In the Name of God

Fruit Breeding

M. Gholami

Methods in Fruit Breeding
by James N. Moore (Author) ,
Jules Janick (Author)


FRUIT BREEDING
Volume I. Tree and Tropical Fruits
Edited by
Jules Janick
FRUIT BREEDING
Volume II. Vine and Small Fruits
FRUIT BREEDING
Volume III. Nuts
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Biotechnology of Fruit and Nut Crops
CABI Publishing
Shri Mohan Jain
P. M. Priyadarshan
EDITORS
Breeding Plantation Tree Crops
Temperate Species
Springer

- Rudolph Jacob Camerer (1665-1721)

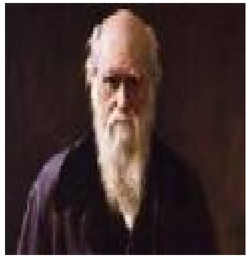
- Linnacus (1707-1778)

- Kölreuter (1733-1806)

- Fairchid (1719)

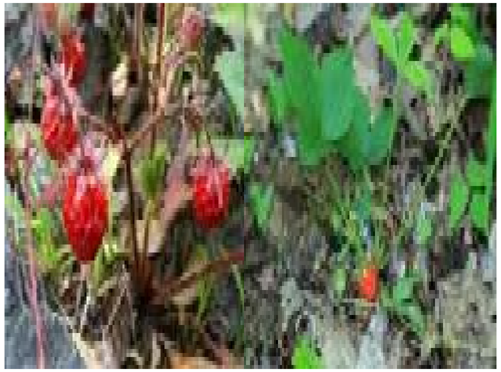
- Thomas Andrew (1759-1838)

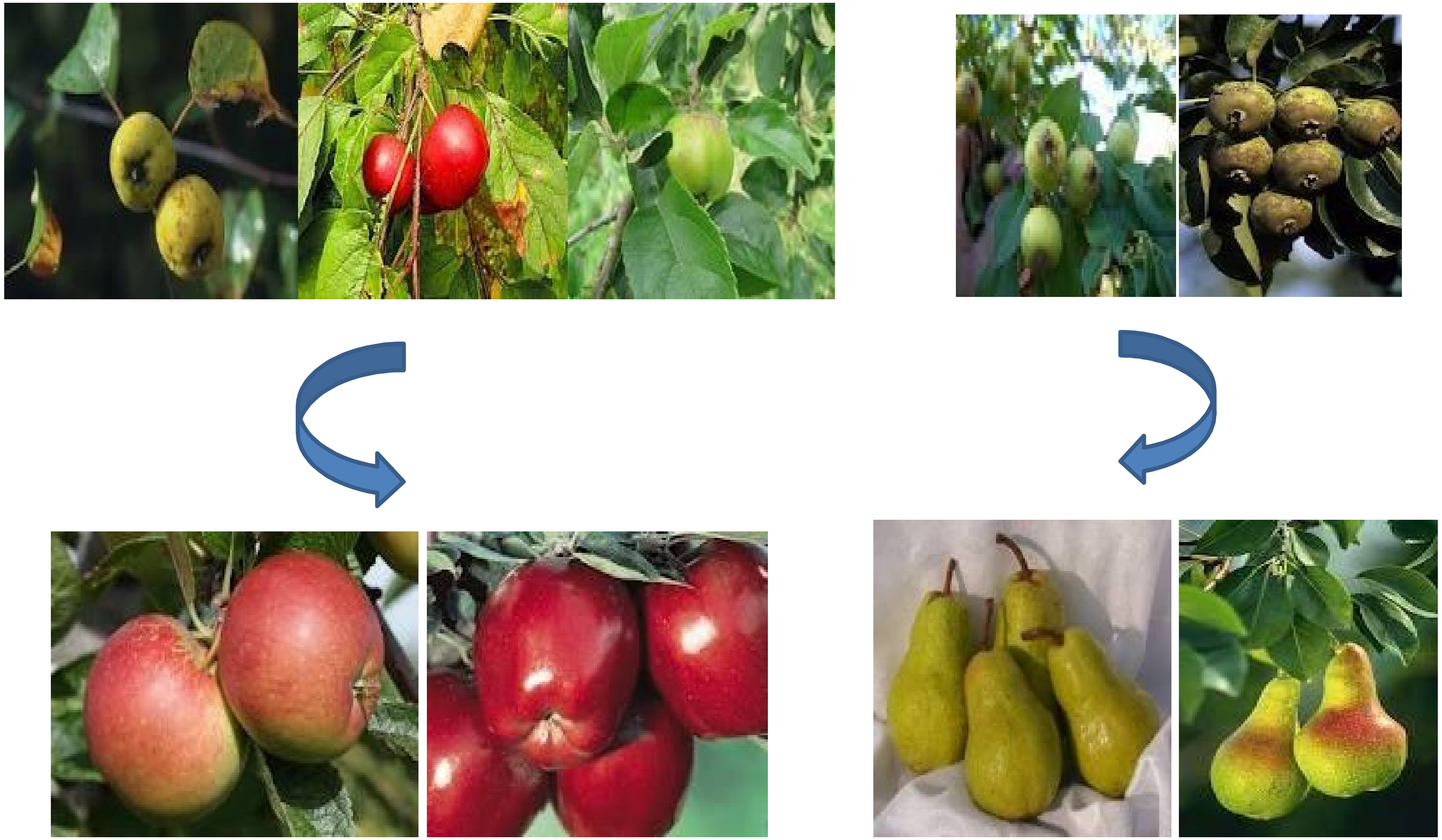
- Charles Darwin (1809-1882)



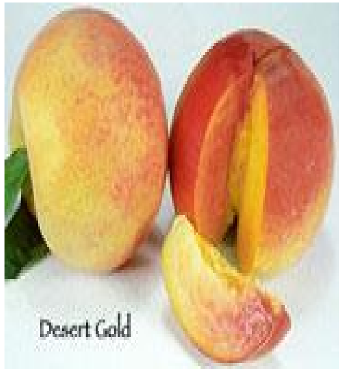
- Johann Mendel (1822-1884)

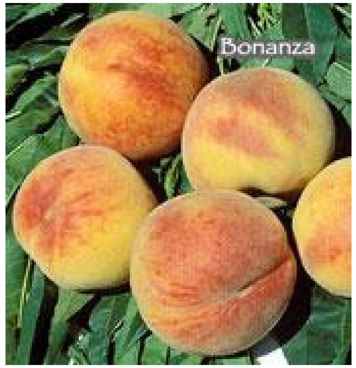
- H. deveries, C. Carens, E. Tschermak





Chilling requirement high, 500 hours





Chilling requirement very low, 250 hours or less

Trends in Fruit Breeding

1-Environmental Issues

کشاورزی پایدار	گرم شدن جهانی زمین	آلودگی زیست محیطی

2-Health Consciousness

- میوه سالم تر
- میوه با ارزش غذایی بالاتر
- توسعه کشاورزی پایدار و ارگانیک

3-Consumer Expectations and Habits

محصول ارگانیک (green)

سهولت در مصرف، عطر و طعم خوب، کیفیت ثابت

انبارمانی طولانی، تولید در سراسر سال

4-Producer Expectations: Simplified Management

- رقم های با بیشترین کمیت و کیفیت
- کاهش هزینه کارگری
- کاهش هزینه مواد شیمیایی

Fruit Breeding Goals

Simplifying Orchard Practices

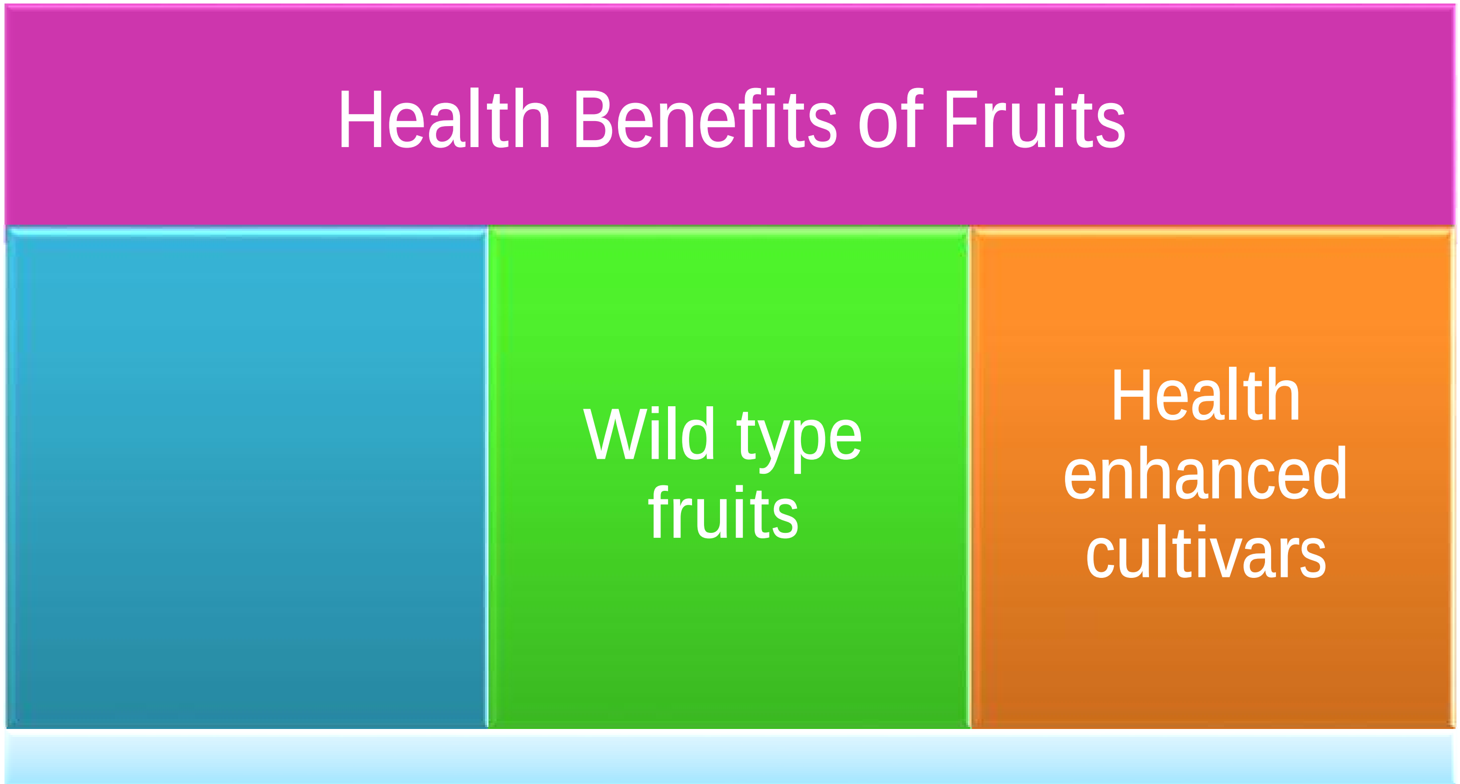
افزایش سفتی میوه یکنواختی رسیدن سهولت در جدا شدن مقاومت به ضربه	پایه های پاکوتاه پیوندک های spur type	تغییر اندازه درخت یا عادت رشد

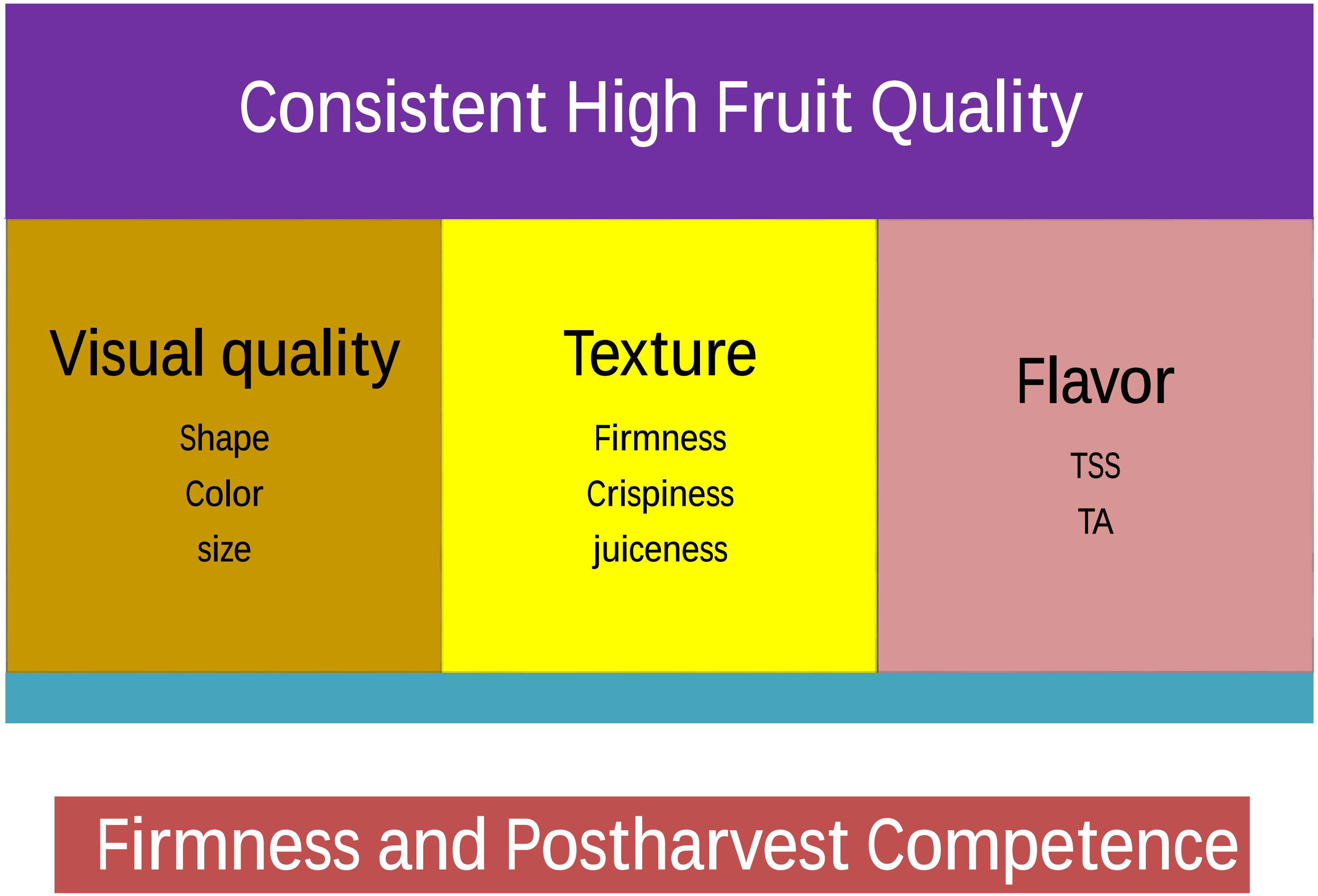
Fruiting Stability

مقاومت به تنش های محیطی	سازگاری به نواحی تولید جدید	مقاومت به آفات و بیماری ها	self fertility

Diversification of fruit Types

عطر و طعم جدید	ظاهر جذاب	ویژگی کیفی متمایز


Health Benefits of Fruits
Wild type fruits
Health enhanced cultivars


Consistent High Fruit Quality
Visual quality
Shape
Color
size
Texture
Firmness
Crispiness
juiceness
Flavor
TSS
TA
Firmness and Postharvest Competence

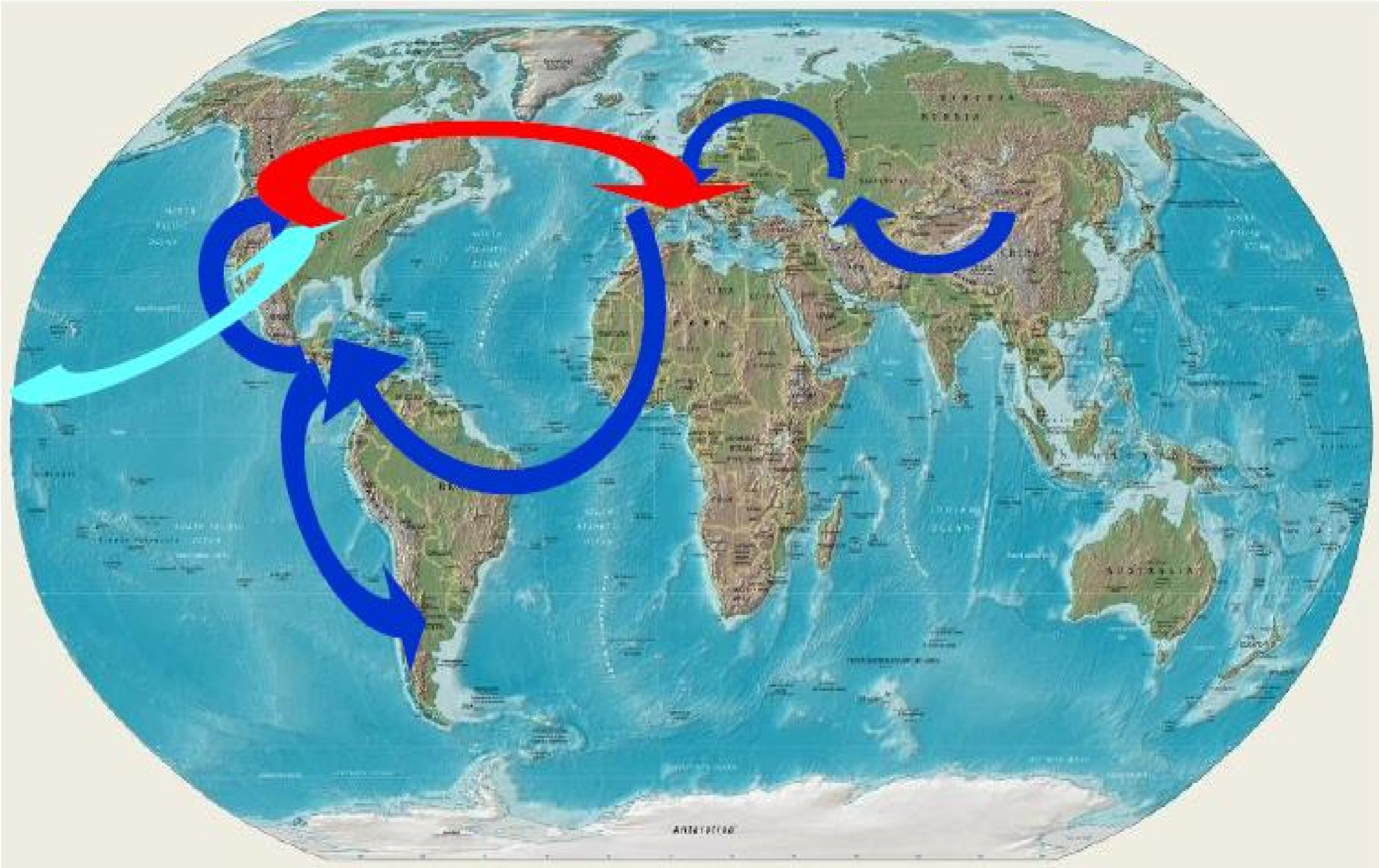
Fruits:

