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A VARIETY OF BIOTECHNOLOGY APPLICATIONS IN THE FIELD OF HEALTH MEDICINE

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Abstract

Biotechnology is an important and wide field that deals with the use of living organisms to develop products beneficial for sustainable development. Biotechnology devices and procedures provide new avenues for researches to develop products and technologies that could help in improving the quality of human life on earth (Yang P., 2021). The aim: This study is to have an overview of major Biotechnology applications in the field of medicine. Material & Methods: Recently literature and scientific researches. This descriptive study highlights a brief review of various applications of medical biotechnology. Results & Conclusions: In the field of medicine, there are a variety of biotechnology applications[2]. Some of them include the following: Molecular diagnosis, Gene therapy, Recombinant insulin, Pharmacogenomics, Vaccines (Shastry BS. 2006; Yang P., 2021). Medical biotechnology is the use of living cells and cell materials to research and produce pharmaceutical and diagnostic products that help treat and prevent human diseases for e.g., autoimmune disease, cancer and infectious diseases as malaria, tuberculosis, AIDS, etc. (Prajapat & Jain 2022).

Keywords: *Biotechnology, applications, health medicine*

1. Introduction

Karl Ereky (1917), a Hungarian engineer, introduced the term biotechnology. He defined biotechnology as "all lines of work by which are produced, products, from raw materials with the aid of living things" (Gupta et.al., 2017). The term biotechnology is composed of two words biology and technology. In 1982, modern biotechnology was defined by OECD (Organization for Economic Cooperation and Development) as the "application of scientific and engineering principles to the processing of materials with biological agents use to provide services and goods for the quality of life improvement" (Prajapat & Jain, 2022). The applications of biotechnology most promising are observed in the medical field. Biotechnology is the application of biological agents (microorganisms, plant and animal cells, and enzymes) to be used in agriculture, animal husbandry, food production, and medicine industries (Mahboudi, et.al; 2012). Biotechnology products have affected the promotion of health care in significant success achievements (Mahboudi, et.al; 2012).

2. Material & Methods

The Aim: This study highlights a brief review of various applications of medical biotechnology. This is a descriptive study.

Research strategy: Literature Review and Search. Our study was focused on finding reliable articles and literature sources in consistent with the objective of our study. Recently literature and scientific researches.

Inclusion criteria: We searched the PubMed, MeSH, NCBI database for studies limiting the search to articles only in English language. The types of articles included were: clinical studies (Review, Systematic Review), Free full texts, Abstracts, articles of various medical journals (MEDLINE Journal articles).

Exclusion criteria: We excluded studies conducted at a time distance of more than 23 years, studies where the text was incomplete and those in languages other than those of the inclusion criteria.

The procedure followed: The search terms were: Biotechnology, applications, health medicine

3. Results and Discussion

There are lot of articles in different sources about biotechnology and its applications in different fields. We focused on those articles which were for applications of biotechnology specially in field of medicine. All the articles were analysed and only those which met the inclusion criteria are taken into consideration for this study.

