

Review Article

DOI: <http://dx.doi.org/10.22192/ijamr.2026.13.05.007>

Principle and Application Recombinant DNA Technology in Health and Agricultural industry

Gizachew Fentahun Desta

Department of Biotechnology, Injibara University, Ethiopia

Abstract

The technology used for producing artificial DNA through the combination of different genetic materials (DNA) from different sources is referred to as recombinant DNA technology. Recombinant DNA technology is popularly known as genetic engineering. The process of recombinant DNA technology includes multiple steps; such as maintained a specific sequence to generate the desired product, isolation of genetic material, cutting the gene at the recognition sites, amplifying the gene copies through polymerase chain reaction (PCR), ligation of DNA molecules and finally insertion of recombinant DNA into host. Once the recombinant DNA is inserted into the host cell, it gets multiplied and is expressed in the form of the manufactured protein under optimal conditions. Recombinant DNA (rDNA) technology revolutionizes multiple industries by merging genetic material from different sources into one organism and leads to transformed modern therapeutics and diagnostics, enhancing global food security and farming sustainability, improves the efficiency, quality, and environmental impact of food processing and bioremediation using engineered microorganisms with specific genes to break down environmental pollutants, hazardous waste, and oil spills. However the technology still has faced challenges and uncertainty and needs further research on the technology.

Keywords

Recombinant DNA,
principle,
application,
restriction enzyme,
ligase,
plasmid

1. Introduction

Recombinant DNA technology comprises altering genetic material outside an organism to obtain enhanced and desired characteristics in living organisms or as their products. This technology

involves the insertion of DNA fragments from a variety of sources, having a desirable gene sequence via appropriate vector (Merten, and Gaillet, 2016). Manipulation in organism's genome is carried out either through the introduction of one or several new genes and

regulatory elements or by decreasing or blocking the expression of endogenous genes through recombining genes and elements (Bazan-Peregrino *et al.*, 2013).

Enzymatic cleavage is applied to obtain different DNA fragments using restriction endo-nucleases for specific target sequence DNA sites followed by DNA ligase activity to join the fragments to fix the desired gene in vector. The vector is then introduced into a host organism, which is grown to produce multiple copies of the incorporated DNA fragment in culture, and finally clones containing a relevant DNA fragment are selected and harvested (Merten *et al.*, 2014).

In the past century, the recombinant DNA technology was just an imagination that desirable characteristics can be improved in the living bodies by controlling the expressions of target genes. However, in recent era, this field has demonstrated unique impacts in bringing advancement in human life. By virtue of this technology, crucial proteins required for health problems and dietary purposes can be produced safely, affordably, and sufficiently (Suliman *et al.*, 2016).

This technology has multidisciplinary applications, for instance, improving health, enhancing food resources, and resistance to divergent adverse environmental effects. Particularly in agriculture, the genetically modified animals have augmented resistance to harmful agents, enhanced product yield, and shown increased adaptability for better survival. Moreover, recombinant pharmaceuticals are now

being used confidently and rapidly attaining commercial approvals. Techniques of recombinant DNA technology, gene therapy, and genetic modifications are also widely used for the purpose of bioremediation and treating serious diseases (Suliman *et al.*, 2016)

2. Literature review

2.1. Techniques and steps of recombinant DNA technology

2.1.1. Isolation of Genetic Material

The genetic material of all living organisms is 'nucleic acid'. In most organisms, it is DNA, whereas in some it is RNA. The first step in rDNA technology is to isolate the desired DNA in its pure form i.e. free from other macromolecules. However, in a normal cell, the DNA not only exists within the cell membrane, but is also present along with other macromolecules such as RNA, polysaccharides, proteins, and lipids. So, to break open the cell and obtain DNA that is free from other macromolecules; there are enzymes for specific each purpose: such as lysozyme to break bacterial cell wall, cellulase –to break plant cell wall, chitinase – to break fungal cell wall, ribonuclease – removes RNA and protease – removes proteins (such as histones that are associated with DNA). Other macromolecules are removable with other enzymes or treatments. Ultimately, the addition of ethanol causes the DNA to precipitate out as fine threads (Gates *et al.*, 2021).

