IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Review On Role Of Viral Vector In Recombinant Technology

Urmi Prajapati*, Vidhi Patel, Bijal Yadav, Dr. Sachin Narkhede, Dr. Shailesh Luhar

Abstract: -

Viral vectors play a pivotal role in recombinant technology, serving as vehicles for delivering foreign genetic material into host cells. They are engineered viruses that have been modified to carry and express desired genes. Through their natural ability to infect cells and integrate their genetic material, viral vectors efficiently transfer genes into target cells. This technology has widespread applications in gene therapy, vaccine development, and gene editing. By utilizing viral vectors, researchers can introduce therapeutic genes into specific tissues to treat genetic disorders or deliver vaccines against infectious diseases. Adeno-associated virus (AAV), lentivirus, and adenovirus are commonly used viral vectors, each with unique properties and applications. Despite their potential, careful consideration of safety and immunogenicity concerns is essential in their design and implementation. Overall, viral vectors represent a versatile tool in recombinant technology, offering promising avenues for medical advancements.

`Keywords: - Recombinant technology, Viral vector, Adenoviral vector, Lentivirus

Introduction: -

1. Introduction to Recombinant Technology: -

1.1 Recombinant Technology: -

The process of recombination involves breaking off DNA strands and reassembling them to create new combinations of alleles. Genetic variation is produced at the gene level by this recombination process, which represents variations in the DNA sequences of various organisms. In cells with nuclei and a nucleus, known as eukaryotic cells, recombination usually takes place during meiosis. Gametes, or egg and sperm cells, are created during the process of meiosis, a type of cell division. The homologous pairs of paternal and maternal chromosomes align during the first phase of meiosis. During the alignment, the arms of the chromosomes can overlap and temporarily fuse, causing a crossover. Crossovers result in recombination and the exchange of genetic material between the maternal and paternal chromosomes. As a result, offspring can have different combinations of genes than their parents.