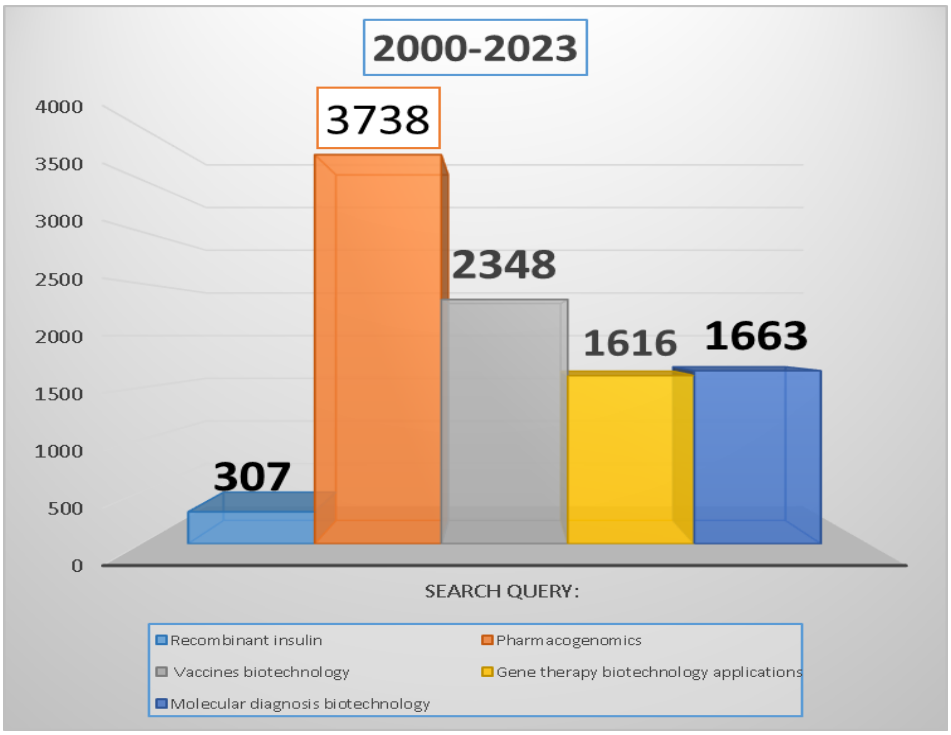

Figure 1: Number of articles categorised on search queries

As it's obviously presented at the chart above, as result of our searches for the period of 2000-2023, it resulted the highest number of articles for pharmacogenomics, followed by vaccines biotechnology, molecular diagnosis biotechnology, Gene therapy biotechnology applications, and the lowest number of articles for Recombinant insulin.

Table 1: Categorised articles grouped by each year

Search query:	Recombinant insulin	Pharmacogenomics	Vaccines biotechnology	Gene therapy biotechnology applications	Molecular diagnosis biotechnology
2023	10	168	265	133	142
2022	21	305	413	162	223
2021	30	380	508	207	244
2020	7	332	301	143	148
2019	14	265	127	121	79
2018	15	250	108	117	65
2017	17	249	96	104	72
2016	27	244	99	77	73
2015	15	221	80	83	48
2014	20	218	74	69	39
2013	15	153	58	42	38
2012	13	223	34	40	42
2011	14	138	29	40	50
2010	12	140	26	28	34
2009	11	99	34	35	51
2008	18	81	26	37	58
2007	9	61	20	39	44
2006	6	63	7	31	15
2005	5	40	13	32	11
2004	9	33	17	26	180
2003	7	23	4	12	2
2002	6	27	5	14	2
2001	2	18	2	11	1
2000	4	7	2	13	2

At the table above are presented for each year for the period 2000 till 2023, the number of articles resulted from search queries: pharmacogenomics, vaccines biotechnology, molecular diagnosis biotechnology, Gene therapy biotechnology applications, and Recombinant insulin.

The literature review results are presented as follows:

In the field of medicine, there are a variety of biotechnology applications and some of them include the following:

3.1 Molecular Diagnosis

Medical diagnosis is one of the most important applications of biotechnology in the health sector (Gupta et.al., 2017). Many times the concentration of pathogen increases by the time the disease is diagnosed. So, early diagnosis and knowledge of pathophysiology are very important for for an effective cure and it can be achieved with the techniques such as: Recombinant DNA Technology, PCR (Polymerase Chain Reaction) and Enzyme-Linked Immunosorbent Assay (ELISA), etc. (Sagar Aryal, 2022; Siew, et.al., 2021; Suliman Khan, et.al., 2016).

3.1.1 Polymerase Chain Reaction (PCR)- Principle, Steps, Applications

Polymerase chain reaction (PCR) is widely used in basic science and biomedical research (Li, A., et.al., 2018). PCR is a laboratory technique to amplify specific DNA segments for various laboratory and clinical applications (Demeke, T., & Dobnik, D., 2018). Allowing for more than the billion-fold amplification of specific target regions, this reaction has become an important instrument in many applications, including gene cloning, infectious diseases' diagnosis, and prenatal screening for deleterious genetic abnormalities (Sagar Aryal, 2022).