DNA Extraction

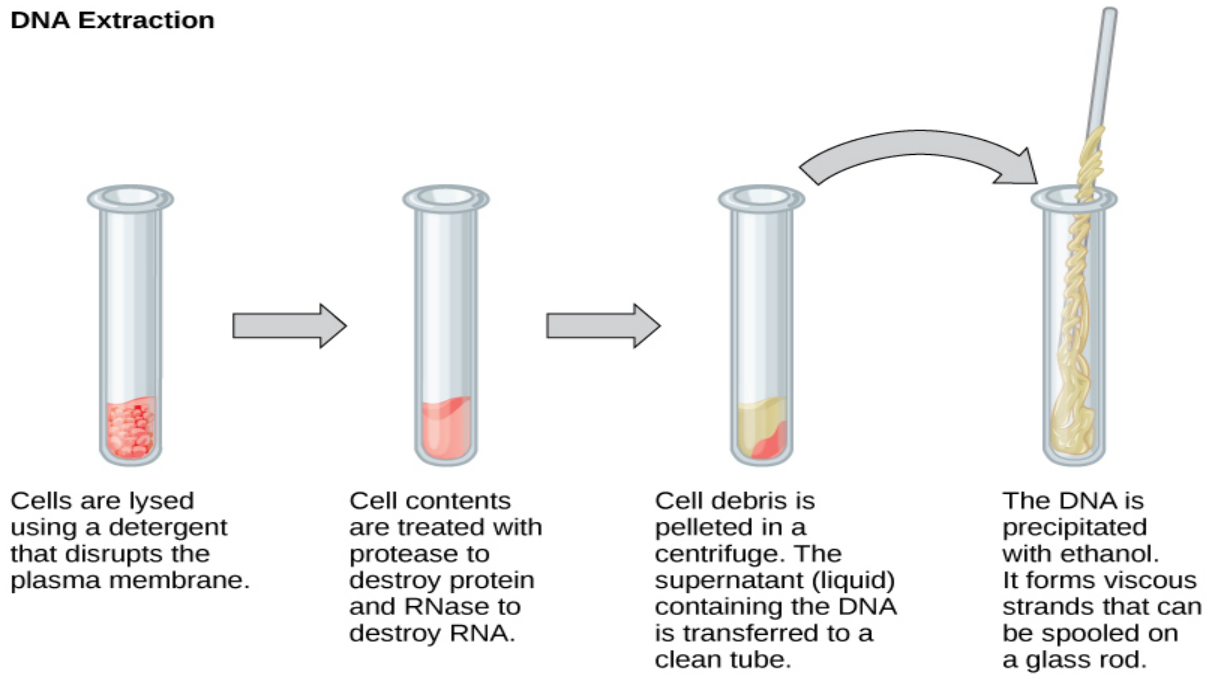


Figure 1: Steps in DNA isolation (Gates *et al.*, 2021).

2. 1.2. Restriction Enzyme Digestion

Restriction enzymes act as molecular scissors that cut DNA at specific locations. These reactions are called ‘restriction enzyme digestions’. They involve the incubation of the purified DNA with the selected restriction enzyme, at conditions optimal for that specific enzyme. The technique – ‘Agarose Gel Electrophoresis’ reveals the progress of the restriction enzyme digestion. This technique involves running out the DNA on an Agarose gel. On the application of current, the negatively charged DNA travels to the positive electrode and is separated out based on size. This allows us to separate and cut out the digested DNA fragments. The vector DNA is also processed using the same procedure (Joutey *et al.*, 2013).

2.1.3. Amplification Using PCR

Polymerase Chain Reaction or PCR is a method of making multiple copies of a DNA sequence using the enzyme – DNA polymerase. It helps to amplify a single copy or a few copies of DNA

into thousands to millions of copies. PCR reactions are run on ‘thermal cyclers’ using different components: such as template – DNA to be amplified, primers small, chemically synthesized oligonucleotides that are complementary to a region of the DNA, enzyme – DNA polymerase and nucleotides – needed to extend the primers by the enzyme (Sanchez and Demain, 2008).

2.1. 4. Plasmid

After restriction digestion, genes of interest are commonly inserted into plasmids, small pieces of typically circular, double-stranded DNA that replicate independently of the bacterial chromosome. In recombinant DNA technology, plasmids are often used as vectors, DNA molecules that carry DNA fragments from one organism to another. Plasmids used as vectors can be genetically engineered by researchers and scientific supply companies to have specialized properties, as illustrated by the commonly used plasmid vector pUC19 (Raylene *et al.*, 2011).

