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PLAN BREEDING AND EVOLUTION

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I. Introduction

- Population increases
- Food scarcity
- Nutritional deficiency
- Hunger
- Malnutrition
- Limited Space

Improve varieties of Crop plants, Cereals, pulses, jute, cotton, coffee, tea, rubber plants, timber yielding plants.

II. Definition

Plant breeding is the art of improving economically important plants on a scientific basis.

III. Objectives

1. **High yield** of grains, fooder, fibre, oil & other plant products
2. **Better quality:** It regards to shape, size, colour, nutrition, taste, malting, milling, baking, keeping, cooking etc in food grains, vegetables, fruit & flower.

3. **Resistance:** to disease, insects, pests, flood, drought, wind storm, alkaline & saline condition of soil.
4. **Change in duration:** of plants. It specially earliness (or) Lateness in Maturity as needed.
5. **Change in growth habits:** Such as dwarfness, few branching, less tillering, Tallness.
6. **Adaptability:** to wide regions.
7. **Suitability:** To machine harvesting in mechanized areas.

METHODS OF BREEDING CROP PLANTS

1. Plant Introduction

The process of introducing the plants from their growing place to a new locality with different climate is termed as **plant introduction.**

Both new crops as well as new varieties of crops may be introduced either in the forms of seeds (or) cuttings. In vegetatively propagated crops the cuttings are imported and in sexually propagated crops the seeds are imported. The crops may be introduced a locality either from outside the country (or) from different regions within the country. Introduction of plants from a foreign country is called **Exotic** collection.

Introduction of plants from one state to another is called **indigenous collection.**

Eg: 1. Sonara 64 - Semi dwarf wheat varieties introduced from mexico. 2. Rice varieties - IR8, IR21, IR36, introduced from IRRI (International Rice research institute, Philippines).

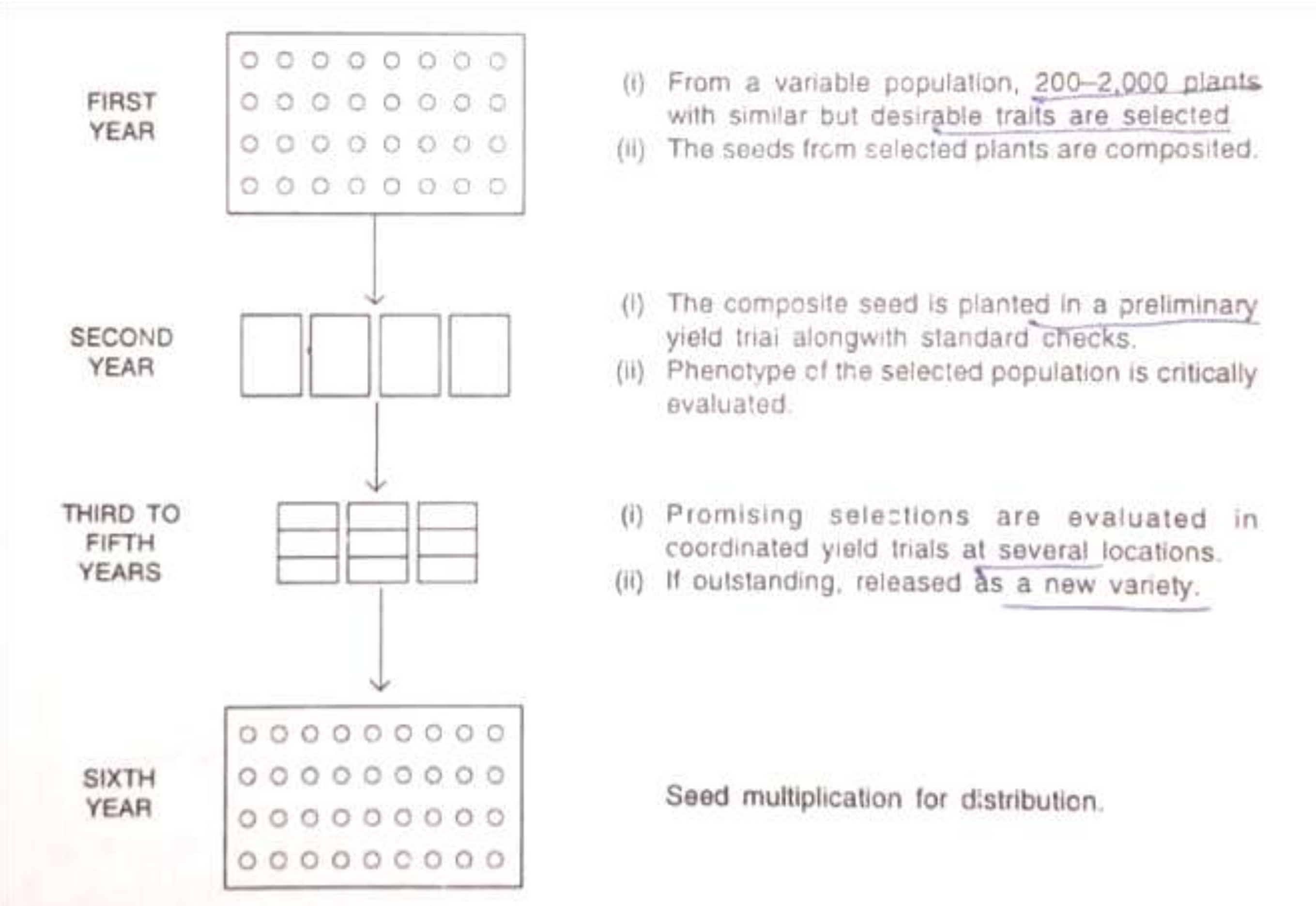
2. Selection

It is one of the oldest method of plant improvement (or) breeding procedure. Either it may be natural (or)artificial, by which individual plants on groups of plants the sorted out from mixed population. The efficiency of selection of dependent upon the presence of genetic variability.