Trees | Shrubs | Climbing vines | Perennial Herbs

Diospyros virginiana


New
World
(Americas)
Old
World

PEACH ORIGIN AND DISPERSAL



Prunus persica peach pêche pesco préssec

PEACH FRUIT MORPHOLOGY

Skin pubescence

PEACH

NECTARINE

G/g

Flesh consistency

MELTING

NON-MELTING

M/m

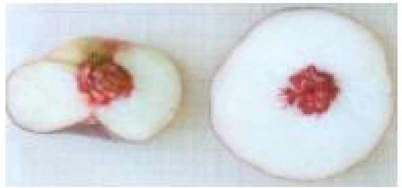
Fruit shape

ROUND

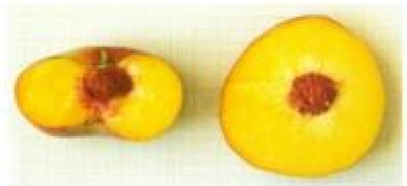
FLAT

Sh/sh

Flesh color



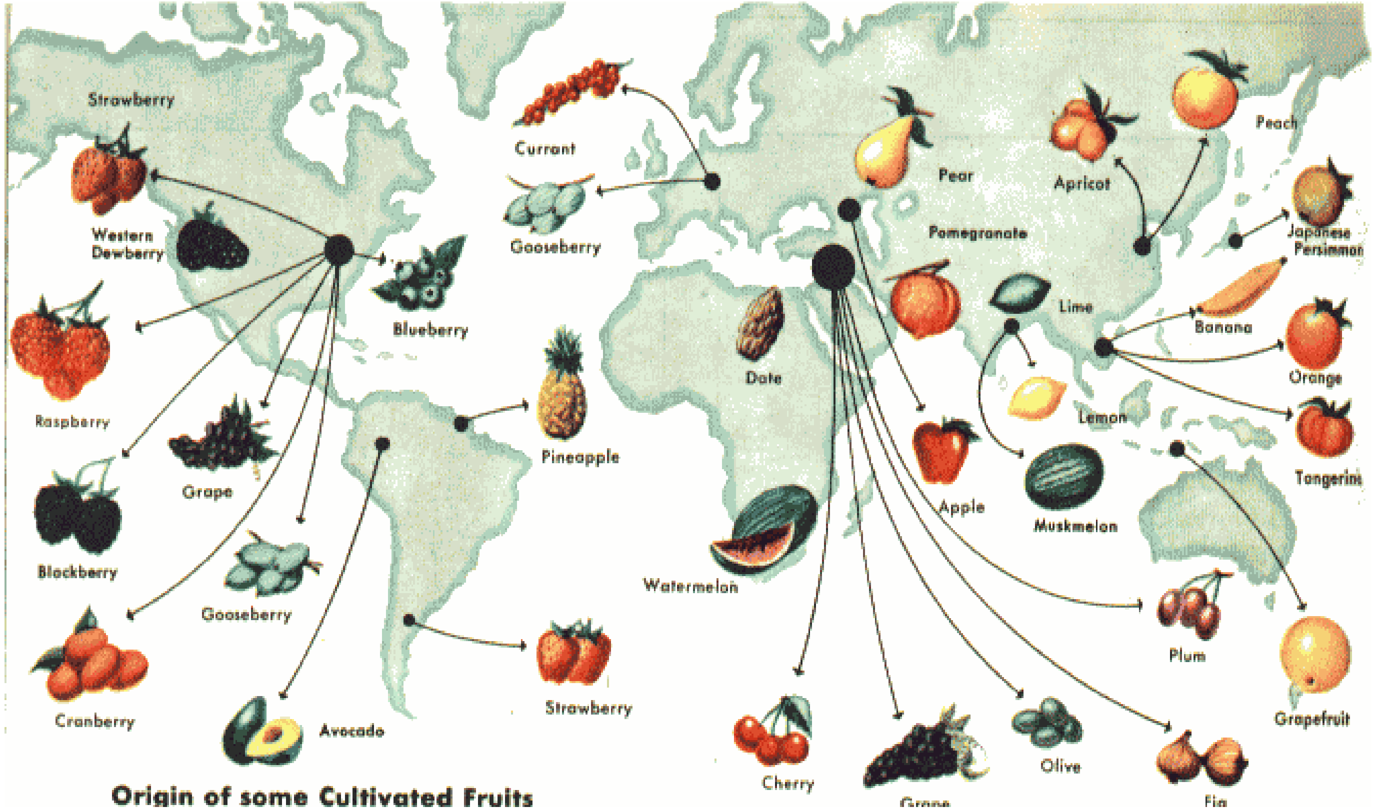
WHITE



YELLOW

Y/y

Genetic Variation



Origin of some Cultivated Fruits

Apple scab resistant variety

Introgression, also known as introgressive hybridization, in genetics (particularly plant genetics) is the movement of a gene (gene flow) from one species into the gene pool of another by the repeated backcrossing of an interspecific hybrid with one of its parent species. Purposeful introgression is a long-term process; it may take many hybrid generations before the backcrossing occurs. Introgression is an important source of genetic variation in natural populations.

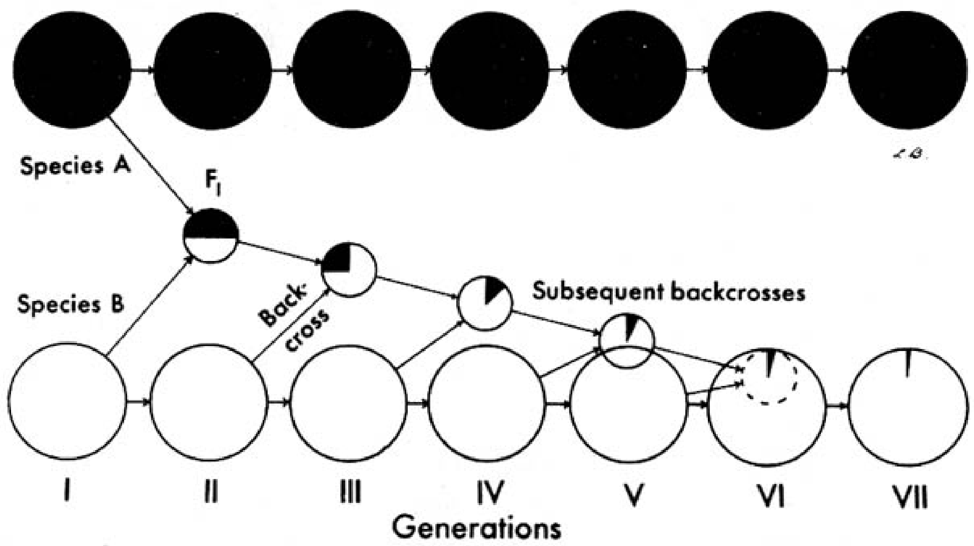
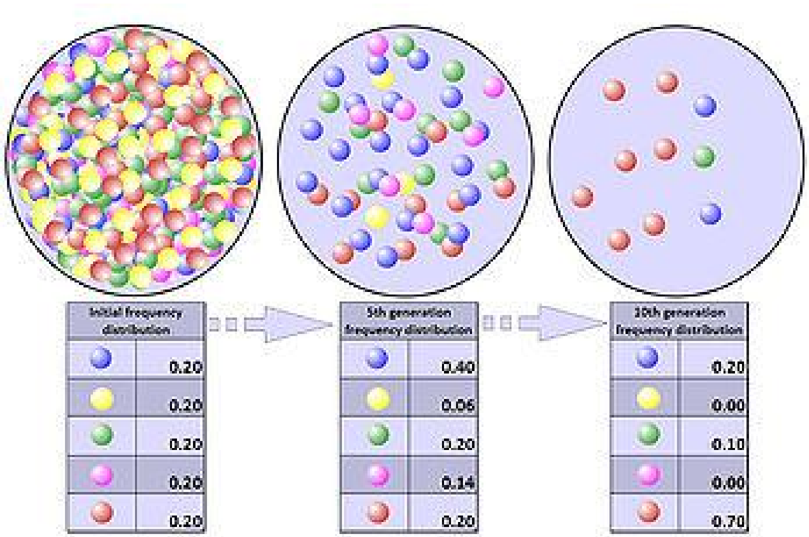


Fig. 11.11. Diagram illustrating introgression between two species. Backcrossing of the F_1 hybrid to species B ultimately results in the absorption of some genes from species A into at least some individuals of species B. Reprinted by permission of John Wiley & Sons, Inc. from Benson (1962), *Plant taxonomy*. © 1962.

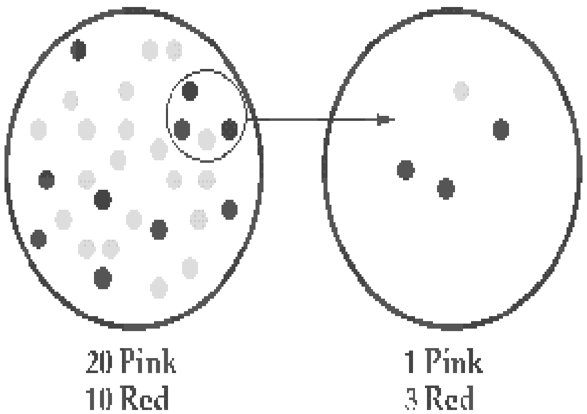
Genetic drift or allelic drift is the change in the frequency of a gene variant (allele) in a population due to random sampling. The alleles in the offspring are a sample of those in the parents, and chance has a role in determining whether a given individual survives and reproduces. A population's allele frequency is the fraction of the copies of one gene that share a particular form. Genetic drift may cause gene variants to disappear completely and thereby reduce genetic variation.



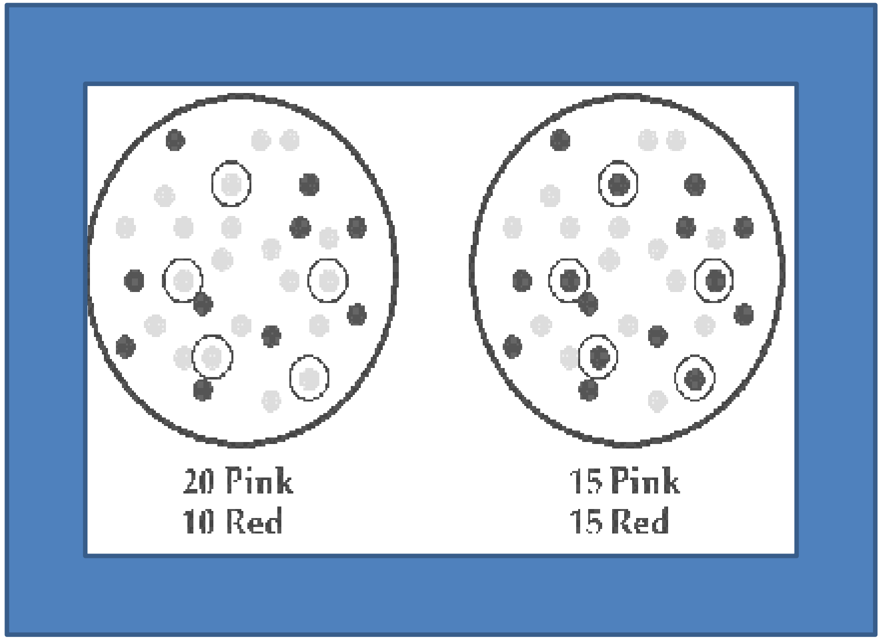
Changes in a population's allele frequency following a population bottleneck: the rapid and radical decline in population size has reduced the population's genetic variation

The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals. That, in a nutshell, is genetic drift. It happens to ALL populations—there's no avoiding the vagaries of chance.

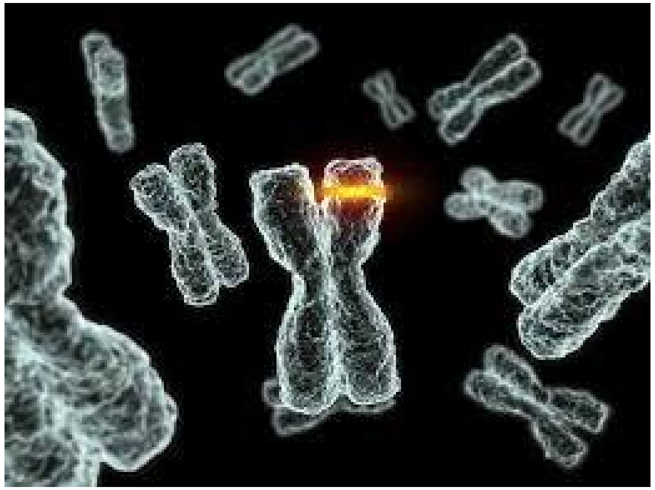
Genetic Drift



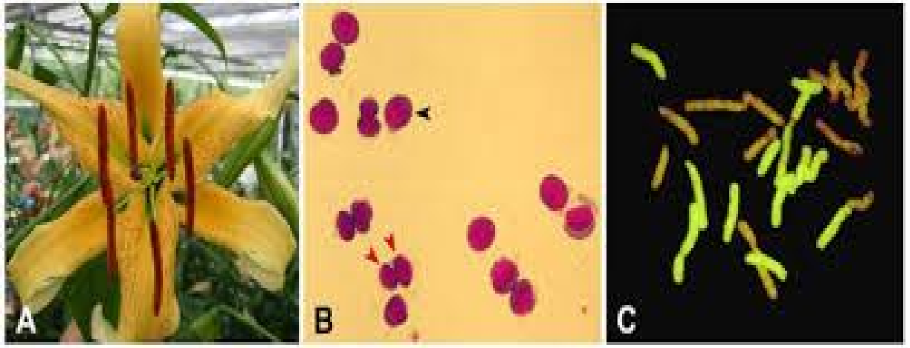
Mutation

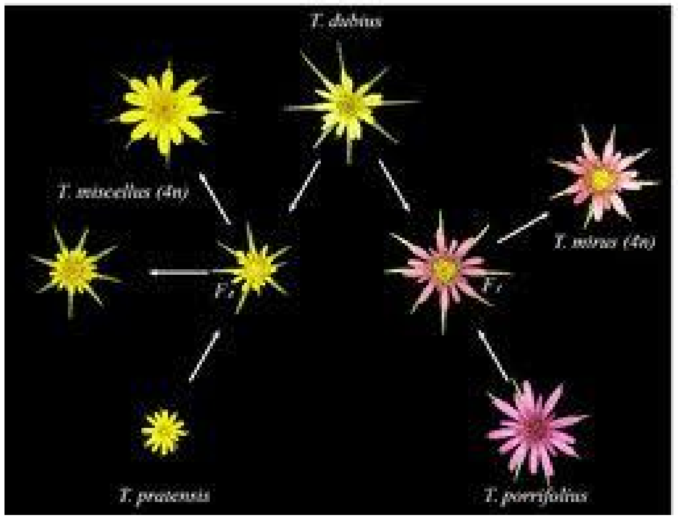


Mutation as an Agent of Domestication



Interspecific Hybridization and Polyploidization

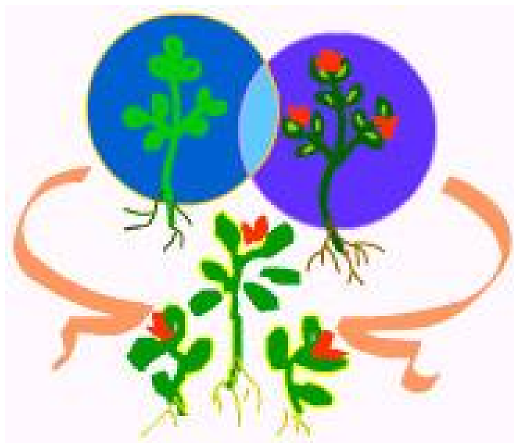








Hybridization and Selection



Champions

Domestication of blueberry was initiated by a single researcher, Frederick Vernon Coville (1888–1937), USDA botanist, who recognized the potential of this species, and later had a fortunate collaboration with Elizabeth White, a blueberry enthusiast from Whitesbog, New Jersey. Later influential researchers included George Darrow and Arlen Draper, both USDA researchers. In strawberry, Amédee François Frézier introduced *F. chiloensis* to France, resulting in the fortuitous hybridization with *F. virginiana*, and the great French botanist, Antoine Nicolas Duchesne, who explained the dioecious nature of *Fragaria*, interpreted *F. ananassa* as an interspecific hybrid, and identified hermaphroditic types. The origin of the grapefruit (once known as forbidden fruit), which was discovered from natural intercrosses between orange and pummelo, called shaddock in Barbados, can be traced to the trader Philip Chaddock, who in the mid-17th century introduced the pummelo to Barbados. Domestication does not just happen but is carried out by acts of real people and they need to be honored.






Low Carbon: *Wild fruit trees facing extinction*

By James Shepherd on May 12, 09 10:29 AM in News

The wild ancestors of common domestic fruit trees are in danger of becoming extinct, scientists have warned.

Researchers have published a "red list" of threatened species that grow in the forests of Central Asia.

These disease-resistant and climate-tolerant fruit trees could play a role in *our future* food security.

But in the last 50 years, about 90% of the forests have been destroyed, according to conservation charity, Fauna & Flora International.

The Red List of Central Asia identifies 44 tree species in Kyrgyzstan, Kazakhstan, Uzbekistan, Turkmenistan and Tajikistan as under threat from extinction.

It cites over-exploitation and human development as among the main threats to the region's forests, which are home to more than 300 wild fruit and nut species including apple, plum, cherry, apricot and walnut.


Alexander Lees
Protect biodiversity
Preserve habitat
Extinction
is forever

IV. GENETIC CHANGES AND CULTURAL FACTORS IN DOMESTICATION

fruit crops are characterized by a number of common features.

appeal of taste—often a combination of sweetness and acidity with many considered delicious because of aromatic constituents. The appealing, sweet taste of many fruit is probably a trait associated with natural selection for seed dispersal mediated by mammals.

cross-pollinated,

intercrosses among elite clones
or with wild or introduced clones, that vastly speeded up the process.

long juvenility and long-life.

have the ability to propagate vegetatively.

The genetic changes associated with domestication in fruit crops

Table 8.4. Genetic changes associated with domestication in fruit crops.

Breakdown of dioecy	
carob, fig, grape, papaya, strawberry (unchanged, date palm, kiwifruit)	
Loss of self-incompatibility	
cherry	
Parthenocarpy & seedlessness	
apple & pear, banana & plantain, citrus, fig, grape, persimmon, pineapple	
Allopolyploidy	
banana & plantain, blackberry & raspberry, blueberry, citrus, tart cherry, European plum, strawberry	
Polyploidy	
Triploidy:	**banana and plantain, apple, pear**
Tetraploid:	**tart cherry, raspberry, blackberry, blueberry, kiwifruit (*Actinidia sinensis*)**
Hexaploid:	**European plums, kiwifruit (*A. deliciosa*)**
Octaploid:	**strawberry**
Loss of toxic substances	
"Sweet" seed:	**almond**
Nonastringency:	**apple & pear, persimmon, pomegranate**
Ease of vegetative propagation	
Offshoots:	**date palm**
Rooting:	**apple** (rootstock)
Nucellar embryony:	**citrus, mango**
Loss of spines, thorns, or pubescence	
apple, brambles, citrus, peach, pear, pineapple	

Table 8.5. Effects of organized fruit breeding on the commercial world industry.

