

Classification of Haploids

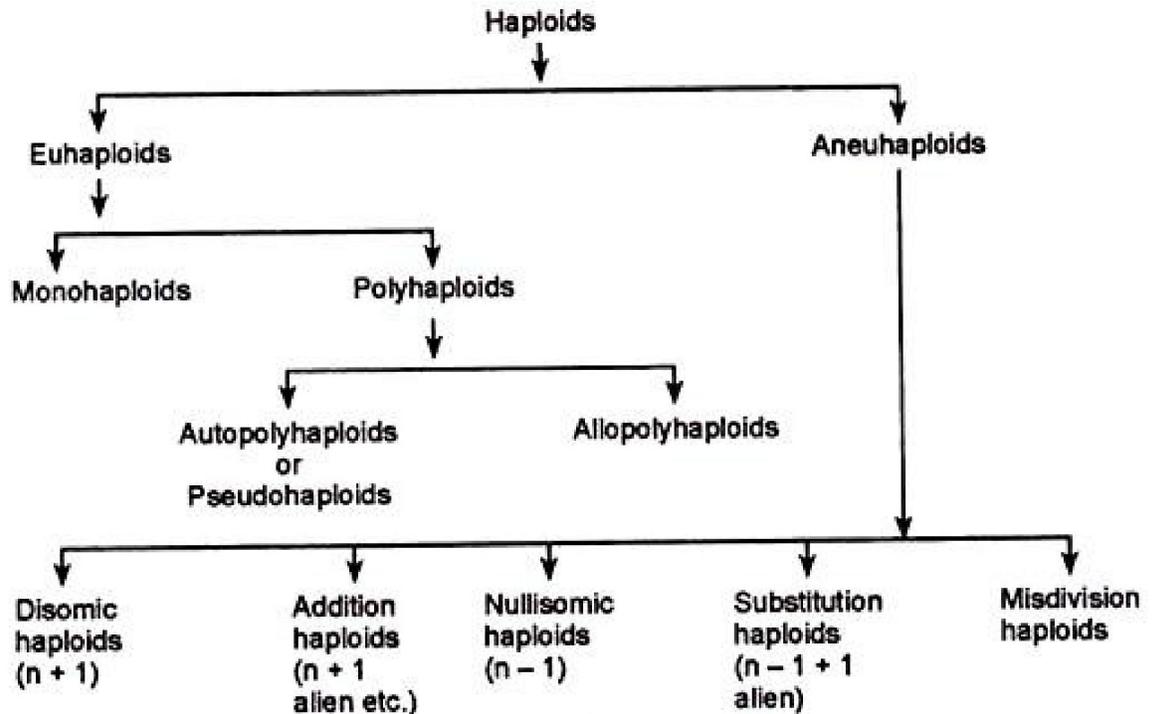


Fig. 17.1. Classification of haploids.

Haploids: Plants (or the sporophyte) having gametic chromosome number are called haploids.

Classification of Haploids:

According to their cytological features, haploids have been classified into different types (Fig. 17.1), a brief description of which is given below.

I. Euhaploid:

The chromosome number of such a haploid is an exact multiple of one of the basic numbers of the group. Euhaploids are of two types:

i) Mono-haploid or monoploid:

It arises from a diploid species ($2x$) and possesses the gametic chromosome number of the species; it is designated as “ x ”.

(ii) Polyhaploid:

Haploid individuals arising from a polyploid species ($4x$ (autotetraploid), $6x$ (autohexaploid), etc.) are called polyhaploids; they may be di-haploids (with $2x$), tri-haploids ($3x$) and so on. Based on their auto- or allo-ploid condition, polyhaploids have been divided into two groups:

(a) Auto-polyhaploid : Autopolyploid species give rise to auto-polyhaploids. For example,

Autotetraploid ($Ax = AAAA$) \longrightarrow Auto-di-haploid ($2n = AA$)

Auto-hexaploid ($6x = AAAAAA$) \longrightarrow Auto-tri-haploid ($3x = AAA$)

(b) Allopolyploid : Such individuals arise from allopolyploid species. For example,

Allotetraploid ($Ax = AABB$) \longrightarrow Allodihaploid ($2x = AB$)

Allohexaploid ($6x = AABBDD$) \longrightarrow Allotrihaploid ($3x = ABD$)

II. Aneuhaploid:

The chromosome number of such a haploid is not an exact multiple of the basic number of the group.

Aneuhaploids have been classified into five types:

(i) Disomic haploids ($n + 1$): Such haploids have one chromosome in disomic condition, i.e., there is one extra chromosome belonging to the genome involved.

(ii) Addition haploids ($n + \text{few alien}$): The extra chromosome(s) in the haploid is an alien chromosome.

(iii) Nullisomic haploids ($n-1$): In such haploids, one chromosome is missing from the haploid complement.

(iv) Substitution haploids ($n-1 + 1 \text{ alien}$): One or more chromosomes of the haploid complement are substituted by alien chromosomes.

(V) misdivision haploids: such haploids contain telocentric or isochromosomes resulting from misdivision of centromeres.

Origin and occurrence of haploids

Origin of Haploids:

Haploids arise spontaneously, and haploidy can be artificially induced by modified pollination methods in vivo such as delayed pollination, or by in vitro culture of immature male (pollen culture) or female gametophytes (cells in the embryo sac). In nature, they arise through the development of egg cells without fertilization (parthenogenesis) or through pseudogamy.

The rate of haploid production increased up to 20/1000 in interspecific pollination and up to 200/1000 when combined with delayed pollination.