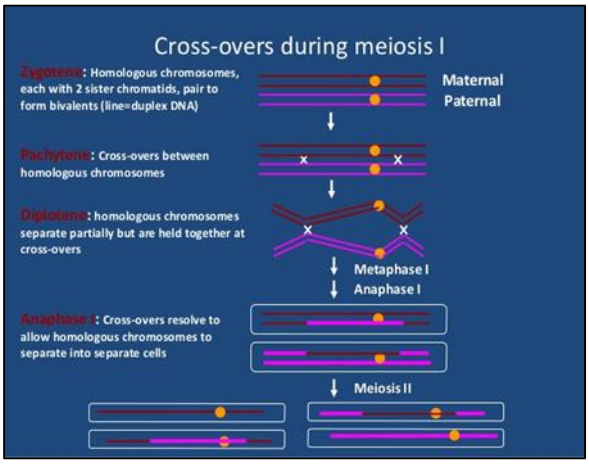

Figure 1 Cross overs during Meiosis I

1.2 Types of Recombination: -

1. Homologous Or General

a) Double Strand Break Repair (Dsbr) Or Dobule Holliday Junction Model

b) Synthesis Dependent Strand Annealing (Sdsa) Pathway

2. Non-Homologous or Illigimate
3. Site Specific Recombination
4. Replicative Recombination or Transposition

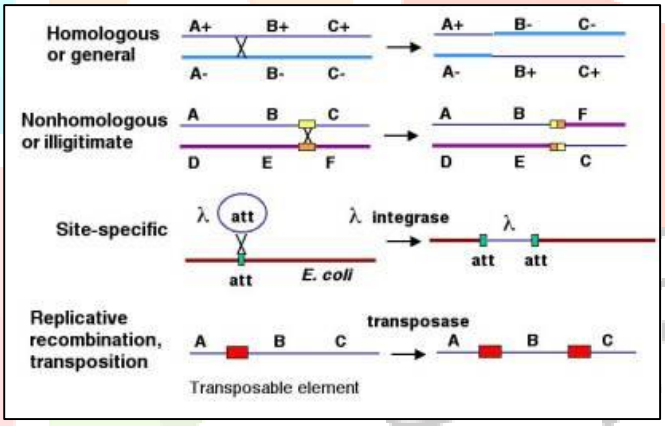

Figure 2 Type of Recombination

1. Homologous Or General: -

It occurs when DNA molecules with very similar sequences come together, as when homologous chromosomes in diploid animals do. In diploid species, general recombination can take place through one or a limited number of common enzyme routes across the entire genome. Almost all of this chapter will be concerned with general recombination. It is a physical phenomenon in which nucleotides are exchanged without a net gain or loss.It is predicated on complementarity of sequences. occurs (during meiosis) between essentially similar sequences. In Coli, homologous recombination is thoroughly investigated. In e. Coli, recombination involves at least 25 different proteins. Within a diploid organism, homologous chromosomes have two segments of DNA that contain identical genes, one from each parent. Put another way, your parents each contribute a whole genome. The 23 chromosomes, which encode the identical genes, are contributed by each parent. In horizontal gene transfer, homologous recombination is also utilised to transmit genetic material between different strains and species of viruses and bacteria.

a) Double Strand Break Repair (Dsbr) Or Double Holliday Junction Model: -

Two homologous DNA duplexes that are aligned have their corresponding strands nicked. The nicked strand then crosses over to couple with the nearly matching strand of the homologous duplex, and the nicked are sealed.

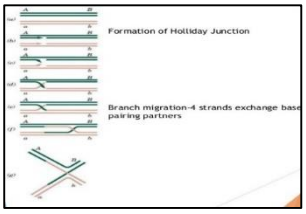

Figure 3 Double strand break Repair

b) Synthesis Dependent Strand Annealing (Sdsa) Pathway:-

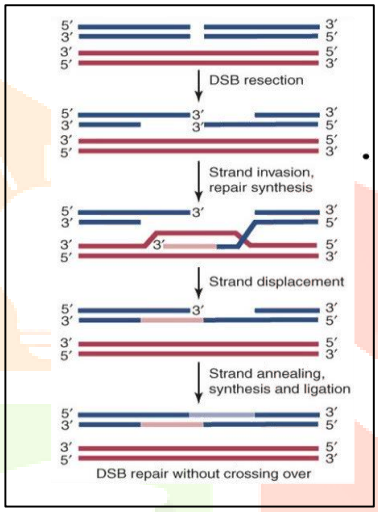

Figure 4 Synthesis dependent strand annealing

2. Non-Homologous or Illigimate: -

Recombination takes place in places where there isn't any obvious large-scale sequence similarity, like translocations across distinct chromosomes or deletions that eliminate many genes along a chromosome. On the other hand, short periods of sequence similarity are occasionally discovered when the DNA sequence at the breakpoints for these events is examined. For example, in somatic cells, recombination between two comparable genes separated by several million base pairs can result in the deletion of the intervening gene.

3. Site Specific Recombination: -

It occurs in between specific short sequences found on a parentral molecule that is otherwise different. DNA molecules can be rearranged by breaking and reconnecting the strands at particular locations, a process known as "site-specific recombination." Two short DNA sequences, known as sites, may be found in separate molecules or inside the same molecule during site-specific recombination.

4. Replicative Recombination or Transposition: -

It can produce a fresh clone of a DNA snippet. Replicative recombination is a method used by many transposable elements. It is now understood that DNA replication and cell viability depend on DNA recombination. Replication can successfully navigate around obstacles like as broken or collapsed replication forks thanks to recombination. It is now possible to identify the signals and regulators that allow cells to switch between the replication and recombination modes.

1.3 Application of Recombination: -

- Recombinant DNA technology enables the development of gene therapy, where defective genes are replaced or supplemented with functional ones to treat genetic disorders such as cystic fibrosis or haemophilia.
- Recombinant DNA technology is utilized in pharmaceuticals to produce therapeutic proteins like insulin, growth hormones, and vaccines in large quantities and with high purity, reducing dependency on scarce natural sources.
- Recombinant DNA technology provides indispensable tools for molecular biology research, including gene cloning, DNA sequencing, and site-directed mutagenesis, enabling the study of gene function and regulation.
- Recombinant DNA technology enables the production of safer and more effective vaccines by incorporating antigen genes into harmless vectors, stimulating immune responses without causing disease.
- Recombinant DNA technology is pivotal in the production of biopharmaceuticals such as monoclonal antibodies and cytokines, which are used in the treatment of various diseases including cancer, autoimmune disorders, and inflammatory conditions.