Negligible	Slight	Moderate	Major
Banana & plantain	Cranberry	Almond	Blueberry
Chestnut	Cherry (tart)	Apple	Brambles (raspberry & blackberry)
Date palm	Citrus	Apricot	Cherry (sweet)
Fig	Hazelnut	Avocado	Currants
Grape (wine)	Papaya	Pear Asian	Grape (table)
Lingonberry	Persimmon	Pecan	Strawberry
Olive	Pear European		Peach & nectarine
Pomegranate	Pineapple		Plum

Some idea of how this

DOMESTICATION

occurred can best be inferred from the history of two recent domesticates:

cranberry and kiwifruit.

What occurred in these crops probably occurred
in the past with others, although each crop is unique with its own set of
problems and prospects, and each has its own story

In both cranberry and kiwifruit, the early elite selections of wild plants were of high quality and could be vegetatively propagated—by cuttings in the case of cranberry and grafting in the case of kiwifruit. Selection, combined with the ability to fix unique combinations by vegetative propagation, was the key breeding technique in these two crops, as in all fruit crops. Breeding work has continued but even after 100 years, the selections made very early still dominate the industry.

In both cranberry and kiwifruit, related species are under consideration as potential new crops. In kiwifruit, the related yellow-fleshed *Actinidia chinensis* has been introduced, and the small-fruited, hardy *A. arguta* (also known as tara fig) is under consideration as a new domesticate and now widely planted in northern home gardens. In the vaccini-

While the domesticates of cranberry and kiwifruit are little changed from their wild forms the blueberry has undergone remarkable transformation due to interspecific hybridization and ploidy manipulation.

The culture of blueberry was dependent on the understanding that the vacciniums are an acid-loving species and required the ammonium form of nitrogen. Intensive selection and breeding with various species of different ploidy levels transformed this crop into a relatively large industry of wide adaptation.

National seed storage laboratory at Fort Collins, Colorado.

U.S. Department of Agriculture
- National plant genetics resources board (NPGRB)
- National plant germplasm committee (NPGC)

NPGC

Davis, California: stone fruits, grape, walnut, almond, pistachio
Geneva, New York: apple, grape
Riverside, California: citrus, fig, some subtropical fruits
Carbondale, Illinois: filbert, hickory
Corvallis, Oregon: strawberry, small fruits, pear, filbert
Byron, Georgia: stone fruits, apple
Orlando, Florida: citrus
Miami, Florida: avocado, mango, tropical and subtropical fruits
Mataguez, Puerto Rico: cacao, banana, mango, pineapple, tropical and subtropical fruits
Indio, California: date
Brownwood, Texas: pecan

National Clonal Germplasm Repository in Corvallis

Home

Tree Fruits and Nuts

(crop-specific catalogs and links)

***Amelanchier* - Serviceberry, Saskatoon**

***Corylus* - Hazelnut or Filbert**

***Cydonia* - Quince**

Intergeneric Hybrids

***Juglans* - Butternut**

***Mespilus* - Medlar**

***Pyrus* - Pear**

***Sorbus* - Mountain Ash**

Pear Genetic Resources

- Home
- Historic Images and Publications
- Germplasm Distribution Policy
- *Corylus* - Hazelnut
- *Cydonia* - Quince
- *Fragaria* - Strawberry
- *Humulus* - Hops
- *Juglans* - Butternut
- *Mespilus* - Medlar
- *Pyrus* - Pear
- *Ribes* - Currant, Gooseberry
- *Rubus* - Raspberry, Blackberry
- *Vaccinium* - Blueberry, Cranberry
- National Plant Germplasm System
- NPGS Taxonomic Queries
- NPGS Accession Queries
- Other NPGS Genebanks
- About Us
- Research
- Products & Services
- People & Places
- News & Events

Why Pear Germplasm Should Be Preserved- H. Hartman, 1957

NCGR Pear Catalogs with links to the GRIN database:

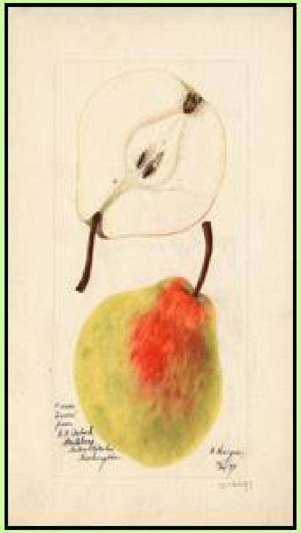
- All NCGR Pear Cultivars and Selections
- *Pyrus* Species Maintained as Trees
- Seed Accessions

Crop Subsets

- Asian Cultivars
- European Cultivars
- Hybrid (Asian x European) Cultivars
- Ancient Cultivars (400 years or older)
- Heirloom Cultivars (100 years or older)
- Curator's Choice! - a few of our favorite pears
- Top 10 Requested Pears

Trait Subsets

- Fruit Characters
  - Early Ripening
  - Late Ripening
  - Large Fruit
  - Red Flesh
  - Red Skin
- Tree Characters
  - Compact Habit
  - Cold Hardy
  - Low Chill
  - Ornamental
  - Polyploid



Pear Cultivars, Species, Conservation

- Curators Choice! - Descriptions of Some Favorite Pears from the NCGR Pear Collection
- US Plant Patent Database - search for pears - Retrieve the full text of plant patents issued since 1976
- Brogdale Horticultural Trust- National Fruit Trials in England
- ECP/GR *Pyrus*Database - European Cooperative Program for Genetic Resources
- Pear Varieties Important in the Pacific Northwest US
- American Pomological Society
- California Rare Fruit Growers
- Home Orchard Society
- North American Fruit Explorers

Asian Cultivars

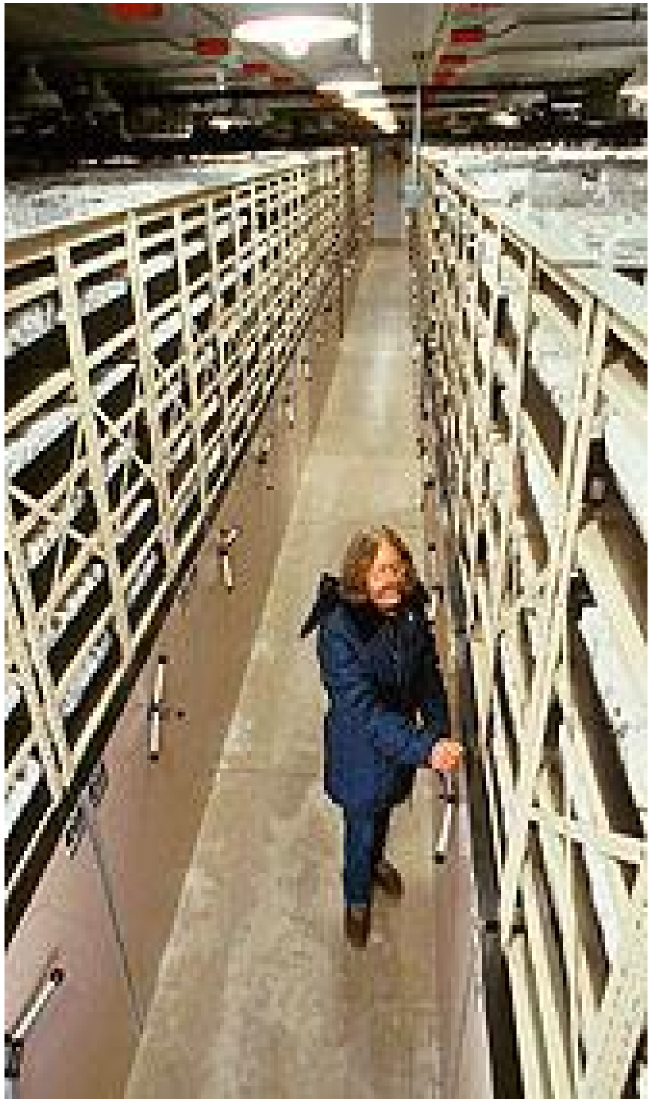
Note: Scions cannot be certified free of *Erwinia amylovora*

Follow links to the Germplasm Resources Information Network (GRIN) for additional accession information.
Catalog last updated: 04 September 2012

NCGR-Corvallis Distribution Policies

Traits listed are intended for preliminary subgrouping of accessions. Traits are from germplasm release notices, published reports, or observations made at NCGR-C

- Ba Li Xiang [Ba Li Hsiang] = PI 541985 **(27.002) - Pyrus ussuriensis Maxim. - VIRUS INFECTED**
  - Pedigree: old pear local selection from Liaoning and Hebei Provinces
  - Virus Lab Assays - Negative: PBCVd-2000
  - Virus Biological Assays - Positive: MM-2003, Negative: NP-1988 PV-1988
  - Traits: VERY LATE RIPE, FIRE BLIGHT RESISTANT, MILDEW RESISTANT, ROOTSTOCK, SCAB RESISTANT, DIPLOID (flow cytometry), HEIRLOOM
- Bai Li = PI 654959 **(2785.001) - Pyrus ×bretschneideri Rehder**
  - Pedigree: Recived from Kazakhstan, where they are used as pear rootstocks. Originated in China.
  - Virus Biological Assays - Negative: NP-2003
  - Traits: DIPLOID, ROOTSTOCK
- Bou Tsu Li = PI 617673 **(2618.001) - Pyrus pyrifolia (Burm. f.) Nakai - VIRUS INFECTED**
  - Virus Lab Assays - Negative: PBCVd-2000
  - Virus Biological Assays - Positive: NP-2003, Negative: PV-2001
  - Traits: DIPLOID, SCAB RESISTANT
- Chiao-Ma = PI 665778 **(2853.001) - Pyrus ussuriensis Maxim.**
  - Traits: DIPLOID
- Chieh Li x Japanese Golden Russet (Decline Resist.) = PI 541760 **(1226.001) - Pyrus hybrid**
  - Pedigree: Chieh Li x Jap. Gold Russet
  - Virus Biological Assays - Negative: N.Poiteau-1985 Pyronia-1987
  - Traits: ROOTSTOCK, PEAR DECLINE RESISTANT
- Chieh Li x Japanese Golden Russet (Decline Susc.) = PI 541761 **(1227.001) - Pyrus hybrid**
  - Pedigree: Chieh Li x Jap. Gold. Russet
  - Virus Biological Assays - Negative: N.Poiteau-1991 Pyronia-1988 V.Crab-1991
  - Traits: ROOTSTOCK, SCAB RESISTANT, PEAR DECLINE SUSCEPTIBLE
- Chien Li = PI 617537 **(2338.001) - Pyrus ussuriensis Maxim.**




Seed sample stored in liquid nitrogen are inspected at the National Seed Storage Laboratory at Fort Collins, Colorado. Cryopreservation cuts storage costs because seed life is extended. Fewer grow-outs are needed to replenish seed when it begins to lose its ability to sprout. Credit: U.S. Department of Agriculture, Agriculture Research Service.


1 mm

only ~ 4% of flowering plant species are dioecious – so how do they avoid inbreeding depression?

Means of Promoting Outcrossing

1) Spatial and temporal differences between flowers and stamen/pollen

    -Heteromorphic flowers

    -Dichogamy (timing)

        -Protogyny

        -Protandry

2) Self-incompatibility genes

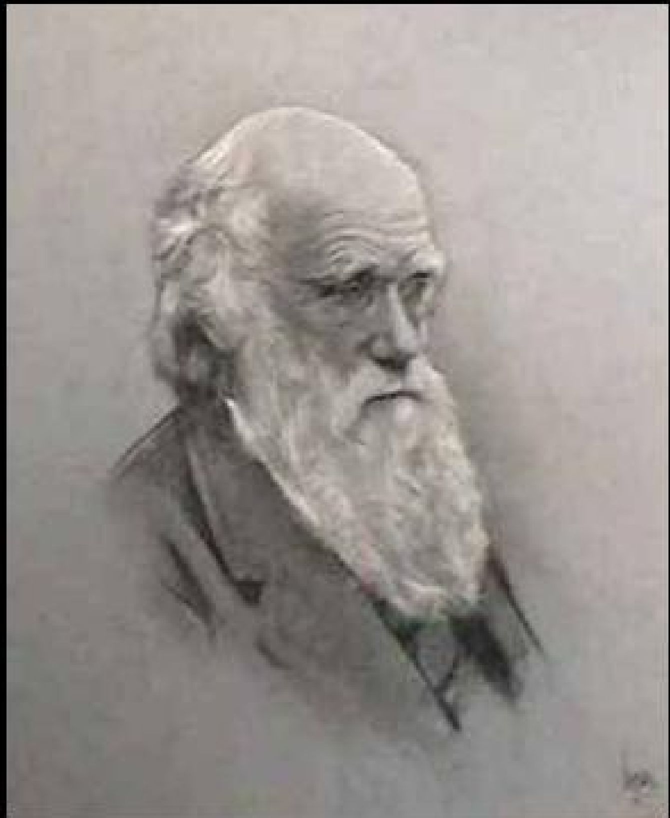
    Gametophytic and sporophytic

3) Sexual expression

    Monoecy and Dioecy

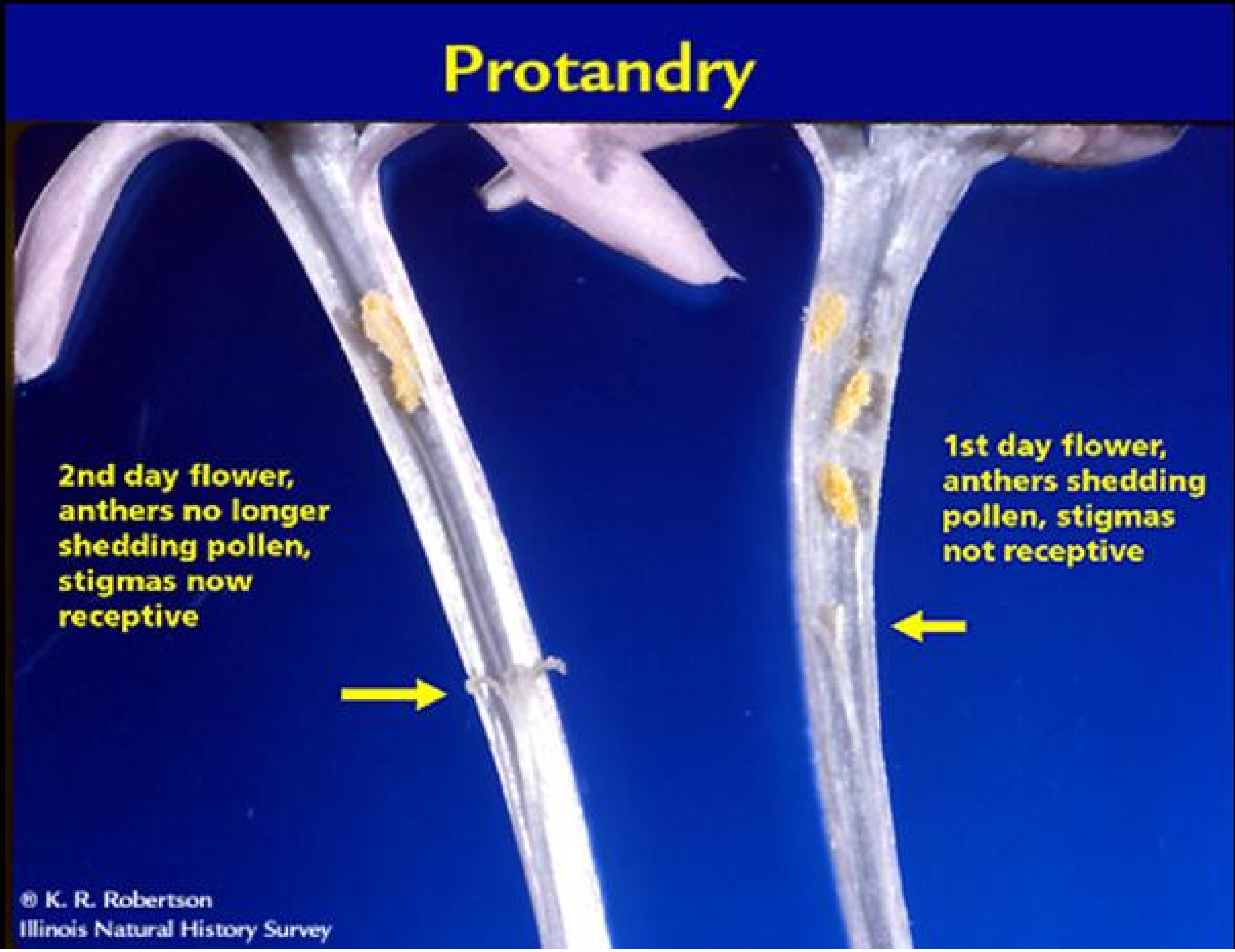
4) Sterility

HETEROMORPHIC FlOWERS



Darwin, C. 1893. *The different forms of flowers on plants of the same species.* New York, D.

Dichogamy I



Protandry
2nd day flower, anthers no longer shedding pollen, stigmas now receptive
1st day flower, anthers shedding pollen, stigmas not receptive
© K. R. Robertson
Illinois Natural History Survey

Dichogamy II

Protogyny – extremely obvious here, stigma out before the flower even opens

WHY MALE STERILITY AND SELF INCOMAPATABILITY?

- Production of large scale of F_1 seeds.
- Reduced cost of hybrid seed production.
- Speedup the hybridization programme.
- Commercial exploitation of hybrid vigour.

Male Sterility in Plants

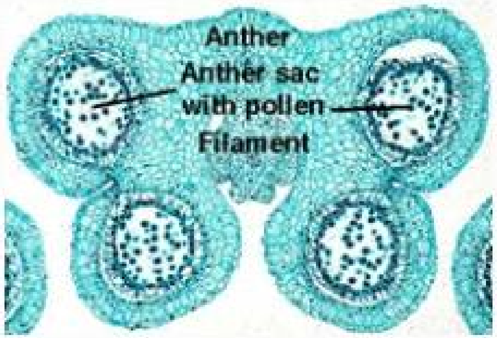
What is Male Sterility? – Definition?
Male sterility refers to either absence of pollen grain or if present it is non-functional.