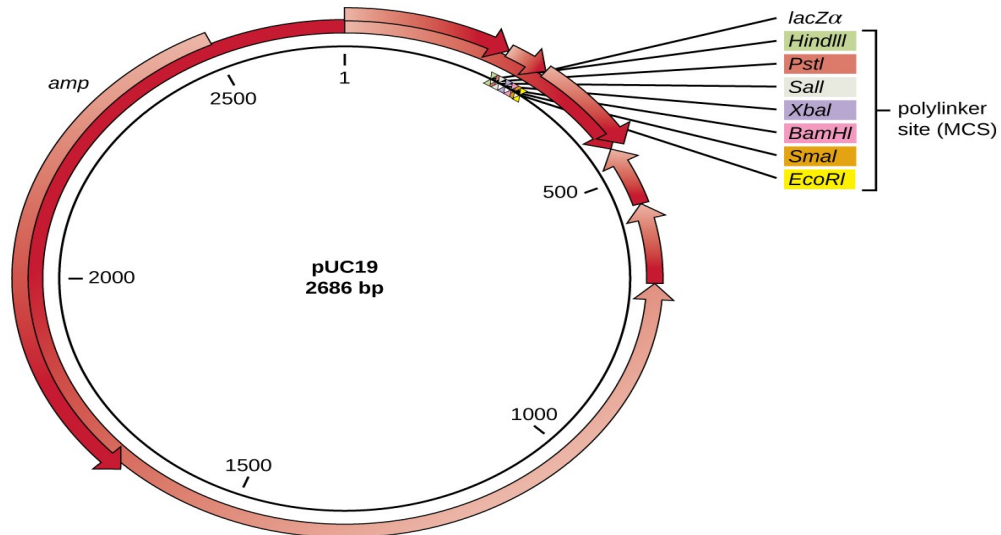


Figure 2: E. coli pUC19 plasmid (Raylene *et al.*, 2011)

2.1. 5. Ligation of DNA Molecules

The purified DNA and the vector of interest are cut with the same restriction enzyme. This gives us the cut fragment of DNA and the cut vector that is now open. The process of joining these two pieces together using the enzyme ‘DNA ligase’ is ‘ligation’. The resulting DNA is ‘recombinant DNA’ (William and Karoly, 2013).

2.1. 6. Insertion of Recombinant DNA into Host

In this step, the recombinant DNA is introduced into a recipient host cell. This process is ‘Transformation’. Bacterial cells do not accept foreign DNA easily. Therefore, they are treated to

make them ‘competent’ to accept new DNA. During transformation, if a recombinant DNA bearing a gene for ampicillin resistance is transferred into recipient E. coli cells, then the E. coli cells also become ampicillin-resistant (Glick and Patten, 2017).

This aspect is useful in differentiating transformed cells from non-transformed cells. For example, if we spread the transformed cells on agar plates containing ampicillin, only the transformed, ampicillin-resistant cells will grow while the untransformed cells will die. Therefore, in this case, the ampicillin resistance gene acts as the ‘selectable marker’ (Grilo and Mantalaris, 2019).

