Applications of Crispr/ Cas 9 System

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Key Points

- Innovative genome editing technologies allow alteration in genetic sequences
- CRISPR-Cas System has become a powerful tool to manipulate genes with the help of RNA guided DNA recognition
- Extremely useful technology for agriculture and crops, curing genetic diseases, and engineering useful genetic traits, etc.
- CRISPR is considered to be the most disruptive technology in genetics since the discovery of PCR

Technologies for genetic sequencing and gene alteration have been developed more recently. Not only can these technologies be used to alter the genetic code of plants or animals, but its use extends to the human realm as well. Such innovative genome editing technologies allow alteration in genetic sequences with a greater accuracy and precision. Among these technologies are: zinc-finger nucleases (ZFNs), transcriptional activator-like effector nucleases(TALENS), and the most effective is the clustered regularly inter-spaced short palindromic repeats(CRISPR)-associated nucleases(CAS).[1] The CRISPR technology is more efficient, cheaper and user-friendly as compared to other genome sequencing and editing technologies. The CRISPR-Cas System has become a powerful tool to manipulate genes with the help of RNA guided DNA recognition.[2] A small guide RNA or gRNA helps the protein Cas reach to a targeted locus and bind with it to form a double-strand break. The Cas 9 cuts the strands of DNA at a specific sequence point and removes a small piece, creating a certain gap which can be filledby adding a new DNA segment. It is an extremely useful technology for agriculture and crops, curing genetic diseases, and engineering useful genetic traits, as well as new applications like live cell imaging, high-throughput functional genomic screens, transcriptional regulation, epigenome modification, gene-drive, and point-of-care diagnostic.[3] CRISPR is considered to be the most disruptive technology in genetics since the discovery of PCR (Polymerase Chain Reaction), a technique useful in producing a large number of copies of selected DNA parts or RNA for analysis. The pioneers of this technology, Emmanuelle Charpentier and Jennifer Doudna share the Nobel Prize in Chemistry of 2020, for creating this genome-editing technology.[4]

Applications of CRISPR-Cas9 for genome engineering

Advances in genome engineering technologies based on the CRISPR associated RNA guided endonuclease Cas9 are enabling the systematic interrogation of mammalian genome function. Analogous to the search function in modern word processors, Cas9 can be guided to specific locations within complex genomes by a short RNA search string. Using this system, DNA sequences within the endogenous genome and their functional outputs are now easily edited or modulated in virtually any organism of choice. Cas9-mediated genetic perturbation is simple and scalable, empowering researchers to elucidate the functional organization of the genome at the systems level and establish causal linkages between genetic variations and biological phenotypes. In this Review, we describe the development and applications of Cas9 for a variety of research or translational applications while highlighting challenges as well as future directions. Derived from a remarkable microbial defense system, Cas9 is driving innovative applications from basic biology to biotechnology and medicine.[5]

Applications of CRISPR-Cas 9 in microorganisms

Bacteria and archaea possess a range of defense mechanisms to combat plasmids and viral infections. Unique among these are the CRISPR-Cas (clustered regularly interspaced short palindromic repeats-CRISPR associated) systems, which provide adaptive immunity against foreign nucleic acids. CRISPR systems function by acquiring genetic records of invaders to facilitate robust interference upon reinfection.[6]

Applications of CRISPR–Cas in agriculture and plant biotechnology

Prokaryote-derived CRISPR–Cas genome editing technology has altered plant molecular biology beyond all expectations. Characterized by robustness and high target specificity and programmability, CRISPR–Cas allows precise genetic manipulation of crop species, which provides the opportunity to create germplasms with beneficial traits and to develop novel, more sustainable agricultural systems. Furthermore, the numerous emerging biotechnologies based on CRISPR–Cas platforms have expanded the toolbox of fundamental research and plant synthetic biology.[7]

Applications of CRISPR as a potential therapeutic

Genetic disorders and congenital abnormalities are present in 2-5% of births all over the world and can cause up to 50% of all early childhood deaths. The establishment of sophisticated and controlled techniques for customizing DNA manipulation is significant for the therapeutic role in such disorders and further research on them. One such technique is CRISPR that is significant towards optimizing genome editing and therapies, metabolic fluxes as well as artificial genetic systems. CRISPR-Cas9 is a molecular appliance that is applied in the areas of genetic and protein engineering. The CRISPR-CAS system is an integral element of prokaryotic adaptive immunity that allows prokaryotic cells to identify and kill any foreign DNA. The Gene editing property of CRISPR finds various applications like diagnostics and therapeutics in cancer, neurodegenerative disorders, genetic diseases, and blindness.[8]

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