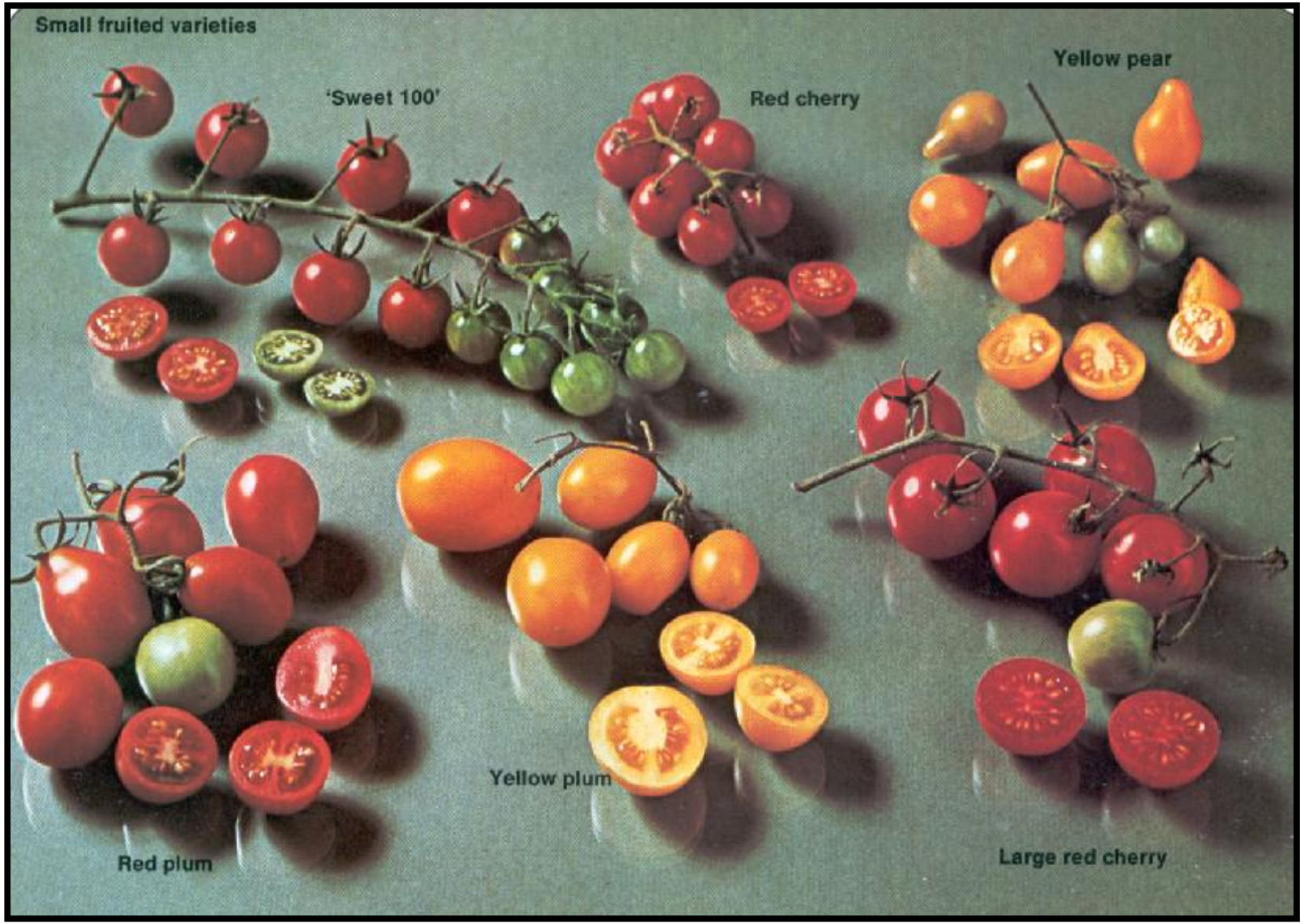
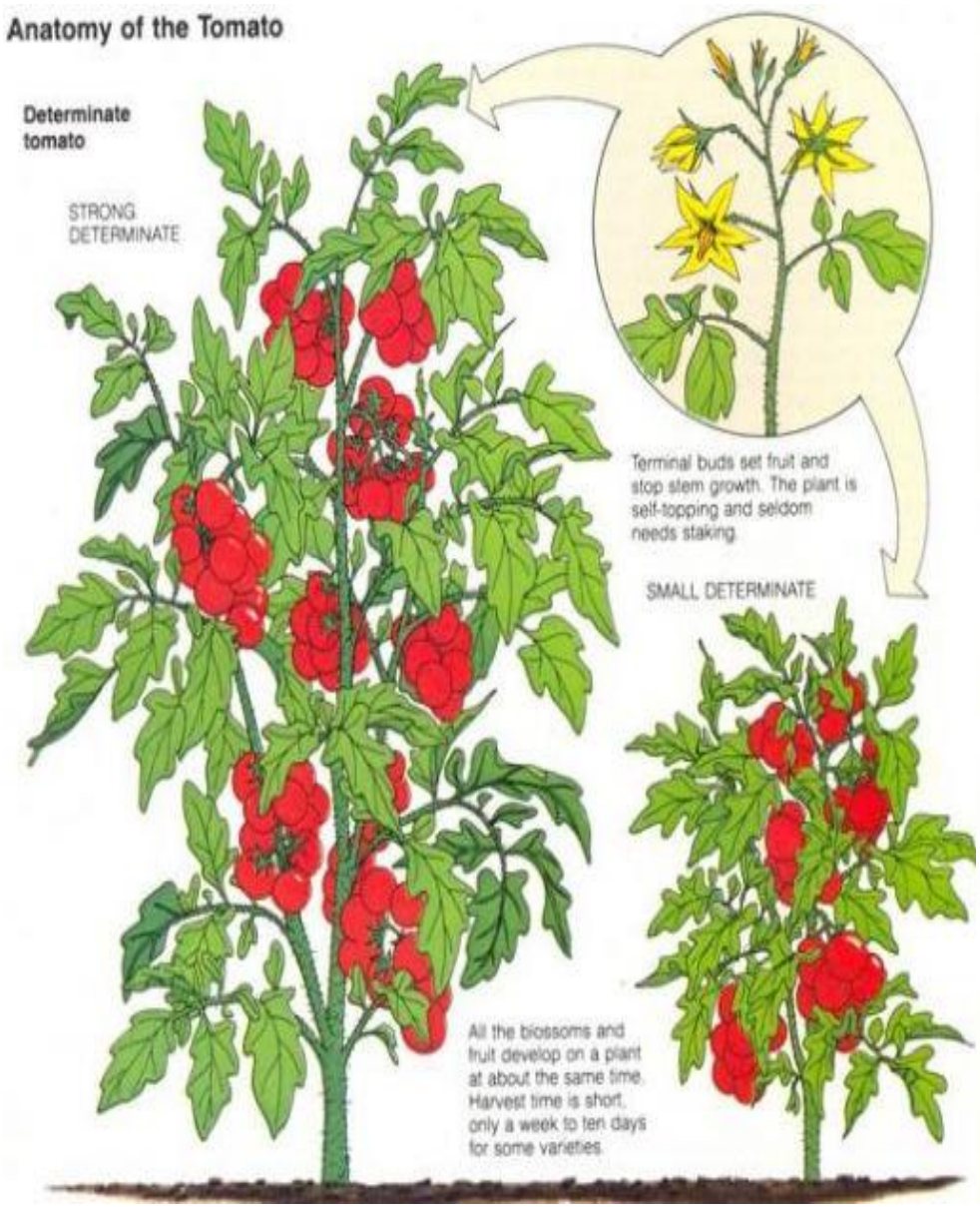
Tomato Breeding



Anatomy of the Tomato



Necessities of the processor, growers and consumers and some associated breeding objectives in tomato for processing

Requests	Breeding objectives
Processor	
High % usable fruits	Fruit firmness, resistance to cracking Ripe conservation capacity Resistance to diseases Good foliar cover
High factory yield for each type of processed product: paste, peeled (canned whole, sliced, crushed, halved, blended), ketchup and sauces, juices and soups, dehydrated	Soluble solid content, viscosity, pectins, Uniform shape and size Soluble solids, acidity, dry matter
Flexibility in factory timing: early start-up , main season, late season	Early maturity, cold ability, heat set ability, disease resistance
Grower	
High yield	Adequate number of fruits and fruit weight
Low production costs: low pesticide use, easy handling of plant	Resistance to pests and diseases, adequate growth habit and branching of the plants, varieties adapted to mechanical harvest
Flexibility: diverse cultivation cycles and periods, varieties with multiple uses	Early and late varieties, varieties with multiple uses
Consumer	
Nutritional value	Increase in vitamin content, energetic value
Culinary appeal: colour, texture, flavour	Increase in carotenoid content, especially lycopene, soluble solids content

