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Gene Silencing

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Gene silencing is the regulation of gene expression in a cell to prevent the expression of a certain gene. Gene silencing can occur during either transcription or translation and is often used in research.

Gene silencing verses gene knockdown

Gene silencing is often considered the same as gene knockdown. When genes are silenced, their expression is reduced. In contrast, when genes are knocked out, they are completely erased from the organism's genome and, thus, have no expression. Gene silencing is considered a gene knockdown mechanism since the methods used to silence genes, such as RNAi, CRISPR, or siRNA, generally reduce the expression of a gene by at least 70% but do not completely eliminate it.

Types of Gene Silencing

1. Transcriptional

Transcriptional gene silencing (TGS), which involves decreased RNA synthesis because of promoter methylation, and posttranscriptional gene silencing (PTGS), which involves sequence-specific RNA degradation.

- **Genomic Imprinting:** Genomic imprinting is an epigenetic phenomenon that causes genes to be expressed in a parent-of-origin-specific manner. Forms of genomic imprinting have been demonstrated in fungi, plants and animals. As of 2014, there are about 150 imprinted genes known in the mouse and about half that in humans. Genomic imprinting is an inheritance process independent of the classical Mendelian inheritance. It is an epigenetic process that involves DNA methylation and histone methylation without altering the genetic sequence.
- **RNA-directed DNA methylation:** RNA-directed DNA methylation (RdDM) is an epigenetic process first discovered in plants. During RdDM, double-stranded RNAs (dsRNAs) are processed to 21-24 nucleotide small interfering RNAs (siRNAs) and guide methylation of homologous DNA loci.

2. **Post-transcriptional** The principal common feature of all the PTGS phenomena is that they lead to a specific decrease in the level of the mRNA of both the homologous host gene and the introduced transgenes. In fact, most of the PTGS phenomena were identified by the characteristic loss of function of the endogenous gene. In plants, for example, introduction of a chalcone synthase transgene or a dihydroflavonol-4-reductase transgene produces plants with reduced/lack of floral pigmentation.

- **RNA interference:** RNA interference (RNAi) is a biological process in which RNA molecules inhibit gene expression or translation, by neutralizing

targeted mRNA molecules. Historically, it was known by other names, including co-suppression, post-transcriptional gene silencing (PTGS), and quelling.

Applications of Gene Silencing Technologies in Plants

1. **Crown gall:** Gene silencing has been used to interrupt the process of tumor formation in crown gall disease. Crown gall disease is a tumor disease caused by a bacterium *Agrobacterium tumefaciens* which have the ability to transfer its own DNA into the DNA of the plant it infects and directs the plant to produce the proteins that trigger tumor formation as a response to certain chemicals released from the wound.
2. **Viral infection**: Greater than 90% of all plant viruses are RNA viruses that replicate through a dsRNA intermediate. So, RNA interference in plants has evolved, in part, as a means for protection against viral infection and retrotransposon proliferation. Gene silencing can be used to introduce virus resistance into plants via inserting a piece of a DNA that has been modified to include one small fragment of a virus into a plant. This then effectively vaccinates the plant
3. **Disease resistant root stocks:** Gene-silencing techniques have been used to produce disease resistant root stocks for growing non-transgenic crops. The root stocks would carry the disease resistance traits introduced through gene silencing.
4. **Post Transcriptional Gene Silencing (PTGS):** Over a decade, PTGS have been used commercially to develop plants with resistance to viral infections. Among them were the transgenic papayas (***Carica papaya***) with resistance to Papaya rings pot virus and the Monsanto-produced New Leaf Plus and New Leaf Y potatoes (*Solanum tuberosum*) with resistance to Potato leaf roll virus and PVY.

Advantages and Limitations of Gene Silencing Technologies

Advantages:

- This method could be effective against a broad spectrum of a pathogen's species and have implication for the control of other plant parasites and pathogens.
- It is reliable, reduce labor, lower expenses, easy, increase cropping choices and eliminate the need for chemicals that may be harmful to the environment.
- It could be used for functional analysis of plant genes through loss-of-function of genes.
- It generates rapid phenotype that plant transformation is not needed (Lu *et al*., 2003).

Limitations:

- Complete loss-of-function by VIGS might not be achieved. Generally, 75-90% down regulation in the expression level of the targeted gene is accomplished.
- Since, the system relies on sequence information, it can only be used for specific gene silencing if only the sequence information is known
- VIGS might suppress non-targeted gene in silenced plant cell or tissue

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