2. Introduction to Recombinant DNA Technology: -

2.1 Recombinant DNA Technology: -

The separation a target gene—a gene of interest—is the first step in the recombinant technology process. After that, the target gene is put into the vector, such as a plasmid or phage, to create a replicon. The replicon is then inserted into host cells in order to clone them and determine whether or not they express the protein. Recombinant DNA is the term used to describe the cloned replicon. It is known as Recombinant DNA Technology.

2.2 Six Steps of Recombinant DNA: -

1) Isolation (Target Gene & Vector)
2) Cutting (Clevage)
3) Joining (Ligation)
4) Transforming
5) Cloning
6) Selecting (Screening)

3. Introduction to Viral Vector: -

3.1 Viral Vector: -

A virus which has been modified in a controlled environment in order to deliver genetic material into a cell is called a viral vector. The gene in the virus that causes sickness is removed in order for a viral vector to arise. then swaps out those genes for ones that encode the desired outcome (in diabetics' case, the generation of insulin).

A viral vector is a genetically modified virus used to deliver specific genes into cells for various purposes, such as gene therapy or vaccine development.

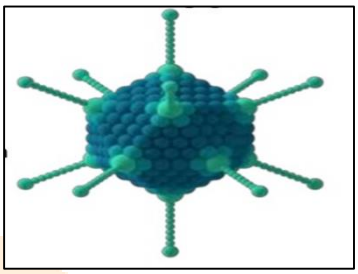

Figure 5 Viral Vector

3.2 Properties of Viral Vector: -

- Viral vectors possess the ability to efficiently infect target cells, facilitating the delivery of genetic material into the host genome.
- Viral vectors have a limited capacity for carrying foreign DNA, which may restrict the size of the gene or genes that can be inserted.
- Viral vector are often given certain gene that help identify which cell took up the viral gene. These gene are called markers.
- Viral vectors should maintain stability and integrity during production, storage, and delivery to ensure their effectiveness in delivering genetic material to target cells.

3.3 Types of Viral Vector: -

1. **DNA Viral Vector: -**
   - **A. Adenoviral vector**
   - **B. Adeno – Associated Viral vector**
2. **RNA Viral Vector: -**
   - **A. Retroviral vector**
   - **B. Lentiviral vector**

1. **DNA Viral vector: -**
   - **A. Adenoviral vector: -**

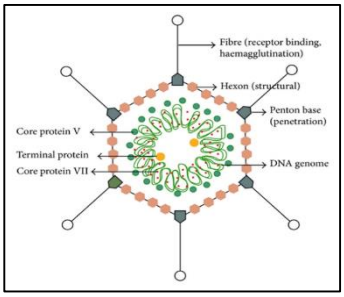

Figure 6 Adenoviral Vector

- **Characteristics: -** Adenoviral vectors are derived from adenoviruses, which are non-enveloped viruses with a double-stranded DNA genome. They have a high transduction efficiency and can infect both dividing and non-dividing cells.
- **Advantages: -** Adenoviral vectors can accommodate large DNA inserts, making them suitable for delivering large genes or multiple genes. They typically induce strong immune responses, which can be advantageous for vaccine development.
- **Limitation:** - Adenoviral vectors are associated with transient gene expression due to their immunogenicity. Pre-existing immunity to adenoviruses in the host population can also limit their effectiveness.