Two methods of selection are practiced in breeding new varieties of self-pollinated crops. (i) Mass Selection (ii) Pureline Selection.

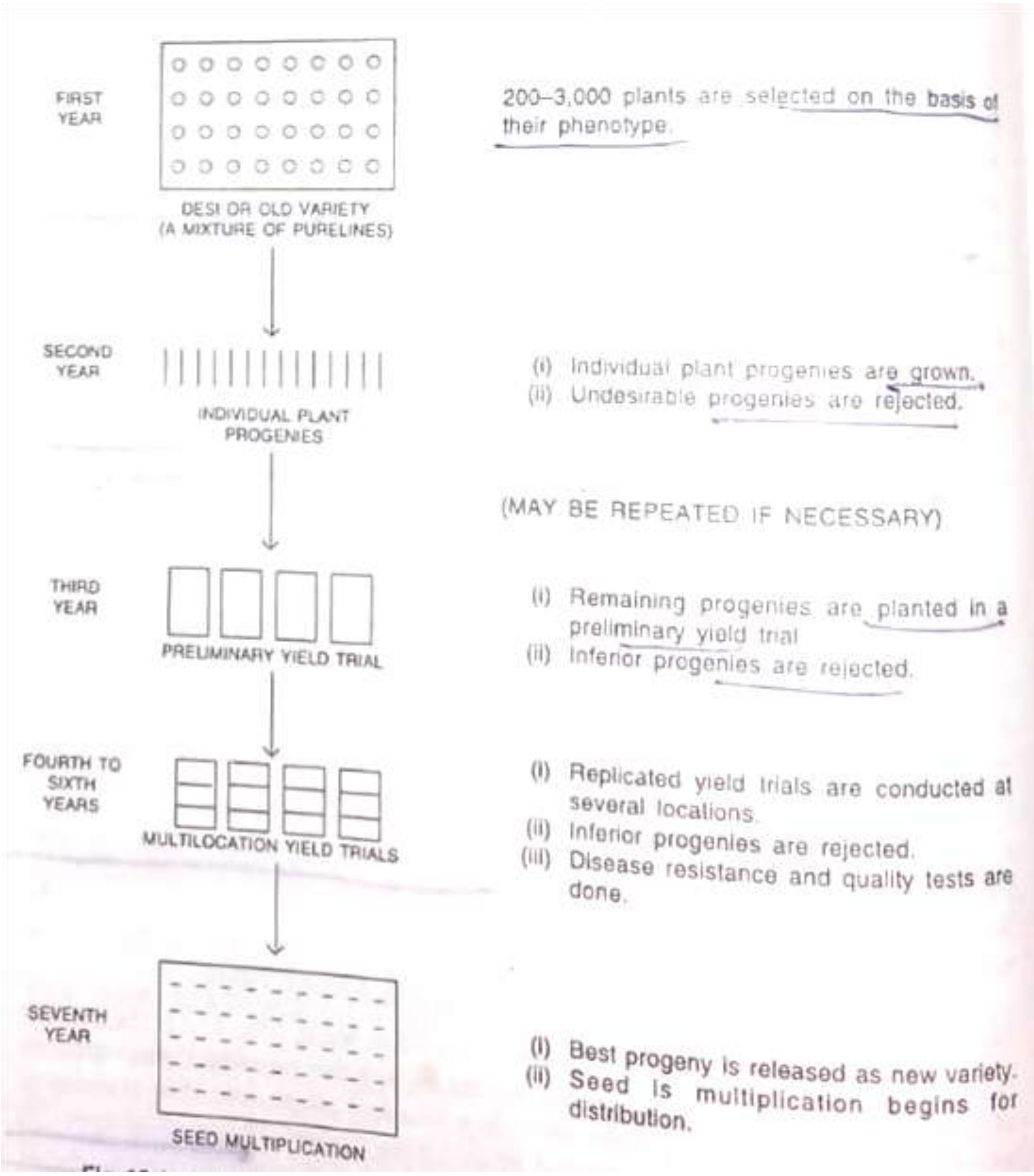
(i). Mass selection

Mass selection in self-pollinated crops as used to develop new varieties.
For maintaining the purify of pureline varieties, operations of the first year may be repeated every year of after few years.



(ii) Pure Line Selection

Schematic representation of pureline selection in self-pollinated crops



3. Hybridization

Hybridization is the method of producing new crop varieties in which two (or) more plants of unlike genetically constitution are crossed together. The plants which are crossed together may be belong to the same species (or) different species (or) different genera.

Definition

The mating or crossing of two plants or lines of dissimilar genotype is called hybridization. The seeds as well as the progeny resulting from the hybridization are called hybrid of F_1.

Objectives of hybridization

1. Transgressive breeding
2. Combination breeding
3. Hybrid Varieties

i. Transgressive breeding

It aims at improving yield of crops

ii. Combination breeding

Transfer of one or more traits into a single strain from another strain.

iii. Hybrid varieties

F_1 can be utilised directly as a strain, such a variety is known as hybrid variety.

Types of hybridization

Based on the taxonomic relationship of the parents, hybridization can be classified into two broad categories.

(i) Intervarietal hybridization

In this hybridization, the parents belong to the same species.

Intervarietal crosses can be simple or complex depending upon the number of parents involved.

(a) Simple cross

Two parents are crossed to produce the F_1

A X B

↓

F1 (A x B)

(b) Complex cross

More than two parents are crossed to produce the hybrid.

A X B

↓

F1 (AXB) XC

↓

Complex hybrid [(A X B) X C]

(ii) Distant hybridization

Distant hybridization consists of crosses between different species of the same genus or of different genera.