اهداف اختصاصی اصلاح گوجه فرنگی

۱. Earliness

۲. Growth Habit

۳. Machine Harvestability

۴. Disease Resistance 

a. Fusarium Wilt

b. Anthracnose fruit Rot

c. Tobacco Mosaic Virus

۵. Insect Resistance 

۶. Nematode Resistance

اهداف اختصاصی اصلاح گوجه فرنگی

۷. Fruit Quality

a. Appearance

b. Fruit Color

c. Texture and Firmness

d. Flavour

e. Nutritional Value

۸. Processing Quality

a. Color

b. Fruit pH

c. Titratable Acidity

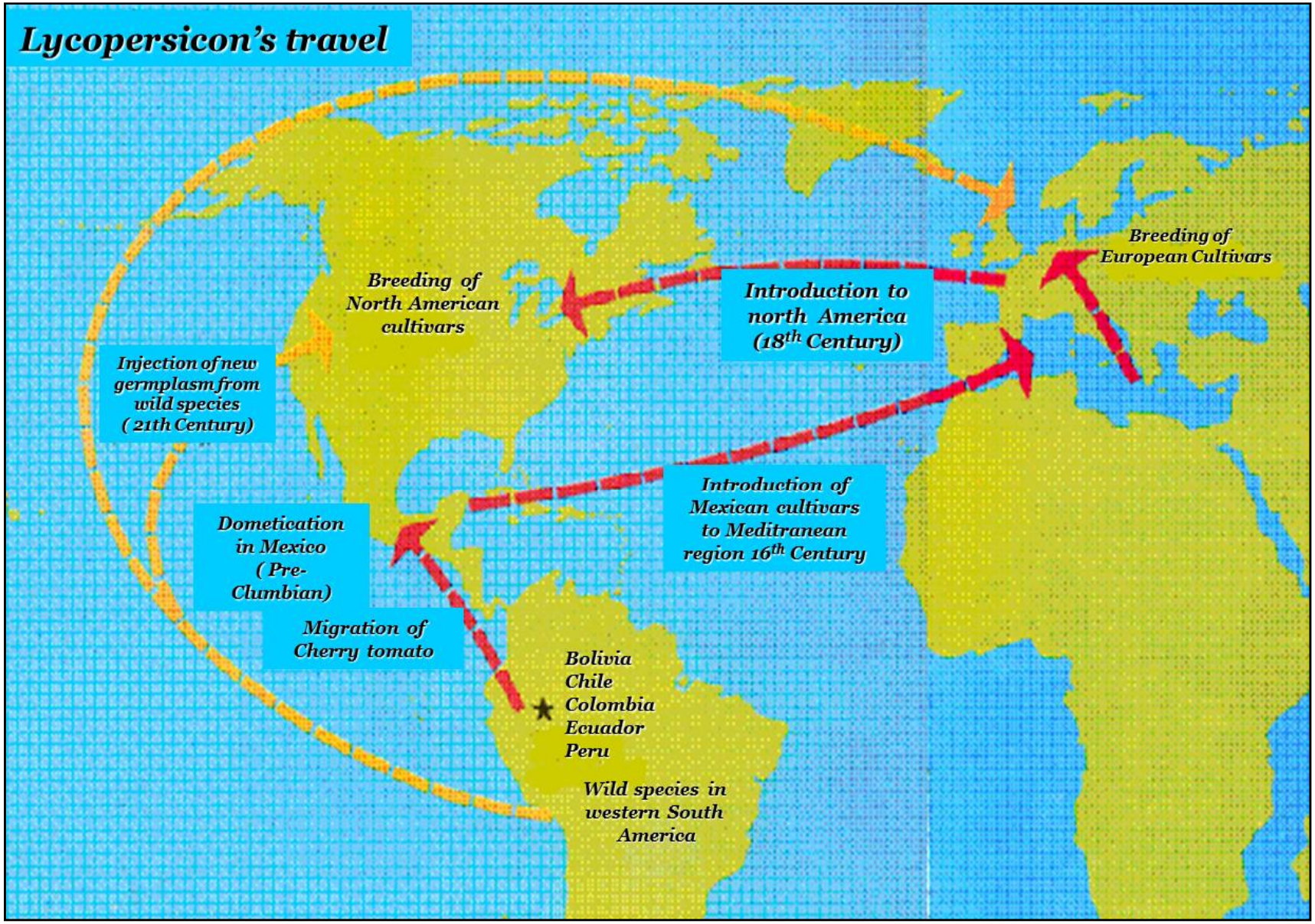
d. Soluble solides

e. Viscosity

Research organism

The main attributes of the tomato as an ideal research organism are:

1. **Short life cycle (65 to 75 days seed to seed)**
2. **Self pollinates but it is easy to hybridize (easy to emasculate, collect and store pollen)**
3. **Many seeds per plant.**
4. **Large, recognizable chromosomes .**
5. **Good array of wild relatives, 8 species.**


Lycopersicon's travel
Breeding of North American cultivars
Introduction to north America (18th Century)
Breeding of European Cultivars
Injection of new germplasm from wild species (21th Century)
Introduction of Mexican cultivars to Meditranean region 16th Century
Dometication in Mexico (Pre-Clumbian)
Migration of Cherry tomato
Bolivia
Chile
Colombia
Ecuador
Peru
Wild species in western South America

Wild relatives in tomato

Classically,

The *Lycopersicon* species are divided into two major subgenus according to fruit color

subgenus *Eulycopersicon* for red-fruited *ssp*.
subgenus *Eriopersicon* for green-fruited *ssp*.

These are also classified by their hybridization affinity to cultivated tomato into two main complexes

Esculentum complex
Peruvianum complex

The *Lycopersicon* species

A. Red fruited species *Eulycopersicon*

L. esculentum SC

L. esculentum var cerasiforme Red Cherry SC

L. pimpinellifolium SC

L. cheesmanii form typicum SC

L. cheesmanii form minor SC

SC " Self compatible

The *Lycopersicon* species

B. Green fruited species *Eriopersicon*

L. peruvianum , races glandulosum, dentatum SI

L. chilense SI

L. hirsutum form typicum SI

L. hirsutum form glabratum SC

L. parviflorum SC

L. chmielewskii SC

L. pennellii SI / SC

SC " Self compatible SI " Self incompatible

The Species of the Genus *Lycopersicon*

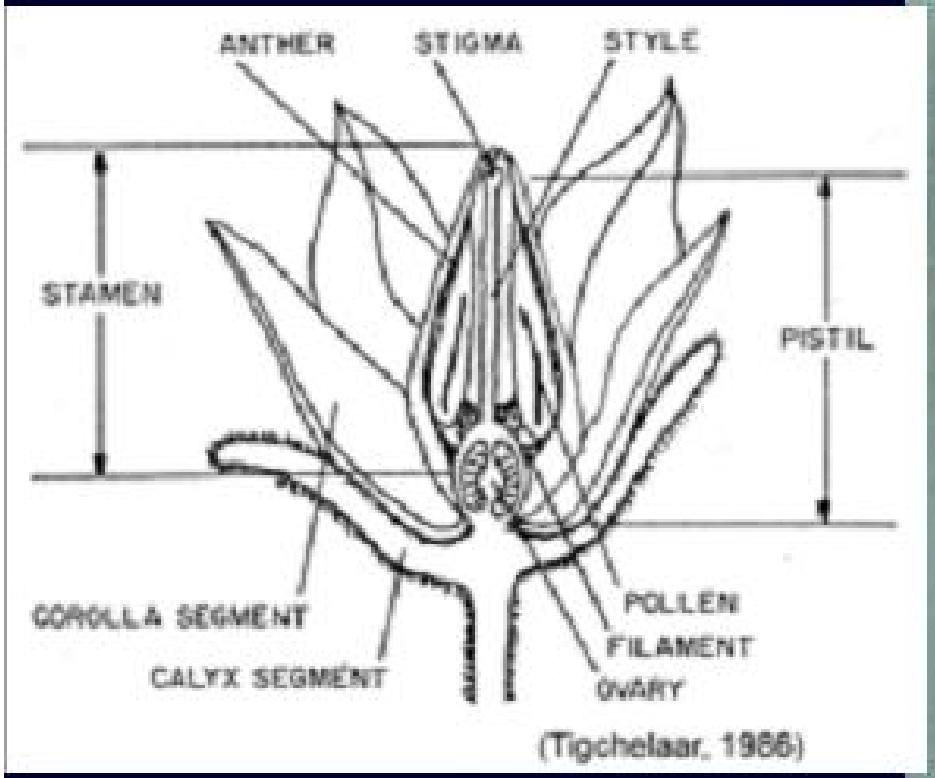
Species	Common name	Somatic chromosome number	Reproductive features[b]
L. esculentum	Common tomato	24	SP
L. pimpinellifolium	Currant tomato	24	SP + CP
L. cheesmanii	Wild species	24	SP
L. parviflorum	Wild species	24	SP
L. chmielewskii	Wild species	24	CP
L. pennellii	Wild species	24	SI
L. hirsutum	Wild species	24	SF, SI
L. chilense	Wild species	24	SI
L. peruvianum	Wild species	24	SI

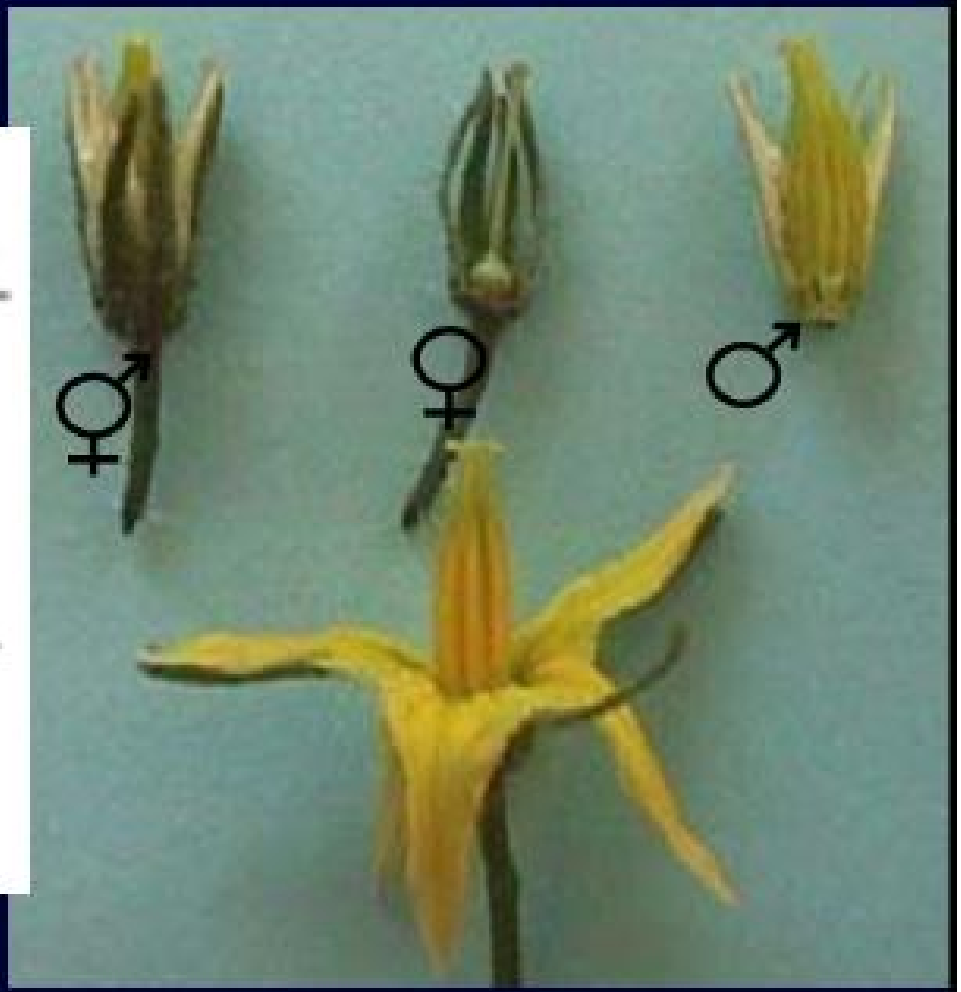
[b]SP, self-pollinated; CP, cross-pollinated; SF, self-fertile; and SI, self-incompatible.