B. Adeno – Associated Viral vector: -

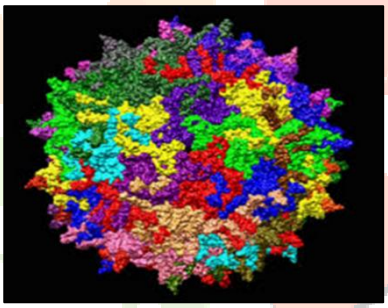

Figure 7 Adeno- Associated Viral vector

- **Characteristics: -** Adeno-associated viral vectors are derived from adeno-associated viruses, which are small, non-pathogenic viruses with a single-stranded DNA genome. AAVs can infect both dividing and non-dividing cells and establish long-term transgene expression.
- **Advantages:** - AAV vectors have low immunogenicity and are capable of mediating long-term gene expression in target cells, making them ideal for gene therapy applications. They have a broad tropism and can transduce a wide range of cell types and tissues.
- **Limitation:** - AAV vectors have a limited packaging capacity, restricting the size of the gene that can be delivered. Pre-existing immunity to AAV in the host population may reduce transduction efficiency.

2. **RNA Viral Vector: -**

A. Retroviral vector: -

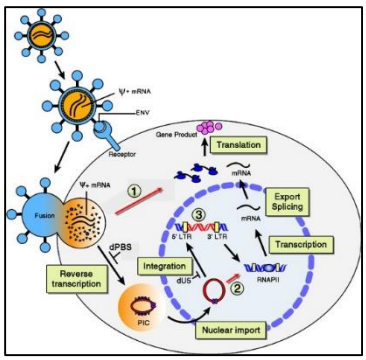

Figure 8 Retroviral vector

- **Characteristics: -** Retroviral vectors are derived from retroviruses, which are enveloped viruses with a single-stranded RNA genome. They integrate their genetic material into the host genome, leading to stable, long-term transgene expression.
- **Advantages:** - Retroviral vectors offer efficient integration of the transgene into the host genome, leading to sustained gene expression in dividing cells. They have a broad tropism and can infect a variety of cell types.
- **Limitations:** - Retroviral vectors are less effective at transducing non-dividing cells. They may also pose a risk of insertional mutagenesis, where the integration of the viral vector into the host genome disrupts normal gene function.

B. Lentiviral Vector: -

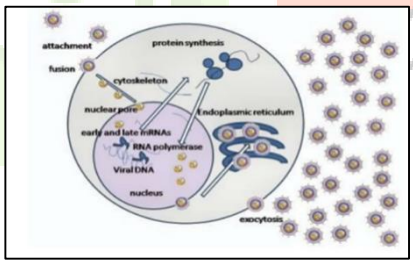

Figure 9 Lentiviral Vector

- **Characteristics:** - Lentiviral vectors are derived from lentiviruses, which are a subgroup of retroviruses. Lentiviruses can infect both dividing and non-dividing cells and integrate their genetic material into the host genome.
- **Advantages: -** Lentiviral vectors have a large packaging capacity and can accommodate large genes or multiple genes. They offer efficient transduction of a wide range of cell types, including stem cells and neurons.
- **Limitation:** - Lentiviral vectors may pose a risk of insertional mutagenesis, similar to retroviral vectors. They also require specialized biosafety precautions due to their potential to integrate into the host genome.

3.4 Application of viral vector: -

1. Gene Therapy: -

- **Treatment of Genetic disorder: -** Viral vectors are extensively used in gene therapy to treat genetic disorders caused by mutations in specific genes. They can deliver functional copies of the defective gene to target cells, correcting the underlying genetic defect.
- **Cancer Therapy:** - Viral vectors are also being investigated as a tool for cancer therapy. They can be engineered to selectively target and destroy cancer cells or to deliver therapeutic genes that inhibit Tumor growth or enhance the immune response against cancer.

2 Vaccine development: -

- **Viral vector vaccine: -** Viral vectors are used to develop vaccines against infectious diseases by delivering genetic material encoding antigens from the target pathogen. The vector acts as a delivery vehicle to stimulate the immune system to produce an immune response against the antigen, conferring immunity against the pathogen.
- **Cancer Vaccine: -** Viral vectors are being investigated for the development of therapeutic cancer vaccines. These vaccines aim to stimulate the immune system to recognize and attack cancer cells by delivering tumor-specific antigens via viral vectors.