Intergeneric hybridization

When the species belong to two different genera, it is called intergenic hybridization. eg. Triticum turgidum X Secale Cereale → Triticale.

Interspecific hybridization

When two species of the same genus are crossed it is called interspecific hybrdization.

(eg.) Avena Sativa x Avena byzantina → Clinton oat varieties

Hybridization techniques

1. Choice of the parents
2. Evaluation of the parents
3. Emasculation
4. Pollination
5. Bagging
6. Tagging
7. Harvesting & Storage of F_1 Seeds

1. Choice of the parents

It depends on objectives of breeding programme (yield, disease resistance).

- One of the parents is well adapted and proven variety in the area.
- Other variety having characters, which is absent in this variety.
- Some parents produce superior F_1 / F_2 whereas others do not.
- This property of parents is called **combing ability.**
- Combining ability serve as useful guide in the selection of parents.
- All the characters to be improved present in one or other parent.
- In this case, complex cross is done.

2. Evaluation of the parents

- If the performance of parents at particular area is known, evaluation not necessary
- If the performance of parents not known, particularly an introduced parent, evaluation necessary.
- Disease resistance is important because introduced parent is susceptible to new races of pathogen or even to disease present in the particular area.
- New species should be checked for heterozygosity.
- To eliminate heterozygosity, self-pollinate the parents one or more generations.

3. Emasculation

Removal of stamens or anther or killing of pollengrains of flower, without affecting anyway the female reproduce organ before anthesis is called emasculation.

<u>An efficient emasculation technique should</u>

- Prevent self-fertilization
- Produce high percentage of seed set on cross-pollination.
- Emasculation is done in evening at 4-6 p.m.
- One day before anther dehiscence.
- Stigma usually receptive at its peak in morning hour.

Various techniques of Emasculation

(a) Hand Emasculation

- In case of large flowers stamens are removed with help of forceps.
- In many species androecium is epipetalous.
- In such case, corolla may be totally removed.

(b) Suction method

- This method is employed for species with small flowers
- The petals are removed completely with forceps.
- Anthers and stigmas are exposed.
- Anthers are sucked from flower using suction pump.
- By using this method, considerable self pollination likely to occur.

Pollens are more sensitive than female reproductive organs both genetic and environmental factors.

Based on this property, various emasculation treatment like hotwater, alcohol treatment and cold water treatment is practiced to kill pollengrains.

(c) Hotwater Emasculation

In this type of emasculation, temperature and duration of treatment vary to crop to crop.

- Jowar —> 42 - 48°C - 10 minutes
- Rice —> 40 - 44°C - 10 minutes
- It is highly effective treatment provided correct temperature and treatment duration.

(d) Alcohol treatment

- It is not commonly used method.
- Immersing flower in suitable concentration of alcohol for brief period.
- Then rinse it with water.
- Better method than suction
- Even slightly prolonged period of treatment greatly reduce seed setting because female reproductive organ is killed by longer treatment.

(e) Coldwater treatment

- Cold is less effective than hot.
- Because self-pollination greater in cold treatment than hot water.
- For wheat, 0-2°C is required for 15 - 24 hour to kill pollen.

(f) Genetic Emasculation

- Many species are **self - incompatible**
- In such cases, emasculation not necessary because self-fertilization not take place.
- Protogyny facilitates crossing without emasculation.
- Stigmas become receptive before anther mature (*Pennisetum americanum*).

4. Pollination

- Emasculation and pollination are two most important operations determine seed set in hybridization.
- Mature, fertile and viable pollen placed on receptive stigma to bring about fertilization.
- Duration of pollen viability differ from species to species.
- Pollination can be done in any one of several ways.
    a. Dusting pollen on stigma of female inflorescence.
    b. Pollen applied to the stigma with camel hair brush, tooth picks or forceps
    c. Spike of male inflorescence is shaken over the emasculated inflorescence.

5. Bagging

1. Immediately after emasculation, flower (or) inflorescence enclosed in a suitable bag of appropriate size to prevent cross pollination.
2. Bags of paper, butter paper are commonly used.
3. Cloth bag permit some degree of chance of cross pollination.
4. Bas are tied to the base of flower with thread.
5. Moisture and temperature is high inside the bag compared to outside
6. Bagging promote fungus development.
7. Fungus development is prevented by removing bags 2-3 days after pollination.

6. Tagging

- Emasculated flower is tagged after bagging.
- Tag is available in different sizes
- Circular - 3 cm dia: Rectangle - 3x2 cm.
- Following information is recorded in the tag by pencil.

(a) Date of emasculation.

(b) Date of pollination

(c) Names of female and male parent

(d) Female parent name - first; male parent name later.

7. Harvesting & storing of F1 seeds

- Crossed heads or pods are harvested & threshed.
- Seeds are dried.
- Protect them from pest during storage.
- Care must be taken to avoid contamination of hybrid seed with other seeds.
- Seed from each cross kept separately along with original tags.

8. Raising F_1 generation

- There are controversies regarding size of F_1.
- Allard (1960) - Even $12F_1$ seeds is enough for breeding programmes.
- Elliot (1958) - F_1 should be as large as possible because opportunity for rare combination occur.
- If F_1 is larger - Hand crossing is tedious & time taking; rare combinations may not be detected to making influence of environment.

(1) Heterosis of Hybrid Vigour

When two homozygous inbreds of genetically unlike constitutions are crossed together, the resulting hybrids obtained from the crossed seeds are usually vigorous, productive, sturdier and taller than either parents. This increased productivity or superiority of than hybrids over the parents is known as **heterosis** or **hybrid vigour** and is defined as follows.