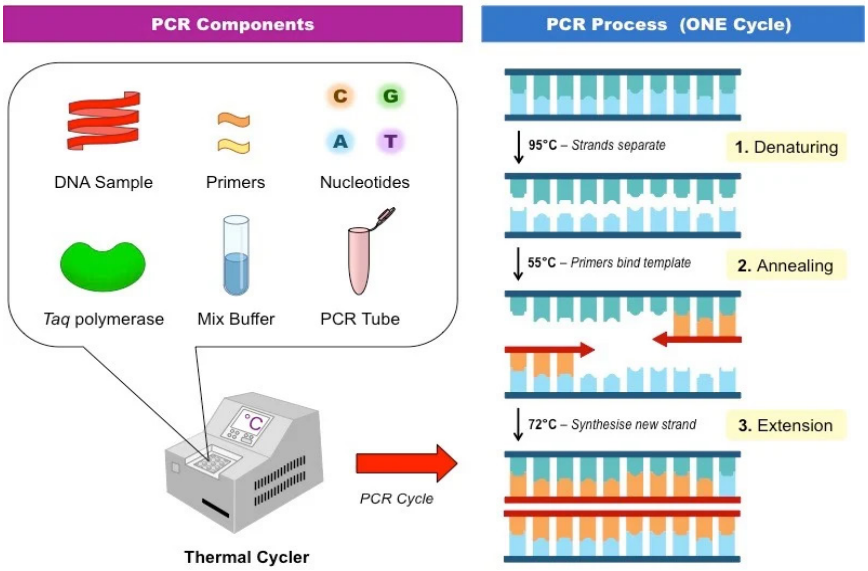

Figure 2: Aschematic view of PCS components & process

https://microbenotes.com/polymerase-chain-reaction-pcr-principle-steps-applications/#applications-of-pcr

3.1.2 Recombinant DNA Technology

Since the year 2019 due to the exposure of COVID-19 pandemic worldwide, biotechnology has had a tremendous scope for the discovery of medicine and vaccine to save human life. The rDNA technology used host organisms to produce therapeutic products for the treatment of human diseases e.g., E. coli used for the production of insulin hormone, growth hormones, monoclonal antibody, yeast cells used to produce Hepatitis B vaccine (Yang Peter, 2021; Sagar Aryal, 2022; Siew, et.al. 2021; Suliman Khan, etl. al. 2016). The basic steps involved in rDNA technology are illustrated schematically below (Figure 3):

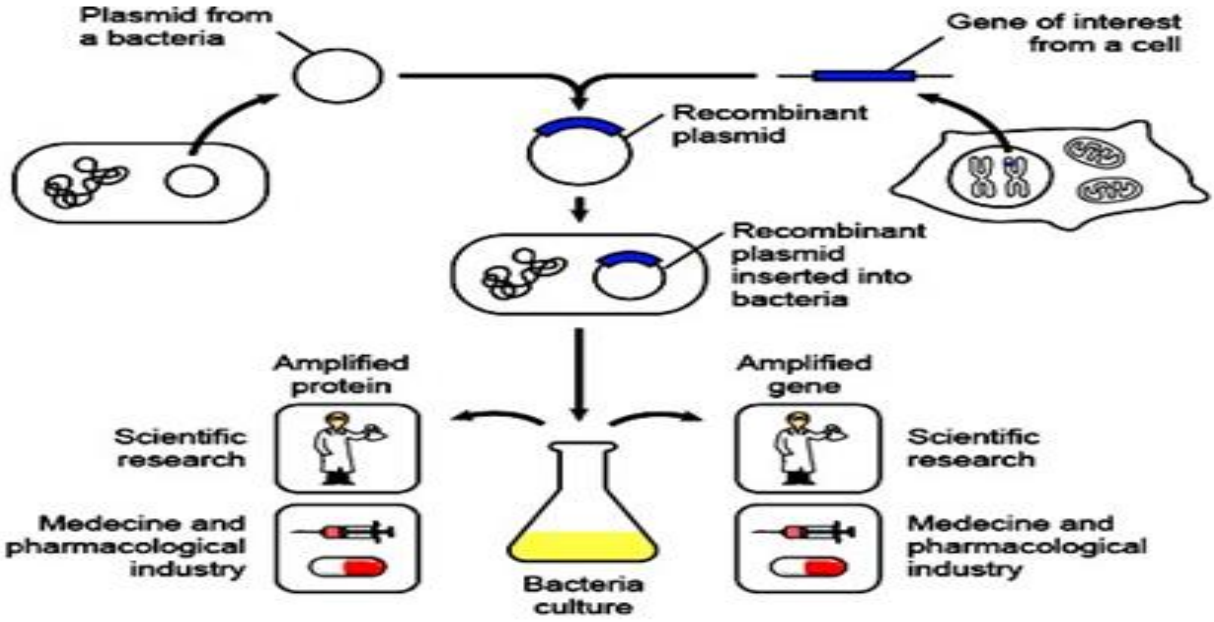

Figure 3. Recombinant DNA Technology Stepsand Applications.

