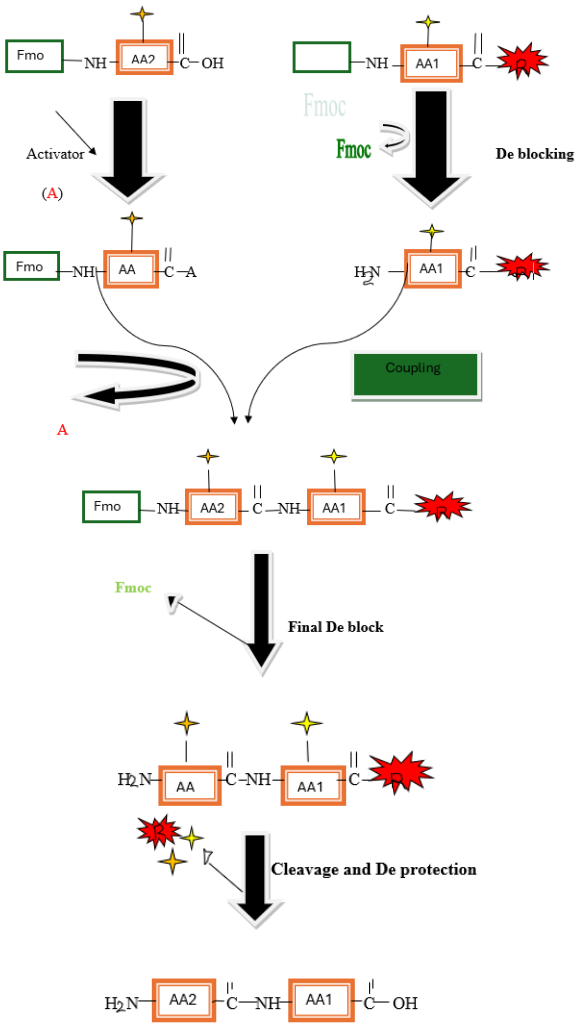

Figure 1: Flow diagram of Solid Phase Protein Synthesis (SPPS): Attachment of a C-terminus amino acid to a resin, preventing polymerization, and washing the resin to remove excess reagents. Activator is used to increase reaction specificity, and the resin is detached, forming a peptide.

Synthetic way of Molecular control of brown fat development (BAT) and energy homeostasis

Brown adipose tissue plays a crucial role in reducing body fat accumulation and treating obesity. It dissolves chemical energy in heat, providing protection against cold and overfeeding. It can also cure obesity-related diseases like insulin resistance. BAT-mediated thermogenesis, activated by fluoro-labeled 2-deoxyglucose positron emission tomography, can help dissolve body fat accumulation. Brown adipocytes, lacking ATP synthetase, can use UCP1 to treat non-

shivering thermogenesis. Classical brown adipocytes and beige/bright cells (reduce fats) are types of thermo genic Adipocytes play a crucial role in energy metabolism and are controlled by transcriptional cascades. Endogenous hormones like irisin, Cardiac natriuretic peptides, and Prostaglandins guide brown and beige cell development, which has gained attention as a potential therapeutic for obesity [19].

Synthetic approach of DNA Synthesis and Assembly

Synthetic DNA is crucial for managing biology and has vast applications when combined with next-generation sequencing technology. Gene synthesis methods are used to synthesize DNA into genes, synthons, and entire genomes. Advancements in DNA sequence and writing DNA sequences have been made, with GenBrickTM synthesis shown in figure 2 being one of the best methods for assembling long DNA sequences, making synthetic biology research easier, interesting, and faster [20].

Figure 2: GenBrickTM Synthetic process of DNA Oligos is designed by oligo design software followed by oligo synthesis by phosphoramidite reaction. Oligos are assembled by polymerase chain assembly and cloned into vector. Colonies are screened. Further confirmation is done by sequence primers that bind to vector regions ensure correct inserted sequence of synthesized gene insert. FINAL validation is done by NGS. Final synthetic product can be utilized.

High molecular weight DNA assembly in vivo for synthetic biology

DNA assembly is a crucial technology in synthetic biology, involving in vitro assembly of smaller DNA fragments and in vivo assembly of high molecular weight DNA molecules through homologous recombination in host cell.