Characteristics of interest of wild tomato relatives in tomato breeding

Species	Characteristic of interest
S. lycopersicum var. *cerasiforme* L.	Tolerance to humidity, resistance to fungi and root rot
S. cheesmaniae L.	Tolerance to salinity, *jointless* gene and thick pericarp
S. pimpinellifolium L.	Colour, characteristics of quality, resistance to diseases
S. chmielewskii	High sugar content
S. neorickii	Resistance to bacteria
S. pennellii Correll	Resistance to drought
S. habrochaites	Tolerance to cold and chilling, resistance to insects and diseases
S. chilense	Resistance to drought and diseases
Complex peruvianum: *S. peruvianum* *S. arcanum*, *S. corneliomuelleri*, *S. huaylasense*	Resistance to viral, fungal and bacterial diseases

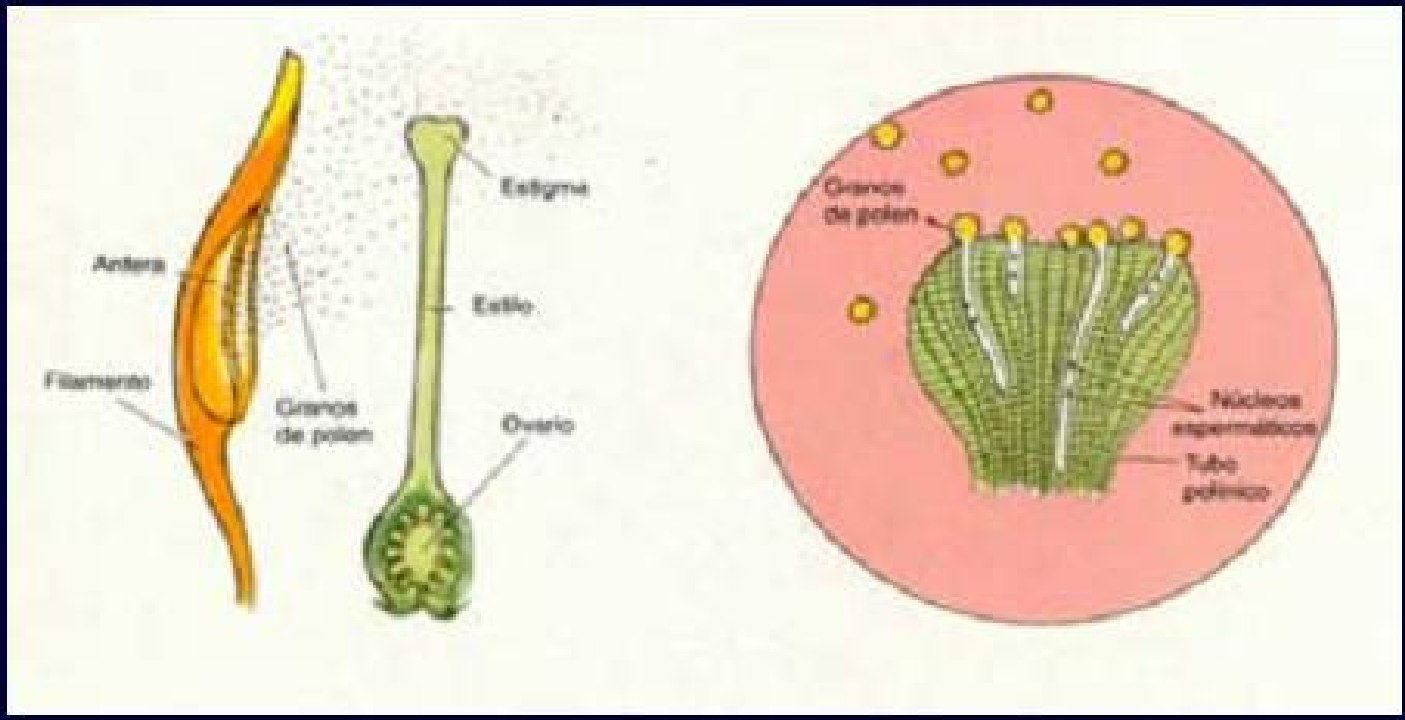
Tomato flower:



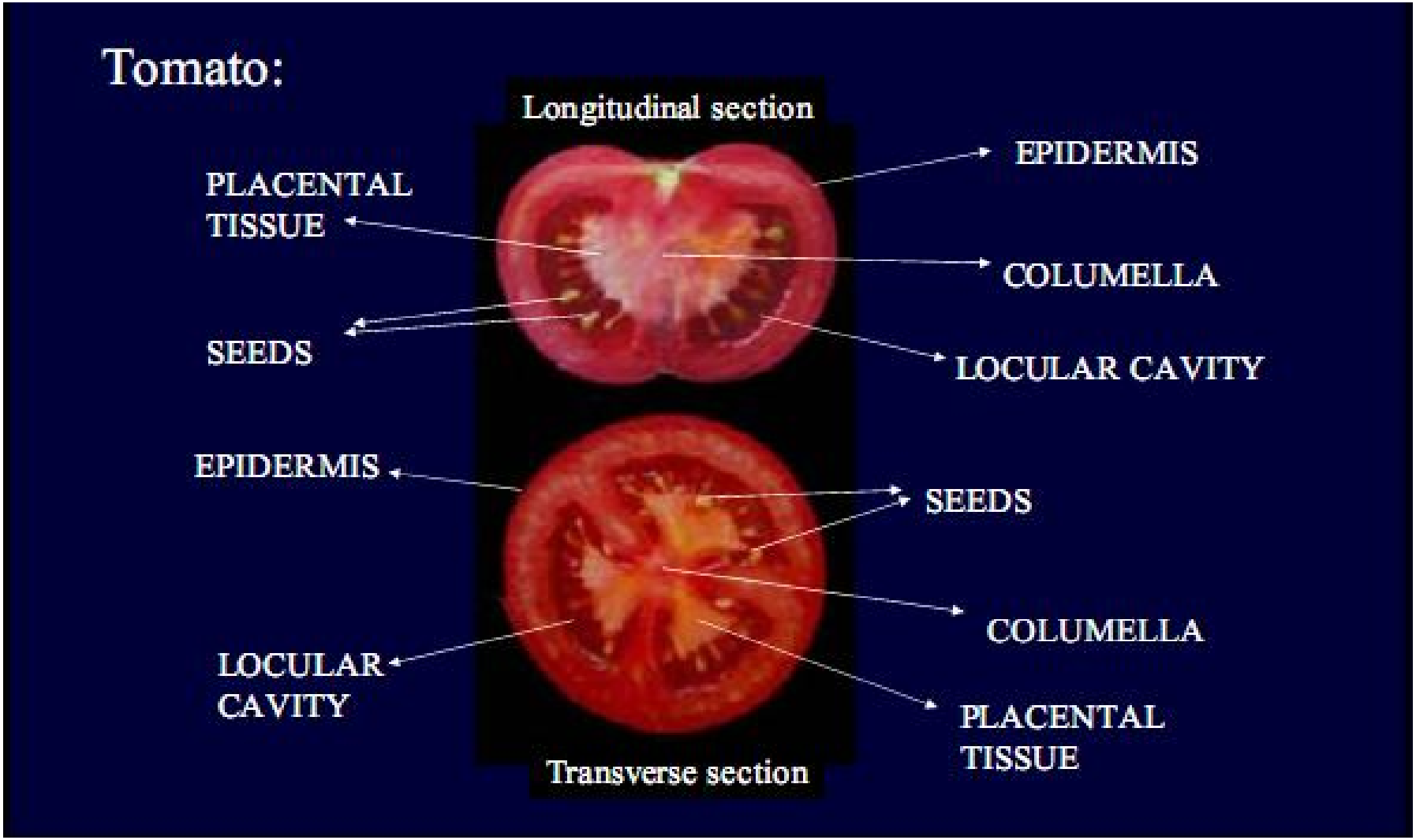


c) Natural pollination mechanisms

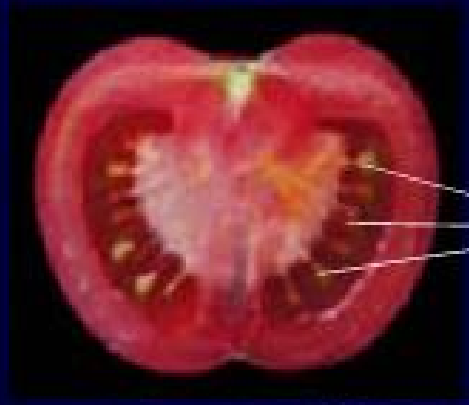
Tomato:



Tomato:

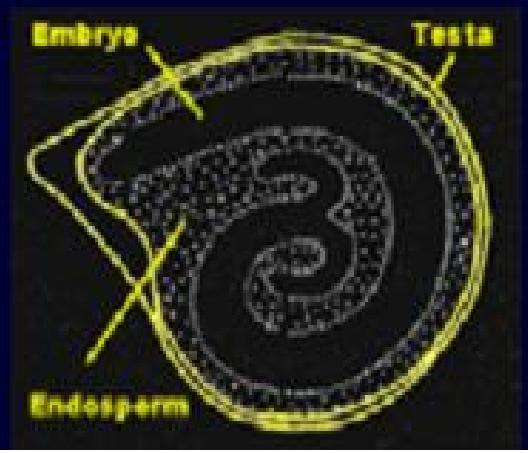

Longitudinal section
PLACENTAL TISSUE
SEEDS
EPIDERMIS
LOCULAR CAVITY
Transverse section
EPIDERMIS
COLUMELLA
SEEDS
COLUMELLA
LOCULAR CAVITY
PLACENTAL TISSUE