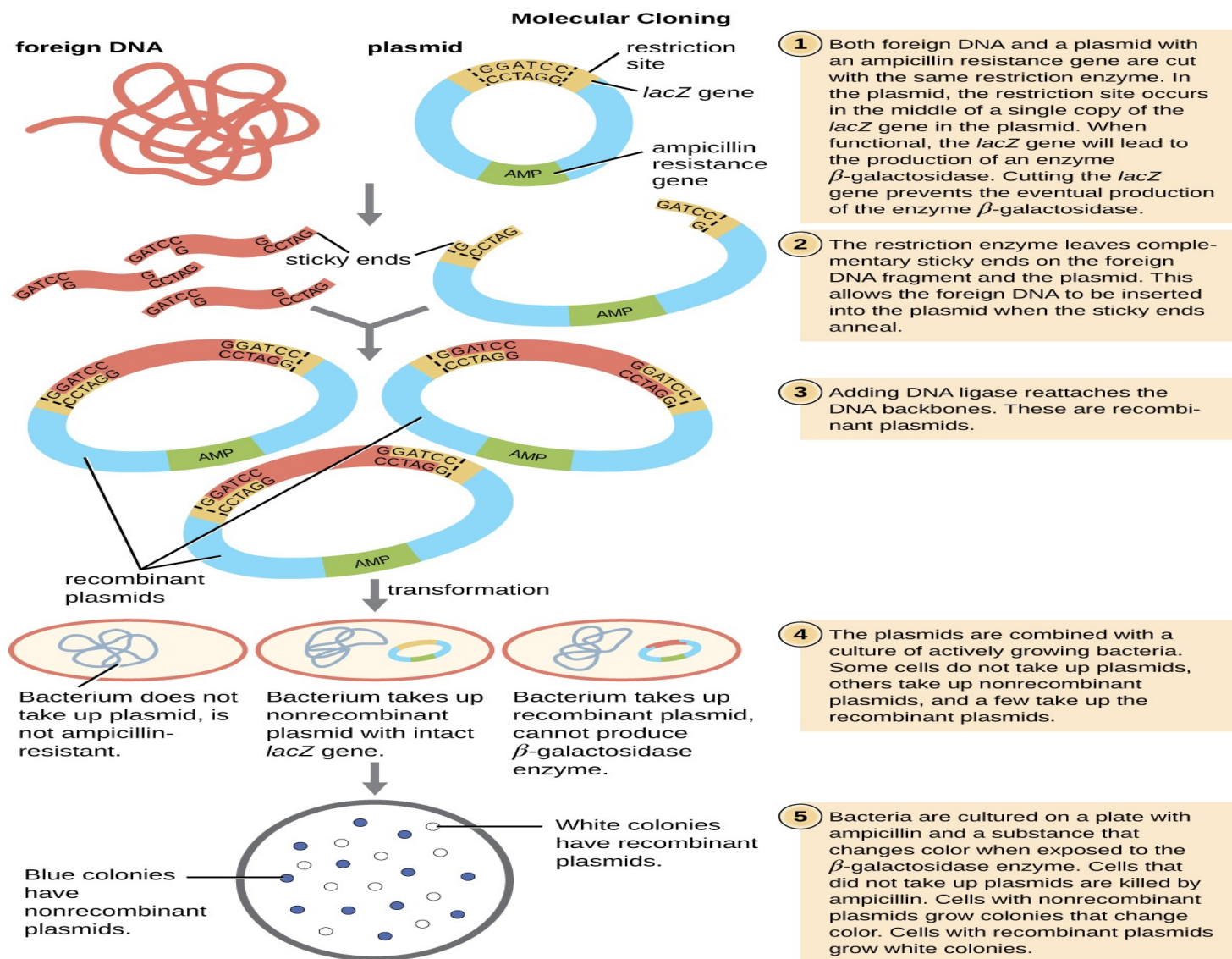


Figure 3: processes of recombinant DNA (William and Karoly, 2013)

2.2. Applications of Recombinant DNA Technology

2.2.1. Gene Therapy

Gene therapy is an advanced technique with therapeutic potential in health services. The use of lentiviral vector was made successful for the first time to treat genetic human disease (Montini et al., 2012). The first successful report in field of gene therapy to treat a genetic disease provided a more secure direction toward curing the deadliest genetic diseases (European Commission, 2015). This success in the field of health sciences opened

up new doors to extend the research to treat serious death causing diseases through immunotherapy (Robbins et al., 2011). Highly sustained levels of cells that were engineered for tumor recognition in blood using a retrovirus encoding a T-cell receptor in two patients up to 1 year after infusion resulted in regression of metastatic melanoma lesions. This strategy was later used to treat patients with metastatic synovial cell carcinoma (Robbins et al., 2011). Autologous T-cells were genetically modified to express a Chimeric Antigen Receptors (CAR) with specificity for the B-cell antigen CD19 for the treatment of chronic lymphocytic leukemia.

Combination of gene and drug therapy's potential has recently been highlighted in a trial seeking to confer chemo protection on human HSCs during chemotherapy with alkylating agents for glioblastoma. Gene transfer to a small number of cells at anatomically discrete sites is a targeted strategy that has the potential to confer therapeutic benefit. It showed impressive results for incurable autosomal recessive dystrophies such as congenital blindness and Leber congenital amaurosis (LCA). Swiss– German phase I/II gene therapy clinical trial aimed to treat chronic granulomatous disease in April 2006 that came up with success (Adair *et al.*, 2012).

Mobilized CD34+ cells isolated from peripheral blood were retro virally transduced and infused into the patient where two-thirds of the patients showed clear benefit from this treatment. After the treatment silencing of the transgene as a result of methylation of the viral promoter caused the severity of infection that led to the death of patient (Stein *et al.*, 2010). Many different cancers including lung, gynecological, skin, urological, neurological, and gastrointestinal tumors, as well as hematological malignancies and pediatric tumors, have been targeted through gene therapy. Inserting tumor suppressor genes to immunotherapy, oncolytic virotherapy and gene directed enzyme pro drug therapy are different strategies that have been used to treat different types of cancers. The p53, a commonly transferred tumor suppressor gene, is a key player in cancer treating efforts. In some of the strategies, p53 gene transfer is combined with chemotherapy or radiotherapy. The most important strategies that have been employed until now are vaccination with tumor cells engineered to express immunostimulatory molecules, vaccination with recombinant viral vectors encoding tumor antigens and vaccination with host cells engineered to express tumor antigens (Ginn *et al.*, 2012).