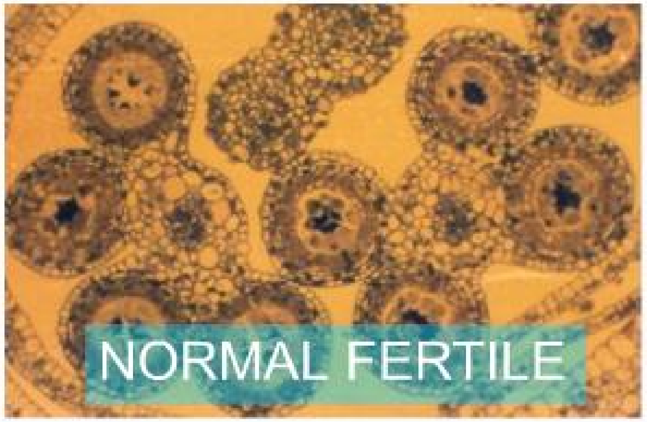
Features of Male Sterility

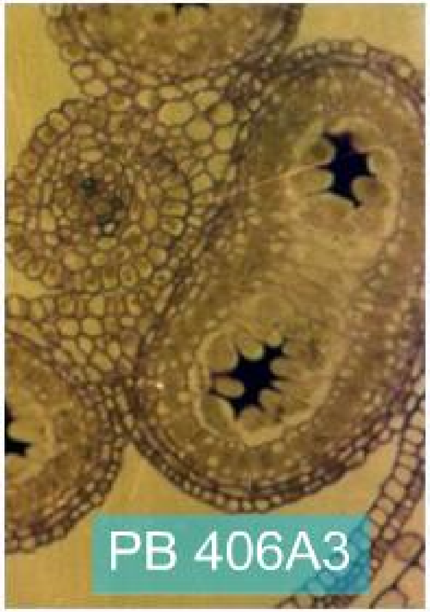
- Prevents self pollination, permits cross pollination.
- Leads to heterozygosity
- Female gametes function normally
- Assayed through staining techniques
- In nature, occur due to spontaneous mutations
- Can be induced artificially

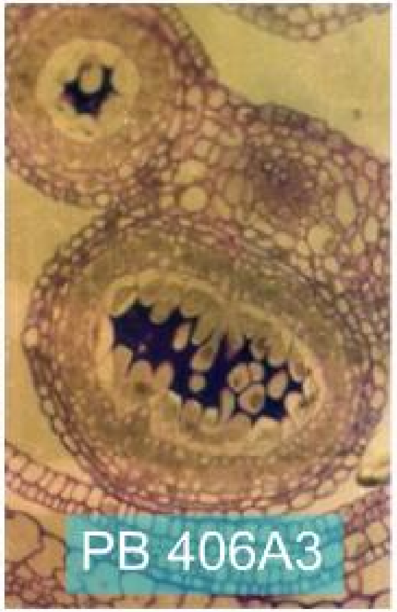
Phenotypic expressions of MS

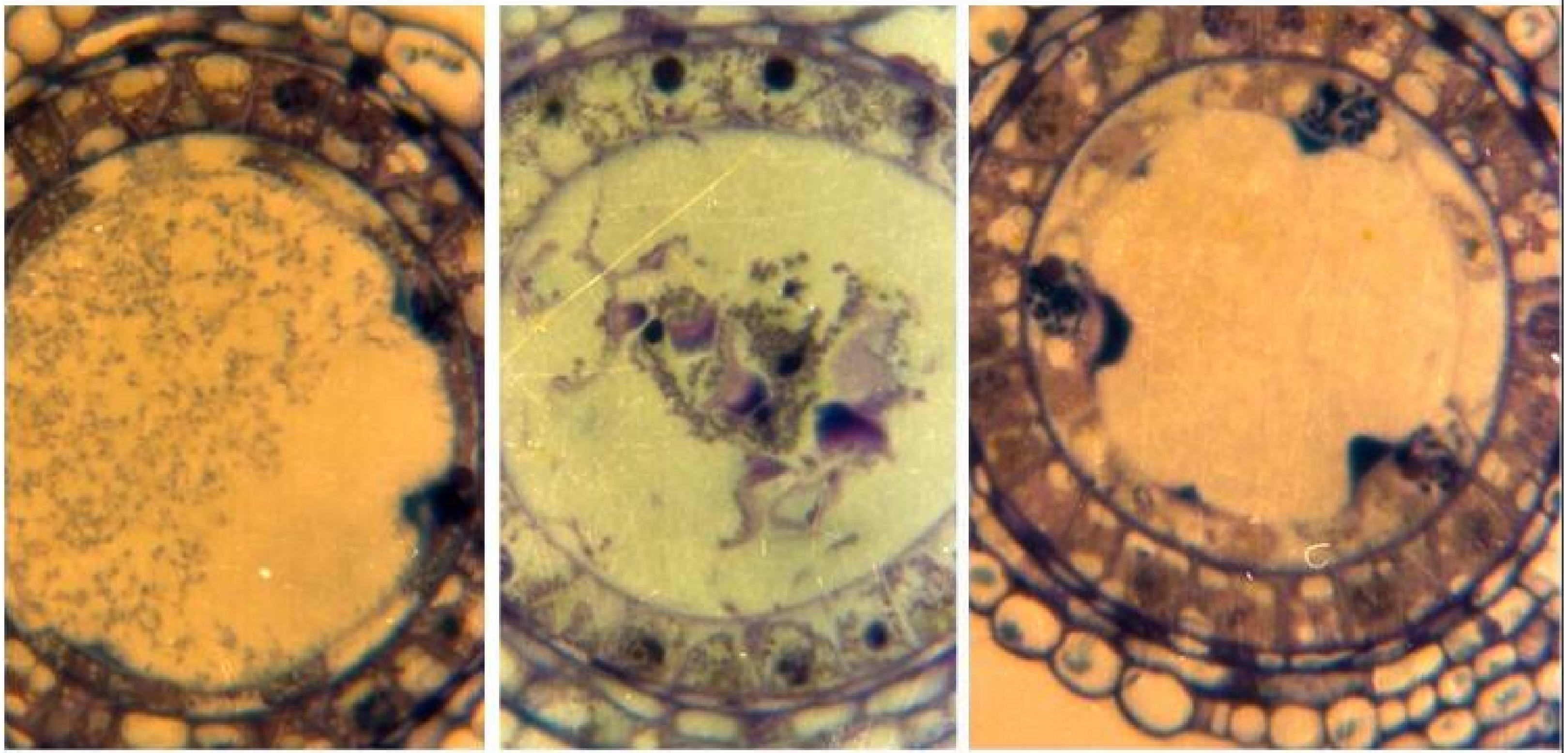
- **Absence , atrophy or malformation of androecium**
- **Lack of normal anther sac or anther tissues**
- **Inability of the pollen to mature or to be released from anther sac**
- **Inability to develop normal microspores or pollen**











STERILE FERTILE

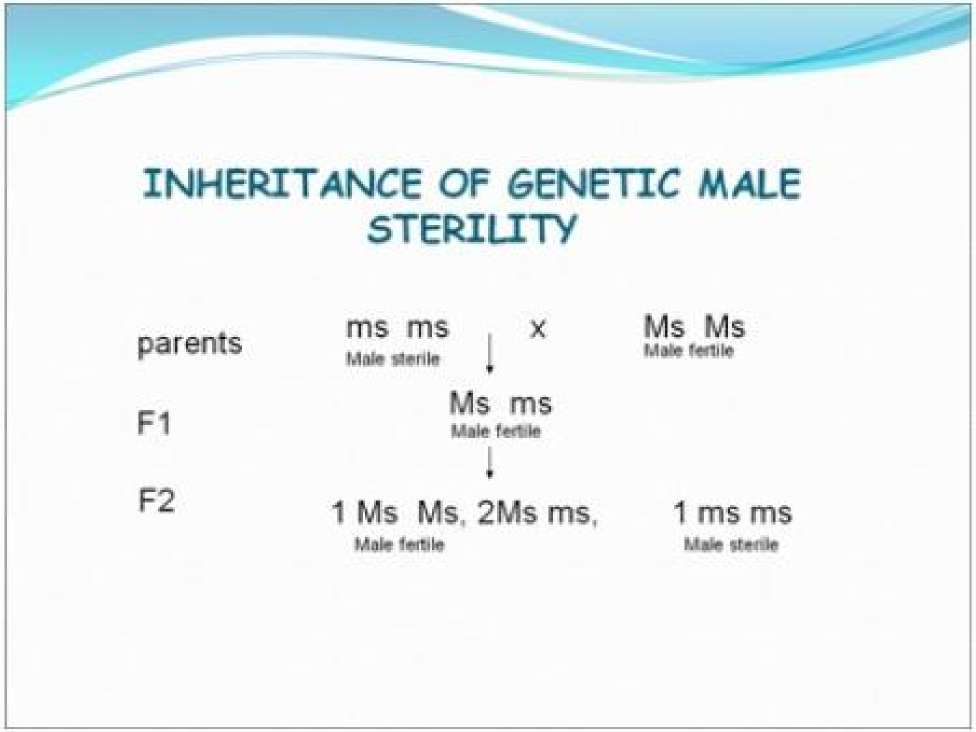
Classification of male sterility

- Genetic Male Sterility
  1) Temperature-sensitive Genetic Male Sterility
  2) Photoperiod-sensitive Genetic Male Sterility
  3) Transgenic Genetic Male Sterility

- Cytoplasmic Male Sterility
- Cytoplasmic-Genetic Male Sterility
- Chemically induced Male Sterility

Genetic Male Sterility

- Ordinarily governed by single recessive gene but sometimes by dominant genes e.g. Safflower
- Alleles arise spontaneously by mutation or may be artificially induced by use of mutagens
- MS x MF = MF in F_1 while a ratio of 3(MF):1(MS) in F_2



Molecular mechanism of *ms* Action

Many possible causes viz.

- Proline deficiency
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- Disturbed balance of endogenous growth regulators e.g. gibberellins, cytokinins, auxins, ABA, ethylene etc.

But no single reason clearly explains the molecular mechanism of ms Action, So ms genes are expected to act in more than one biochemical pathways.

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- Environment insensitive GMS : ms Gene expression is much less affected by the environment
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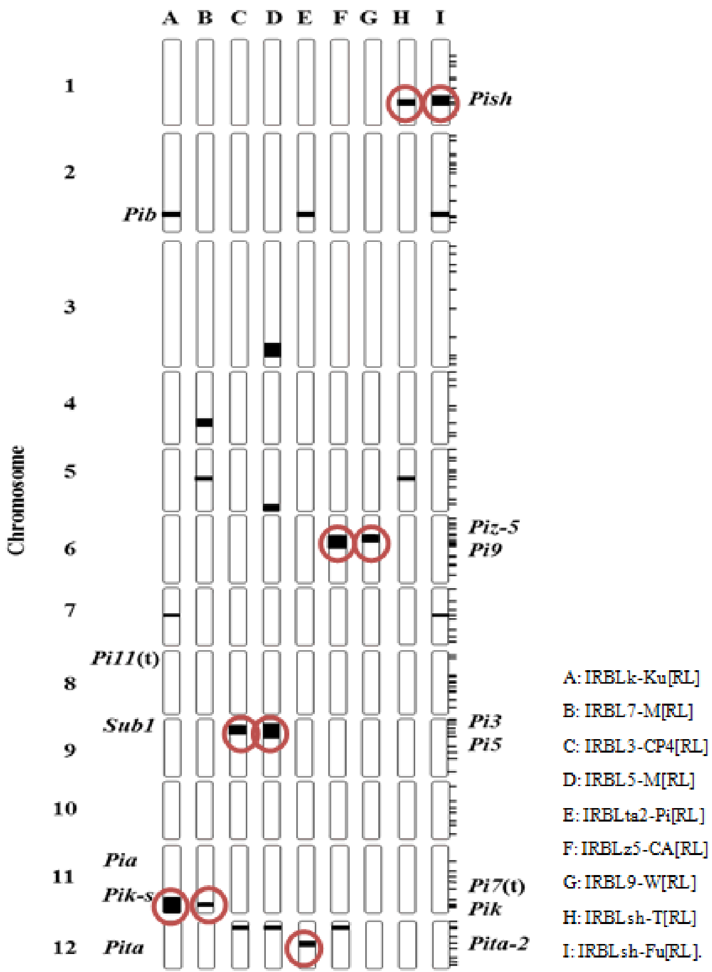

Fig.1. Graphical genotypes of nine near isogenetic lines (NIL) with IR49830-7-1-2-2 genetic background.

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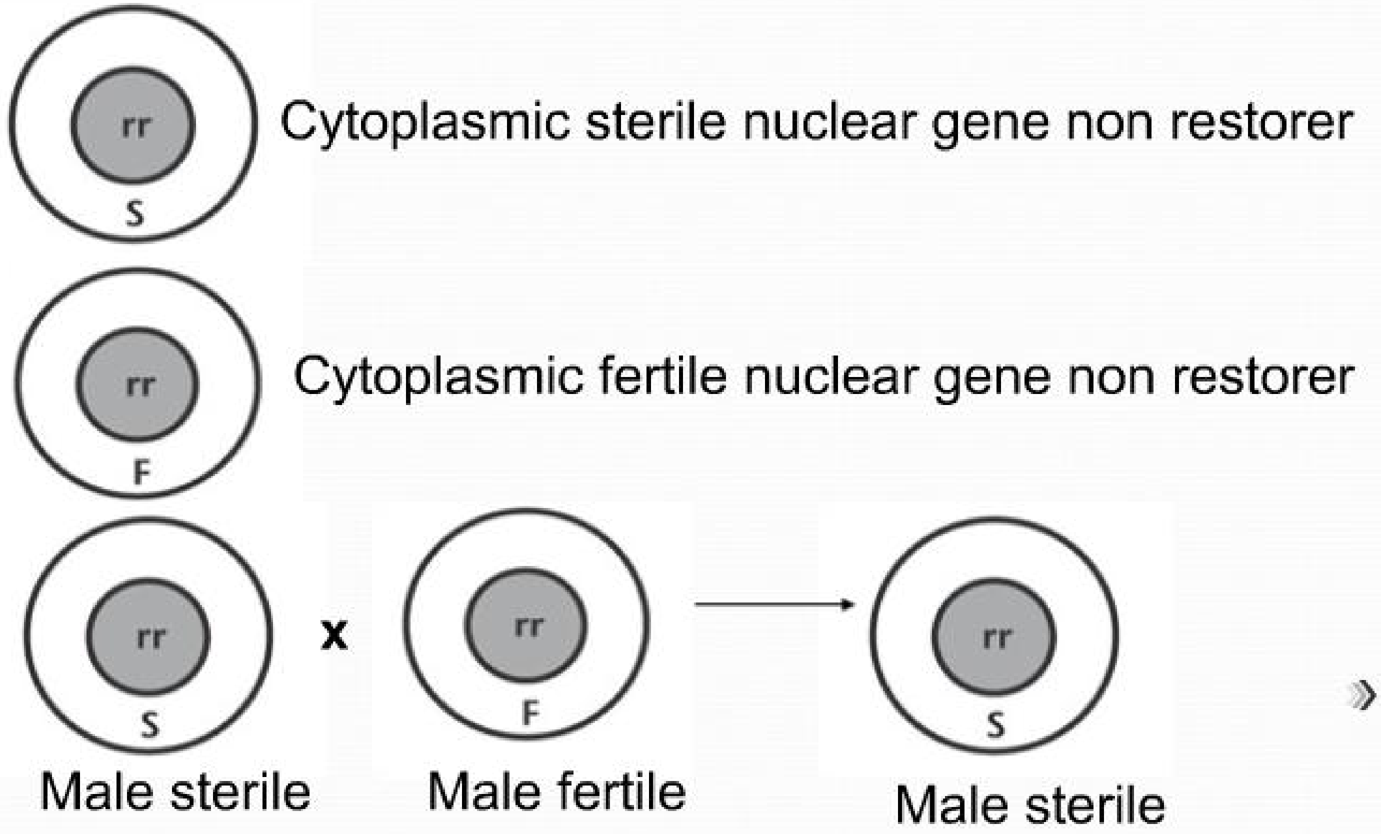
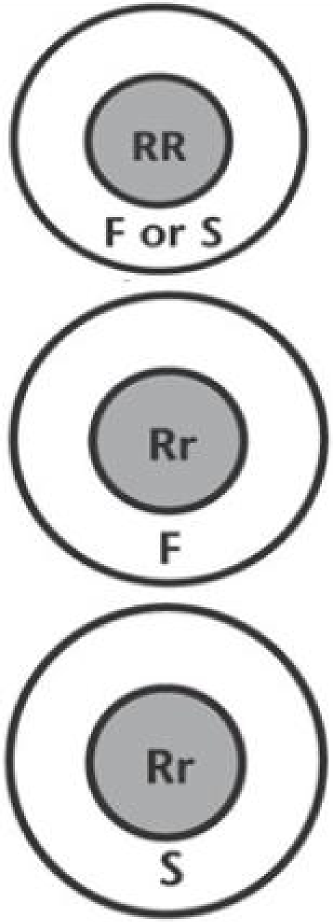
CYTOPLASMIC MALE STERILITY



CYTOPLASMIC - GENETIC MALE STERLITY



Male fertile

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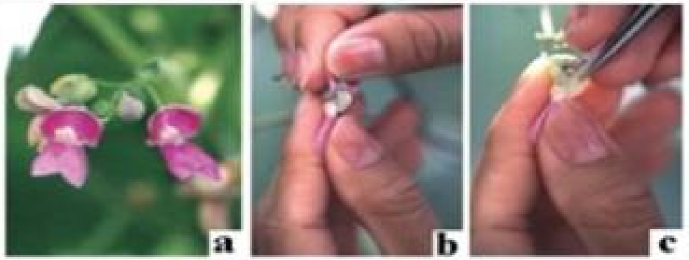
Hybrid seed production in canola



AVOIDED

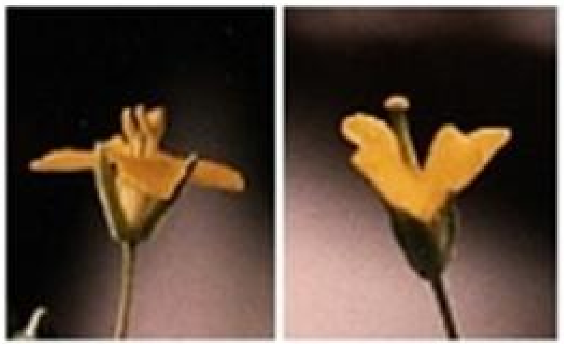
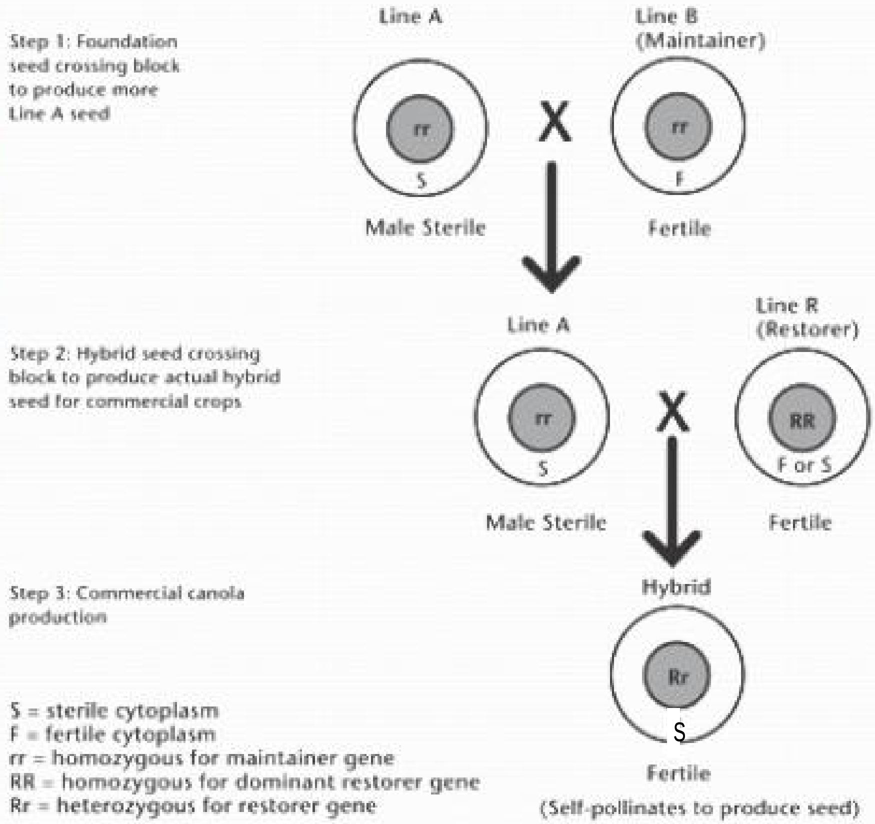


Figure 2. Hybrid Seed Production



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- CHA based hybrids are fully fertile, so F_2 of such hybrids showing high vigour can be used to reduce the cost of hybrid seed production






Low Carbon: *Wild fruit trees facing extinction*

By James Shepherd on May 12, 09 10:29 AM in News

The wild ancestors of common domestic fruit trees are in danger of becoming extinct, scientists have warned.