Tomato:



(http://www.oardc.ohio-state.edu/seedid)

(http://www-plb.ucdavis.edu/labs/rost/Tomato/Reproductive/flrfert.html#testa)

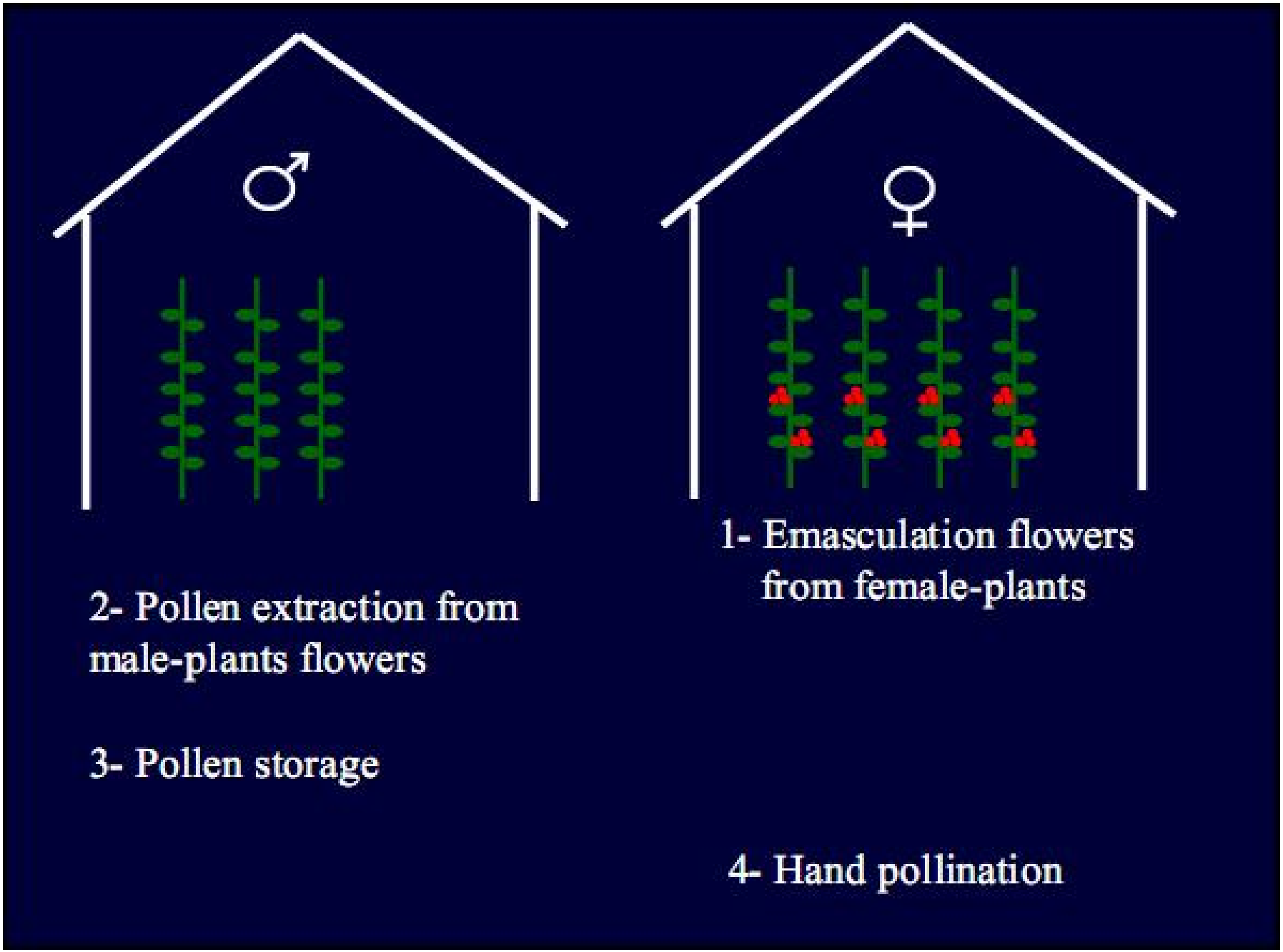


Seed production in protected structures

/www.avrdc.org)

B.

C.


♂
♀
1- Emasculation flowers
from female-plants
2- Pollen extraction from
male-plants flowers
3- Pollen storage
4- Hand pollination

a) Emasculation

Importance of optimal moment:

before ⟶ damage to flower, low yield

after ⟶ contamination (self-pollination), low quality

b) Pollen extraction

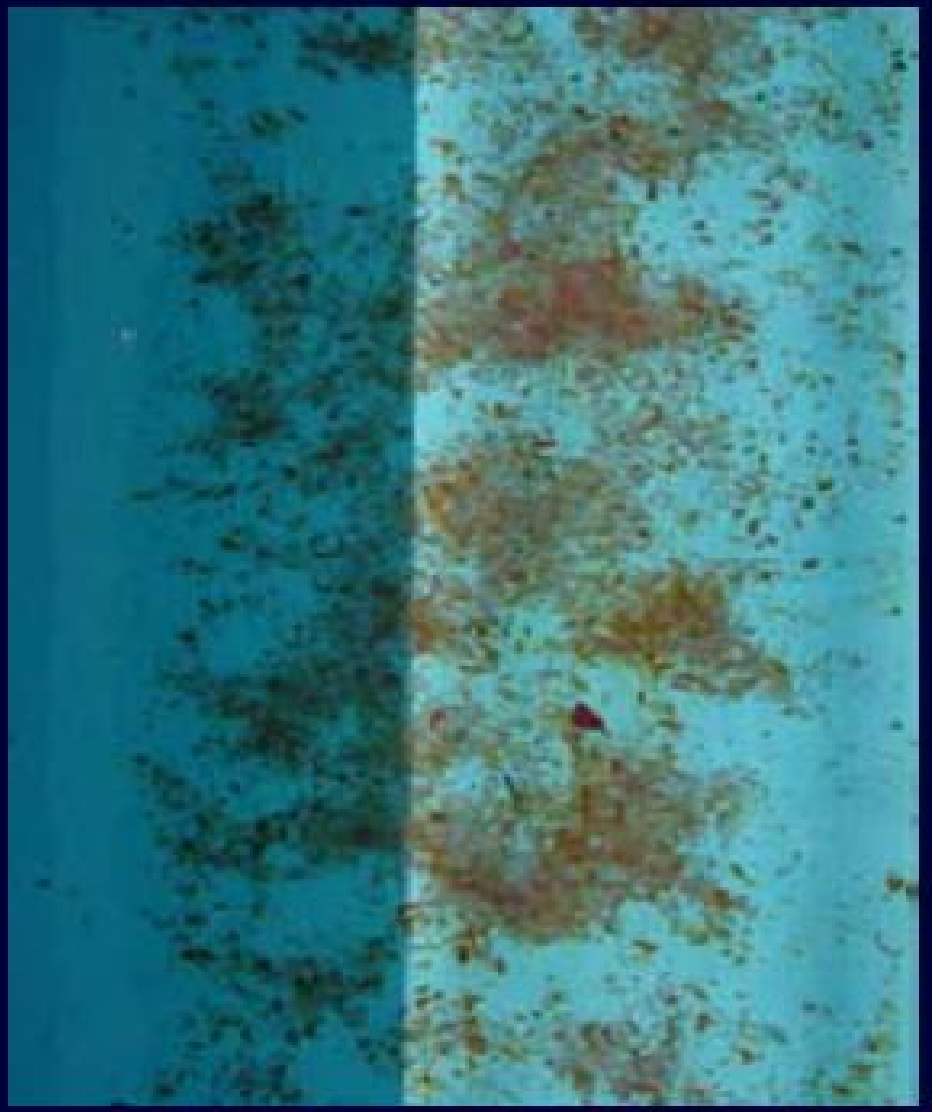
c) Pollen storage

e) Hand pollination

Separation of seeds from gelatinous covering

- **Natural fermentation**
- **Sodium carbonate**
- **Hydrochloric acid**

Washing



Onion Breeding

Origin

Scientific name : *Allium cepa* L.
Family : Alliaceae (Amaryllidaceae)

Onions are grown in just about every country in the world.

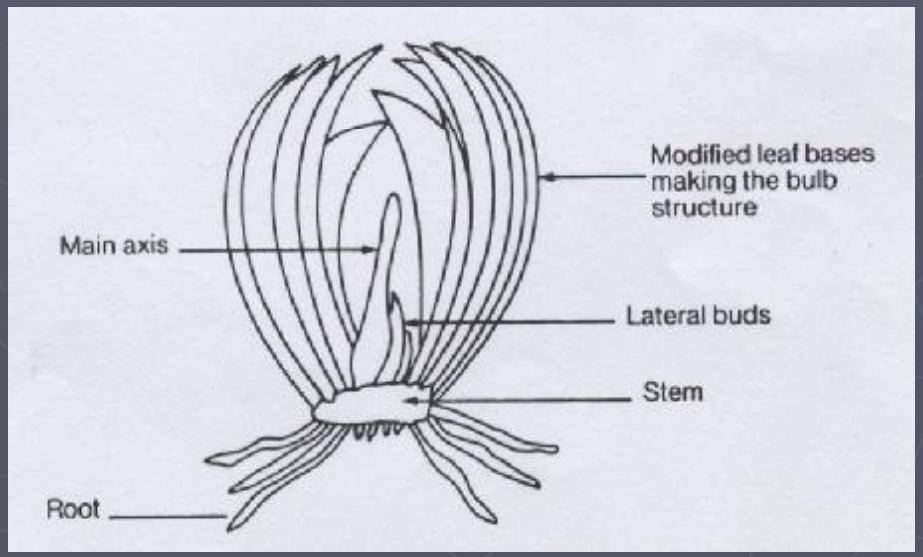
They are used in salads, as a raw or cooked vegetable, and as a condiment.

