Al-Farabi Kazakh National University (KazNU)

Faculty of Biology and Biotechnology

DISCIPLINE: «Modern Problems of Plant Genetics»

Lecture 5

Genetic Resources, Chromosome Engineering, and Crop Improvement.

Amirova Aigul Kuzembayevna

Associate Professor
Candidate of Biological Science

***Purpose of the lesson*:**
Acquaintance with application of *Genetic Resources, Chromosome Engineering, and Crop Improvement*.
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Plan of the lesson:

1. **Genetic Resources,**
2. **Chromosome Engineering**
3. **Crop Improvement**

- **Genetic resources**

- **Genetic resources are genetic material of actual or potential value, where genetic material means any material of plant, animal, microbial or other origin containing functional units of heredity.**

- **Genetic resources is one of the three levels of biodiversity defined by the Convention on Biological Diversity in Rio, 1992**

- **Plant genetic resources**

- **Plant genetic resources describe the variability within plants that comes from human and natural selection over millennia. Their intrinsic value mainly concerns agricultural crops (crop biodiversity).**

- **According to the 1983 revised International Undertaking on Plant Genetic Resources for Food and Agriculture of the Food and Agriculture Organization (FAO), plant genetic resources are defined as the entire generative and vegetative reproductive material of species with economical and/or social value, especially for the agriculture of the present and the future, with special emphasis on nutritional plants.**

- **Plant genetic resources**

- **In the State of the World's Plant Genetic Resources for Food and Agriculture (1998) the FAO defined Plant Genetic Resources for Food and Agriculture (PGRFA) as the diversity of genetic material contained in traditional varieties and modern cultivars as well as crop wild relatives and other wild plant species that can be used now or in the future for food and agriculture.**

- History

- The first use of plant genetic resources dates to more than 10,000 years ago, when farmers selected from the genetic variation they found in wild plants to develop their crops.

- As human populations moved to different climates and ecosystems, taking the crops with them, the crops adapted to the new environments, developing, for example, genetic traits providing tolerance to conditions such as drought, water logging, frost and extreme heat. These traits - and the plasticity inherent in having wide genetic variability - are important properties of plant genetic resources.

- **History**

- **In recent centuries, although humans had been prolific in collecting exotic flora from all corners of the globe to fill their gardens, it wasn't until the early 20th century that the widespread and organized collection of plant genetic resources for agricultural use began in earnest.**

- **Russian geneticist Nikolai Vavilov, considered by some as the father of plant genetic resources, realized the value of genetic variability for breeding and collected thousands of seeds during his extensive travels to establish one of the first gene banks.**

- **History**

- **Vavilov inspired the American Jack Harlan to collect seeds from across the globe for the United States Department of Agriculture (USDA).**
- **David Fairchild, another botanist at USDA, successfully introduced many important crops (e.g. cherries, soybeans, pistachios) into the United States.**

- **It wasn't until 1967 that the term genetic resources was coined by Otto Frankel and Erna Bennett at the historic International Conference on Crop Plant Exploration and Conservation, organized by the FAO and the International Biological Program (IBP).**

- **History**

- ***“The effective utilization of genetic resources requires that they are adequately classified and evaluated”*** **was a key message from the conference.**

- **Conservation**

- **Plant genetic resource conservation has become increasingly important as more plants have become threatened or rare.**
- **At the same time, an exploding world population and rapid climate change have led humans to seek new resilient and nutritious crops.**

- **Conservation**

- **Plant conservation strategies generally combine elements of conservation on farm (as part of the crop production cycle, where it continues to evolve and support farmer needs), *ex situ* (for example in gene banks or field collections as seed or tissue samples) or *in situ* (where they grow in the wild or protected areas).**

- **Most *in situ* conservation concerns crop wild relatives, an important source of genetic variation to crop breeding programs.**

- Conservation

- Plant genetic resources that are conserved by any of these methods are often referred to as germplasm, which is a shorthand term meaning "any genetic materials".

- The term originates from germ plasm, August Weismann's theory that heritable information is transmitted only by germ cells, and which has been superseded by modern insights on inheritance, including epigenetics and non-nuclear DNA.

- Conservation

- After the Second World War, efforts to conserve plant genetic resources came mainly from breeders' organizations in the USA and Europe, which led to crop-specific collections primarily located in developed countries (e.g. IRRI, CIMMYT).