Researchers have published a "red list" of threatened species that grow in the forests of Central Asia.

These disease-resistant and climate-tolerant fruit trees could play a role in *our future* food security.

But in the last 50 years, about 90% of the forests have been destroyed, according to conservation charity, Fauna & Flora International.

The Red List of Central Asia identifies 44 tree species in Kyrgyzstan, Kazakhstan, Uzbekistan, Turkmenistan and Tajikistan as under threat from extinction.

It cites over-exploitation and human development as among the main threats to the region's forests, which are home to more than 300 wild fruit and nut species including apple, plum, cherry, apricot and walnut.


Alexander Lees
Protect biodiversity
Preserve habitat
Extinction is forever

IV. GENETIC CHANGES AND CULTURAL FACTORS IN DOMESTICATION

fruit crops are characterized by a number of common features.

appeal of taste—often a combination of sweetness and acidity with many considered delicious because of aromatic constituents. The appealing, sweet taste of many fruit is probably a trait associated with natural selection for seed dispersal mediated by mammals.

cross-pollinated,

intercrosses among elite clones
or with wild or introduced clones, that vastly speeded up the process.

long juvenility and long-life.

have the ability to propagate vegetatively.

The genetic changes associated with domestication in fruit crops

Table 8.4. Genetic changes associated with domestication in fruit crops.

Breakdown of dioecy	
carob, fig, grape, papaya, strawberry (unchanged, date palm, kiwifruit)	
Loss of self-incompatibility	
cherry	
Parthenocarpy & seedlessness	
apple & pear, banana & plantain, citrus, fig, grape, persimmon, pineapple	
Allopolyploidy	
banana & plantain, blackberry & raspberry, blueberry, citrus, tart cherry, European plum, strawberry	
Polyploidy	
Triploidy:	**banana and plantain, apple, pear**
Tetraploid:	**tart cherry, raspberry, blackberry, blueberry, kiwifruit (*Actinidia sinensis*)**
Hexaploid:	**European plums, kiwifruit (*A. deliciosa*)**
Octaploid:	**strawberry**
Loss of toxic substances	
"Sweet" seed:	**almond**
Nonastringency:	**apple & pear, persimmon, pomegranate**
Ease of vegetative propagation	
Offshoots:	**date palm**
Rooting:	**apple** (rootstock)
Nucellar embryony:	**citrus, mango**
Loss of spines, thorns, or pubescence	
apple, brambles, citrus, peach, pear, pineapple	

Table 8.5. Effects of organized fruit breeding on the commercial world industry.

Negligible	Slight	Moderate	Major
Banana & plantain	Cranberry	Almond	Blueberry
Chestnut	Cherry (tart)	Apple	Brambles (raspberry & blackberry)
Date palm	Citrus	Apricot	Cherry (sweet)
Fig	Hazelnut	Avocado	Currants
Grape (wine)	Papaya	Pear Asian	Grape (table)
Lingonberry	Persimmon	Pecan	Strawberry
Olive	Pear European		Peach & nectarine
Pomegranate	Pineapple		Plum

Some idea of how this

DOMESTICATION

occurred can best be inferred from the history of two recent domesticates:

cranberry and kiwifruit.

What occurred in these crops probably occurred
in the past with others, although each crop is unique with its own set of
problems and prospects, and each has its own story

In both cranberry and kiwifruit, the early elite selections of wild plants were of high quality and could be vegetatively propagated—by cuttings in the case of cranberry and grafting in the case of kiwifruit. Selection, combined with the ability to fix unique combinations by vegetative propagation, was the key breeding technique in these two crops, as in all fruit crops. Breeding work has continued but even after 100 years, the selections made very early still dominate the industry.

In both cranberry and kiwifruit, related species are under consideration as potential new crops. In kiwifruit, the related yellow-fleshed *Actinidia chinensis* has been introduced, and the small-fruited, hardy *A. arguta* (also known as tara fig) is under consideration as a new domesticate and now widely planted in northern home gardens. In the vaccini-

While the domesticates of cranberry and kiwifruit are little changed from their wild forms the blueberry has undergone remarkable transformation due to interspecific hybridization and ploidy manipulation.

The culture of blueberry was dependent on the understanding that the vacciniums are an acid-loving species and required the ammonium form of nitrogen. Intensive selection and breeding with various species of different ploidy levels transformed this crop into a relatively large industry of wide adaptation.

National seed storage laboratory at Fort Collins, Colorado.

U.S. Department of Agriculture
- National plant genetics resources board (NPGRB)
- National plant germplasm committee (NPGC)

NPGC

Davis, California: stone fruits, grape, walnut, almond, pistachio
Geneva, New York: apple, grape
Riverside, California: citrus, fig, some subtropical fruits
Carbondale, Illinois: filbert, hickory
Corvallis, Oregon: strawberry, small fruits, pear, filbert
Byron, Georgia: stone fruits, apple
Orlando, Florida: citrus
Miami, Florida: avocado, mango, tropical and subtropical fruits
Mataguez, Puerto Rico: cacao, banana, mango, pineapple, tropical and subtropical fruits
Indio, California: date
Brownwood, Texas: pecan

National Clonal Germplasm Repository in Corvallis

USDA ARS United States Department Of Agriculture
Agricultural Research Service

Home

Tree Fruits and Nuts

(crop-specific catalogs and links)

***Amelanchier* - Serviceberry, Saskatoon**

***Corylus* - Hazelnut or Filbert**

***Cydonia* - Quince**

Intergeneric Hybrids

***Juglans* - Butternut**

***Mespilus* - Medlar**

***Pyrus* - Pear**

***Sorbus* - Mountain Ash**

- Historic Images and Publications
- Germplasm Distribution Policy
- *Corylus* - Hazelnut
- *Cydonia* - Quince
- *Fragaria* - Strawberry
- *Humulus* - Hops
- *Juglans* - Butternut
- *Mespilus* - Medlar
- *Pyrus* - Pear
- *Ribes* - Currant, Gooseberry
- *Rubus* - Raspberry, Blackberry
- *Vaccinium* - Blueberry, Cranberry
- National Plant Germplasm System
- NPGS Taxonomic Queries
- NPGS Accession Queries
- Other NPGS Genebanks
- About Us
- Research
- Products & Services
- People & Places
- News & Events

Pear Genetic Resources

Why Pear Germplasm Should Be Preserved- H. Hartman, 1957

NCGR Pear Catalogs with links to the GRIN database:

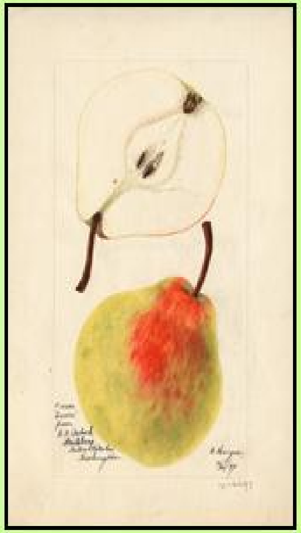
- **All NCGR Pear Cultivars and Selections**
- ***Pyrus* Species Maintained as Trees**
- **Seed Accessions**

Crop Subsets

- **Asian Cultivars**
- **European Cultivars**
- **Hybrid (Asian x European) Cultivars**
- **Ancient Cultivars (400 years or older)**
- **Heirloom Cultivars (100 years or older)**
- **Curator's Choice! - a few of our favorite pears**
- **Top 10 Requested Pears**

Trait Subsets

- **Fruit Characters**
  - **Early Ripening**
  - **Late Ripening**
  - **Large Fruit**
  - **Red Flesh**
  - **Red Skin**
- **Tree Characters**
  - **Compact Habit**
  - **Cold Hardy**
  - **Low Chill**
  - **Ornamental**
  - **Polyploid**



Pear Cultivars, Species, Conservation

- Curators Choice! - Descriptions of Some Favorite Pears from the NCGR Pear Collection
- US Plant Patent Database - search for pears - Retrieve the full text of plant patents issued since 1976
- Brogdale Horticultural Trust- National Fruit Trials in England
- ECP/GR *Pyrus*Database - European Cooperative Program for Genetic Resources
- Pear Varieties Important in the Pacific Northwest US
- American Pomological Society
- California Rare Fruit Growers
- Home Orchard Society
- North American Fruit Explorers

Asian Cultivars

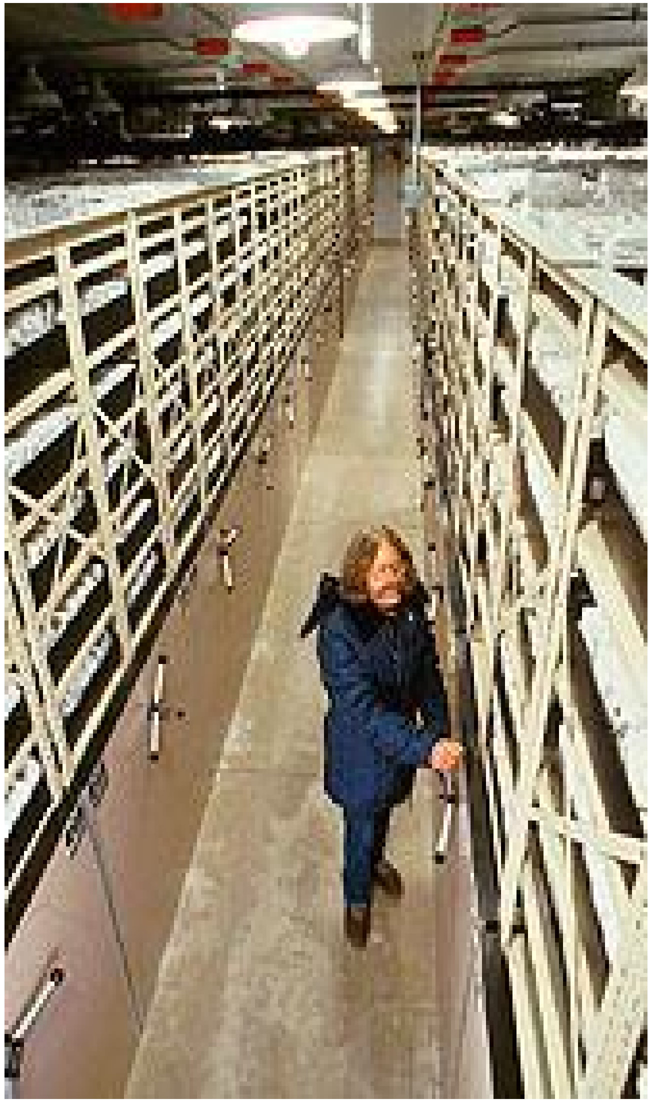
Note: Scions cannot be certified free of *Erwinia amylovora*

Follow links to the Germplasm Resources Information Network (GRIN) for additional accession information.
Catalog last updated: 04 September 2012

NCGR-Corvallis Distribution Policies

Traits listed are intended for preliminary subgrouping of accessions. Traits are from germplasm release notices, published reports, or observations made at NCGR-C

- Ba Li Xiang [Ba Li Hsiang] = PI 541985 **(27.002) - Pyrus ussuriensis Maxim. - VIRUS INFECTED**
  - Pedigree: old pear local selection from Liaoning and Hebei Provinces
  - Virus Lab Assays - Negative: PBCVd-2000
  - Virus Biological Assays - Positive: MM-2003, Negative: NP-1988 PV-1988
  - Traits: VERY LATE RIPE, FIRE BLIGHT RESISTANT, MILDEW RESISTANT, ROOTSTOCK, SCAB RESISTANT, DIPLOID (flow cytometry), HEIRLOOM
- Bai Li = PI 654959 **(2785.001) - Pyrus ×bretschneideri Rehder**
  - Pedigree: Recived from Kazakhstan, where they are used as pear rootstocks. Originated in China.
  - Virus Biological Assays - Negative: NP-2003
  - Traits: DIPLOID, ROOTSTOCK
- Bou Tsu Li = PI 617673 **(2618.001) - Pyrus pyrifolia (Burm. f.) Nakai - VIRUS INFECTED**
  - Virus Lab Assays - Negative: PBCVd-2000
  - Virus Biological Assays - Positive: NP-2003, Negative: PV-2001
  - Traits: DIPLOID, SCAB RESISTANT
- Chiao-Ma = PI 665778 **(2853.001) - Pyrus ussuriensis Maxim.**
  - Traits: DIPLOID
- Chieh Li x Japanese Golden Russet (Decline Resist.) = PI 541760 **(1226.001) - Pyrus hybrid**
  - Pedigree: Chieh Li x Jap. Gold Russet
  - Virus Biological Assays - Negative: N.Poiteau-1985 Pyronia-1987
  - Traits: ROOTSTOCK, PEAR DECLINE RESISTANT
- Chieh Li x Japanese Golden Russet (Decline Susc.) = PI 541761 **(1227.001) - Pyrus hybrid**
  - Pedigree: Chieh Li x Jap. Gold. Russet
  - Virus Biological Assays - Negative: N.Poiteau-1991 Pyronia-1988 V.Crab-1991
  - Traits: ROOTSTOCK, SCAB RESISTANT, PEAR DECLINE SUSCEPTIBLE




Seed sample stored in liquid nitrogen are inspected at the National Seed Storage Laboratory at Fort Collins, Colorado. Cryopreservation cuts storage costs because seed life is extended. Fewer grow-outs are needed to replenish seed when it begins to lose its ability to sprout. Credit: U.S. Department of Agriculture, Agriculture Research Service.

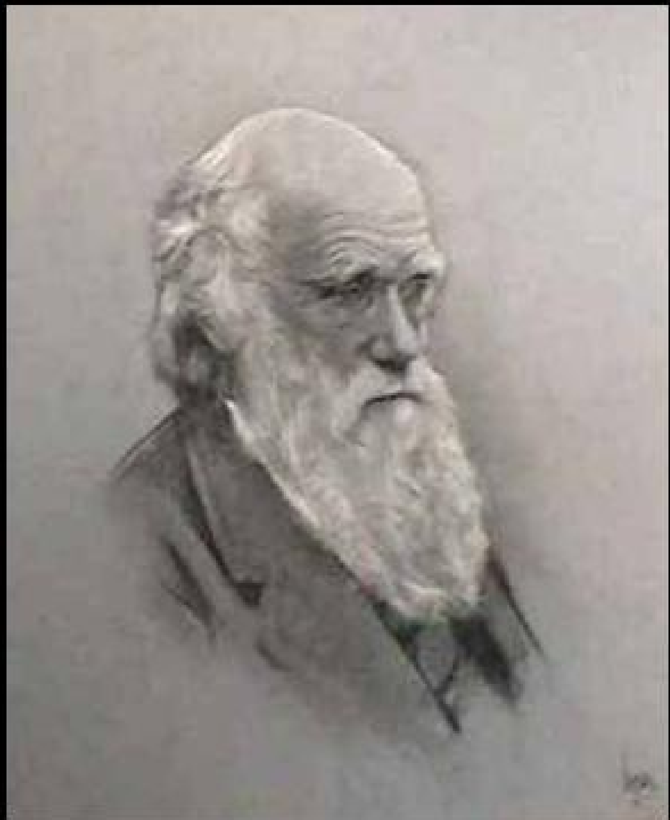

1 mm

only ~ 4% of flowering plant species are dioecious – so how do they avoid inbreeding depression?

Means of Promoting Outcrossing

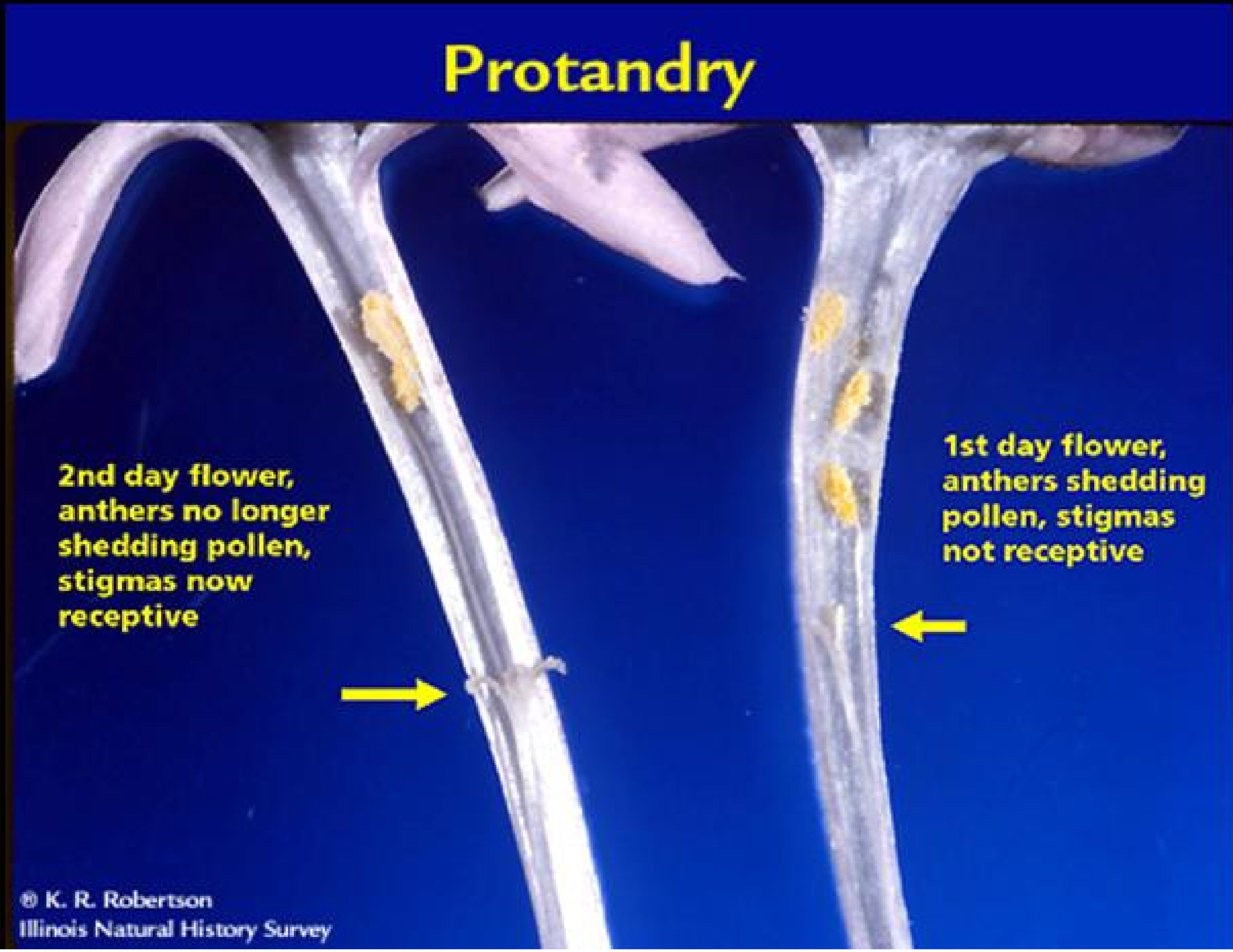
1) Spatial and temporal differences between flowers and stamen/pollen
   - -Heteromorphic flowers
   - -Dichogamy (timing)
     - -Protogyny
     - -Protandry
2) Self-incompatibility genes
   - Gametophytic and sporophytic
3) Sexual expression
   - Monoecy and Dioecy
4) Sterility

HETEROMORPHIC FlOWERS



Darwin, C. 1893. *The different forms of flowers on plants of the same species.* New York, D.