As its' presented at the figure above Recombinant DNA Technology Steps are:

- Treating foreign DNA and plasmid with restriction enzymes and join using ligase.
- Introducing the recombinant plasmid into host bacteria.
- Applications of amplified genes and proteins are explained at the figure above.

Technology of Recombinant DNA has major uses on new enzymes manufacture which are suitable for specified food-processing. RDNA technology has wide spectrum of applications in treating diseases and improving health conditions as production of Antibodies and their derivatives, Investigation of the Drug Metabolism etc (Khan S. et.al 2016). A broad range of applications of recombinant DNA technology has been summarized in Figure 4.

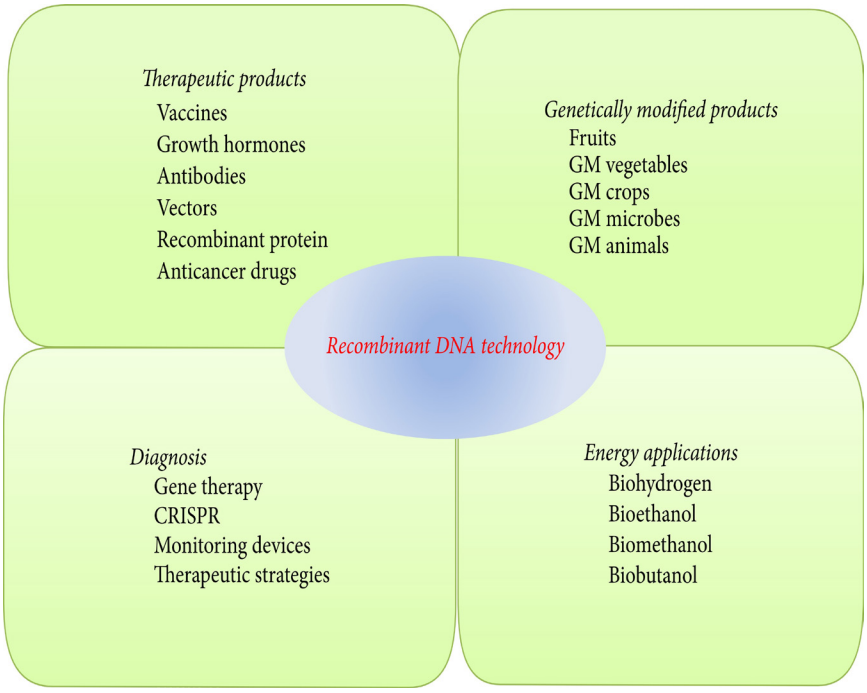

Figure 4: Ilustration of various applications of recombinant DNA technology.

https://www.hindawi.com/journals/ijg/2016/2405954/fig1/

3.2 Recombinant Insulin

Diabetic patients require Insulin to remove excess sugar from the blood. Diabetic patients produce by their body have a very low level of insulin or no insulin (Siew, & Zhang, 2021). Therefore, in order to control blood glucose levels, they need external insulin. Later it was discovered that, by the pancreas of the pigs it can be produced the insulin which can be used by humans (Suliman Khan et.al., 2016). But to provide the quantities of insulin required, there were not enough pigs (Mendell, J. R., et.al, 2021). So this led to the cloning of the human insulin gene. Then were introduced in E. coli bacteria the specific gene sequence that codes for human insulin (Yang Peter, 2021., Siew, & Zhang, 2021). The genetic composition of the E. coli cells was altered by the gene sequence, and were produced several E. coli bacteria containing the recombinant human insulin gene within 24 hours. Then from E. coli cells was isolated the recombinant human insulin (Papaioannou, I., et.al., 2023).