Heterosis or hybrid vigour is the increased vigour, growth, yield or function of a hybrid, over the parents, resulting from the crossing of genetically unlike organisms.

Effects of Hybrid Vigous

Heterosis does not affect an individual as a whole but only its separate parts such as root in carrot; tuber in potato and knol-knol; corn in colocasia; hypocotyl in turnip, beet and radish, leaf in cabbage, spinach and lettuce; flower in cauliflower; fruit in pea, lobia, bhindi, brinjal and cucurbits; kernels in maize, ears in cearals, and the seeds in green peas and Dolichos lablab.

The effects of heterosis in these parts can be expressed in three ways:

(1) Quantitative effects

There is an increase in size and number of quantities characters like yield, fruit, vegetative pars, etc. due to a greater number of cells resulting from a faster cell division and cell activities. This improves the general well-being of an organism similar to that resulting from placing in a more favourable environment.

(2) Biological effects

There is an increase in biological efficiency of an organism such as reproductiveness and survival ability exhibited in economic characters. Some confusion has crept in due to not clear cut distinguishing line between these two different manifestations of heterosis.

(3) Physiological effects

Effects of the heterosis are also manifested in many physiological traits like adaptability, disease and insect resistance, earliness, etc.

All these effects of heterosis can be represented more cat gorily as follows.

1. Greater height, weight, size and number of the different parts of the plant.
2. Increase in yield and growth.
3. Greater fertility and viability
4. More efficient seed germination
5. Longevity, i.e., greater length of life than their parents.

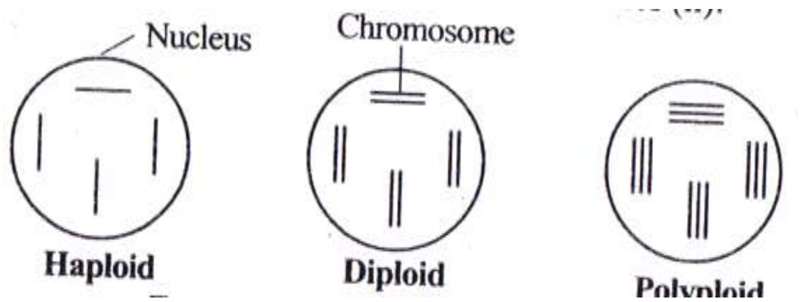
6. Earlier flowering and maturiting

7. The increased resistance to disease, insects and drought, and the lessened susceptibility to adverse environmental conditions.

8. Many other good manifestations.

POLYPLOIDY

Polyploidy is a chromosomal aberration. It is the presence of more than two sets of chromosomes in an animal. The animals containing polyploidy are called polyploids. A normal adult plant or a normal animal contains in its cell two sets of chromosomes or a diploid number of chromosomes. These chromosomes are arranged in pairs. The gametes produced by adults contain only one set of chromosomes or a haploid number of chromosomes.



When two haploid gametes fuse together in fertilization, a diploid organism is produced. This is the normal life cycle of plants and animals.

Rarely in some organisms the chromosome number is increased or multiplied and the organism contains more than two sets of chromosomes. This condition is called polyploidy.

Types of Polyploidy

Polyploidy is classified in two ways:

A. Based on the number of sets chromosomes and

B. Based on the nature of chromosomes.

A. Based on the Number of sets Chromosomes

Based on the number of chromosomes polyploidy is divided into about 8 types. They are as follows:

1. Triploidy (3 n): It contains 3 sets of chromosomes

2. Tetraploidy (4n) : It contains 4 sets of chromosomes

3. Pentaploidy (5n): It contains 5 sets of chromosomes

4. Hexaploidy (6n): It contains 6 sets of chromosomes

5. Hectaploidy (7n): It contains 7 sets of chromosomes

6. Octoploidy (8n) : It contains 8 sets of chromosomes

7. Nanaploidy (9n): It contains 9 sets of chromosomes

8. Decaploidy (10 n): It contains 10 sets of chromosomes

B. Based on the Nature of Chromosomes

Polyploidy is divided into two, namely autopolyploidy and allopolyploidy.

1. Autopolyploidy: In autopolyploidy, all the chromosome sets are derived from the same species.

2. Allopolyploidy: In allopolyploidy, the chromosome sets are derived from two different species.

Causes for Polyploidy

Polyploidy is caused by many factors. They are as follows:

1. Abnormal Mitosis: During mitosis the chromosomes duplicate in the normal way. But the cytoplasm fails to divide. Hence the cell contains additional sets of chromosomes.

2. Abnormal Meiosis: During meiosis all the chromosomes enter a single gamete. This gamete is a diploid one. When this fuses with a haploid sperm, a triploid individual is produced.

3. Chemicals: Polyploidy can be induced by chemicals like colchicine, indole acetic acid, sulphanilamide, etc.

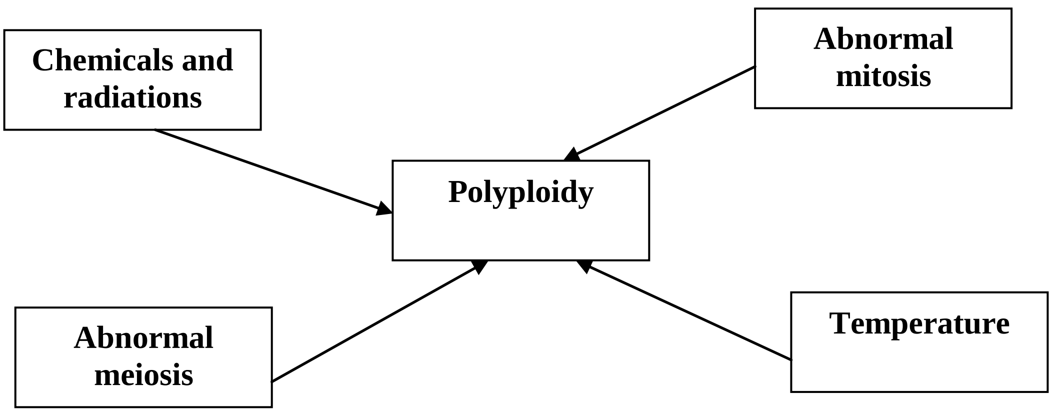
4. Temperature: Polyploidy can also be induced by temperature.