- In the 1960s and 1970s, more focus was put on the collection and conservation of plant genetic resources in face of genetic erosion by organizations such as the Rockefeller Foundation and the European Society of Breeding Research (EUCARPIA).

- Conservation

- A key event in the conservation of plant genetic resources was the establishment of the International Board for Plant Genetic Resources (IBPGR) (now Bioversity International) in 1974, whose mandate was to promote and assist in the worldwide effort to collect and conserve the plant germplasm needed for future research and production.

- IBPGR mobilized scientists to create a global network of gene banks, thus marking the international recognition of the importance of plant genetic resources.

- Conservation

- In 2002, the Global Crop Diversity Trust was established by Bioversity International on behalf of the CGIAR and the FAO through a Crop Diversity Endowment Fund.

- The goal of the Trust is to provide a secure and sustainable source of funding for the world's most important ex situ crop collections.

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- **Chromosome engineering**

- **The manipulation of whole chromosomes or parts of them is called chromosome engineering.**

- **Methods of chromosome engineering makes it possible to replace one or both homologous chromosomes with others or introduce additional chromosomes into the genotype of an organism.**

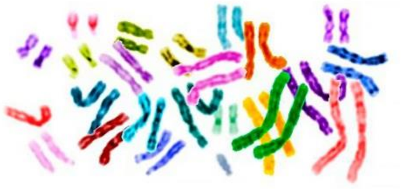
- **Chromosome engineering**

- **Chromosome engineering is "the controlled generation of chromosomal deletions, inversions, or translocations with defined endpoints."**

- **Chromosome engineering**

- **By combining chromosomal translocation, chromosomal inversion, and chromosomal deletion, chromosome engineering has been shown to identify the underlying genes that cause certain diseases in mice.**

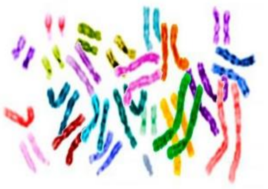
- **In coming years, it is very likely that chromosomal engineering will be able to do the same identification for diseases in humans, as well as all other organisms.**



- **Aneuploids**

- **A collection of aneuploids and substituted soft wheat lines, which is successfully used to localize of genes that determine the adaptive and economically valuable traits.**

- **This research was initiated by the pioneering work of prof. E. Sears, who received aneuploids lines of various chromosomes: complete sets of monosomic, nulli-tetrasomic, tetrasomic, trisomic lines according to the Chinese Spring (CS) variety (Sears, 1954).**



- **Monosomal analysis.**

- **The new cytogenetic methods was developed by Sears E. for the analysis of the genome of soft wheat using various types of aneuploids.**

- **Monosomal analysis has been widely used for chromosomal localization of genes.**

- **Monosomy**

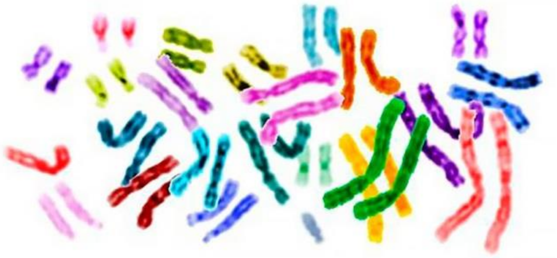
- **Monosomy is a form of aneuploidy with the presence of only one chromosome from a pair. Partial monosomy occurs when a portion of one chromosome in a pair is missing.**
- **Monosomic analysis [from Greek. “monos” - one and only and “soma”- body; from Greek “analysis” is decomposition] - a set of methods of genetic analysis based on the comparison of normal (2n) and monosomal (2n-1) chromosomesof individuals (cells) carrying the analyzed genes.**

- **All alleles are expressed in monosomics, including recessive ones.**

- The localization of genes within the chromosome arm were carried out using of di- and monosomal lines.

- The most significant advances in the localization of genes of soft wheat and other representatives of the tribe Triticeae were achieved using of nulli-tetrasome analysis.