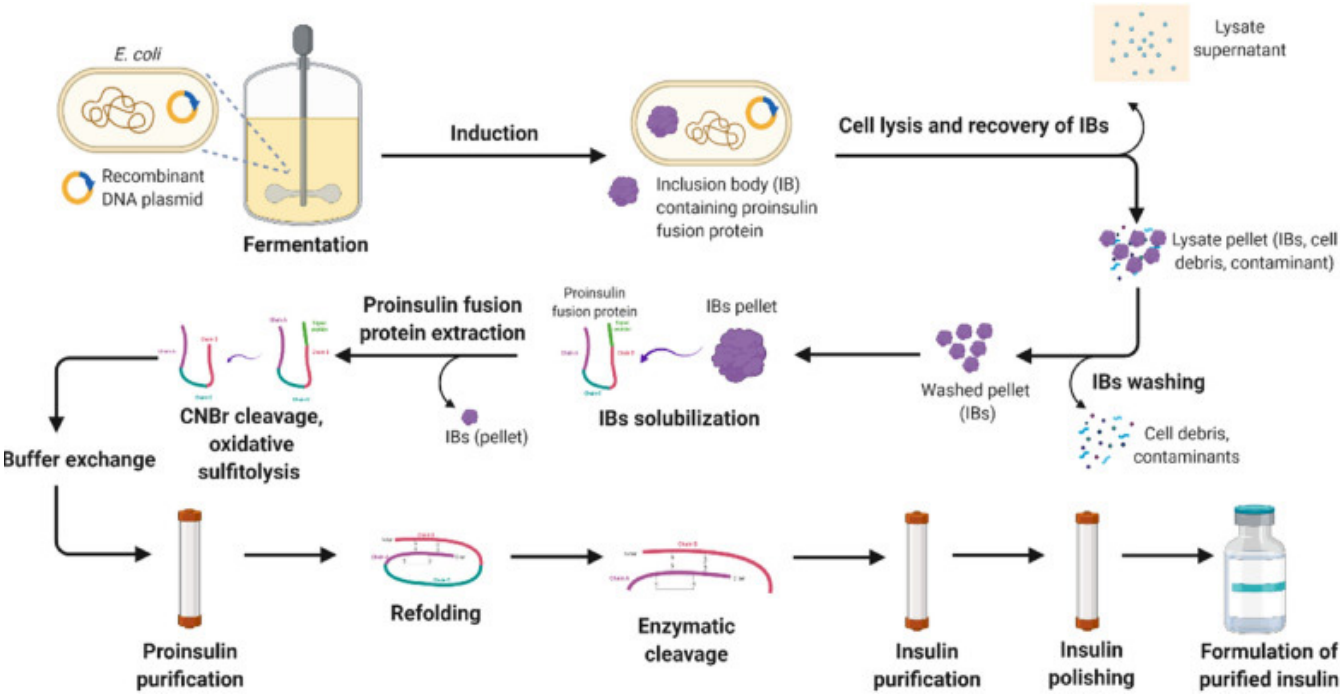

Figure 5. The general workflow for the downstream processing of recombinant human insulin and its analogues (created with BioRender. com)

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8313369/figure/Fig1/

3.3 Gene Therapy field

Originally gene therapy was envisioned as the in situ modification of genetic information of cells within tissues (Jensen & Geoffrey, 2015), The field has evolved beyond that encompassing more aspects of nucleic acid technology, particularly oligonucleotide technology, which aims to modify gene expression, without necessarily changing the cell's genetic information (Mendell, J. R., et.al., 2021).

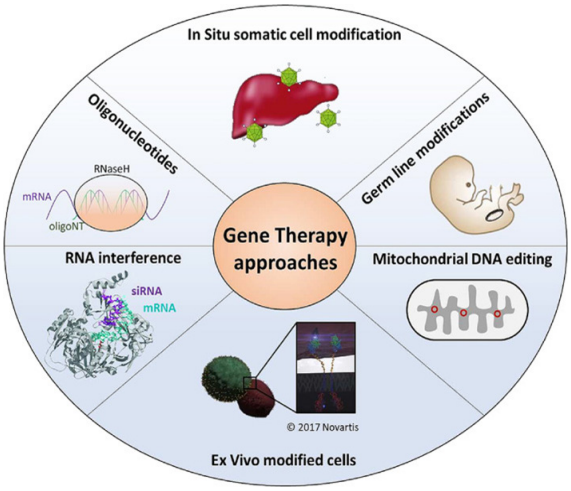

Figure 6: gene Therapy approaches

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10349259/figure/iep12478-fig-0001/

The modification of a patient's cells ex vivo, outside the body prior to reimplantation has proven to be a successful clinical strategy (Papaioannou,I..et.al. 2023) Although recent technological advancements have now enabled mitochondrial and germ line or embryonic cell gene therapy, these approaches are not yet being used due to safety and ethical issues (Yang Peter, 2021) .