2. 2.2. Investigation of the Drug Metabolism.

Complex system of drug metabolizing enzymes involved in the drug is crucial to be investigated for the proper efficacy and effects of drugs.

Recombinant DNA approaches have recently contributed its role through heterologous expression, where the enzyme's genetic information is expressed in vitro or in vivo, through the transfer of gene (Karrer *et al.*, 2012).

2.2.3. Increase animal disease resistance

Recombinant DNA in animals has the potential to improve disease resistance by introducing specific genes into livestock and provide opportunities to genetically engineer livestock that are healthier and have superior disease resistance. One specific example where transgenesis has been applied to disease resistance in livestock is the attempt to produce cattle resistant to mastitis by inserting the gene responsible for Lysostaphin. It is an antimicrobial peptide that protects mammary glands against *Staphylococcus aureus* infection by killing the bacteria in a dose-dependent manner. Transgenic dairy cows that secrete Lysostaphin into their milk have been produced to address the mastitis issue (Lewin, 2011).

2.2.4. Enhance growth and meat trait

Altering the fat or cholesterol composition of the carcass is valuable benefit that can be delivered via DNA technology. By changing the metabolism or uptake of cholesterol and/or fatty acids, the content of fat and cholesterol of meats, eggs and cheeses could be lowered by introducing beneficial fats such as the omega-3 fatty lipoprotein receptor gene and hormones like leptin that would decrease fat and cholesterol in animal products (Lai *et al.*, 2012).

The use of recombinant technology to improve feed efficiency and/or appetite could profoundly impact livestock production and deliver significant benefits to producers, processors, and consumers. Increased uptake of nutrients in the digestive tract, by alteration of the enzyme profiles in the gut, could increase feed efficiency. Introduce enzymes such as Phytase or xylanase into the gut of species where they are not normally present, such as swine or poultry, is particularly attractive and complete digestion of

the dietary Phytase phosphorus (Golovan *et al.*, 2011).

2.2.5. Desired milk yield and composition

Advances in *recombinant* DNA technology have provided the opportunity either to improve the composition of milk or to produce entirely novel proteins in milk. These changes may add value to, as well as increase, the potential uses of milk. Changing milk composition may improve animal growth is the addition or supplementation of beneficial naturally occurring hormones, growth factors or bioactive factors to the milk through the use of genetic engineering. It has been suggested that bioactive substances in milk possess important functions in the neonate with regard to regulation of growth, development and maturation of the gut, immune system and endocrine organs (Brundidge *et al.*, 2010).

Transgenic alteration of milk composition has the potential to enhance the production of certain proteins and/or growth factors that are deficient in milk. The increased expression of a number of these proteins in milk may improve growth, development, health and survivability of the developing offspring. Some of these factors are insulin-like growth factor 1 (IGF-1), epidermal growth factor (EGF), transforming growth factor (TGF) and lactoferrin and increase proteins that have physiological roles within the mammary gland itself such as lactalbumin, lysozyme, Lysostaphin or other antimicrobial peptides (Brundidge *et al.*, 2010).

4.2.6. Development of Vaccines and Recombinant Hormones.

Comparatively vaccines have lower efficacy and specificity than recombinant vaccine. A fear free and painless technique to transfer adenovirus vectors encoding pathogen antigens is through nasal transfer which is also a rapid and protection sustaining method against mucosal pathogens. This acts as a drug vaccine where an anti-influenza state can be induced through a transgene expression in the airway (Stein *et al.*, 2010).

In vitro production of human follicle-stimulating hormone (FSH) is now possible through recombinant DNA technology. FSH is considerably a complex heterodimer protein and specified cell line from eukaryotes has been selected for its expression. Assisted reproduction treatment through stimulating follicular development is an achievement of recombinant DNA technology. A large number of patients are being treated through r-FSH. Most interestingly r-FSH and Luteinizing Hormone (LH) recombination was made successful to enhance the ovulation and pregnancy (Bendand *et al.*, 2010).

2.2.7. Bioremediation

In bioremediation *Pseudomonas putida* and *Nitrosomonas European* 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 (Paukner *et al.*, 2018). 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 create problems under natural conditions (Singh R. K., & Prasad, 2016).