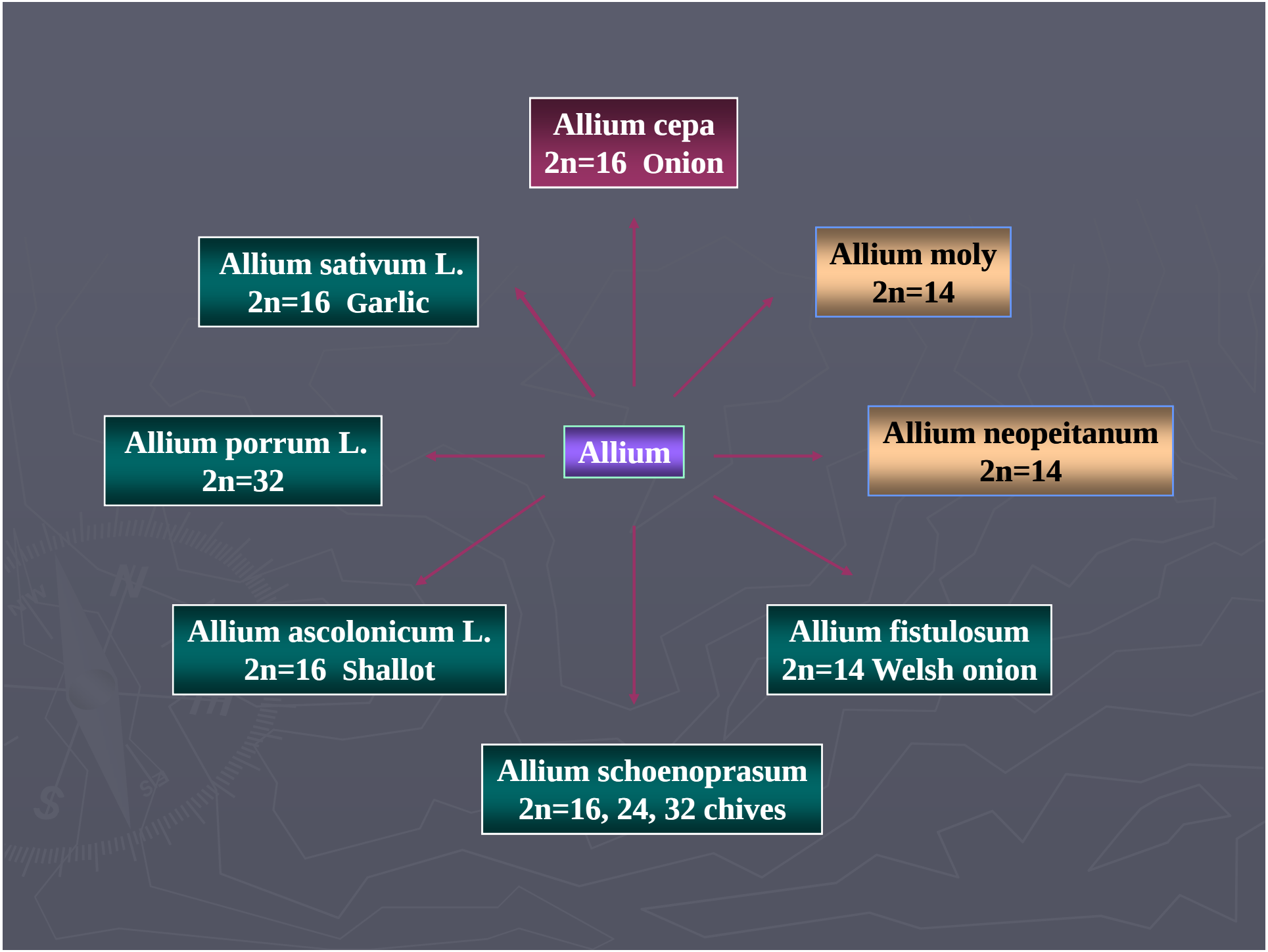
Iran to Pakistan, cultivated in very ancient times & possibly never found in the true wild state.

Introduced to the Americas by the Spanish very early and quickly spread throughout most of North & South America.

Parts Used for Food

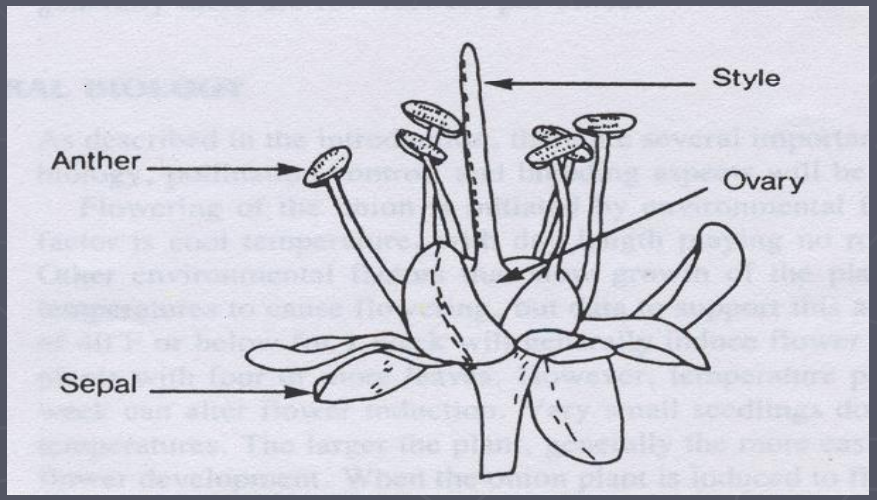
Bulb, sometimes leaves. The bulb consists of enlargements of the leaf bases in which food reserves are stored.




Allium cepa
2n=16 Onion
Allium sativum L.
2n=16 Garlic
Allium moly
2n=14
Allium porrum L.
2n=32
Allium
Allium neopeitanum
2n=14
Allium ascolonicum L.
2n=16 Shallot
Allium fistulosum
2n=14 Welsh onion
Allium schoenoprasum
2n=16, 24, 32 chives

Floral biology

The floral structure consists of : three carpels united into a single Pistil, six stamens (3 inner and 3 outer) 3 inner perianth segments (petals), 3 outer perianth segments (sepals), Sepals and petals are alike and sometimes called tepals. The ovary is superior.



Inflorescence

An umbel composed of many smaller inflorescences (cymes) of 5-10 flowers each.

The flowers open in a sequence within each of the cymes with a delay between flowers.

Flowering may be in progress within a single umbel for two weeks or more.

Inflorescence

50 to 2000 florets are borne in a simple oval umbel at the top of the elongated seed stalk.

The individual floret, only 3 to 4 mm in length, a simple style leading to a three-celled ovary with two ovules in each cell.

The anthers of the three inner stamens open first, & one after another, shed their pollen. Then the anthers of the outer whorl open, also at irregular intervals.

Pollination

Onion is a dichogamous plant and largely cross pollinated by insects, primarily by honey bees.

Self pollinations can occur because pollen may be transferred between different flowers on the same plant.

Most of the pollen is shed between 9 am and 5 pm of the first day the flower is open.

Inflorescence

When flowering begins, only a few flowers open each day on an umbel, but the number increases until at full bloom 50 or more florets may be open on a single day.

They continue to open over a two -week period, and 30 days or more may be involved in the flowering on all of the flower stalks.

The normal flower in onions is perfect, but genetic & cytoplasmic sterility variations were reported in a single plant segregant of the cultivar Italian Red.

Floral biology

Plants grown from seed usually produce only one seed stem if induced to flower.

Plants grown from bulbs may produce six or more seed stems since several lateral buds may be present that formed during development of the bulb.

It is common for plants to produce bulbs and seed stems when grown during the winter and into the spring.

Flowering

Flowering of the onion is initiated by Environmental factors

The primary inductive factor is cool temperature with day length that playing no role as with bulb development.

Temperatures of 4.5° C or below for one week will induce flower formation in bulbs or growing plants with 4 or more leaves.

Flowering

The larger the plant, generally the more easily it can be induced to initiate flower development.

When the onion plant is induced to flower, the shoot apex ceases to produce leaf primordia and initiates the inflorescence.

The number of seed stems produced per plant depends on the number of lateral buds contained on the stem. which is the compact base plate on the bottom of the bulb.

Major Breeding Achievements

Onions fall into 2 major types, Short day and long day onions.

The third group should be recognized as intermediate day legth types, which bulb somewhere between the two major groups.

The onion has been greatly improved in characteristics such as :

- Quality
- Yield
- Uniformity

Major Breeding Achievements

The important traits that are controlled by multiple genes or additive action and should be considered in the onion breeding program includes :

- Male sterility
- Ease of bolting
- Bolt resiatance
- Long storage
- Insect resistance
- Bulb shape and color
- Foliage color
- Foliage morphology
- Disease resistance
- High percentage of dry matter

Progenies Resulting from Various Genetic and Cytoplasmic Combinations Crossed onto a Male-Sterile onion Line

Male-sterile line (A)	Male-fertile line (B)	Progenies
Sms/ms ×	*Nms/ms*	*Sms/ms*
	NMs/ms	*SMs/ms*
		Sms/ms
	NMs/Ms	*SMs/ms*
	SMs/Ms	*SMs/ms*
	SMs/ms	*SMs/ms*
		Sms/ms

[a]Only the *Sms/ms* condition is male sterile.

The Genetics of Several traits In the Onion

Onion traits	Genetic condition
Albino seedling	*a/a*
Yellow seedling linked with glossy	*y1/y1*
Yellow seedling not linked with glossy	*y2/y2*
Pale green seedling	*pg/pg*
Virescent seedling	*v/v*
Glossy foliage	*gl/gl*
Exposed anther	*ea/ea*
Yellow anther	*ya/ya*
Pink root resistance	*pr/pr*
Male sterility[b]	*ms/ms*
Bulb color	
Homozygous red	*i/i,C/C,R/R*
Heterozygous red	*i/i,C/c,R/R*
Heterozygous red	*i/i,C/C,R/r*
Heterozygous red	*i/i,C/c,R/r*
Homozygous yellow	*i/i,C/C,r/r*
Heterozygous yellow	*i/i,C/c,r/r*
Homozygous recessive white	*i/i,c/c,R/R*
Homozygous recessive white	*i/i,c/c,R/r*
Homozygous recessive white	*i/i,c/c,r/r*
Homozygous dominant white	*I/I,–,–*
Heterozygous dominant white (buff)	*I/i,–,–*

Fundamentals of Seed Production I: Genetics, Breeding, and Seed Production

How to deal with the increasing demand?