Figure 7. Current Clinical Applications of In Vivo Gene Therapy with AAVs

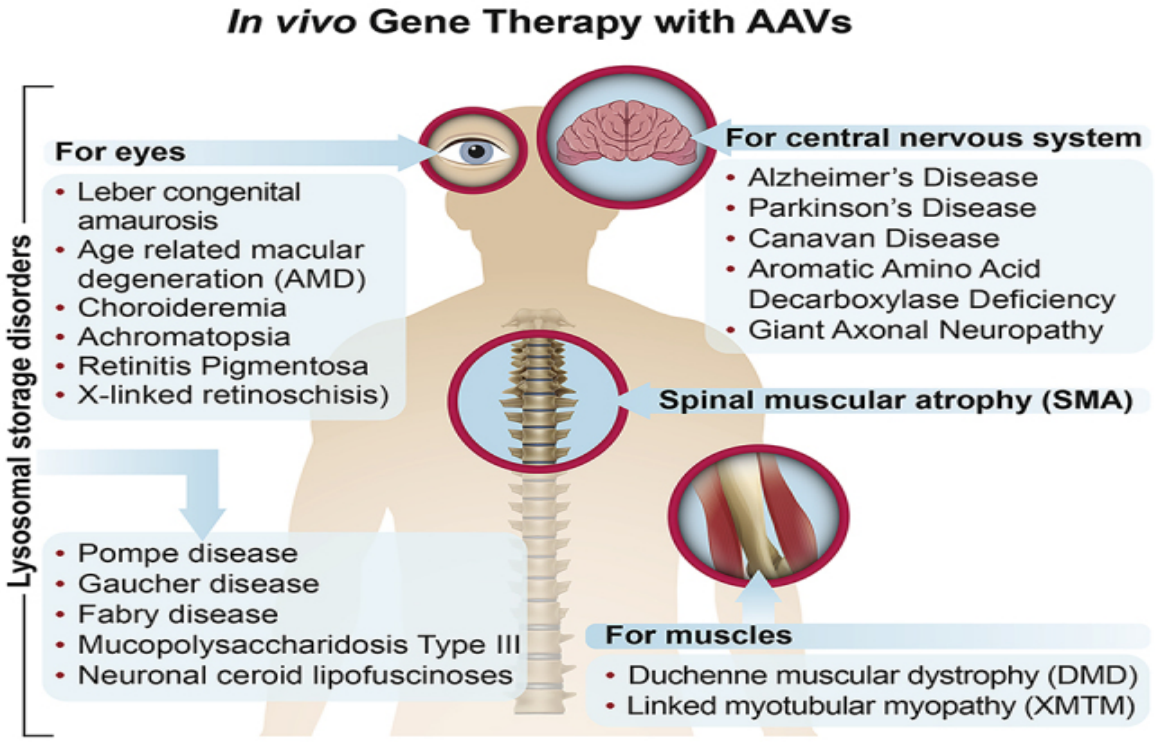

Figure 7: Current Clinical Applications of In Gene Therapy with AAVs

3.5 Pharmacogenomics

Pharmacogenomics has led to the production of drugs that are best suited to an individual's genetic makeup (Rysz, J. et.al., 2020). It can be applied in diseases such as cancer, depression, HIV, asthma,

etc (Daniell et.al., 2009; Cossarizza, 2021). The Pharmacogenomics Knowledgebase (PharmGKB) is a resource that collects, curates, and disseminates information about the impact of human genetic variation on drug responses (Balestrini, & Sisodiya, 2018). It provides clinically relevant information, including dosing guidelines, annotated drug labels, and potentially actionable gene–drug associations and genotype–phenotype relationships (Whirl-Carrillo, M., et.al 2012). The PharmGKB is a publicly available Web-based knowledge darbase whose aim is to aid researchers in understanding how genetic variation among individuals contributes to differences in reactions to drugs (Whirl-Carrillo, M., et.al 2012). A visual summary of the data available and how these various types of information are integrated within the PharmGKB is provided in the PharmGKB Knowledge Pyramid (see Figure 8) (M. Whirl-Carrillo1, et.al., 2021).