2.2.8. Biotechnology

In biotechnological success and new commercial application is the production of genetically modified fluorescent zebra fish, *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 (Khan, 2016).

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. 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 (Khan, 2016). In generaly the technology has numerous applications which summarized in diagram below.

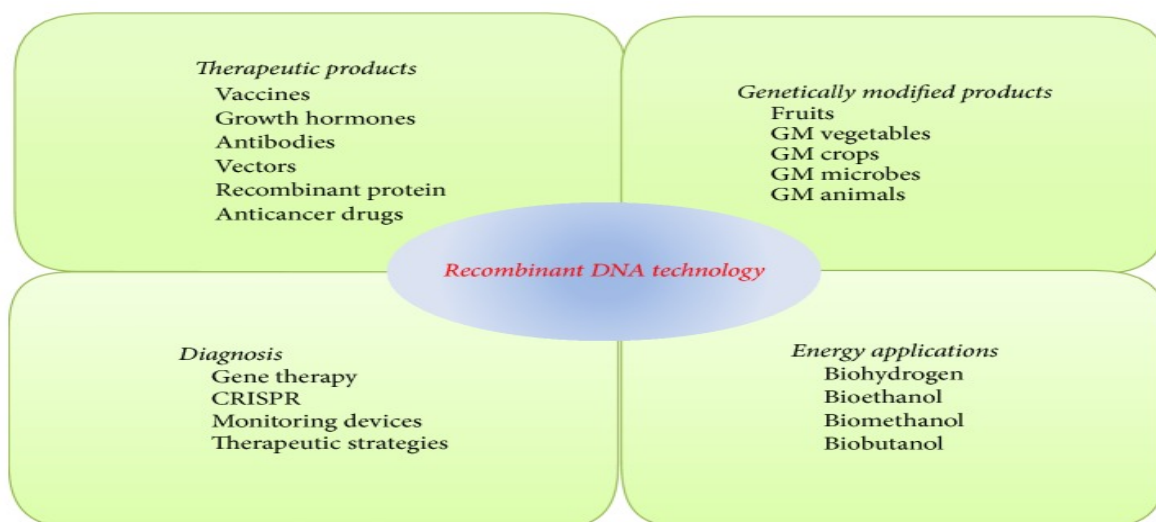


Figure 4: Application of recombinant DNA (Rajakaruna and Taylor, 2016)

2.3. Current Challenges and Future Prospects

The fact that microbial cells are mostly used in the production of recombinant pharmaceutical indicates that several obstacles come into their way restricting them from producing functional proteins efficiently but these are handled with alterations in the cellular systems. Common obstacles which must be dealt with are posttranslational modifications, cell stress responses activation, and instability of proteolytic activities, low solubility, and resistance in expressing new genes. Mutations occurring in humans at genetic levels cause deficiencies in proteins production, which can be altered by incorporation of external genes to fill the gaps and reach the normal levels. The use of *Escherichia coli* in recombinant DNA technology acts as a biological framework that allows the producers to

work in controlled ways to technically produce the required molecules through affordable processes (Ullah, 2016).

Recombinant DNA research shows great promise in further understanding of yeast biology by making possible the analysis and manipulation of yeast genes, not only in the test tube but also in yeast cells. Most importantly, it is now possible to return to yeast by transformation with DNA and cloning the genes using a variety of selectable marker systems developed for this purpose. These technological advancements have combined to make feasible truly molecular as well as classical genetic manipulation and analysis in yeast. The biological problems that have been most effectively addressed by recombinant DNA technology are ones that have the structure and organization of individual genes as their central issue (Ullah *et al.*, 2015).

Recombinant DNA technology is recently passing thorough development which has brought tremendous changes in the research lines and opened directions for advanced and interesting ways of research for biosynthetic pathways through genetic manipulation. Actinomycetes are being used for pharmaceutical productions, for example, some useful compounds in health sciences and the manipulation of biosynthetic pathways for a novel drugs generation. These contribute to the production of a major part of biosynthetic compounds and thus have received immense considerations in recombinant drugs designing. Their compounds in clinical trials are more applicable as they have shown high level activity against various types of bacteria and other pathogenic microorganisms. These compounds have also shown antitumor activity and immunosuppressant activity (Ullah, 2016).