Polyploidy originates in two ways:

1. Natural polyploidy, 2. Induced polyploidy

1. Natural Polyploidy

Owning to abnormal meiosis a gamete with diploid number of chromosomes is produced. If this diploid gamete (2n) fuses with a haploid gamete (n) during fertilization, a triploidy (32n) is produced.



When a diploid gamete (2n) fuses with another diploid gamete (2n) fuses with the haploid gamete (n) during fertilization, a triploidy (3n) is produced.

When a diploid gamete (2n fuses with another diploid gamete (2n), the resulting individual is a tetraploid (4n).

Triploid **Tetraploid**

Origin of Polyploidy

When both diploid gametes belong to the same species, the resulting tetraploid is called autotetraplodi. When the two diploid gametes belong to two different species the resulting tetraploid is called allotetraploid.

2. Induced Polyploidy

Colchicine induces abnormal mitosis. This produces polyploids. Similarly, sulphanilamide, indole acetic acid, etc. induced polyploidy. Again a high temperature also induces polyploidy.

Characteristics of polyploidy

1. The cells are larger in polyploids
2. The plant is larger
3. There is high yield
4. The leaves are larger, darker and thicker
5. Flowers, fruits and seeds are bigger

6. There is an increase of vitamin contents. Eg. Tomato

7. There is an increase of nicotine. Eg. Tobacco

8. There is an increase of sugar contents. Eg. Beet

9. There is low fertility

10. There is slow growth rate.

11. There is delayed flowering

Significance of polyploidy

1. Polyploidy brings about speciation at a single stroke.
2. The studies of polyploidy can provide much information about the past history of plant groups.
3. Polyploidy results in the fixation of heterozygous gene combinations, particularly those derived by hybridization.
4. Polyploidy results in the fixation of heterozygous gene combination, particularly those derived by hybridization.
5. Whenever heterozygotes have an adaptative advantages, polyploidy will be favoured because it makes heterozygous populations easier to maintain by selective elimination of the few homozygotes. Polyploidy is therefore a conservative process.
6. Polyploidy has greater stabilizing effect.
7. Polyploidy facilitates gene exchange between distantly related species.
8. Polyploid evolution is irreversible.
9. The evolutionary steps that give rise to new polyploid species can be repeated experimentally.

10. The formation of new polyploids in gardens offers opportunities for conducting synthetic experiments on evolution.

Polyploidy in Plants

Polyploidy is more common in plants than in animals. Most of the commercial crops are polyploids. A few plant polyploids are given below.

1. Cotton

All kinds of cotton belong to the genus Gossypium. There are about 20 different species. The Old World (Africa, Australia, Southern Asia) contains about 16 species. All these species are diploid with 26 chromosomes (13 Pairs) Eg. G.Arboreum, G. herbaceus, etc.

The New World (America, Mexico, Galapagos Islands, Peru) contains wild varieties of cotton and the cultivated varieties of cotton.

All the wild species G.Raimondii contains 26 chromosomes (13 pairs) and is diploid.

But the cultivated verities of cotton (G. hirsutum, G. Barbadense) contain 52 chromosomes (26 pairs) and are tetraploid. It is believed that the tetraploid originated by the crossing of Asian and American Varieties.

G. arboreum (Asia) X G. raimondii (S.America)
2n = 26 (AA) 2n = 26 (DD)

↓

Amphidiploid
2n=26(AD)

↓

Tetraploid
4n=52(AADD)

Formation of polyploid cotton

Hybridization experiments clearly show that 13 pairs of chromosomes of tetraploid cultivated cotton of America resemble the 13 pairs of chromosomes of Old World diploid cotton; the other 13 pairs of tetraploid cultivated cotton of America resemble the 13 pairs of chromosomes of diplod wild cotton of America.

It clearly shows that the tetraploid American cultivated cottons are allotetraploids. It is strongly believed that these allotetraploids were formed in the remote past by natural hybridization between the diploid Old world cottons and the diploid American cottons. It is a direct evidence of the origin of new species in nature by hybridization and polyploid.

2. Raphanobrassica

Recreation of new species by experiments was demonstrated by Karpenchenko in 1924. He crossed two naturally incurring diploid species and obtained a tetraploid.

The two diploid plants crossed were radish Raphanus sativus containing 18 chromosomes and cabbage Brassica alercea containing also 18 chromosomes.

The F1 hybrids were diploid containing 18 chromosomes; 9 belonged toradish and the other 9 belonged to cabbage. Most of the F1 hybrids were sterile; they did not produce seeds. But a few hybrids were fertile; they produced seeds.

Most of the F2 hybrid were tetraploids containing 36 chromosomes in their somatic cells. Of these, 18 chromosomes belonged to radish and the remaining 18 belonged to cabbage. They were formed by the fusion of diploid gametes of F1 hybrids. So the hybrid was an allotetraploid.

Karpenchenko named this as Raphanobrassica. These plants were fully fertile and bred true. It was reproductively isolated from both parents.

EVOLUTION
Unit - V

Origin of Life

Life can be defined as a physicochemical entity which exhibits reproduction, irritability, adaptation and locomotion. The problem of origin of life is still shrouded in mystery. However, there are a few speculations explaining the probable origin of life. They are as follows.

