

Genetics Notes: Chapter 15

15.1-The Discovery of Transposable Elements in Maize

- In a study of **maize** researcher Barbara McClintok realized that chromosome number 9 frequently broke in the same location.
- Two genetic elements were necessary for this breakage to occur **Ds (dissociation)** a factor located at the break site and **Ac (activator)** an unlinked gene that's presence was needed for the break to occur.
- She discovered that it was impossible to map a singular gene locus for these elements and so termed them **mobile genetic elements**.
- Speckled corn grains displayed the ability of these mobile elements to change phenotype causing an **unstable phenotype**.
- Ds element has the ability to deactivate a C color gene by inserting itself into its coding region causing colorless cells.
- Ac activates Ds to leave the cell (**transposing it**) causing a restoration of gene function and color to the kernel's cells.
- Sometime Ac itself inserts itself into the coding region leading to an always unstable phenotype.
- Ac can transform into a Ds element, Ds is a mutated version of Ac.
- Elements like Ac that require no other elements to be mobile are called **autonomous elements**.
- Elements like Ds require another element for their mobility and are termed **nonautonomous elements**.

15.2-Transposable Elements in Prokaryotes

- Two broad types of **transposable elements** in prokaryotes:
 - **IS elements** which can move themselves to different positions but don't carry any other genes other than those used for movement.
 - **Transposons**, are longer carry both the genes necessary for their movement and other genes as well.
- **Insertional Sequence (IS) elements** can move from one gene locus to another. By landing in a coding sequence they can interrupt gene expression, and by landing in any part of an operon it can affect the expression of all downstream genes.
- All IS elements encode for the **enzyme transposase** which enables the movement of IS elements.
- IS elements begin and end with **short inverted repeat sequences** required for mobility.
- Resistance to antibiotics is conferred to **R plasmids** through transposons.
- Two types of transposons:
 - **Composite transposons**-Have two identical IS elements on either end oriented in the opposite direction. One of the elements encodes transposase. Genes are located in between these two elements. IS elements cannot move independently, need the entirety of the transposon.
 - **Simple transposons**-bacterial genes flanked by short IS elements but these elements do not encode transposase. Instead the transposase region is in between the IS elements.
- Transposase (enzyme) moves the transposable element through two different methods:

- **Replicative**-A new copy of the transposable element is generated resulting in one copy at the new site and one copy that remains at the old site. The information of the old copy is transferred to the new site and new copy through a recombination-like process called cointegration.
- **Conservative**-No replication occurs, the element is excised from the DNA and is integrated into a new site also called "cut and paste".
- In insertion, transposase makes **staggered cuts** into the DNAs target site.
- These staggered cuts cause an overhang which is filled by the DNA machinery of the host DNA.
- These sites of the former overhang are called **target-site duplication** and are flanked by almost every transposable element.

15.3-Transposable Elements in Eukaryotes

- Two classes of transposons in eukaryotes:
 - **Retrotransposons**-Are "retrovirus-like" transposable elements that are transcribed into mRNA, processed, and then go through a process of reverse transcription which converts the mRNA back into DNA which is then integrated into a new site. They are known as **class 1 transposable elements**.
 - **Long Terminal repeats** at the ends of certain retrotransposons term another class called **LTR-retrotransposons** transpose through a "**copy and paste**" mechanism.
 - **DNA transposons-Class 2 Elements** that transpose by integrating itself or a copy of itself (DNA to DNA without RNA intermediate).
 - An example of these are **P elements** which are similar to bacterial transposable elements in that they have short inverted repeating sequences at either end and that the only gene it carries encodes transposase.
 - **Hybrid dysgenesis** in drosophila was studied in that females from lab stocks were of **M cytotype** and males from natural populations were **P cytotype**. When mated they produced sterile offspring.
 - The opposite mating produces flies that are normal.
 - P elements are more common in P cytotypes but are repressed and silenced in P cytotypes. However when transposed into M cytotypes the P elements disrupt normal gene function.
 - Laboratory strains seem to have evolved to **lose** their P elements.
 - Sterile offspring only occur when female M cytotype is mated with male P cytotype because females contribute the most cytoplasm without P elements to the zygote.
- P elements inserted at random can create mutant phenotypes. This mutated gene can be tagged, isolated, and cloned in order to determine wild type function.
- P elements can be used to introduce transgenes.

15.4 More Transposable Elements than Previously Imagined

- It was discovered that DNA content had little to do with the complexity of the organisms (**C-Value Paradox**).

- The majority of these large eukaryotic genomes are made up of repetitive sequences derived from transposable elements.
- About half of the human genome is derived from transposable elements.
- The vast majority of these transposable elements are retrotransposons:
 - **Long Interspersed Elements LINEs**-encode their own reverse transcriptase but lack some of the other structural features that “retrovirus-like” retrotransposons have (see above for description)
 - **Short Interspersed Elements SINEs**-Have structural features of LINEs but are nonautonomous because they do not encode a reverse transcriptase. Can be moved by other reverse transcriptase enzymes encoded for in LINEs. Most abundant SINE is the Alu it contains a target site for an Alu restriction enzyme.
- DNA is not damaged by the majority of these transposons because the majority of them fall within introns and so are spliced out.
- Those that fell into exons probably caused deleterious mutations and were negatively selected against in natural selection and so did not pass on their genes.
- The vast majority of these transposons are inactivated or immobile.
- It is thought that many transposons have survived through time by inserting themselves into safe havens, places where they will do no harm to their hosts. In most organisms these safe havens are often within other retrotransposons or within highly heterochromatic areas.
- Some transposons are able to target where they insert themselves in order to ensure that they are not harming their host and that they will not be selected against.

15.5-Epigenetic Regulation of Transposable Elements by the Host

- RNA interference can repress transposable element transcription by transcribing the element into dsRNA which activates a dicer and RISC complex that chop up any RNAs produced from these genes.