Dichogamy I



Protandry
2nd day flower, anthers no longer shedding pollen, stigmas now receptive
1st day flower, anthers shedding pollen, stigmas not receptive
© K. R. Robertson
Illinois Natural History Survey

Dichogamy II

Protogyny – extremely obvious here, stigma out before the flower even opens

WHY MALE STERILITY AND SELF INCOMAPATABILITY?

- Production of large scale of F_1 seeds.
- Reduced cost of hybrid seed production.
- Speedup the hybridization programme.
- Commercial exploitation of hybrid vigour.

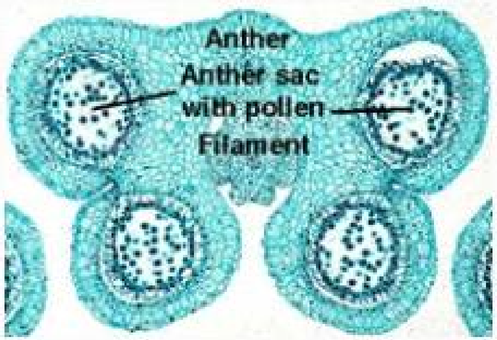
Male Sterility in Plants

What is Male Sterility? – Definition?
Male sterility refers to either absence of pollen grain or if present it is non-functional.

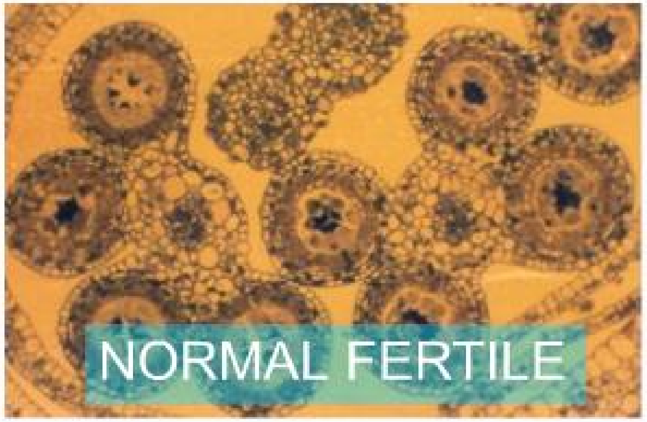
Features of Male Sterility

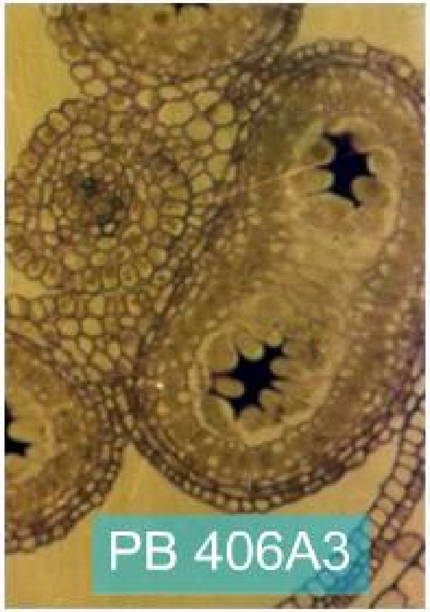
- □Prevents self pollination, permits cross pollination.
- □ Leads to heterozygosity
- □ Female gametes function normally
- □ Assayed through staining techniques
- □ In nature, occur due to spontaneous mutations
- □ Can be induced artificially

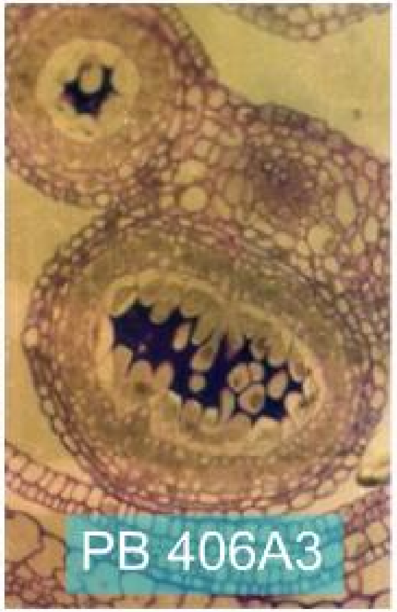
Phenotypic expressions of MS

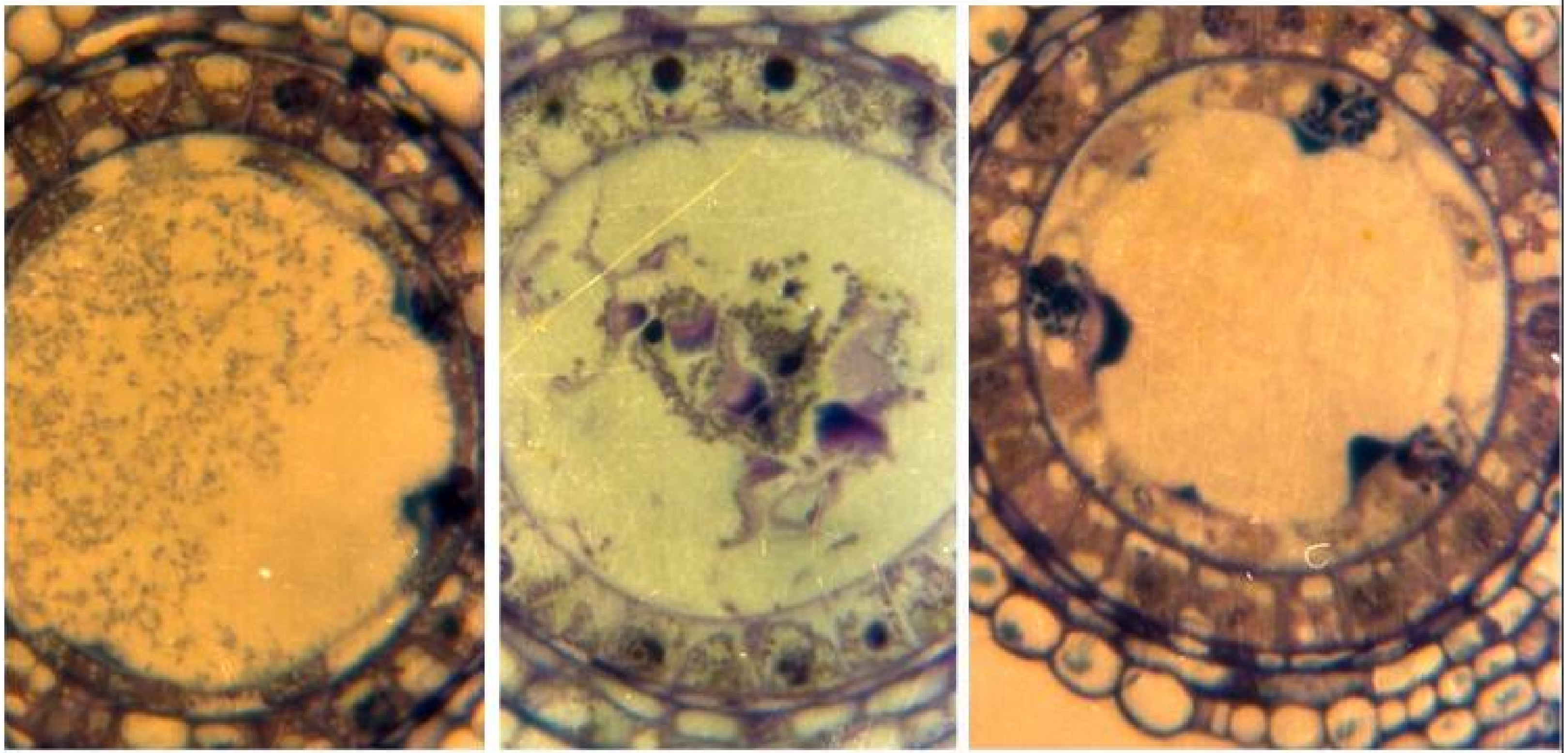


- **Absence , atrophy or malformation of androecium**
- **Lack of normal anther sac or anther tissues**
- **Inability of the pollen to mature or to be released from anther sac**
- **Inability to develop normal microspores or pollen**









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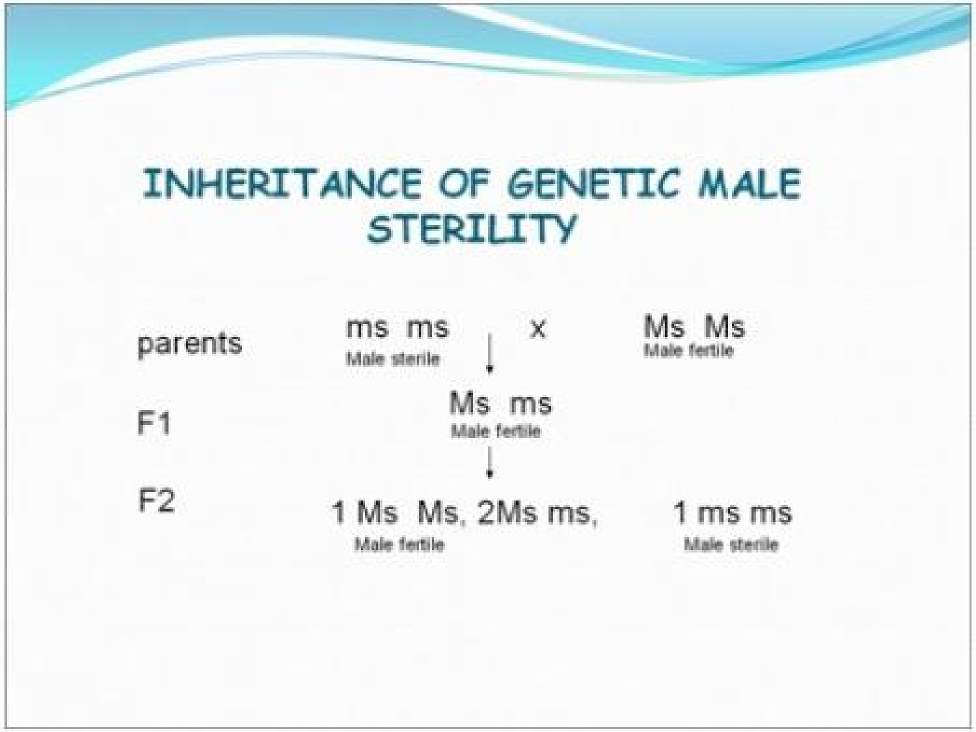

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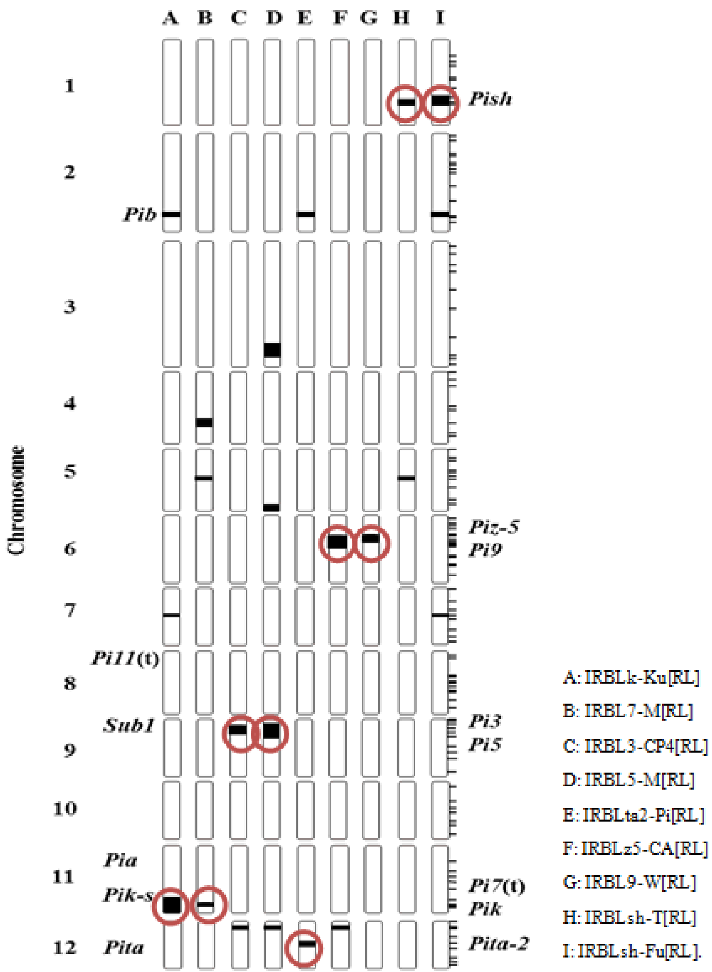

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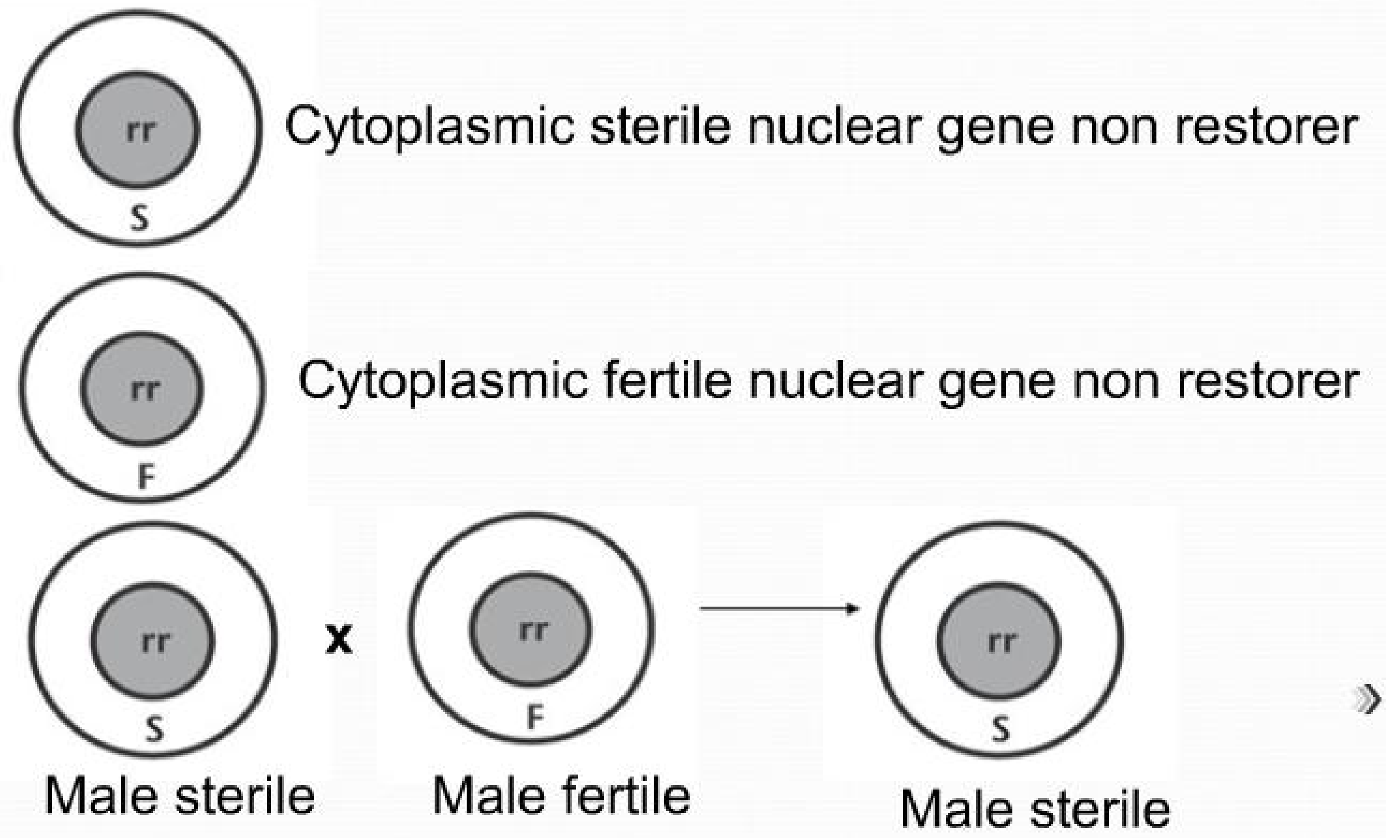

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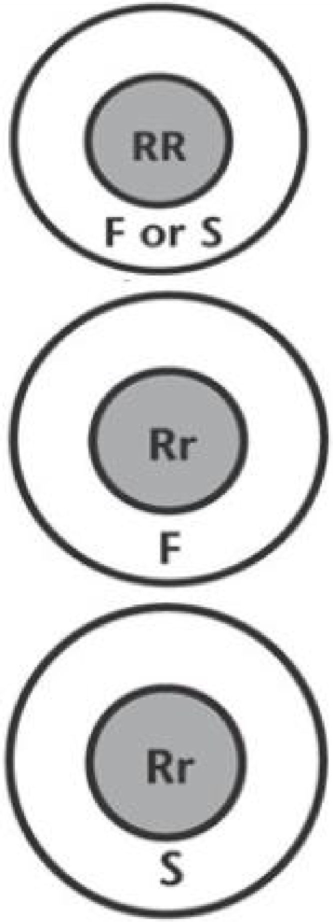

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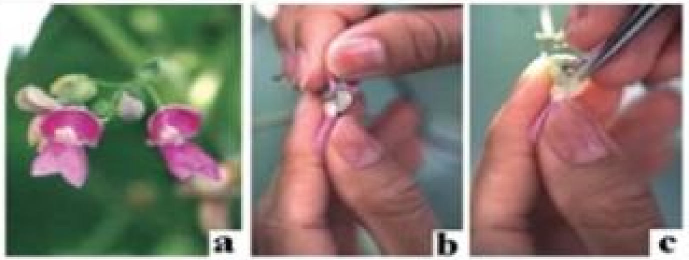
Hybrid seed production in canola