Recombinant DNA tech as a tool of gene therapy is a source of prevention and cure against acquired genetic disorders collectively. DNA vaccines development is a new approach to provide immunity against several diseases. In this process, the DNA delivered contains genes that code for pathogenic proteins. Human gene therapy is mostly aimed to treat cancer in clinical trials. Research has focused mainly on high transfection efficacy related to gene delivery system designing, transfection for cancer gene therapy with minimal toxicity, such as in case of brain cancer, breast cancer, lung cancer, and prostate cancer, is still under investigation. Also renal transplantation, gaucher disease, hemophilia, Alport syndrome, renal fibrosis, and some other diseases are under consideration for gene therapy (Misra, 2010).

2.4. Ethical issue and uncertainty

Most of the downsides of recombinant DNA technology are ethical in nature. Some people feel that recombinant DNA technology goes against the laws of nature, or against their religious beliefs. Some people worry that if companies can pay scientists to patent, buy and sell genetic material, then genetic material could become an expensive commodity. Such a system might lead

to people having their genetic information stolen and used without permission. Many people worry about the safety of modifying food and medicines using recombinant DNA technology. Other people worry that humans may begin tampering too much with their own genetic material and create societal problems (Maria, 2018).

3. Conclusion and Recommendation

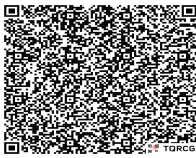
Recombinant DNA technology is any technological application that uses biological systems, living organisms, or derivatives to make or modify products or processes for specific use and involves the insertion of DNA fragments from a variety of sources, having a desirable gene sequence via appropriate vector. Manipulation in organism's genome is carried out either through the introduction of one or several new genes and regulatory elements or by decreasing or blocking the expression of endogenous genes through recombining genes and elements. The technology uses different tools to produce recombinant DNA such as the gene of interest, plasmid or any other vector, PCR, different enzymes like restriction and ligase. Recombinant DNA technology have a wide range of application both in animal and human life improvement like gene therapy, bioremediation, biotechnology, increasing diseases resistance, producing desired milk, meat and egg composition and creating diseases resistant animals. Even though the technology have various benefits and crucial science; there is ethical issue uncertainty on recombinant DNA due to religious believe, violation rule of nature and refusing to use recombinant by products. so to make the technology wide applicable the researchers expected to do a lot on community awareness about recombinant DNA technology and further research on uncertainty and challenges of technology.

4. References

Adair, J. E. Beard, B. C. Trobridge, G. D., et al., (2012). "Extended survival of glioblastoma patients after chemoprotective HSC gene

- therapy," *Science Translational Medicine*, **4**, pp.133
- Bazan-Peregrino, M., Sainson, R. C. A. And Carlisle R. C. (2013). "Combining virotherapy and angiotherapy for the treatment of breast cancer," *Cancer Gene Therapy*, **8**: 461–468.
- Bendandi, M., Marillonnet, S. Kandzia, R. et al., (2010). "Rapid, highyield production in plants of individualized idotype vaccines for non-Hodgkin's lymphoma," *Annals of Oncology*, vol. 21, no. 12, pp. 2420–2427.
- Brundige, D.R., Maga, E.A., Klasing, K.C. and Murray, J.D. (2010): Consumption of pasteurized human lysozyme transgenic goats' milk alters serum metabolite profile in young pigs. *Transgenic Res.*, **19**: 563-574.
- European Commission (2015): Restrictions of geographical scope of GMO applications/authorisations: Member States demands and outcomes.
- Gates AJ, Gysi DM, Kellis M, Barabás A-L. A wealth of discovery built on the human genome project — by the numbers. *Nature*. 2021;590:212–5.
- Ginn, S. L. Alexander, I. E. Edelstein, M. L. Abedi, M. R. and Wixon, J. (2013). "Gene therapy clinical trials worldwide to 2012— an update," *Journal of Gene Medicine*, **15**: pp.2 65–77.
- Glick BR, Patten CL. *Molecular biotechnology: principles and applications of recombinant DNA*. John Wiley & Sons; 2017.
- Grilo AL, Mantalaris A. The increasingly humawn and profitable monoclonal antibody market. *Trends Biotechnol*. 2019;37(1):9–16.ww
- Joutey NT, Bahafid W, Sayel H, ElGhachtouli N. Biodegradation: involved microorganisms and genetically engineered microorganisms. *Biodegrad Life Sci*. 2013;1:289–320.
- Karrer, E. . Bass, S. H. Whalen, R. and P. A. (2012). Patten, U.S. Patent No. 8,252,727.
- Khan S, Nabi G, Ullah MW, Yousaf M, Manan S, Siddique R, Hou H. (2019). Overview on the role of advance genomics in conservation biology of endangered species. *International Journal of genomics*.
- Lewin, H.A. (2011): Disease resistance and immune response genes in cattle: strategies for their detection and evidence of their existence. *J. Dairy Sci.*, **72**:1334-1348.
- Maria, C., 2018. Pros and Cons of Recombinant DNA Technology Home » Science » Biology » Genetics; Updated April 26.
- Mert, O. and Gaillet, B. (2016). "Viral vectors for gene therapy and gene modification approaches," *Biochemical Engineering Journal*, **108**: 98–115.
- Misra, A. (2010). Challenges in Delivery of Therapeutic Genomics and Proteomics, Elsevier, Amsterdam, Netherlands, Forbioremmdation technology.
- Paukner S., Kohl G., & Lubitz W. (2018). Bacterial ghosts as novel advanced drug delivery systems: *antiproliferative79Int J Pharma Res Health Sci.*, **6**: 2346-50 11.
- Rajakaruna, S.S. and Taylor-Robinson A.W. (2016) .Application of recombinant DNA technology (genetically modified organisms) to the advancement of agriculture, medicine, bioremediation and biotechnology industries. *J Appl Biotechnol Bioeng*; 1:78–80.
- Raylene Ramos Moura, Luciana Magalhães Melo, and Vicente José de Figueirêdo Freitas, (2011): "Production of Recombinant Proteins in Milk of Transgenic and Non-Transgenic Goats." *Brazilian Archives of Biology and Technology* **54**: 927–938.
- Robbins, P. F., Morgan, R. A. Feldman, S. A., et al. (2011), "Tumor regression in patients with metastatic synovial cell sarcoma and melanoma using genetically engineered lymphocytes reactive with NY-ESO-1," *Journal of Clinical Oncology*, **29**: pp. 917–924.
- Sanchez S, Demain AL. Metabolic regulation and overproduction of primary metabolites. *Microb Biotechnol*. 2008;1(4):283–319.
- Shivanand P. & Noopur S. (2010). Recombinant Dna Technology and Genetic Engineering: A Safe and Effective Meaning For Production Valuable Biologicals. *International Journal of Pharmaceutical Sciences Review and Research*, **1**: 14-20.