- New technologies for yield improvement:
  - Development of new cultivars (breeding) → **50%**
  - Establishment techniques
  - Watering
  - Nutrient supply
  - Crop protection
  - Post harvest
  - etc.

- Seed has become a delivery mechanism for new technologies and a high value products

Open pollinated seed production

Heterozygous population

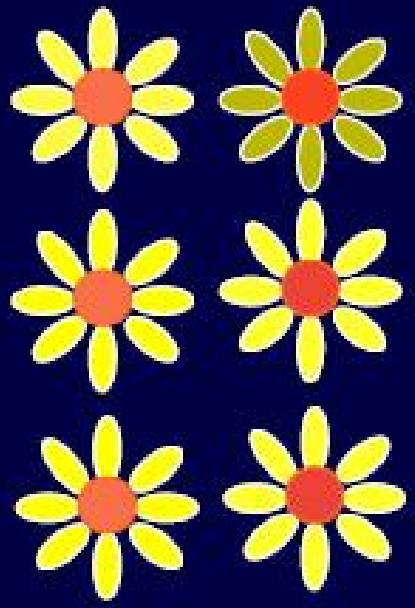
Breeding

Selected cultivar

Open pollinated seed production

Selected cultivar

Seed production:
- Isolation
- Roguing

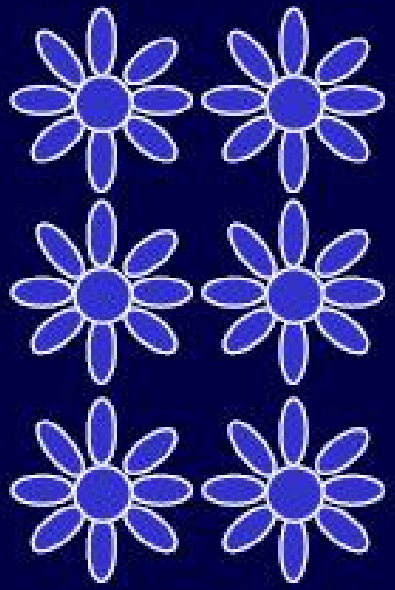


Progeny from OP seed

Hybrid seed production

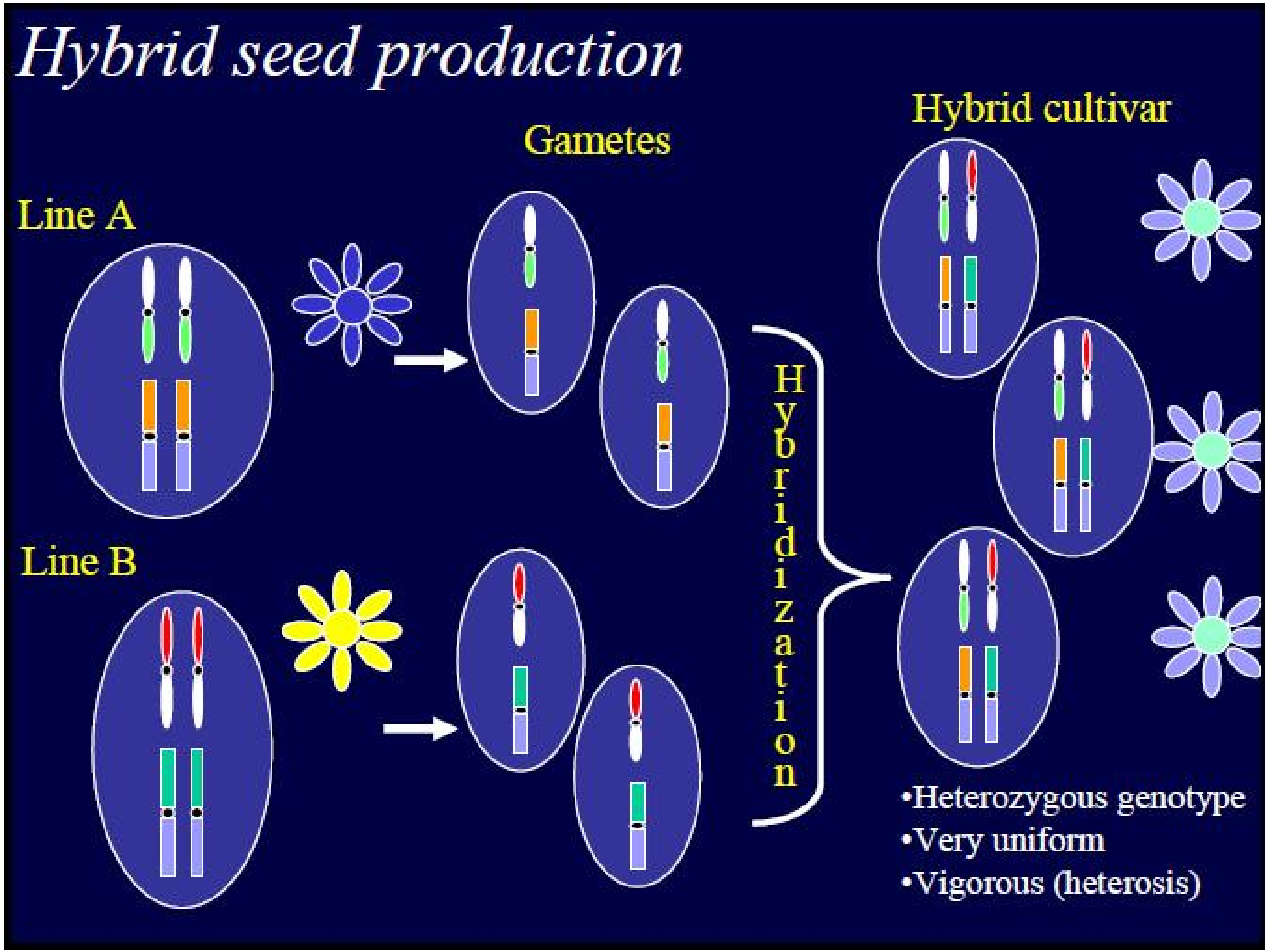
Heterozygous population

Enforced self-pollination of selected individual through several generations



Inbred line

- Homozygous genotype
- High uniformity
- Low vigor (inbreed depression)


Hybrid seed production
Hybrid cultivar
Gametes
Line A
Line B
Hybridization
•Heterozygous genotype
•Very uniform
•Vigorous (heterosis)

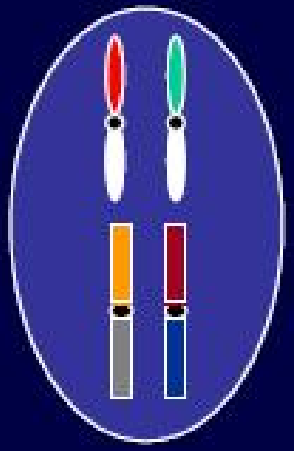
Hybrid seed production

- An ***hybrid cultivar*** may be defined as the first generation from a cross that results from controlled pollination between progenitors with different genotype. The seed obtained from that cross is the only commercial seed that may be designated as hybrid.

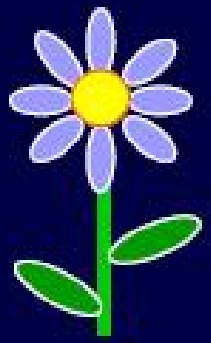
Attributes of genetically pure seed (Kester et al 1997):

- Trueness to name
- Trueness to type
- Freedom from contaminants

• In general, the objective of any propagation technique is to multiply a specific *genotype* and produce the kind of plant or *phenotype* that we are interested.

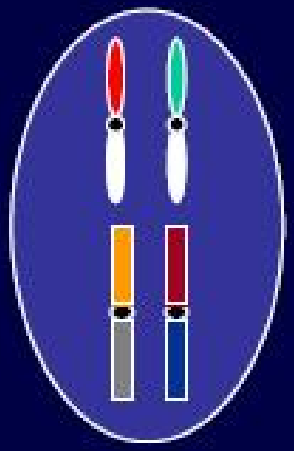


Genotype
(genetic constitution)



Phenotype
(external appearance)

• In general, the objective of any propagation technique is to multiply a specific *genotype* and produce the kind of plant or *phenotype* that we are interested.