AVOIDED

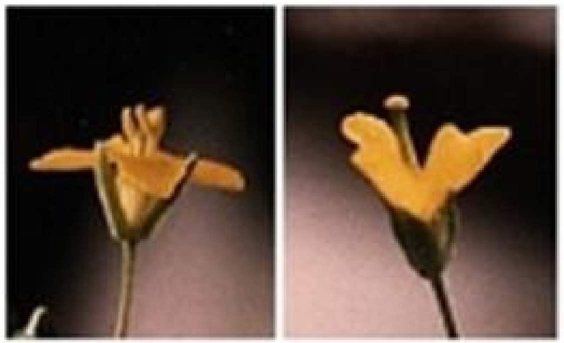
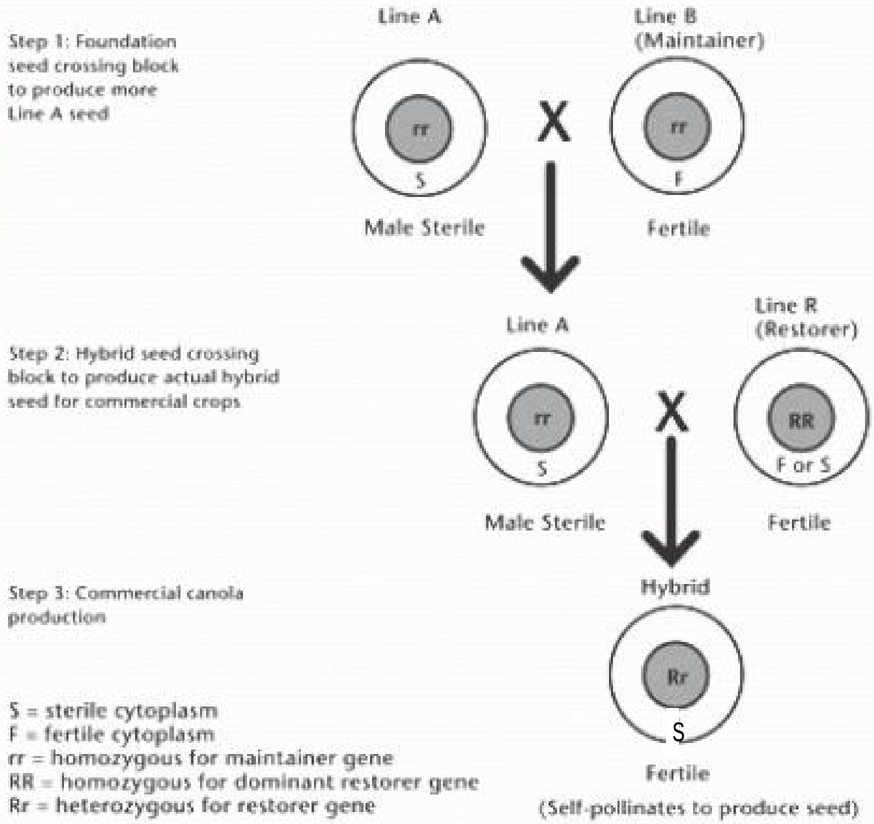


Figure 2. Hybrid Seed Production



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- CHA based hybrids are fully fertile, so F_2 of such hybrids showing high vigour can be used to reduce the cost of hybrid seed production

Limitation of CHA's

- Expression of MS is stage specific
- MS is vulnerable to prevailing environmental conditions
- Incomplete MS can lead to selfing on female parent
- Many CHAs are toxic to animals & plants
- Some CHAs e.g. Arsenicals can have carry-over effect for next generations
- Certain CHAs e.g. RH531 interfere with cell division
- CHAs are generally genotype, dose & stage specific

there are various biotechnology approaches for suppressing pollen formation. All approaches involve combining two methodological steps:

- A gene present in the plant, the activity of which is required for the function or development of cells (or pollen), is ‘switched off’. It could also be possible to introduce a new gene which disrupts pollen formation in the cell.

- To ensure that this effect is limited exclusively to the cells involved in pollen production, the relevant gene constructs are linked to tissue-specific promotors. These cause the gene activity to be triggered only in specific cell types.

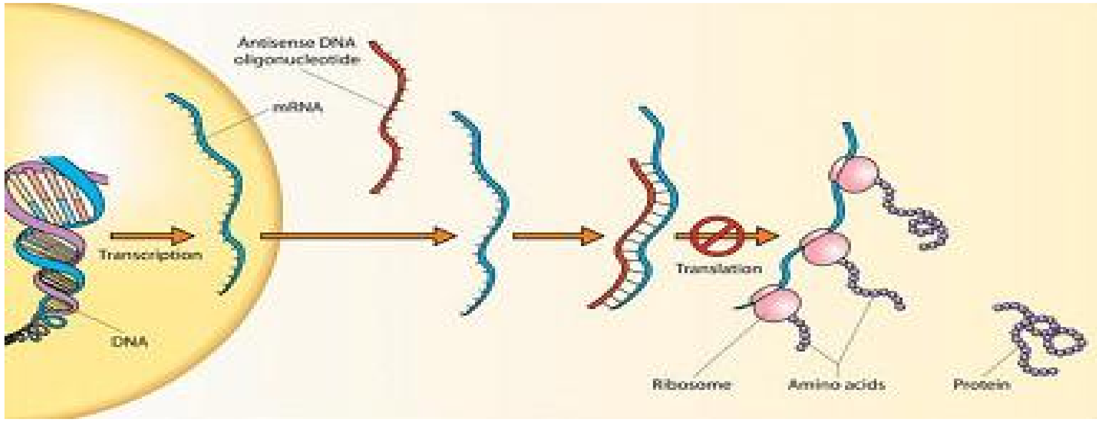
One genetic engineering approach is based on inhibition of the enzyme invertase, which is essential for pollen development.

This anther-specific invertase breaks down sucrose into the monosaccharides fructose and glucose, two important carbon sources for pollen development. Without the breakdown of sucrose, the pollen is deprived of its food source and is unable to develop fully: the plant is sterile.

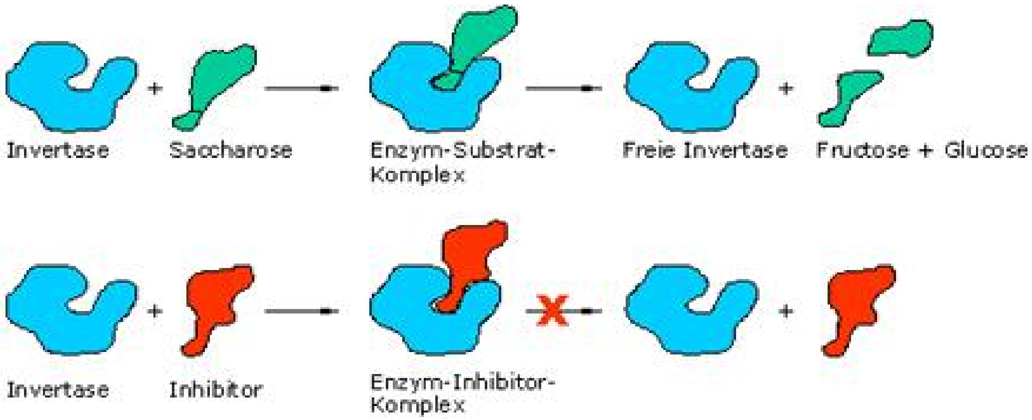
Two methods can be used to limit or switch off invertase activity: The gene responsible for invertase can be switched off using the antisense technique or, alternatively, the enzyme activity can be directly blocked using an invertase inhibitor.

In a biosafety research project that finished in 2008, the two methods described were applied to oilseed rape and maize. In the case of oilseed rape, the project succeeded in producing male-sterile plants.

Antisense inhibition



Enzyme inhibitors

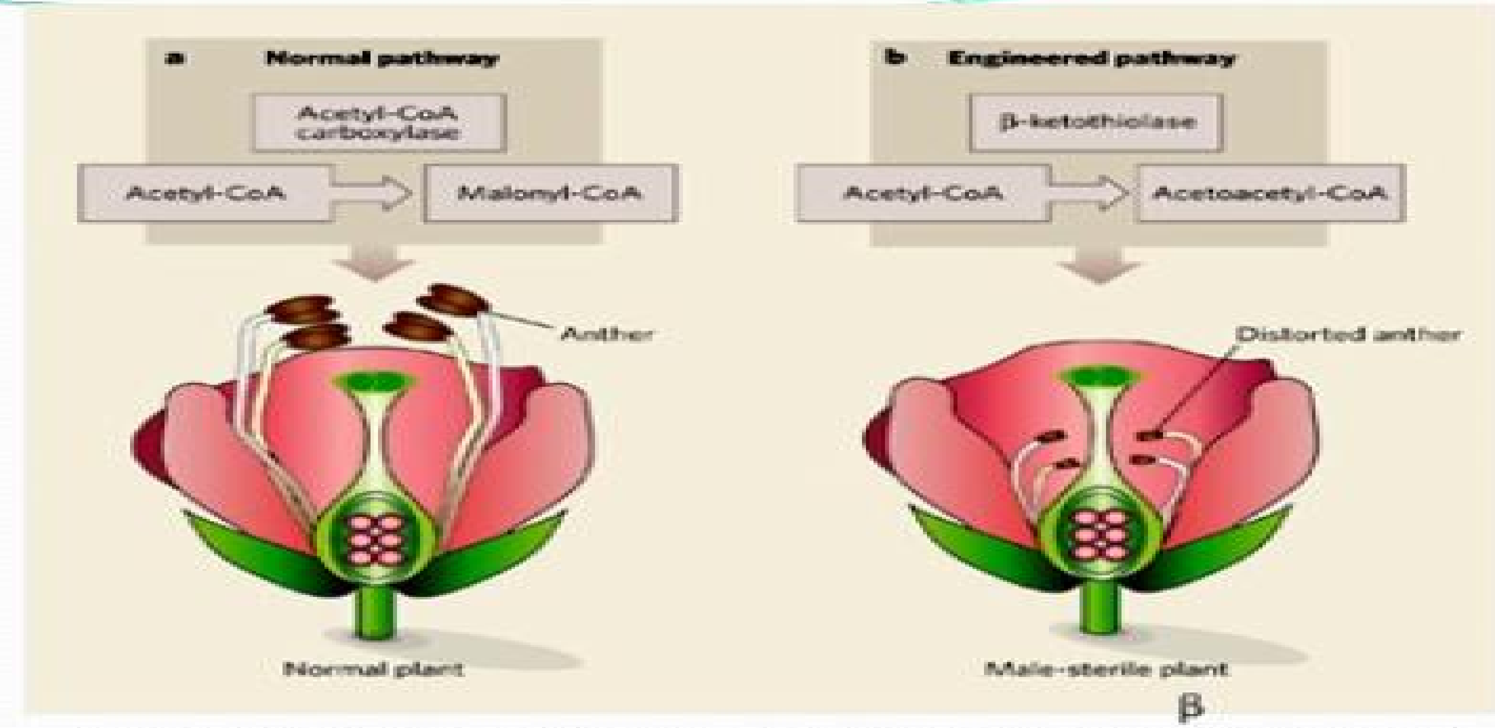


Enzyme activity can be inhibited by substances that have a chemical structure similar to the actual substrate . the pollen-specific invertase (blue) can be blocked with a substrate resembling sucrose (red). If the gene for the invertase inhibitor is introduced into a plant, it produces the inhibitor which then blocks the invertase: pollen formation is suppressed.

Several other approaches using recombinant DNA techniques to obtain ms in plants have been undertaken.

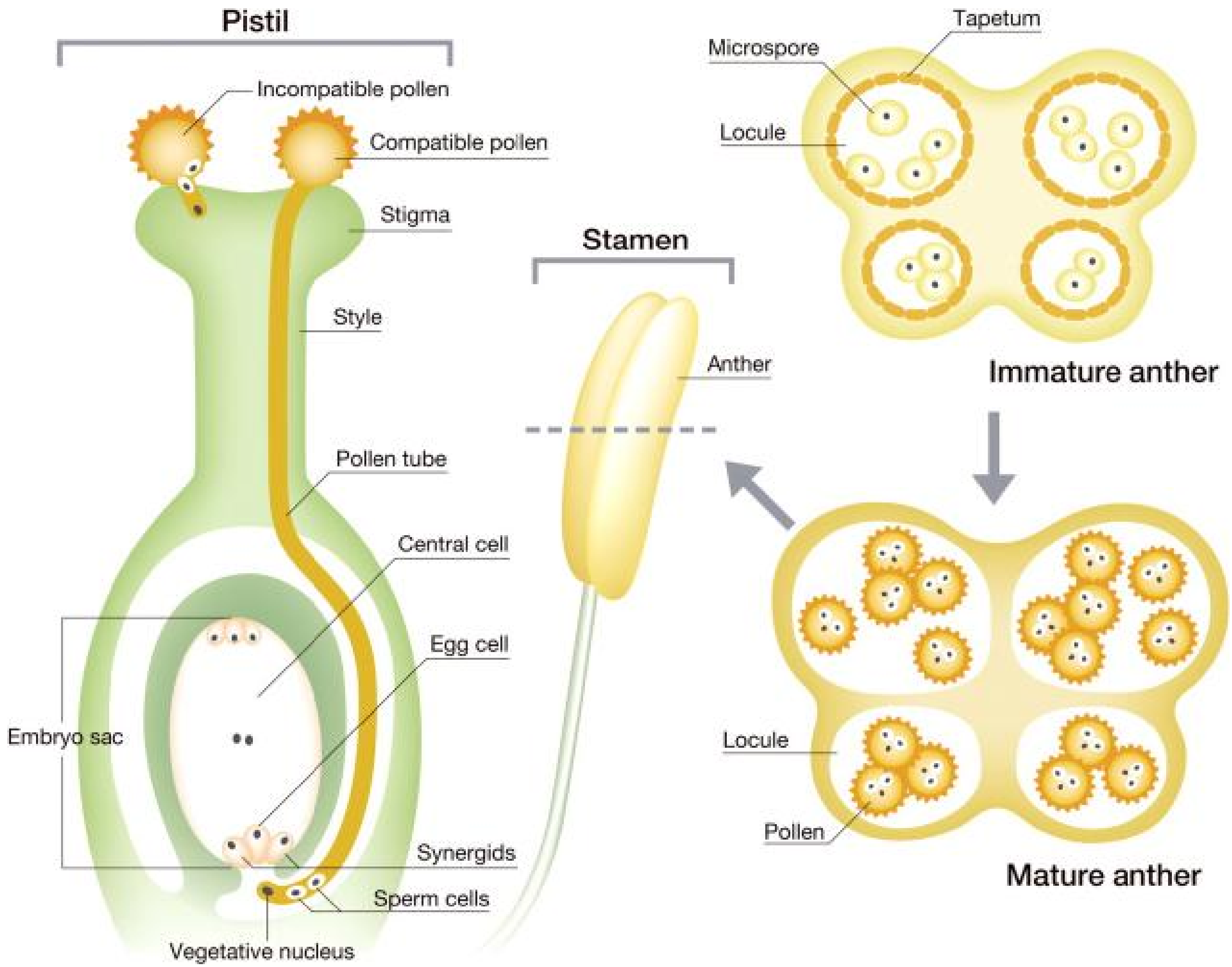
Nuclear ms has been achieved in *Petunia hybrida* by depletion of flavonoid pigments in the anthers leading to the arrest of pollen maturation.

The tapetum specific expression of an enzyme (ArgE) that deacetylates the non toxic herbicide derivative *N*-acetyl-phosphinothricin led to the release of the active herbicide and thereby to a specific cell death in *Nicotiana tabacum*. While flowers treated with the inducer substance produced 100% hybrid seeds, untreated plants remained completely fertile



β

a, In chloroplasts, acetyl-CoA, the substrate for the synthesis of fatty acids, is normally converted by acetyl-CoA carboxylase to yield malonyl-CoA. This pathway results in the correct development of anthers, pollen grains and seeds. **b**, In the transgenic chloroplasts, ketothiolase out-competes acetyl-CoA carboxylase for acetyl-CoA, with acetoacetyl-CoA being produced instead. The upshot is distorted anthers and failure of pollen development. Fertility in plants grown from the resulting hybrid seeds is restored under continuous illumination, with reversion to the normal pathway.


Pistil
Incompatible pollen
Compatible pollen
Stigma
Style
Pollen tube
Central cell
Egg cell
Embryo sac
Synergids
Sperm cells
Vegetative nucleus
Stamen
Anther
Tapetum
Microspore
Locule
Immature anther
Locule
Pollen
Mature anther

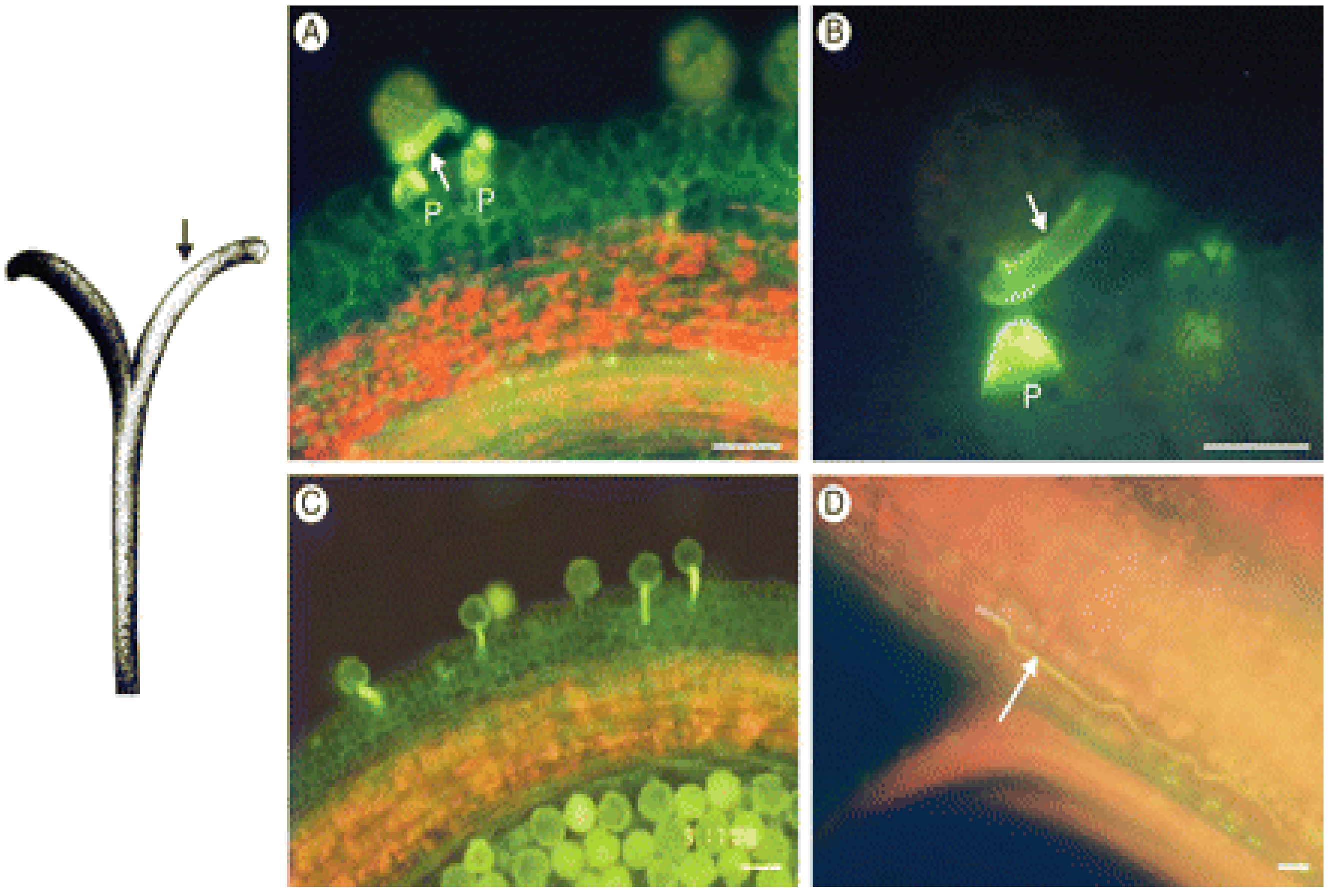
Introduction

- SI was first reported by Koelreuter in middle of 18th century.
- More than 300 species belonging to 70 families of angiosperms show SI.
- The prevention of fusion of fertile functional male and female gametes after self pollination.
- In SI pollen grains fails to germinate on the stigma of the flower that produced them.
- If some pollen grains do germinate, pollen tube fail to enter the stigma.
- The pollen tube enters the style, but grows too slowly to effect the fertilization before the flower drops.
- Some time fertilization is effected but the embryo degenerate at a very early stage.