The golden gate and MASTER methods, which rely on type II restriction enzymes and MspJI endonuclease, are not suitable for large DNA fragment assembly due to their reliance on PCR amplification. BASIC, Paperclip, and RADOM are more accurate and suitable methods for DNA assembly, with RADOM being the most rapid and suitable (Fig3) [3]. It has homologous recombination with yeast, and it combines with *E. coli* for screening. DNA can be assembled in vivo in B. subtilis. This DNA was then incorporated into chromosome of B. subtilis by homologous recombination mediated by RecA [21].

Emerging Research Directions in Adult Congenital Heart Disease

Congenital heart disease (CHD) is a prevalent congenital disorder with increased survival rates and a common cause of tetralogy of fallot. Mechanical circulatory support is effective for patients without transplants. NHLBI and ACHA established a working group to manage gaps and identify CHD causes. Post-traumatic stress disorder (PTSD) is applied to children with heart disease. Stem cell therapy and tissue engineering are used for correction due to spontaneous tissue repair and function improvement [22].

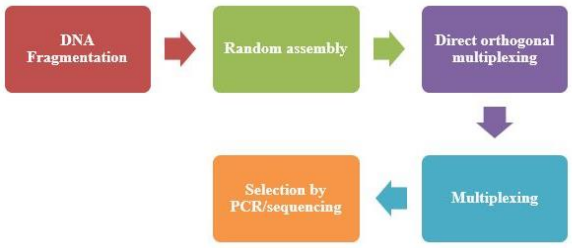

Figure 3: RADOM method of DNA Assembling

Genetic engineering as synthetic approach in health

Synthetic biology techniques are being used to modify plants to produce artemisinin compounds, which are effective for malaria treatment. The COSTREL method is used for more artemisinin production. Genetic engineering also allows for the modification of yeast strains. Tomatoes contain anti-oxidant properties and have been genetically engineered to contain high pro-vitamin content. Other crops, such as carrot, potato, tomato, and canola, have also been genetically engineered for increased carotenoid production [23]. Diabetes is linked to high blood glucose levels due to insulin receptor dysfunction or pancreatic cell dysfunction. Two designer cell systems have been developed to correct these issues. The first is HEK293 kidney cells with transgene expression SEAP assay, and the second is a gene circuit introduced into HEK293 kidney cells in T1 diabetes mice. The gene circuit helps regulate glucose levels, adiponectin levels, and Tet-ELK-1, ultimately helping to treat T1 and T2 diabetes [24]. Synthetic biology tools, such as metabolic engineering, are utilized for the production of ethanol or fatty acids. Lignocelluloses biomass is the source of sugar fermentation to ethanol and useful chemical by using yeast for metabolism of sugar [25]. CRISPR cas-9 editing technology is used to construct specific yeast strains, re-engineer metabolic pathways, and create synthetic cells for bioproduct production. This method was used to identify new genes for a yeast used in the pharmaceutical industry for antibiotics, anticancer drugs, and immune-suppressive drugs. Transcription activator-like effector nuclease technique was used on new animals [26]. The technique of gene editing using TALEN is a fast, efficient, and specific method. It involves Fok1 nuclease and artificial TALE, forming a specific TALEN with an N-terminal domain with

nuclear localization system, central domain with tandem TALE repeats, and C-terminal domain with endonuclease Fok1. TALEN is used to cut specific DNA sites, often causing double strand breaks due to Fok1 heterodimerization [26]. The technique of gene editing using TALEN is a fast, efficient, and specific method. It involves Fok1 nuclease and artificial TALE, forming a specific TALEN with an N-terminal domain with nuclear localization system, central domain with tandem TALE repeats, and C-terminal domain with endonuclease Fok1. TALEN is used to cut specific DNA sites, often causing double strand breaks due to Fok1 heterodimerization [27].

Repair pathways based on synthetic biological engineering

Different repair pathways are used in various applications of genetic engineering technology (Table 1).