(a) Abiogenesis (Spontaneous Generation)

The formation of life from non-living substances is called abiogenesis or spontaneous generation. The belief in abiogenesis started from 300 BC and continued until 17th century.

Aristotle (384-322 BC) believed that fishes originated from mud. Insects (maggots) originated from decaying meat.

Epicurus (342-271 BC) wrote that worms and many other animals originated from soil and manure by the action of sun and rain.

Van Helmount (1577-1644) believed that mice originated from wheat **-** grains and dirty clothes.

A wide variety of scientists like Thales (624-547 BC) and Boethius believed that barnacle goose (a variety of marine bird) was hatched from barnacle.

Anaximander, Newton, Plato (427-347 BC), Descartes, Empedocles (485-425 BC), Paracelsus and others believed in abiogenesis.

(b) Biogenesis

Biogenesis refers to the origin of life from pre-existing life by reproduction. This theory says that horses came only from horses; rates from rats; insects from insects and so on.

I. LAMARCKISM

Lamarckism is the theory of Organic Evolution. It was proposed by Lamarck. It is also called inhertance of acquired characters. It explains the origin of new species.

Principles of Lamarckism

Lamarckism consists of four principles. They are as follows.

1. Internal urge of organism
2. Environment and new needs
3. Use and disuse theory
4. Inheritance of acquired characters

1. Internal Urge of Organism

Animals and plants have the ability to grow and increase in size to attain the maximum size. Not only the body but also each and every part of an organism increases in volume. According to Lamarck, this increase in size is due to internal urge and inherent ability of the animal itself. It is due to desire, some sort of an internal urge of the animal that the size increases.

2. Environment and New Needs

According to Lamarck, environment plays an important role in evolution. Animals co-operate with the environment for their survival. They develop adaptive characters to live comfortably in the environment. Whenever there is a change in the environment. The animals also respond to the changes. The changes in the environment bring about new structures or characters. Thus Lamarck strongly believed that changes in the environment bring about the development of new characters.

3. Use and Disuse theory

When an organ is put to greater and constant use, that particular organ develops well; at the same time, when an organ is not used for a long time, it gets reduced and in due course it degenerates and disappears completely from the organism. This phenomenon is called **use and disuse theory.**

Examples for Use theory

(i) Giraffe

Lamarck believed that the long neck and long fore limbs of giraffes are the results of continuous use. He assumed that the ancestral giraffes were provided with short neck and the fore and hind limbs with uniform length. They were grazing animal feeding on grass. At that time there was scarcity of grass. Hence the ancestral giraffes were forced to feed on the foliage of trees. So they tried to stretch their neck and fore limbs to reach the foliage of trees. This resulted in a slight increase in the length of the neck.

The process of stretching the neck continued generation after generation to get the foliage of taller trees and this resulted in longer neck leading to the origin of modern giraffee.

(ii) Web foot

The web-footed aquatic birds evolved from non web footed birds. The aquatic birds float on the water by propelling the water with their toes. In this process, the toes were spreading out generation after generation. As toes were spreading out, the skin between the toes also widened. This widened skin between the toes after many generations developed into a web.

Examples of Disuse theory

(i) Eyes of Cave Animals

The cave is characterized by complete darkness. In the absence of light, the cave animals cannot use their eyes. Since the eyes are not used for many generation, the eyes become degenerated and in extreme cases eyes disappear completely, Eg. Proteus anguineus (amphibian).

(ii) Fightlessness

Another very good example is the flightless condition in Kiwi of New Zealand. Evidences indicate that kiwi has descended from normal flying birds. When they first came to New Zealand they were good fliers. At that time there were no enemies of the land in New Zealand. hence they led a peaceful life without any attempt to fly and they had no chance to in their wings. This happened generation after generation resulting in the degeneration of wings and loss of light.

(iii) Vestigial Organs.

The vestigial organs of man and of other animal are the result of continuous disuse. Eg. Coccyx, ear muscles and plica semilunaris in man, limbs in snakes etc.,

4. Inheritance of Acquired Characters

The transmission of characters, developed by an organism during its life time, to the young ones is called inheritance of acquired characters.

When the environment changes, animals respond to it. In the response, animals develop new adaptive characters. The characters developed by the animals during their life time in response to the environmental changes are called **acquired characters.** According to Lamarck, these acquired characters are transmitted to the offspring. This is called inheritance of acquired characters.

Examples: 1. The long neck of giraffe is an acquired characters. It is transmitted to the offspring generation after generation.

2. The degenerated wing of kiwi is an acquired character. It is inherited by its progeny generation after generation.

II. DARWINISM (OR) NATURAL SELECTION THEORY

The evolutionary idea contributed by Darwin is called Darwinism or Natural selection theory. It explains the mechanism of evolution. Darwinism consists of five principles. They are the following :

1. Over production
2. Struggle of Existence
3. Variation
4. Survival of the Fittest
5. Origin of new species

1. Over Production or Geometric Ratio of Increase

Animals of plants produce young ones by reproduction this is called prodigality of production. This leads to overcrowding.

Paramecium

Paramecium undergoes binary fission every 16 hours. If all the daughter paramecia of a single paramecium survive and reproduce at this rate for five years, they will produce a cytoplasmic mass, the volume of which will be equal to 10 thousand times the volume of the earth (Woodruff).

2. Struggle for Existence

As the rate of reproduction is high, animal increase in a geometrical ratio. But there is no corresponding increase in space, food and other factors essential for life. This leads to competition for getting requirements of life. This competition is called **struggle for existence.** There are three types of struggle.

a. Intra-specific struggle

The competition between members of the same species is called intra-specific struggle. When the members of the same species are living in the same environment, their needs and requirements are also the same. Hence the competition is heavy.