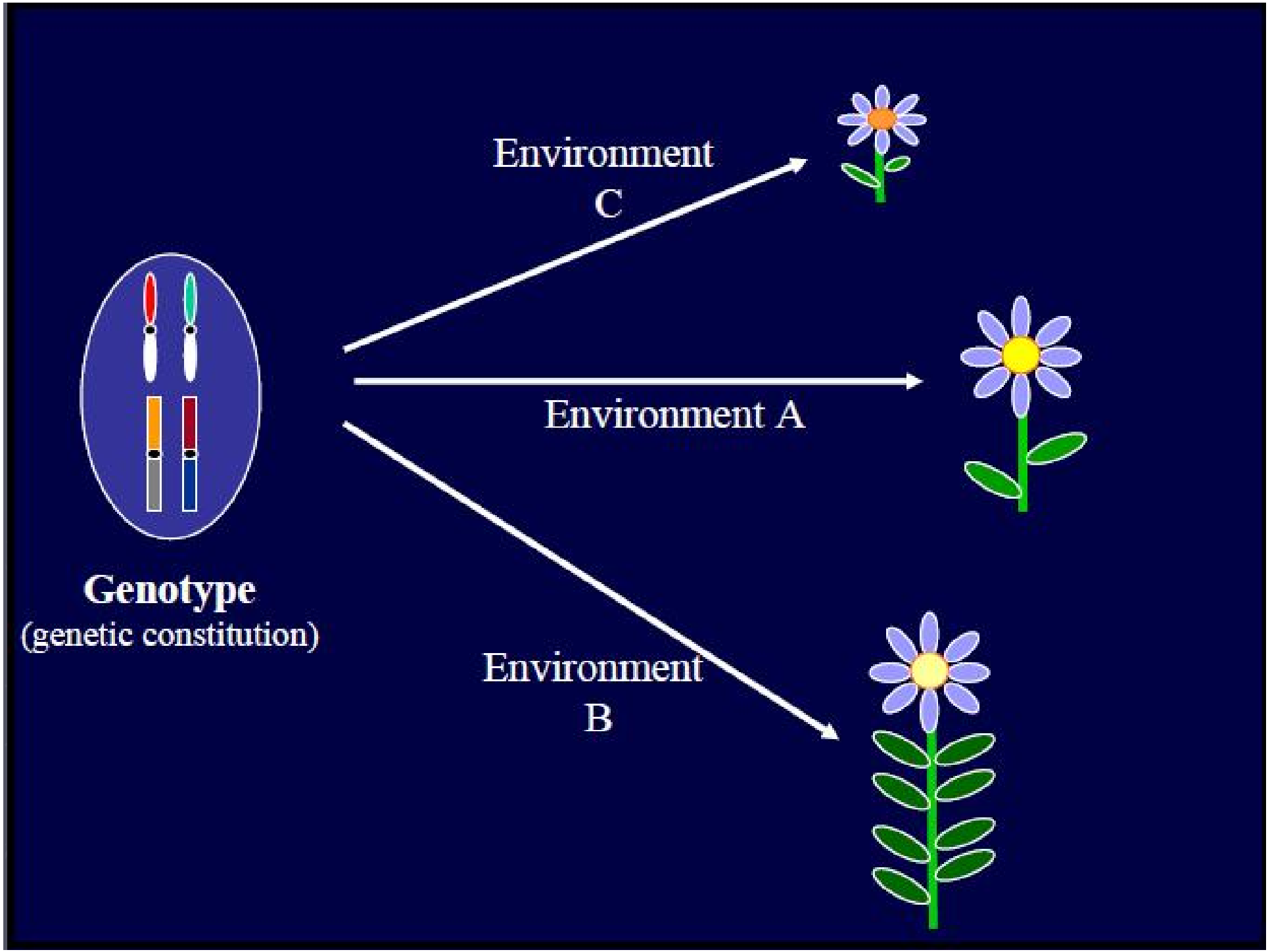


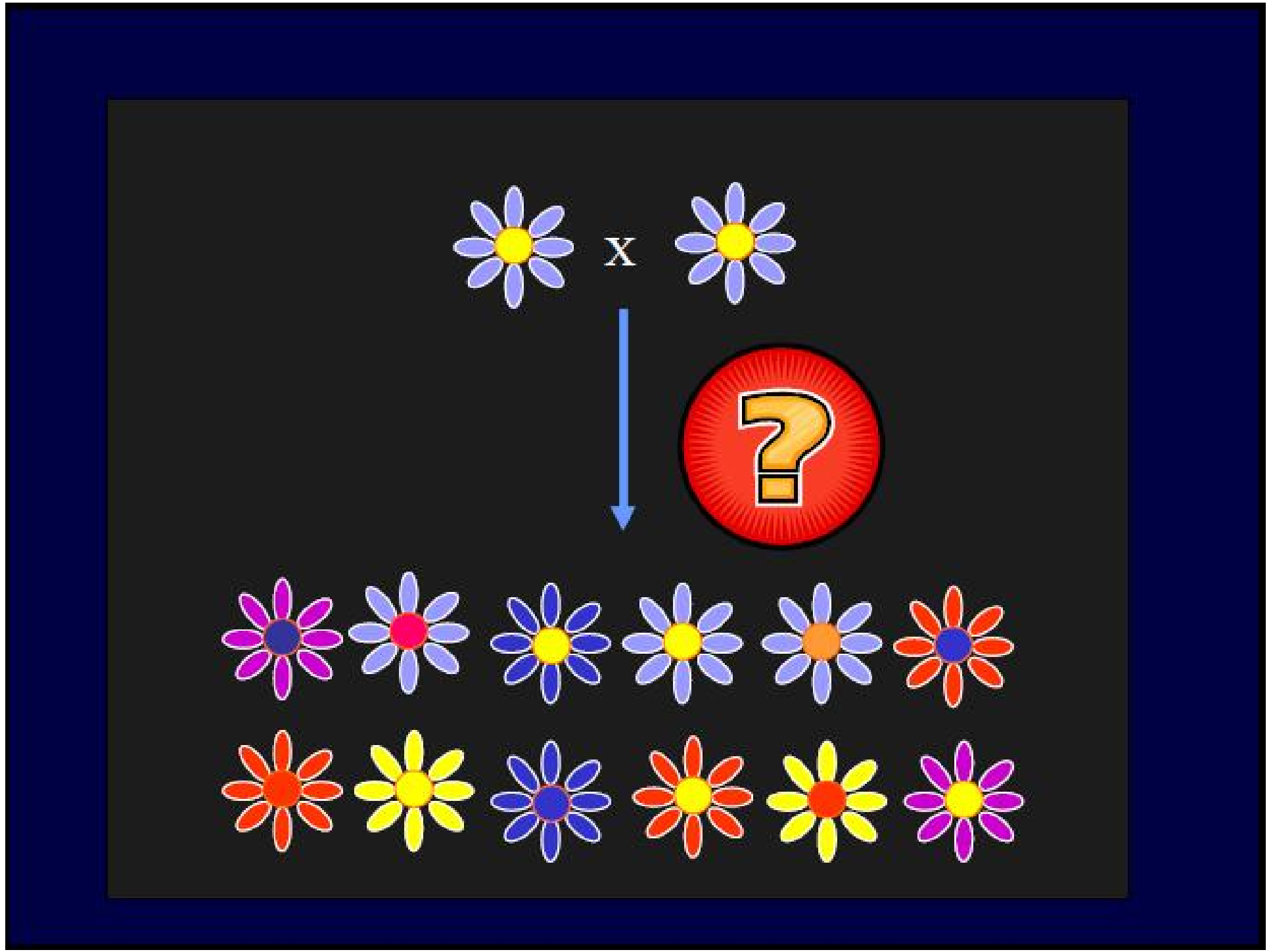
Genotype
(genetic constitution)

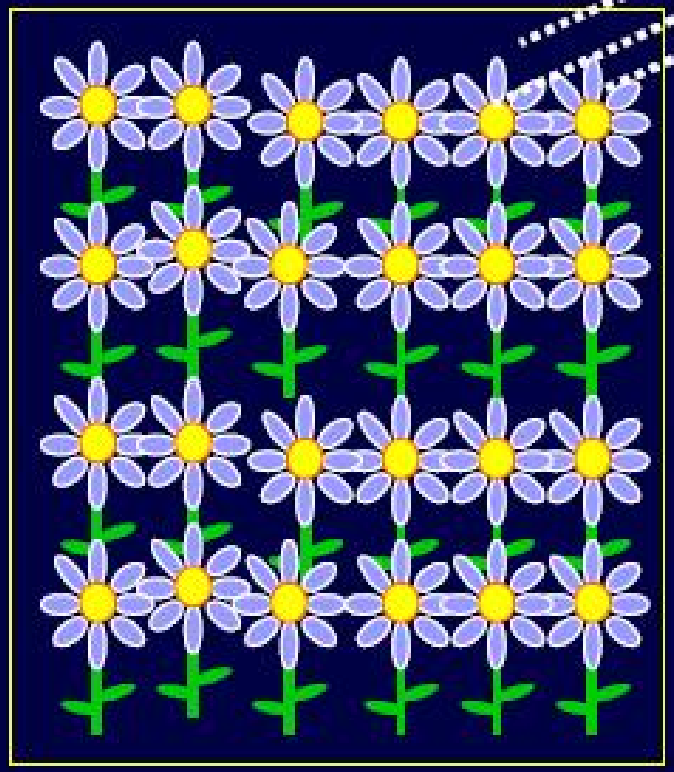
Environment A

Phenotype
(external appearance)