Organism	Organism Genome	Protein	Nucleases	Reference
Human	Mammalian Cell Genome	DNA-Pkes, Ku 70, Ku 80,Ligase 8, XRCCA, Mre 11, Artemis	NHEJ	[28]
Plant	Agrobacterium Transformed T-DNA	YKu70, Rad60, Mre11, Lig 4,Sir 4	NHEJ	[29]
Animal	Bovine Fetus Fibroblast Cell	BLG gene	ZFN	[30]
Plant	Endogenous Plant Gene Tobacco Sur A	SR2163	ZFN	[31]
Insect	Drosophila Embryo	Chromosome CGG97	TALENS	[6,32]
Yeast	*Talaromyces atroroseus*	AMA1 based vector encoded Cas 9,UA08-00425	CRISPR CAS-9 SYSTEM	[29,33]

Table 1: Methods for genetic engineering

Protein engineering in synthetic biology

Computer analysis of proteins allows for the sequencing of amino acids, enabling engineering of proteins and determining the modest rates of enzyme reactions [3]. Recombinant DNA technologies are widely used for engineering proteins, with recent and conventional methods being combined for improved production methods commonly used in laboratories.

Rational designing (site directed mutagenesis)

This method involves incorporating different amino acids into a desired gene through overlap extension methods or whole plasmid single round PCR. It involves selecting desired proteins, computational analysis, synthesis, purification, and use for biological and clinical applications [3].

Evolutionary methods (random mutagenesis method)

This method uses targeted selection from a gene to optimize protein properties, often using saturation mutagenesis to replace one amino acid with another, resulting in maximum variations in protein structure. This involves labeling DNA sequences, DNase1 fragmentation, and PCR amplification [3].

Localized or region directed mutagenesis

The method involves replacing amino acids in specific regions to create new proteins with unique characteristics, resembling site-directed mutagenesis [3].

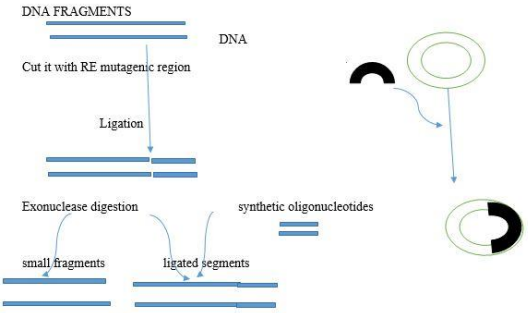

Figure 4: Site directed mutagenesis method (DNA fragment and vector is restricted by RE and ligated segments are formed that are transformed into host cell).

Enzymes engineering

Enzymes are crucial in various fields, including industry, food, medicine, and biotechnology. Synthetic biology aims to improve their catalytic activity, substrate binding, and stability by mutating protein structures. However, understanding protein functions, substrate binding, kinetics, dynamics, sensitivity, side effects, and computational capacity are limited [34].

Antibody Engineering

Antibody production faces challenges in manufacturing, packing, stability, and clinic employment. Technologies improve vaccine production and stability using immunoglobulin proteins, necessitating non-protein parts and bio conjugates with polymers [34]. These Abs are widely used in vast applications involving diagnosis and treatment of cancerous and inflammatory diseases [10].

Synthetic biology in the production of industrial enzymes

Microbes are utilized in various industries, including food, medicine, health, fuels, and agriculture, to produce beneficial products like alcohol. Enzymes, cost-effective, environmentally friendly, and non-toxic, are used in these industries. However, they are sensitive to pH and temperature changes and can be denatured in non-physiological conditions[10]. In pharmaceutical industry, enzymes are used as therapeutic drugs in health issues such as enzymatic

disorders and deficiencies and other diagnostic procedures as ELISA and diabetes tests [18].

Application of Evolutionary science in Synthetic biology

Synthetic biology is advancing our understanding of biological system evolution, similar to the advancements in protein evolution through directed evolution methods [13]. Directed evolution was originally developed to alter protein function. Their function depends on three main factors.