When there is a piece of flesh, dogs fight among themselves to get it; similarly the seedlings growing under a tree compete among themselves for food, light and other means.

b. Inter - specific struggle

The competition between members of different species is called **inter-specific struggle.** When there is a dead body of cattle, vultures will crowd around it to eat the flesh. There will be dogs also trying to get the flesh; but the vultures will chase them away. Thus there is a struggle between the vultures and the dogs. Similarly, in a pond the snakes chase the frogs for their prey; but the frogs try to escape for their survival. In a forest tiger, chases deer for its food; the deer has to escape for its survival.

c. Environmental Struggle

The competition between animals and environmental factors is called environmental struggle. The environmental competition is caused by the following factors:

1. Shortage of food, water and oxygen, 2. Lack of light, 3. Predators, 4. Lack of shelter, 5. Disease, 6. Natural calamities.

All these factors constitute environmental resistance. It checks the reproductive potential of the population and keeps the population from growing indefinitely.

3. Variations

Variations is defined as the difference in character between individuals. No two individuals are exactly alike. Variations occur even between the offspring of the same parent. Even in the same organism variation can be observed. For example in plants, one leaf is different from the other in its size, shape, venation, etc. The length of the same fingers of the two hands may differ in some persons.

Variation is the inherent property of life. Darwin believed that the small **continuous** variations are important for evolution. They arise at random, without any reference to whether they are needed or not, whether they are advantages or harmful Darwin described two types of variation.

a) Favourable variations

These are the characters which are useful to the possessor in the struggle for existence. Eg. The strength and aggressiveness of dogs; the high speed of a deer.

b) Unfavourable variations

These are the characters which are useless or harmful to the possessor in the struggle for existence.

4. Survival of the Fittest and Natural Selection

The organisms provided with favourable variations succeed in the struggle for existence. These organisms are the fittest for survival other animals are unfit to survive and they perish.

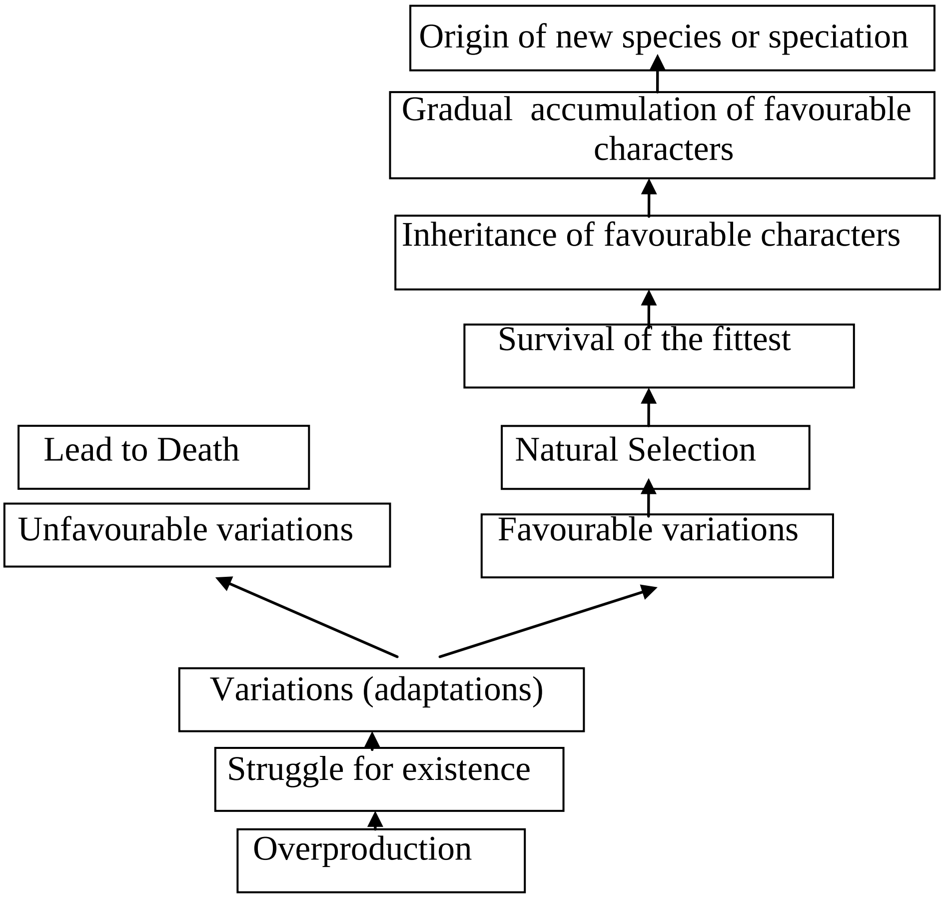
The fitness or unfitness is decided by the environment, the nature. So the environment acts as the selecting force. It selects those organisations which are provided with favourable variation. This process of selection of organisms with favourable variations is called **natural selection.**

The organisms selected by nature reach sexual maturity and they produce young ones. These young ones receive advantageous variations from their parents.

5. Origin of new species or speciation

Darwin stated that new species arise by the cooperation of all the above principles.

Over production leads to struggle for existence. Animals are provided with a bulk of variations. Environment selects.



Central theme of Darwinism

III. MUTATION THEORY OF DEVRIES

Hugo De Vries was born in Netherlands in 1848. he worked as Professor of Plant Physiology.

De Vries proposed the mutation theory of Evolution in 1901. He stated that mutation is the universal source of origin of species.

He made extensive experiments on the ornamental plant evening primrose, Oenothera Lamarckiana. He discovered the sudden appearance of new species of Oenothera from seeds collected from normal plants. The new forms bred true and he called them mutants and they arose by Mutation.