- Shivanand P., & Noopur S. (2010);. Recombinant DNA technology: Applications in the field of biotechnology and crime sciences. *International Journal of Pharmaceutical Sciences Review and Research*, 1(1); 43-49.
- Singh R. K. & Prasad M. (2016). Advances in Agrobacterium tumefaciens-mediated genetic transformation of graminaceous crops. *Protoplasma* 2: 691- 707.
- Stein, S.Ott, M. G., Schultze-Strasser, S et al. (2010). “Genomic instability and myelodysplasia with monosomy consequent to EVI1 activation after gene therapy for chronic granulomatous disease,” *Nature Medicine*, vol. 16, no. 2, pp. 198–204.
- Suliman, K., Muhammad, W. U., Rabeea, S., Ghulam N., Sehrish , M., Muhammad, Y., and Hongwei, H. (2016) . Role of Recombinant DNA Technology to Improve Life.80 *International Journal of Genomics*, pp.14.
- Ullah, M. W., Ul-Islam, M. S. Khan, Y. Kim, and J. K.(2016). Park, “Structural and physico-mechanical characterization of biocellulose produced by a cell-free system,” *Carbohydrate Polymers*, vol. 136, pp. 908–916.
- Ullah, M. W., Ul-Islam, M. S. Khan, Y. Kim, and J. K. (2015). Park, “Innovative production of bio-cellulose using a cell-free system derived from a single cell line,” *Carbohydrate Polymers*, vol. 132, pp. 286–294.
- Ullah, M.W. Khattak, W. AM. Ul-Islam, S. Khan, and J. K. (2016).Park, “Metabolic engineering of synthetic cell-free systems: strategies and applications,” *Biochemical Engineering Journal*, vol. 105, pp. 391–405.
- William S.M. Wold and KarolyToth. (2013): "Adenovirus Vectors for Gene Therapy, Vaccination and Cancer Gene Therapy." *Current Gene Therapy* 13 : 421.

| Access this Article in Online | |
|--|--|
|  | Website: www.ijarm.com |
| | Subject: Recombinant DNA Technology |
| Quick Response Code | |
| DOI: 10.22192/ijamr.2026.13.05.007 | |

How to cite this article:

Gizachew Fentahun Desta. (2026). Principle and Application Recombinant DNA Technology in Health and Agricultural industry. *Int. J. Adv. Multidiscip. Res.* 13(5): 70-80.
DOI: <http://dx.doi.org/10.22192/ijamr.2026.13.05.007>