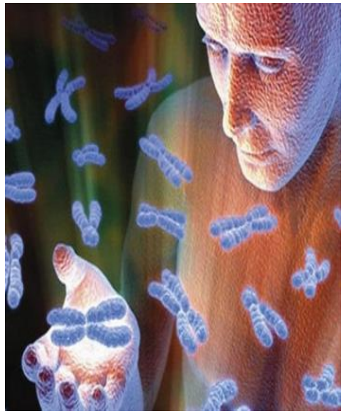
- **Modern molecular genetic maps of wheat were compiled with the participation of nulli-tetrasomic and ditelosomic lines of cultivar Chinese Spring (CS), which are a convenient tool for localizing molecular markers on chromosomes.**

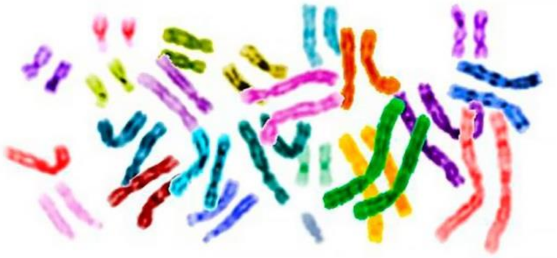


- **Aneuploids**

- **Aneuploids are individuals whose genome lacks a certain number of chromosomes or contains additional ones.**

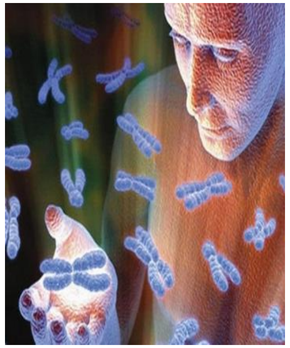
- **If two homologous chromosomes are missing. Such individuals are called nullisomics, one chromosome - monosomics, in the presence of one extra homologous chromosome - trisomics.**



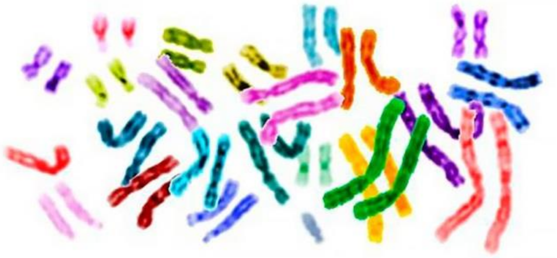


- **Aneuploids**

- **Aneuploid organisms come from gametes with an altered number of chromosomes. Among such aneuploid organisms there may be: tetrasomics, in which one of the chromosomes of the genome is represented four times and the organism has two more chromosomes compared to the diploid - 2n1 * + 2, trisomics - 2n1 * + l, monosomics - 2n1 * -1, nullisomics - 2n1 * -2, while a normal disomic has 2n. (* - number of a homologous pair of chromosomes of the corresponding karyotype).**



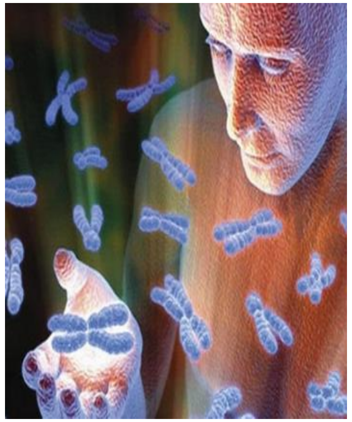
- **Aneuploids**

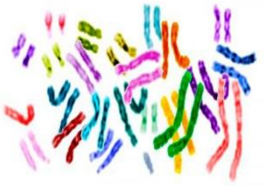


- **It should be noted that an extra chromosome in some homologous pair in karyotype has a less negative effect on the body than its deficiency.**

- **Nullisomic plants can survive extremely rare.**

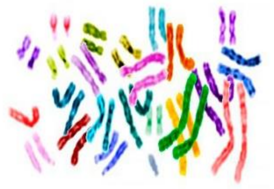
- **All aneuploids are partially or completely sterile.**





- **Nullisomy**

It was possible to show that the gene that controls the red color of grain of wheat is located on the 3D chromosome (the third chromosome of the D genome), since in a nullisomic it is on this chromosome that the grain is white (Maistrenko, 1971).



- **Genetic studies using collections of aneuploid and substituted soft wheat lines indicate the importance of chromosome engineering methods in studying the influence of individual chromosomes on the manifestation of economically valuable traits, localization and mapping of genes.**

- Crop improvement

- Crop improvement, the engineering of plants for the benefit of humanity, is as old as agriculture itself.

- Some 10,000 years ago, primitive people made the transition from hunting and foraging to cultivating crops.

- With that switch began the continuous process of improving the plants on which we depend for food, fiber, and feed.

- **Crop Improvement Methods:**

- **1. Traditional breeding**
- **2. Marker-assisted breeding**
- **3. Transgenic technology**
- **4. Gene Editing**


GOOD LUCK!