Evolutionary synthetic biology to generate diversity

Diversity is the foundation of evolution, and epPCR, a method based on error-prone, thermostable polymerase, can generate diversity through evolution [35]. Taq polymerase is most commonly used due to its highest error rate and error biased towards AT to GC change [36]. Erro-prone PCR basically used to modify a de novo protein for the improvement of solubility and ligand-binding affinity [36]. Site directed mutagenesis (SDM) and CRISPR system increase diversity in synthetic biology by altering expression levels in genome-wide screens and expanding sequence space beyond host genome [35]. Synthetic biology is used to design sensors for metabolic productivity, prioritizing compound production. Adaptive laboratory evolution (ALE) is used to study metabolically productive genomes. Tools like transcriptomics, proteomics, and metabolomics help understand genotype-phenotype relationships. Whole-genome sequencing and systems biology tools can register the evolutionary process, allowing for rational design with new engineering principles[37].Synthetic biology can aid in directed evolution by creating biosensors that can detect specific traits, trigger the expression of fluorescent proteins, or combat antibiotic resistance [35]. Biosensors challenge the evolution of productive genomes by converting desired compound concentrations into cell survival outputs, while small molecule biosensors efficiently engineer biological signal responses [37]. Ligand responsive transcription factor biosensors link intracellular metabolite concentration with gene expression, enabling dynamic regulation and high-throughput metabolite producer screening in *E. coli* for isopentenyl pyrophosphate production [38]. Similarly, Metabolic engineering of yeast is used to produce valuable organic acids. A Saccharomyces cerevisiae WAR1 transcriptional regulator and PDR12 promoter biosensor were established to detect PHBA production levels and control GFP expression. These modifications increased screening efficiency and can be used for dynamic regulation and high-throughput screening applications in synthetic biology and metabolic engineering [38].

Computer engineering in synthetic biology

Synthetic biology combines engineering principles with biology, developing functional biological designer devices by reassembling and systemizing biological elements in a rational and standard process [15]. Synthetic biology and engineering techniques combine to create genetic devices and biological systems. The first genetic designed network, a genetic toggle switch, functions like a computer in a biological system. This has led to the development of new biosensors, enabling the detection of small molecules in microorganisms [14]. RNA and protein sensors are used to detect small molecules and their concentrations. They have two functional regions: one for input and one for output. Reversible binding between target components and input molecules generates week interactions in genes or amino acid residues, causing conformational changes and moving to output components. Output components regulate transcription, translation, and post-transcriptional activity, resulting in various activity changes [39]. The design cycle outlines the process for creating biological devices or circuits for synthetic biology engineering, including computational analysis.

Circuit designing in computer engineering for synthetic biology

Synthetic engineering and biological channels emphasize component tolerances, ensuring design works under innate properties and environmental interferences. *E. coli* lacks robust circuits, but a circuit with minimal temperature resistance can be formed [40]. The toggle switch, repressilator, and auto regulatory circuits are examples of circuits that regulate genes. The toggle switch is bistable, allowing only one or two genes to be active simultaneously. The repressilator involves a ring-like channel with a GP reporter node [41]. Tis circuit has only TetR and GFP reporters. The TetR shows negative feedback modulation of itself transcription which is measured by GF reporter [42]. The metabolator circuit in *E. coli* integrates transcriptional modulation with metabolic enzymes, regulated by glycolytic flux. It controls biological oscillations by converting two metabolite pools, Acetyl-CoA versus acetate, and oscillates once glycolytic flux thresholds are reached. This circuit is parallel to the circadian clock, aiding in gene or protein expression understanding [16].

Engineered Riboregulators and Proteins as molecular switches

RNA-based regulators can be used as transcriptional or translational regulators, as their functionality can be modified with or without ligands. These naturally occurring RNA/RNP molecules are crucial for gene expression control in synthetic biology. RNA contains

interacting loops for 3D structures, including tertiary interactions and kissing loops [43]. Artificial riboregulators control post translational gene expression by inserting a sequence complementary to the ribosomal binding site. This creates a cis-repressed mRNA (crRNA) that blocks the ribosomal binding site, inhibiting translation initiation. A non-coding RNA, taRNA, stimulates crRNA expression by exposing RBS, forming an RNA duplex and unfolding the stem loop. Effective gene expression depends on GC content, cis repressed stem size, and intermolecular interaction [44,45]. Artificial ribozymes were developed from designed RNA, with a catalytic unit selected from a small pool, resulting in designed and selected ligase (DSL) with appropriate catalytic activity [46]. Riboswitches regulate gene expression using metabolites as ligands, and artificial riboregulators use DNA RNA or proteins to modulate mRNA expression, with antisense and aptamer domains available [47]. Proteins act as molecular switches, containing multiple domains for specific functions. Combining these modules creates new cellular behavior, generating new receptors and sensors. CAR, an integrated protein, combines T-cell receptor's regulatory domain with an extracellular single-chain antibody, used in tumor diagnostics by reprogramming cells to detect and attack antigen-carrying cells [48]. Proteins are designed using molecular biomimetic, based on binding affinity, and building agents, such as inorganic surface-specific polypeptides, are used to organize and function materials [49,50]. Proteins are designed using genetic templates and confined at molecular level for proper functioning. To create coherent designs, phage display libraries, containing 12 amino acids, are used. These libraries are then screened to check binding activity to inorganic surfaces using phage and surface display techniques [51].