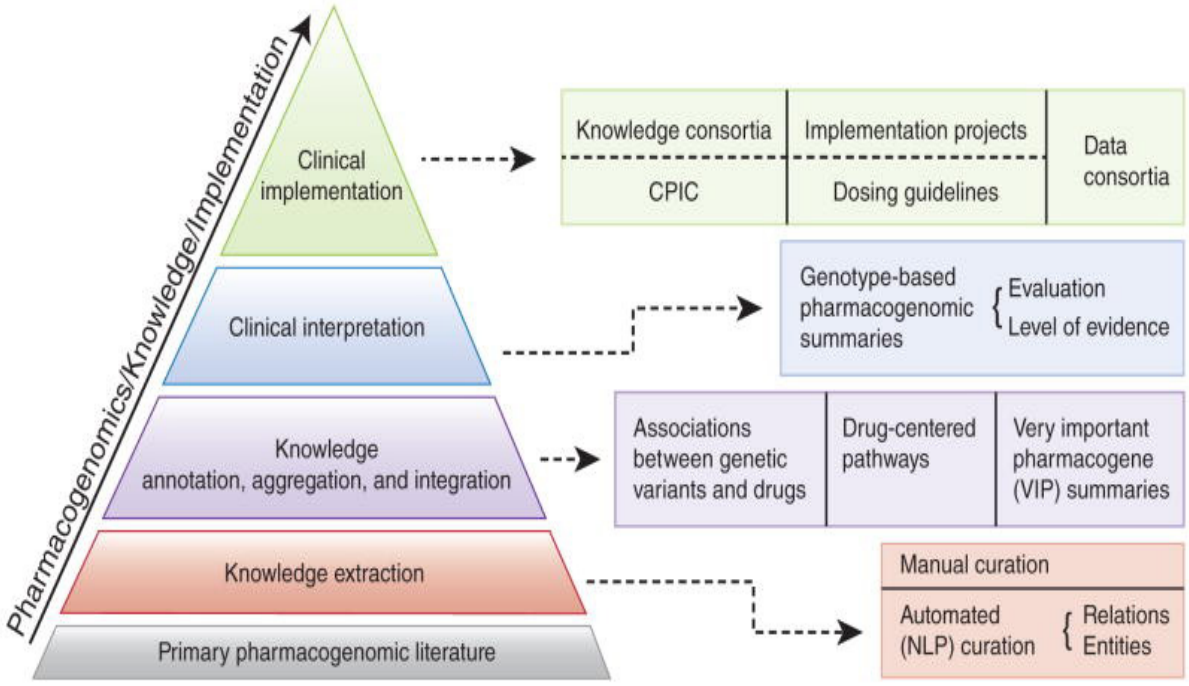

Figure 8: The PharmGKB Knowledge Pyramid

CPIC, Clinical Pharmacogenetics Implementation Consortium; NLP, natural-language processing. From PharmGKB with the permission of PharmGKB and Stanford University. Copyright PharmGKB. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3660037/figure/F1/

3.6 Edible vaccines

Vaccines are obtained by animals and cell cultures. These vaccines contain inactivated pathogens. To make a plant a good edible vaccine candidate, there are a number of factors as: Must have long shelf life (Cereals such as rice, maize, and wheat), Must grow quickly (such as tobacco and tomato) and Easy transformation. The transgenic plants can produce antigens that can be used as edible vaccines (Ranjha, et.al., 2022). Plants such as tomato, potato, tobacco, rice, and maize are widely used for this purpose (Muynck B De, et.al., 2010), (Daniell H, et.al., 2009). Antigenic proteins from several pathogens can be expressed in plants such as tomato and banana (Ranjha, et.al., 2020). Transgenic sugar beet can treat foot and mouth disease of animals, transgenic banana and tomato can cure diseases such as cholera and hepatitis B (Jensen D., 2015),