He rediscovered, independently Mendel's principles of heredity.

In his book Intracellular pangenesis (1889), he proposed a theory of heredity similar to that of Darwin. He gave due importance to Pangenes.

Mutation Theory

Hugo De Vries proposed the mutation theory of Evolution in 1901.

Mutation is a sudden change occurring in the genetic material.

De Vries believed that new species are formed in a single step suddenly without any intermediate stage.

De Vries postulated the mutation theory based on his observation on an ornamental plant called evening primrose oenothera Lamarckiana. This is a wild plant.

De Vries observed three new varieties of Oenothera in his garden. He named them as nannella, O.brevistylis and o-laevifolia.

De Varies reared these three varieties in his garden. He raised about 54343 plants in a period of 8 years. Among these plants he found 837 plants of new varieties and were different from O.lamarckiana.

He provided that these new varieties bred true. De Vries belied that the new varieties were produced by a sudden change in the wild varieties. He classified these new varieties into four, namely. 1.Progressive species, 2.Retrogressive species, 3. degressive species and 4. inconstant species.

1. Progressive species

When the new species is provided with new characters, the species is said to be progressive species. Eg. O. gigas and O.rubinervis.

O. gigas is a giant variety; it has a stout step having twice the thickness of lamarckian; its leaves are more in number and broader; its flower buds are stouter and its seeds are large in size.

O.rubinervis is a red-veined slender variety. The fruits contain red veins and red streaks; the leaves are thin and more brittle.

2. Retrogressive Species

In retrogressive species, there is a loss of some parental characters. Eg. O.laevifolia, O.brevistrlis and O.nannella.

3. Degressive Species

In digressive species, some of the vital characters are lost and the survival is difficult. For example, O.albida is a variety where the chlorophyll system is defective. O.oblonga in a weak variety where the leaves are along and needle - like.

4. Inconstant Species

Inconstant species, do not breed true; very often they produce new varieties. O.lata produces only pistillate flowers; pollen grains are absent; so cross pollination is the rule. O.scintillans produces flowers of its own variety as well as of original variety.

Salient features of mutation theory

1. De Vries believed that new species originate as a result of large **discontinuous variations** which appear suddenly and form new species at once.

2. New species are formed by sudden changes at a single stroke. The animals exhibiting mutations are called mutants.

3. There are no intermediate stages because new species are formed in a single generation.

4. Mutation can take place in any direction

5. Mutation are recurring in nature.

6. A large number of the same type of mutations appear at the same time.

7.Mutations are subjected to natural selection.

Examples of Mutation from Animals

Ancon Sheep: IN 1891, in the flock of Seth Wright a farmer in England, appeared a male lamp with short, bowed legs, Wright reared this lamp and bred from it the Ancon breed of sheep. It was so short that it could not jump over an ordinary stance fence. This breed become extinct about 80 years ago.

Later another short-legged lamp appeared in the flock of a Norwesian farmer representing probably a new occurrence of the same mutation. From this a new strain of short-legged has been bred.

1. Hornless cattle was born for a normal cattle in 1889.
2. Albinism in rats, cats, dogs, rabiits, guinea pigs, man, etc. is another mutation.
3. Multinippled condition in sheep is due to mutation.
4. Hare-lip in man is an instance of mutation.
5. White - eyed condition in Drosophila is an example of mutation.

IV. MODERN SYNTHETIC THEORY OF EVOLUTION

The synthetic theory is a modern theory of evolution combining Darwinian Natural selection and Mendelian Genetics.

It explains the origin of new species and the process of Evolution.

This theory was proposed by Dobzhanksy in 1937 through his book genetics and the origin of species.

Huxley (1942) proposed the term **modern synthesis.**

The main architects of the synthetic theory are Dobzhansky, Mayr, Huxley, Simpson, Stebbins, Fisher, Haldane, Sewall Wright, etc.

Mayr (1978) states that the modern synthetic theory of evolution amplifies Darwin's theory of natural selection in the light of Mendelism, population genetics, biological concept of species and many other concepts of biology and palaeontology.

The new synthesis is characterized by the complete rejection of the inheritance of acquired characters. It gives an emphasis on eh gradualness of evolution.

Huxley (1942) states that 'modern synthesis' ownes much more to Darwin than to any other evolutionists and is built around Darwin's principles.

Aim of Modern Synthesis

The modern synthesis explains the mechanism of evolution. It explains evolution in terms of genetically change in populations leading to the origin of new species.

Concepts of Modern Synthesis

The modern synthetic theory consists of three main concepts. They are the following.

1. Genetic variation
2. Natural selection
3. Isolation

1. Genetic Variation

The difference in closely related animals is called variation. The change is genes and gene frequencies is called genetic variation. Genetic variation is the raw material for evolution.

Gene Pool

The sum of all the genes and genotypes of an interbreeding population is called gene pool.

Gene Flow

Members of a population interbreed with one another and also with members of neighbouring sister populations. During interbreeding gene-carrying gametes are transmitted from one individual to another. Thus genes are transferred from one individual to another during interbreeding. This is called gene flow. Gene flow helps in the mixing of genes in a population and between sister populations.

1. **Gene Frequency**
    a. Gene frequency refers to the proportion of one allele in the gene pool to the other alleles of the same locus.
    b. Gene frequently helps to estimate the number of genes in a population or gene pool.
    c. It also helps to observe the number of genes changed in the population.

Operation Modern Synthesis

Populations develop genetic variations through mutation, hybridization, recombination, etc.

Natural selection allows the favourable genetic variations to spread in the population through differential reproduction in successive generations.

The Populations are isolated geographically and reproductively and this leads to the failure of interbreeding. When interbreeding does not occur, the isolated populations are grouped into a new species.