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Review Article

Recombinant DNA Technology: A Hopeful Ray to Improve Life

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ABSTRACT

The recombinant DNA technology, in the past century was just an imagination that required characteristics can be modified in the living bodies by manipulating the expressions of target genes. In current era, this field has demonstrated unique impacts in bringing advancement in human life. This technology has large number of applications and prospective to deal with important aspects of life, for instance, modifying health, improving food resources, and developing resistance to divergent adverse environmental effects. By the use of this technology, crucial proteins required for health problems and dietary purposes can be produced safely, affordably, and sufficiently. Specifically in agriculture, the genetically modified plants have increased resistance to harmful agents, enhanced product yield, and shown increased malleability for better survival. Also recombinant pharmaceutical products are now being used trustingly and speedily attaining commercial approvals. Recombinant DNA technology, gene therapy, and gene modifications are also widely used for the purpose of treating waste or pollutants and treating serious disorders. Due to tremendous advancement and large number of applications in the area of recombinant DNA technology, this review article mainly highlights on its prominence and the contingent applications in daily life.

Keywords: recombinant DNA technology, genetic engineering, target genes, gene therapy

1. INTRODUCTION

Human life is mainly affected by three factors: food deficiency, health problems, and environment related issues. Beside a clean and safe environment food and health are basic human requirements. Human requirements for food are rapidly increasing with increasing world's population at a greater rate. Safe-food at reasonable cost is the requirement of Humans. Several human related health issues across the world cause large number of deaths. According to data available on http://GlobalIssues.org/ every year approximately 36 million people die from non-

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communicable and communicable diseases, such as cardiovascular diseases, cancer, diabetes, AIDS/HIV, tuberculosis, malaria, and several others. Continuous and rapid growth in industrialization has surged up the environmental pollution and industrial dumping are directly allowed to mix with water, which has overripe aquatic marines and, indirectly, human-beings. Therefore, these issues urge to be addressed through modern technologies. [1]

Recombinant DNA is a DNA molecules constructed *in vitro* outside the living cells that is by combining natural or synthetic DNA segments that can replicate in a living cell.

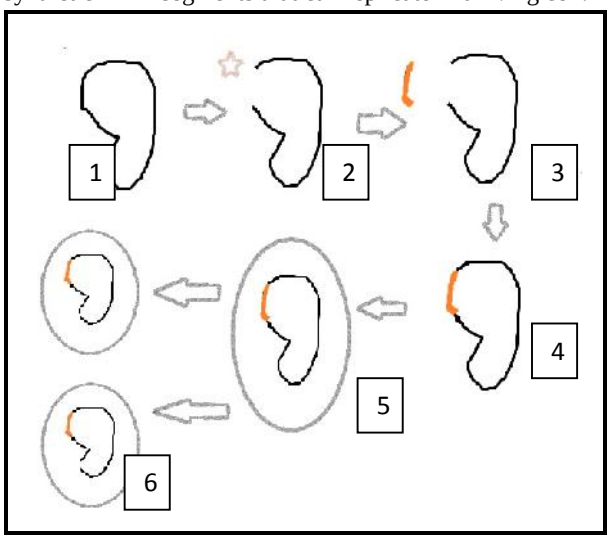

Fig 1: An overview of the recombination process includes the steps 1. Plasmid removed from E. coli cell, 2. The plasmid is opened by a special enzyme, 3. DNA coding for human insulin is inserted in the opened plasmid, 4. Recombination, 5.Introduction of recombined plasmid into E. coli host cell. 6. Host cell divided into new cells identical to the original.

Objectives of Recombinant DNA Technology are to segregate and valuate a gene, to make desired alterations in one or more segregated genes, to revert altered genes to living cells. Basic things of Recombinant DNA Technology are *Nucleic Acid Enzymes* (DNA polymerases and RNA polymerases, reverse transcriptase, DNA ligases, Restriction endonucleases etc.) and *Plasmids and Bacteriophages*. Bacteriophages replicate via the destruction of the infected cell and its membrane and the phage genome is injected into the cell, phage genes are expressed and phage proteins and DNA are made, progeny phages are packaged, and the cell is destructed. Two genetically dissimilar phages that infect the same host cell may rearrange during the lytic cycle. Some PHAGE can also replicate via the Lysogenic cycle. The phage genome is integrated into the host chromosome and is inherited into the chromosomes of all daughter bacteria. This "prophase" can be forced to enter the lytic cycle and kill its host by a variety of stresses like UV light. Plasmids are a circular DNAs that replicate independently. [2, 3]

Recombinant DNA technology consists of altering genetic material outside an organism to obtain improved and desired characteristics in living organisms or as their products. This technology involves the addition of DNA fragments from a various sources, which contains desirable gene sequence via appropriate vector. Changes in organism's genome is carried out either through the insertion of one or more new genes and regulatory components or by reducing or blocking the expression of endogenous genes by recombining genes and elements.[4]