Genotype x Environment = Phenotype

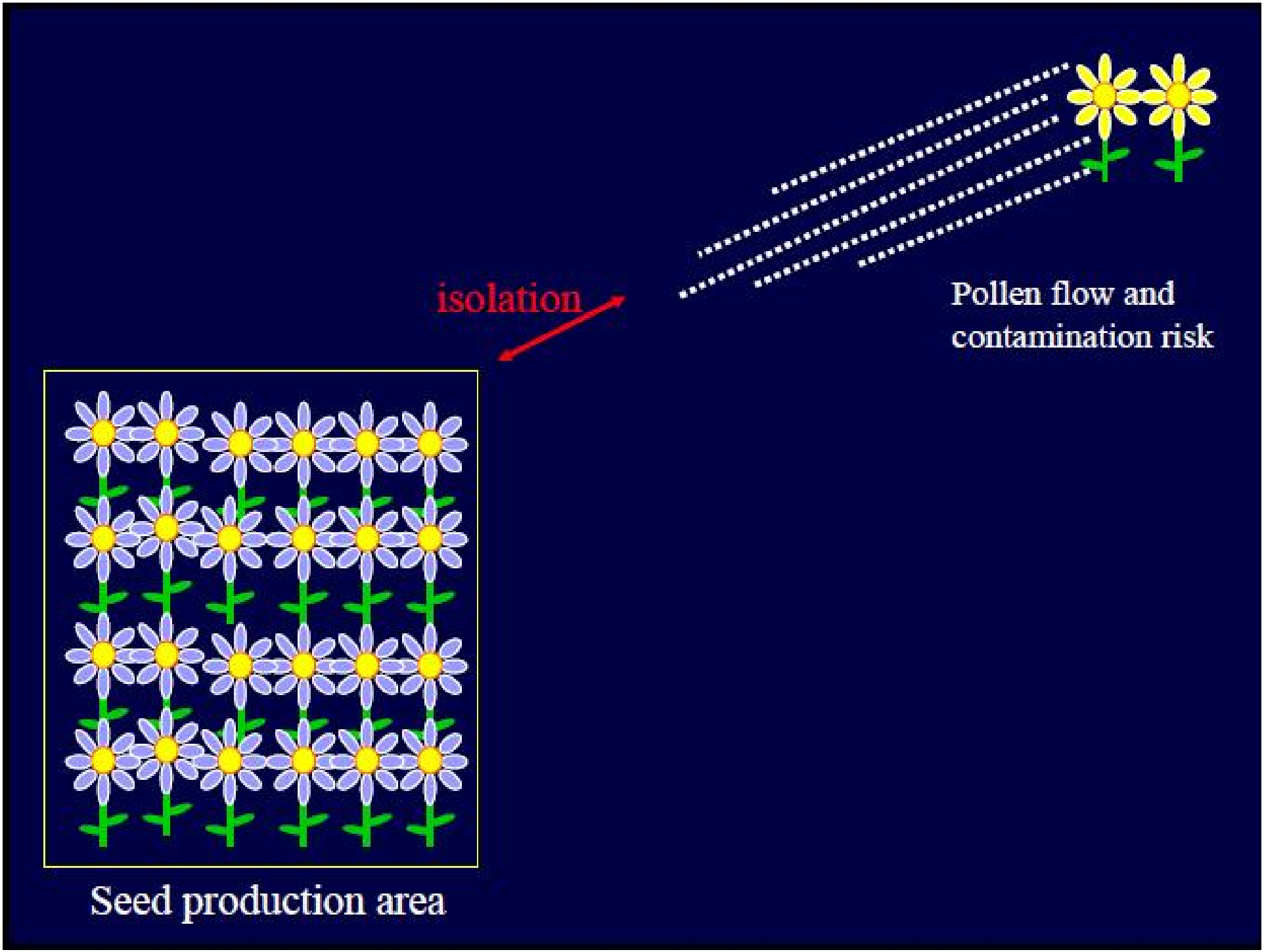

Environment
C
Environment A
Environment
B
Genotype
(genetic constitution)


x
?

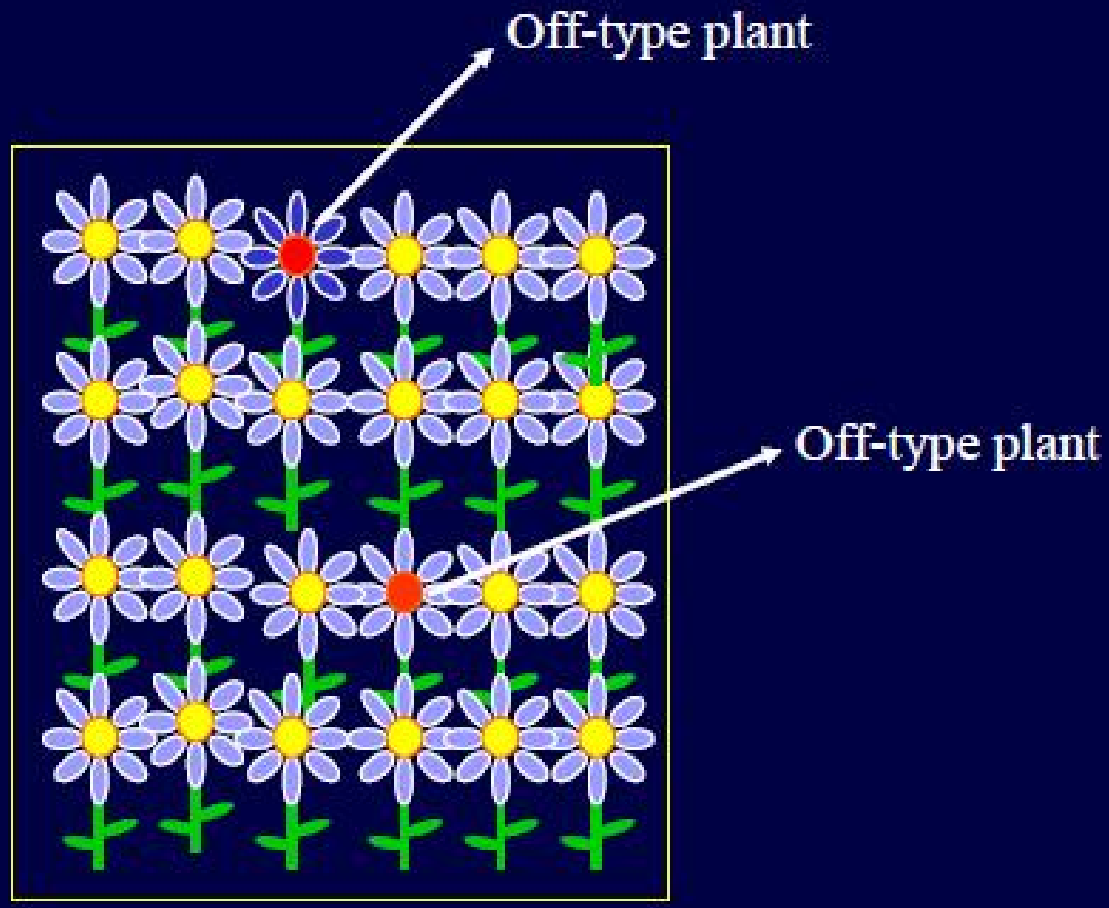


Seed production area

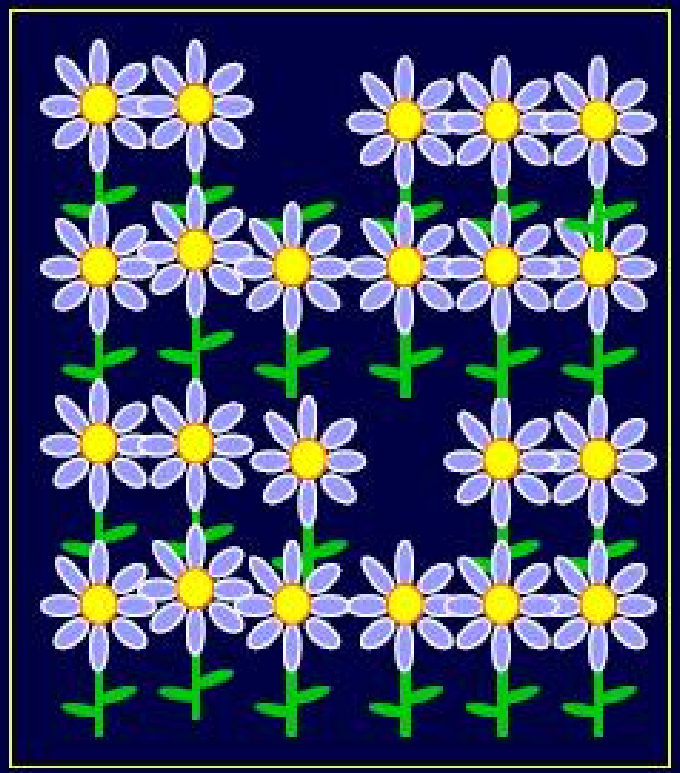
Pollen flow and
contamination risk


isolation
Pollen flow and
contamination risk
Seed production area

Roguing: elimination of off-type plants



Roguing: elimination of off-type plants



Seed production area

Seed certification

گواهی بذر یا Seed certification برنامه ای برای حفظ و تأمین بذرهای با کیفیت عمومی بالا وتکثیر مواد ژنتیکی ارقام گیاهان زراعی و باغی خاص است.

در این برنامه، بذرگواهی شده به وسیله کشاورزان خبره و تولیدکنندگان بذر با رعایت کنترل دقیق کیفی، کاشت به روش شجره ای، بازرسی مرتب درطول فصل رشد و بازرسی پس از برداشت تولید می شود.

گواهی بذر یا Seed certification روش رسمی شناخته شده ای برای حفظ هویت بذر یک رقم در بازار آزاد می باشد . از این رو، گواهی بذر برای گیاهان باغی به ویژه بذور گل وسبزی بسیار مهم و ضروری است

Seed certification

الگوی کلی برنامه تولید بذرگواهی شده از اصلاح یک رقم تا قابلیت دسترسی به آن توسط کشاورزان به صورت زیر است

Breeder's seed بذر اصلاح شده یا بذر نوکلئوس

این بذر زیر نظر مستقیم اصلاح گر تولید می شود و شجره حقیقی یک رقم را نشان میدهد.

Foundation seed بذر پایه

به اولین بذر ی که از تکثیر بذر اصلاح شده به دست می آید، بذر پایه می گویند.معمولاً این کارضمن عقد قرار داد با سازمان های بذر پایه و تحت کنترل اصلاح گر انجام میشود. بذر پایه با برچسب سفید گواهی بذر مشخص می شود.

Seed certification

Registered seed

بذر ثبت شده

به بذر ی که از تکثیر بذر پایه به دست می آید، بذر ثبت شده می گویند . هدف از این مرحله افزایش نسل دیگری از بذرقبل از اقدام به تولید بذر گواهی شده می باشد. بذر ثبت شده در رده تجاری قرار نمی گیرد. این طبقه بندی را با برچسب ارغوانی مشخص می کنند.

Certified seed

بذر گواهی شده

بذر ی است که از تکثیر بذر پایه یا ثبت شده به دست می آید، و آخرین کلاس بذر در برنامه گواهی بذر می باشد. این طبقه با برچسب آبی رنگ علامت گذاری می شود.

Seed Conditioning

- After harvest, seed must be cleaned: a process known as seed conditioning or processing
- Ultimate goal is to obtain the maximum percentage pure seed with maximum germination potential
- Pure Live Seed:

Pure Seed X Germination = Pure Live Seed

95% X 93% = 88.35%

Seed Conditioning

- Objectives
  - Complete separation
  - Minimization of seed loss
  - Upgrading
  - Efficiency
  - Minimization of labor

- Preconditioning
  - A precleaning operation
  - Commonly done by a scalper
    - Enough trash is removed to permit conditioning
    - Seeds feed more evenly through equipment
    - High moisture, green material is removed decreasing time and cost of drying
    - Removal of bulk of trash permits finer top screens to be used resulting in precise separations
    - Cleaning machines are more efficient

- Conditioning
  - Components must differ in some physical characteristic
  - Seed separations usually made on two characteristics
    - Seed size
    - Seed weight