The first report of induced haploidy in plant was that by Blakeslee et al. in 1922, through cold treatment of young buds of *Datura stramonium*.

Production of Haploids

In general, there are three main Methods of Haploid Production:

- (1) Parthenogenesis and apogamy,
- (2) Somatic reduction and chromosome elimination, and
- 3) Anther, pollen and ovule culture.

1. Parthenogenesis and Apogamy: In plants, parthenogenesis is the development of embryo from egg cell without fertilization. In this case, no fertilization is needed. In apogamy, embryo is developed from a cell of the embryo sac without fertilization. The haploids arising from the maternal cell in the embryo sac are called '**gynogenetic haploids**' whereas those arising from male nucleus in the embryo sac are called '**androgenetic haploids**'.

The various methods used to produce parthenogenetic haploids are:

- I. Temperature treatment:** treatment of young flower buds with high or low temperature generate haploids.
- II. Pollination with Irradiated pollen grain with x-rays:** This method inactivates the pollen but can stimulate the egg to develop into embryo parthenogenetically.
- III. Chemical treatment with nitrous oxide stimulate embryogenesis in the cells of embryo sac and thereby resulting in haploid production.**

- IV. **Delayed pollination:** It induces parthenogenic development of egg into a haploid embryo. The success of delayed pollination will actually depend on the viability of stigma and ovules.
- V. Alien cytoplasm:
- VI. **Haploid inducing genes:** Certain inducing genes such as ‘indeterminate gametophyte (ig) gene’ induces both androgenetic as well as gynogenetic haploids in maize. Haploid initiator (hap) gene induces haploids of female origin in barley. The function of this gene is to prevent fertilization of the egg cell, while not affecting fertilization of the polar nuclei and development of the endosperm.
- VII. **Selection of twin seedlings:** twin seedlings arise due to polyembryony. One embryo develops from an egg cell and the other from the synergid resulting in the production of twin embryos.
- VIII. **Semigamy:** a genetically controlled production of chimeric haploids. Here sperm nucleus enters the egg cell but fusion of male and female nuclei does not occur. Instead they both divide simultaneously, giving rise to a chimaeric embryo with both male and female components. Semigamous plants in cotton produce elevated frequencies of maternal haploids, paternal haploids, as well as chimaeric maternal/paternal haploids. Thus semigamy falls between the two extremes, the syngamy (fusion of male and female gametes) and pseudogamy (development of embryo after pollination without involvement of male gamete).

2. Haploid production through Chromosome Elimination following wide hybridization (interspecific and intergeneric hybridization)

The barley example: Bulbosum method is more efficient than microspore culture in producing haploid barley. In this method, haploid plantlets of *Hordeum vulgare* with seven chromosomes are produced as a result of gradual elimination of *H. bulbosum* chromosomes. This is achieved by an interspecific cross between barley (*Hordeum vulgare* ; $2n = 2x = 14$, female) x *Hordeum bulbosum* (wild relative; $2n = 2x = 14$, male). The method was started with the fertilization of *Hordeum vulgare* by *Hordeum bulbosum* followed by gradual elimination of the *H. bulbosum* genome in the early stages of embryo development (few days after fertilization).

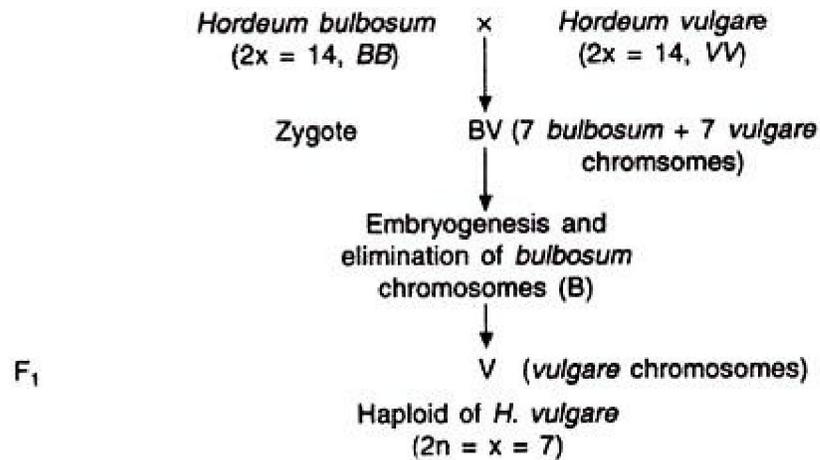


Fig. 17.3. Haploid production in barley through chromosome elimination from interspecific hybrid. *B* and *V* represent the chromosomes of *H. bulbosum* and *H. vulgare*, respectively.

F₁ obtained above will be left with 7 vulgare chromosomes after elimination of 7 chromosomes from *H. bulbosum* (Kasha and Kao). In a similar way, a cross between *T. aestivum* and *H. bulbosum* generates wheat haploids ($2n=3x=21$) with elimination of all 7 chromosomes of *H. bulbosum*.

3. **Somatic reduction:** various chemicals such as chloramphenicol, colchicines, fluorophenylalanine are mutagenic and induce somatic chromosome reduction.
4. **Anther, pollen and ovule culture:** Haploids have been produced by using anther, pollen and ovule culture. Development of haploids from pollen grains was first reported in *datura innoxia* by Guha and Maheshwari. Anthers of most species are cultured at binucleate stage. The best stage of pollen culture lies between the quartet stage and stage just past the first pollen mitosis. In ovule culture, unfertilized ovaries are cultured to get haploids. Haploids obtained from callus cells (caulogenesis).