Paul Berg of Stanford University produced the first recombinant DNA in 1970. In 1973 Herbert Boyer of University of California (San Francisco) generated transformed *Escherichia coli.* After that Eli Lilly Company in 1982 resulted in the production of recombinant human insulin. The practical aspect of genetically modified organisms has developed considerably since after because of the possibilities of virtually expressing any kind of coding sequence from any possible source. Lot of efforts has been made to genetically construct most of the living systems like bacteria, yeast, fungi, plant and animals to have new characteristics or new gene product. Cloning of number of genes has been taken place and expressed using recombinant DNA technology. The genetic manipulations using r-DNA technology are more defined and outcomes are more certain over other methods resulting in faster production of organisms with desired traits. Development in molecular biology and genetic engineering techniques made impact on two major areas (a) knowing the biology of the living system by change of genome information and (b) genaration of useful metabolites or living organisms having desired metabolic properties. This has resulted in the production of specific biomolecules in different organism alongwith synthesis of genetic material and its related product in the laboratory. In fact, the application of genetic engineering and recombinant DNA technology has led to the generation of new classes of organism called genetically modified organisms (GMO) or live modified organism (LMO). More so, the ability of genetic manipulation of almost all living organism has led to the genomics evolution with far reaching applications of the modern biology system. The most remarkable applications of the recombinant technology having direct influence on human kind are:

1. Production of large scale therapeutic proteins such as insulin, hormones, vaccine and Interleukins using recombinant microorganisms.
2. Production of humanized monoclonal antibodies for therapeutic application.
3. Production of insect resistant cotton plant by incorporation of insecticidal toxin of Bacillus thuringiensis (BT cotton plant).
4. Production of golden rice (rice having vitamin A) by introducing three genes required for its synthesis in rice plant.
5. Production of recombinant organisms for Bioremediation and in forensic medicine. Genetic engineering techniques are used. [5]

2. APPLICATIONS

R-DNA technology has been used in order to provide selective improvements in various areas that include crop agriculture, pharmaceutics, gene therapy, vaccine design and bioremediation. Bioremediation is a waste management technique that naturally occurring or deliberately introduces GMO into a site to neutralize environmental contaminants (breaking down hazardous substances into least toxic or non-toxic compounds) with the aim of cleansing of polluted soil or water thoroughly, quickly and cheaply.

Agriculture:

Development of genetically modified crops in agriculture with a purpose to improve both yield and plant pests or herbicides resistance seems to have received a degree of public acceptance and is practiced already in a commercial context in several countries. [6] The tomato CGN-89564-2 which is genetically modified was the first commercially grown, genetically modified crop product to be granted a license for human use. This was developed in 1994 to express the trait of delayed softening of tomato flesh as a practical means to minimize post-harvest crop losses [7]**.** In the US, 88% of corn and 93% of soybeans are genetically modified and much of this finds unlabelled into processed foods. [8] The introduction of pest-resistant brinjal (also known as eggplant or aubergine) was met with disapproval in some countries, in contrast to the consistent popularity of pest-resistant cotton. Both efforts at implementation followed introduction of the identical crystal protein gene (*Cry1Ac*) from the soil bacterium *Bacillus thuringiensis* (Bt) into the genome of the host plant insersion of which synthesizes so-called Bt toxins that offer resistance to plundering by lepidopteran insects.

Medicine:

In medicine the Drug delivery systems that are based on bacterial or viral hosts could prove hazardous if the organism is genetically unstable and converts to a pathogenic type or if there is incomplete purification[9, 10].

In an cognate proof of concept from the agricultural field, use of the soil bacterium *Agrobacterium tumefaciens* is very effective a vehicle for gene transfer and has become widely adopted despite its capability of producing tumors, causing crown gall disease in eudicots. [11] Genetic reversion is also a major concern regarding the experimental technique of gene therapy to treat or prevent incurable genetic disorders and acquired diseases. As the technology advances from development and laboratory research to clinical translational trials Consequently, identification of a desired system to safely and efficiently deliver an altered gene of choice has become a prime concern. [12, 13]

Bioremediation:

In bioremediation *Pseudomonas putida* and *Nitrosomonas europaea* are the typically utilized organisms. The objective is to segregate the original genes located in these bacteria that promote bioremediation, then manipulate and introduce them into a suitable host to be used as a bioremediation agent usually *E. coli* [14] however, this may, impact normal ecosystems as well; bacteria that have an improved ability to digest petroleum, cause destruction of important petroleum products. Therefore, strict monitoring of *in situ* bioremediation is essential. In the production genetically modified bacteria the simplest way of testing is to introduce a marker gene, which, typically offer antibiotic resistance, which attain the determined generation of antibiotic-resistant organisms, if mishandled, could creates problems under natural conditions.