Synthetic fluorescent sensors

Metal ions are crucial for organisms' proper functioning, but their access or reduction can lead to diseases like cancer and neuro degeneration. Aging is another issue, and advancements in probe design and instrumentation are increasing due to the relationship between synthetic chemistry and biological imaging. Fluorescent probes for metal ion detection require careful design, selective ion detection, nontoxic, water-soluble, and auditable in extracellular, intracellular, and subcellular regions [52]. The development of a Zn sensor aims to address brain and other cellular disorders by designing a stable, responsive, and reversible sensor design [53]. Metal ion sensors use organic molecules as fluorescent probes, which bind strongly with metal ions for sensing [54] The molecular sensors, such as fluorescent ligand sensors, bind strongly to each other, with the fluorophore and receptor being Xerox to each other.

Synthetic biology with reference to electrical engineering

Synthetic biology is a field that develops artificial biological systems to investigate biological anomalies and solve problems. It helps forge labored functions and cynosure on extensive changes to existing cellular architectonics, similar to how electrical engineer's mockup circuit fragments on a "Breadboard" to create new modules [55]. Synthetic biology has evolved, making it easier to use biological tools and collaborating with various fields, such as electrical engineering, to design more robust and efficient systems [12]. Synthetic biology lays the groundwork for artificially rejuvenating legitimate biological systems to study the development of narcotic demeanor [45].

Ethical and Regulatory Considerations in Synthetic Biology

Synthetic biology offers potential for medicine and sustainable agriculture, but its dual-use nature raises ethical concerns, including potential bioterrorism and environmental harm [56]. Researchers and policymakers must balance scientific progress with responsible oversight to prevent misuse of synthetic biology technologies, while also assessing environmental impact to mitigate potential risks [57]. Ethical research in synthetic biology requires informed consent for experiments involving human participants, as understanding potential consequences is crucial for ecological balance and biodiversity[58].Researchers must inform individuals about synthetic biology risks and benefits, raising social justice concerns and exacerbated disparities between privileged and underserved communities if unchecked [59]. Responsible research should address disparities in benefits distribution across diverse populations and regions, while intellectual property rights complicate the ethical landscape of synthetic biology, involving commercial interests [59]. Balancing private interests with the greater good is essential to ensure that society reaps the full potential of synthetic biology advancements.

A robust regulatory framework is crucial for effectively addressing ethical challenges in synthetic biology research and applications, including comprehensive risk assessment protocols [60]. Biosafety guidelines must be implemented and adhered to stringently to prevent accidental releases of genetically engineered organisms [61]. The use of synthetic biology technologies requires robust biosecurity measures to prevent intentional misuse[56]. Given the global nature of synthetic biology research, international cooperation is essential for harmonizing

regulations and addressing common challenges [57]. Public engagement also plays a vital role in shaping ethical and regulatory decisions, as it allows for a diverse range of perspectives to be considered [58].

Conclusion

Synthetic biology is a hybrid discipline that combines biology and engineering to create synthetic life forms. It uses computational tools to design oligonucleotides, metabolic pathways to combat diseases, and DNA assembly methods to fabricate primers. Synthetic biology has also been used to develop crops with improved physiological traits and byproducts. It has generated diverse RNA and protein sensors, but more effective systems are needed to solve biological problems and achieve desired results. The success of synthetic biology relies on its ability to transcend traditional engineering approaches and provide user-friendly solutions.

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Author Contributions

HI, AA, ZA, SN, IU, and RSR: Conceptualization and writing-reviewing and editing, HI, AA, ZA, and MUBMI: Investigation and writing, IU, ZA, MUBMI: Literature and data curation, HI, AA, RSR: Resources and literature. All authors wrote, edited, and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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