Conclusion: -

Viral vectors stand as indispensable tools in recombinant DNA technology, facilitating precise gene delivery and manipulation in diverse applications. From gene therapy to vaccine development and basic research, their versatility and efficiency have revolutionized biomedical science. Despite challenges such as immunogenicity and vector limitations, ongoing advancements in vector design promise to further enhance their safety and efficacy.

References: -

1) Khan, S., Ullah, M. W., Siddique, R., Nabi, G., Manan, S., Yousaf, M., & Hou, H. (2016). Role of recombinant DNA technology to improve life. *International journal of genomics*, *2016*.
2) Al-Shami, A. S., & Jha, D. K. A Review On Recombinant DNA Technology: Importance And Progress.
3) Low, K. B. (1988). Genetic recombination: a brief overview. *The recombination of genetic material*, 1.
4) San Filippo, J., Sung, P., & Klein, H. (2008). Mechanism of eukaryotic homologous recombination. *Annu. Rev. Biochem.*, *77*, 229-257.
5) Heyer, W. D., & Kanaar, R. (2004). Recombination mechanisms: Fortieth anniversary meeting of the holliday model. *Molecular cell*, *16*(1), 1-9.
6) Mohammadzadeh, S., Ahmadifar, E., Masoudi, E., Milla, S., Nahed, A., Alagawany, M., ... & Dhama, K. (2022). Applications of recombinant proteins in aquaculture. *Aquaculture*, *561*, 738701.
7) Shinde, S. A., Chavhan, S. A., Sapkal, S. B., & Shrikhande, V. N. (2018). Recombinant DNA technology and its applications: A review. *International Journal of MediPharm Research*, *4*(2), 79-88.
8) Emery, A. E. (1984). *An introduction to recombinant DNA*. Taylor & Francis.
9) Manogaran, P., & Marimuthu, C. Recombinant Dna Technology And Its Applications.
10) Ghosh, S., Brown, A. M., Jenkins, C., & Campbell, K. (2020). Viral vector systems for gene therapy: a comprehensive literature review of progress and biosafety challenges. *Applied Biosafety*, *25*(1), 7-18.
11) Zhao, Z., Anselmo, A. C., & Mitragotri, S. (2022). Viral vector-based gene therapies in the clinic. *Bioengineering & translational medicine*, *7*(1), e10258.
12) Li, X., Le, Y., Zhang, Z., Nian, X., Liu, B., & Yang, X. (2023). Viral Vector-Based Gene Therapy. *International Journal of Molecular Sciences*, *24*(9), 7736.
13) Warnock, J. N., Daigre, C., & Al-Rubeai, M. (2011). Introduction to viral vectors. *Viral vectors for gene therapy: methods and protocols*, 1-25.
14) SM Wold, W., & Toth, K. (2013). Adenovirus vectors for gene therapy, vaccination and cancer gene therapy. *Current gene therapy*, *13*(6), 421-433.
15) Lee, C. S., Bishop, E. S., Zhang, R., Yu, X., Farina, E. M., Yan, S., ... & He, T. C. (2017). Adenovirus-mediated gene delivery: potential applications for gene and cell-based therapies in the new era of personalized medicine. Genes Dis. 2017; 4: 43–63. *J. GENDIS*, *1*.
16) Naso, M. F., Tomkowicz, B., Perry III, W. L., & Strohl, W. R. (2017). Adeno-associated virus (AAV) as a vector for gene therapy. *BioDrugs*, *31*(4), 317-334.
17) Li, C., & Samulski, R. J. (2020). Engineering adeno-associated virus vectors for gene therapy. *Nature Reviews Genetics*, *21*(4), 255-272.
18) Miller, A. D. (1992). Retroviral vectors. *Viral expression vectors*, 1-24.
19) Cepko, C. (1988). Retrovirus vectors and their applications in neurobiology. *Neuron*, *1*(5), 345-353.
20) Dong, W., & Kantor, B. (2021). Lentiviral vectors for delivery of gene-editing systems based on CRISPR/Cas: current state and perspectives. *Viruses*, *13*(7), 1288.