Biotechnology:

In biotechnological success and new commercial application is the production of genetically modified fluorescent zebrafish, *Danio rerio*, and similar species using genes encoding glowing characteristics. This is marketed under the GloFish® patent in the US where fish coloured bright red, green, orange-yellow, blue and purple are sold as pets to be kept in the controlled environment of an indoor aquarium. In the event of release, inadvertent or deliberate, into the environment the survival capacity of these constantly fluorescent fish is markedly reduced due to increased vulnerability to predation compared to wild type fish; thus, the risk of sustained ecological impact is considered to be marginal [18]. However, in-depth research to confirm or refute this notion is currently not possible because of insufficient understanding and a lack of technology to study the nexus of evolutionary biology and ecology with specific reference to the introduction of a novel species into, and its subsequent migration from, an ecosystem. [15]

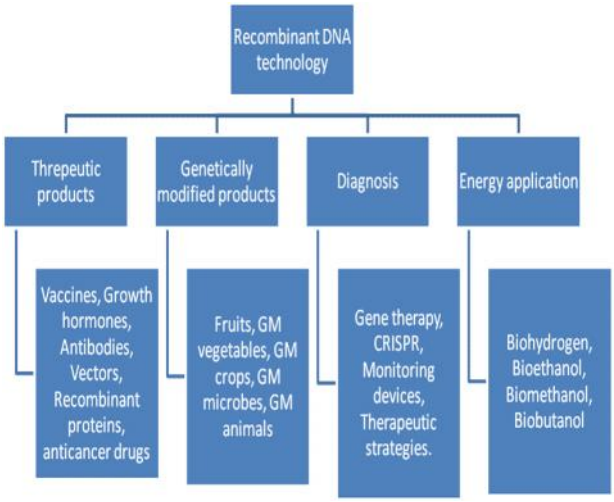

Fig 2: Illustration of various applications of recombinant DNA technology

In Forensic Sciences: The applications of molecular biology in forensics center are largely depends on the ability of DNA analysis to recognize an individual from hairs, blood strains and other items which retrieved from the place where an offence has been committed. These techniques are called genetic fingerprinting in popular media, though the term used today is DNA profiling. DNA profiling can also

be used for identification of criminals to infer if two or more individuals are members of the same family. This type of study is called kinship analysis and its main day-to-day application is in paternity testing.

In the Identification of Crime Suspects: It is almost certainly impossible for a person to perpetrate a crime without leaving behind a trace of DNA. Hairs, spots of blood and even normal fingerprints contain traces of DNA, which are enough to be studied by the polymerase chain reaction (PCR). The analysis does not have to be done immediately and in recent years a number of past crimes have been solved and the criminal brought to justice because of DNA testing that has been carried out on archived material [14-16]. Identical twins are the only individuals who have identical copies of the human genome are the basis of genetic fingerprinting and DNA profiling. The human genome is more or less same in everybody; the same genes will be in the same order with the same stretches of intergenic DNA between them. But the human genome and those of other organisms, contains polymorphisms. The polymorphic sites includes restriction fragment length polymorphisms (RFLPs), short tandem repeats (STRs) and single nucleotide polymorphisms (SNPs) which are used as DNA markers in genome mapping.

Genetic Fingerprinting by Hybridization Probing: Genetic Fingerprinting is first method for using DNA analysis to recognize individuals. This technique was based on different kind of variation in the human genome called as a hyper variable dispersed repetitive sequence. The main characteristic of these sequences is that their genomic positions are variable: they are located at different positions in the genomes of different people (fig 1). For preparation of a fingerprint a sample of DNA is digested with a restriction endonuclease and the fragments are separated by agarose gel electrophoresis and a Southern blot. Hybridization to the blot of a labeled probe containing the repeat sequence reveals a series of bands each one representing a restriction fragment that contains the repeat sequence. If the same procedure carried out with a DNA sample from two people a second person will give a different pattern of bands, as the insertion sites of the repeat sequence are variable.

Sex Identification: The sex of an individual can be identified by DNA analysis. The presence of a Y chromosome by males recognizes genetic difference between the sexes, so detection of DNA specific for the Y chromosome distinguishes males and females. For identification the sex of an unborn child DNA tests can also be used. Detection of fetus is a boy or a girl is usually delayed till the anatomical differences have developed and then by scanning sex can be identified, but under some circumstances an earlier detection of sex is desirable. Example is when pedigree indicates that an unborn male might suffer from an inherited disease and the parents want to take an early decision about whether to continue the pregnancy or not. [16]

3. CONCLUSION

Recombinant DNA innovation is a critical improvement in science that has made the human life significantly simpler. Hereditary building, recombinant DNA innovation, hereditary alteration/control and quality joining are terms that are connected to the immediate control of quality. The part of recombinant DNA innovation in influencing condition to spotless and improved protection of plants to various antagonistic acting variables (dry season, vermin, and salt) has been perceived broadly. The difficulties in enhancing the items at quality level some of the time confront genuine challenges which are should have been managed for the improvement of the recombinant DNA innovation future. In pharmaceuticals, particularly, there are not kidding issues to deliver great quality items as the change brought into a quality isn't acknowledged by the body. Considering medical problems, the recombinant innovation is helping in treating a few ailments which can't be dealt with in ordinary conditions, despite the fact that the invulnerable reactions block accomplishing great outcomes. A few challenges are experienced by the hereditary designing procedures which should have been overwhelmed by more particular quality improvement as indicated by the living being's genome. The presentation of hereditary material from one source into the other is a debacle for wellbeing and biodiversity.

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