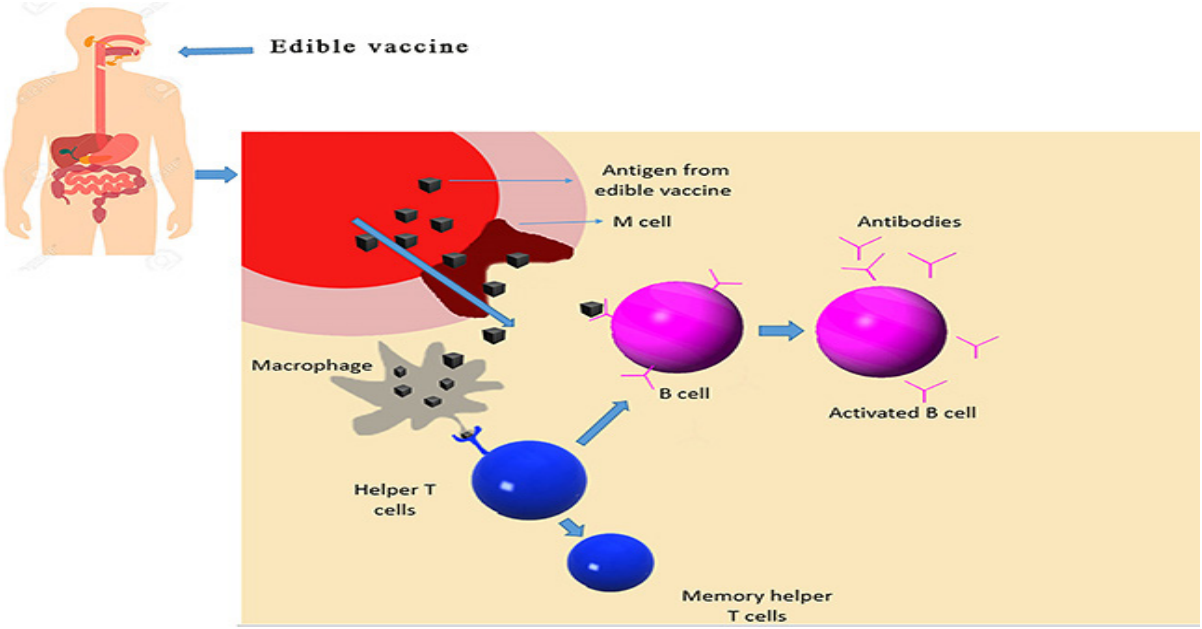

Figure 9: Mechanism of action of edible vaccines.

Edible vaccines are alternatives much safer and cheaper than traditional vaccines. They can make scaling up so much easier, as any edible plant/algae.

The advance of new technologies such as genomics, proteomics, bioinformatics, and recombinant DNA technology are useful for the discovery of new vaccine antigens (Rinaudo CD, et.al., 2009). The approaches used for vaccine development are based on an improved understanding of the microbial structure, physiology, epidemiology, virulence, host-pathogen interactions, and the scale of microbial intra- and interspecies diversity (Figure 10) (Prajapat & Jain 2022).

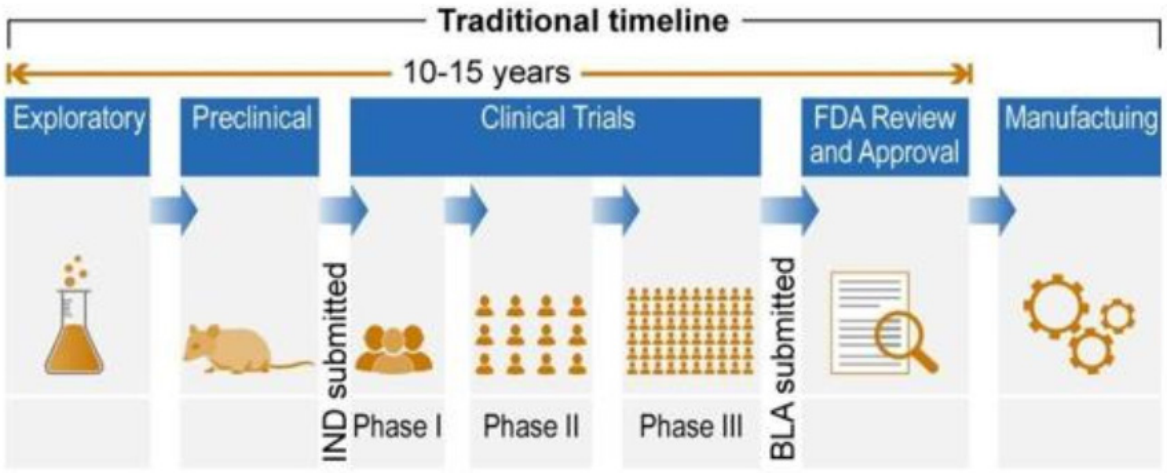

Figure 10: Phases of Vaccine development.

Most current vaccines can target pathogens that have low antigenic variability and for which protection depends on antibody-mediated immunity. This is the case for tetanus, polio, measles, diphtheria, and hepatitis B (Dhouib W, et al.2020).

4. Conclusion

After studying and analysing the recent literature about biotechnology applications, in the field of medicine, we concluded that there are a variety of biotechnology applications[2].

Some of them include the following:

- Molecular diagnosis,
- Gene therapy,
- Recombinant insulin,
- Pharmacogenomics,
- Vaccines.

Medical biotechnology is the use of living cells and cell materials to research and produce pharmaceutical and diagnostic products that help treat and prevent human diseases (e.g., autoimmune disease, cancer and infectious diseases as malaria, tuberculosis, AIDS, etc.).

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SESIONI 2

SHKENCAT SHOQËRORE