Mechanism of self incompatibility

It is grouped into three categories:

- POLLEN STIGMA INTERACTION
  - These interaction occur just after the pollen grains reach the stigma and generally prevent pollen germination.
  - At the time they reach stigma, pollen grains generally have two nuclei in gametophytic system, while have three nuclei in the sporophytic system.
- Pollen tube style interaction:-
  - In most cases of the gemetophytic system, pollen grains germinated pollen tubes penetrate the stegmatic surface.
  - But in incompatible combinations the growth of pollen tube is retarded within the stigma.
- Pollen tube ovule interaction:-
  - Pollen tubes reach the ovule and effect fertilization, however in incompatible combination, embryos degenerated at an early stage of development.



Incompatible and compatible pollinations in *Senecio squalidus.* Squash preparations of stigmas stained with aniline blue and viewed under UV light. (A,B) Incompatible pollination; pollen tube (arrow) blocked from entering papillae (P). (C) Compatible pollination; pollen tubes penetrating stigma tissue. (D) Compatible pollen tube growing through transmitting tissue (arrow). Scale bars = 0·25 µm.

Classification of self incompatibility

1. Heteromorphic system

2. Homomorphic system
   - **Gametophytic control**
   - **Sporophytic control**

Heteromorphic system

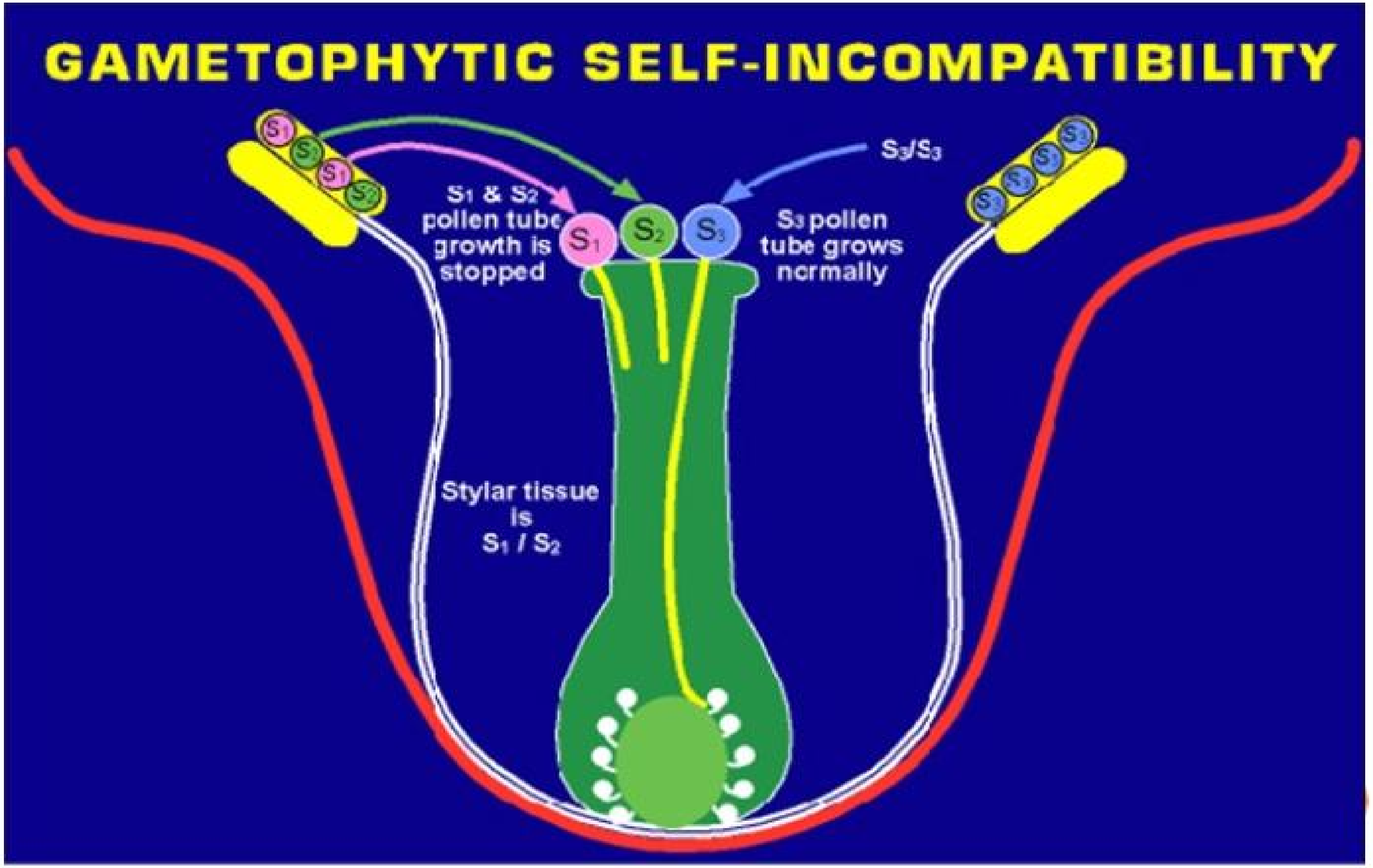
- In this system of different incompatibility group are different in morphology.
- Example :Their are two type of flower in primula.
  - Pin flower- long style and short stamens
  - Thrum flower- short style and long stamens
- This situation is referred as distyly.
- The SI reaction of pollen grain is determined by the genotype of the plant producing them.
- The SI reaction has two alleles 'S' and 's'. 'S' is dominant over 's'.
- 'SS' produces thrum and 'ss' produces pin flowers.
- Pollen grains are produced by pin flowers would all be in genotype as well as incompatibility reaction.

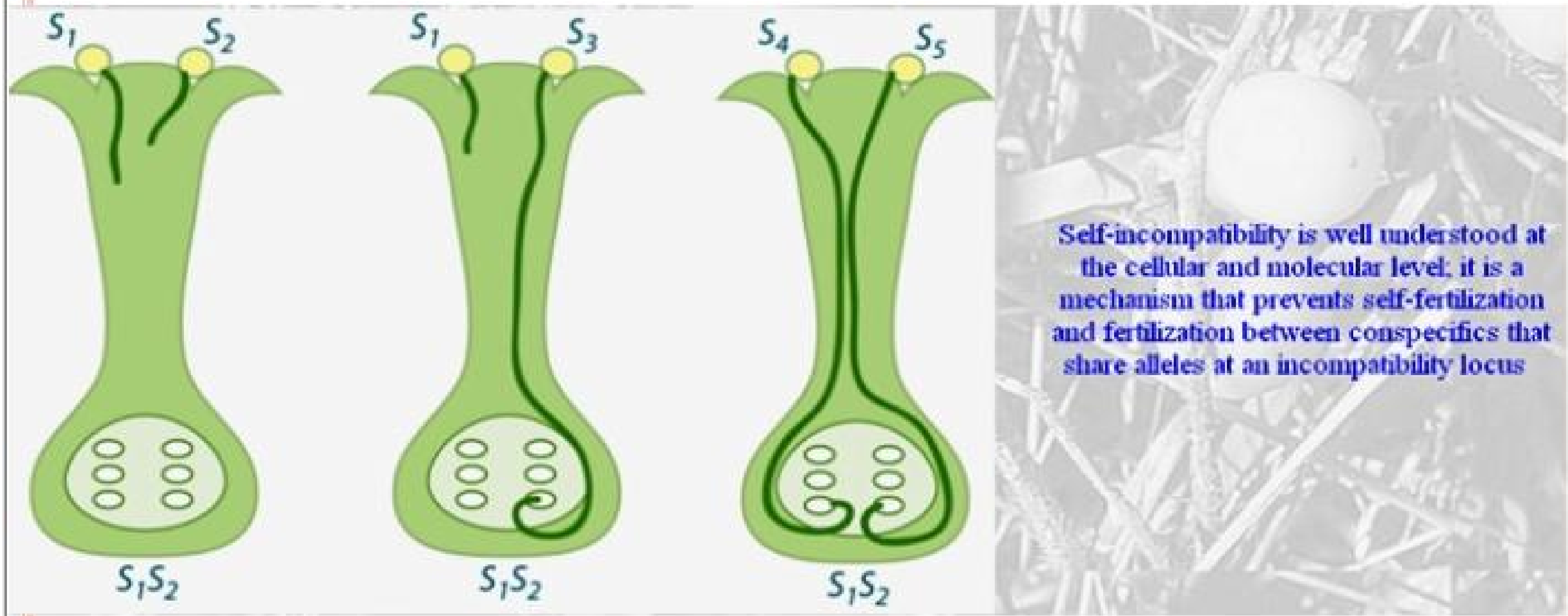
Flowers of *Primula veris*: thrum flower (left) & pin flower (right)


© AJ Silverside

Homomorphic system

- In homomorphic system incompatibility is not associated with morphological differences among flowers.
- The compatibility reaction of pollen may be controlled by the genotype of the plant on which it is produced (sporophytic control) or by its own genotype (gametophytic control) .

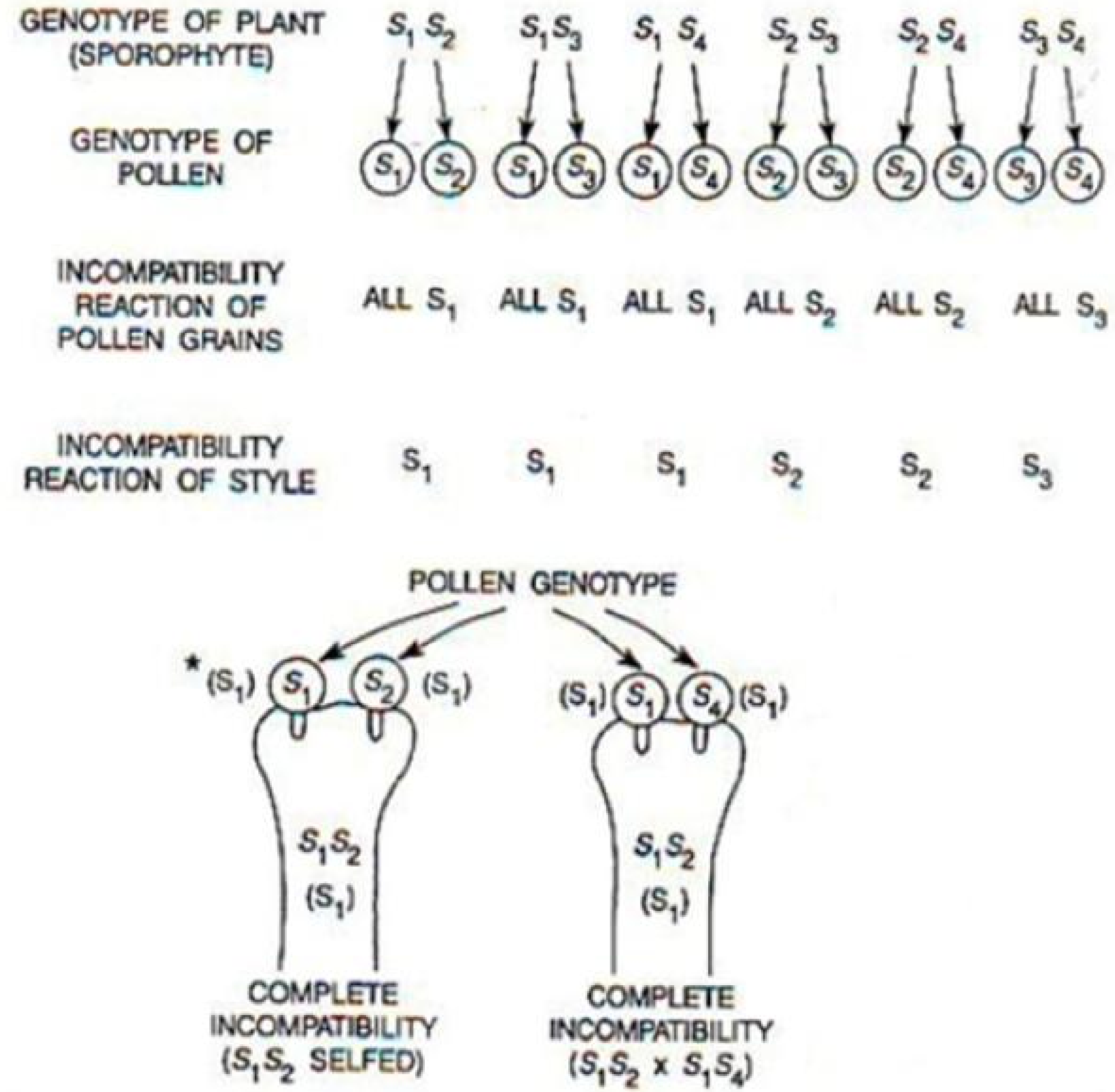

GAMETOPHYTIC SELF-INCOMPATIBILITY
S1 & S2 pollen tube growth is stopped
S3/S3
S3 pollen tube grows normally
S1
S2
S3
Stylar tissue is S1 / S2



Gametophytic incompatibility

Sporophytic system

- The incompatibility reaction of pollen is governed by the genotype of the plant on which pollen is produced and not by the genotype of pollen.
- In the sporophytic system SI is governed by a single gene 'S' with multiple alleles.

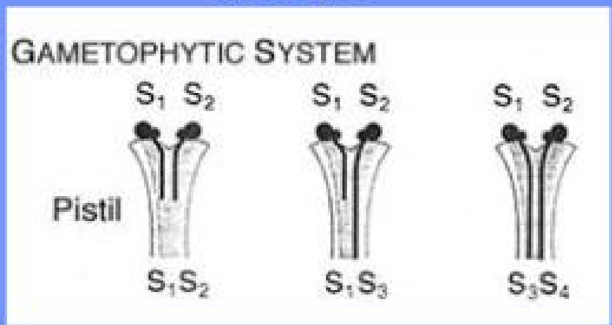

GENOTYPE OF PLANT (SPOROPHYTE)
$S_1 S_2$ $S_1 S_3$ $S_1 S_4$ $S_2 S_3$ $S_2 S_4$ $S_3 S_4$
GENOTYPE OF POLLEN
S_1 S_2 S_1 S_3 S_1 S_4 S_2 S_3 S_2 S_4 S_3 S_4
INCOMPATIBILITY REACTION OF POLLEN GRAINS
ALL S_1 ALL S_1 ALL S_1 ALL S_2 ALL S_2 ALL S_3
INCOMPATIBILITY REACTION OF STYLE
S_1 S_1 S_1 S_2 S_2 S_3
POLLEN GENOTYPE
*(S_1) S_1 S_2 (S_1)
(S_1) S_1 S_4 (S_1)
$S_1 S_2$
(S_1)
$S_1 S_2$
(S_1)
COMPLETE INCOMPATIBILITY ($S_1 S_2$ SELFED)
COMPLETE INCOMPATIBILITY ($S_1 S_2$ x $S_1 S_4$)

GAMETOPHYTIC (GSI)

outcome of the interaction between the pollen tube and the style is determined by the genotype of the pollen (gamete)

S-locus products are synthesized after completion of meiosis

growth of the pollen tube arrests in the style

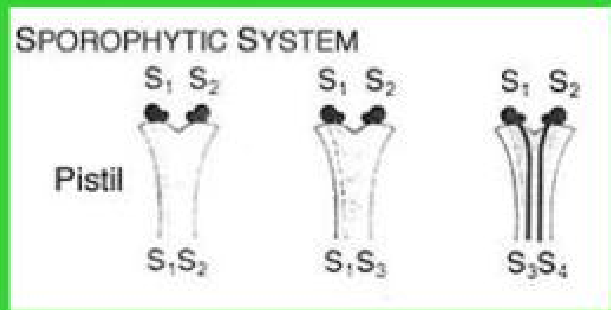


SPOROPHYTIC (SSI)

outcome of the interaction between the pollen tube and the style is determined by the genotype of the sporophyte (diploid tissue)

S-locus products are synthesized before completion of meiosis

growth of the pollen tube arrests at the surface of the stigma



TEMPOARARY SUPRESSION OF SELF-INCOMPATIBILITY

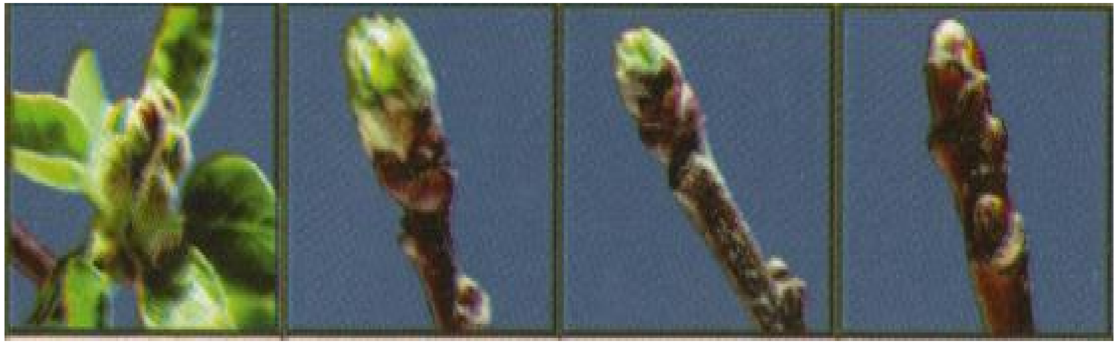
- Bud pollination -
- Application of mature pollen to immature non-receptive stigma.
- End-of-season pollination-
- In some species the degree of incompatibility is reduces towards the end of flowering season.
- High temperature
- In some species exposure of pistils to tem upto 60 c induces pseudo-fertility.
- Irradiation
- X-a or gamma-ray induces a temporary loss of SI.

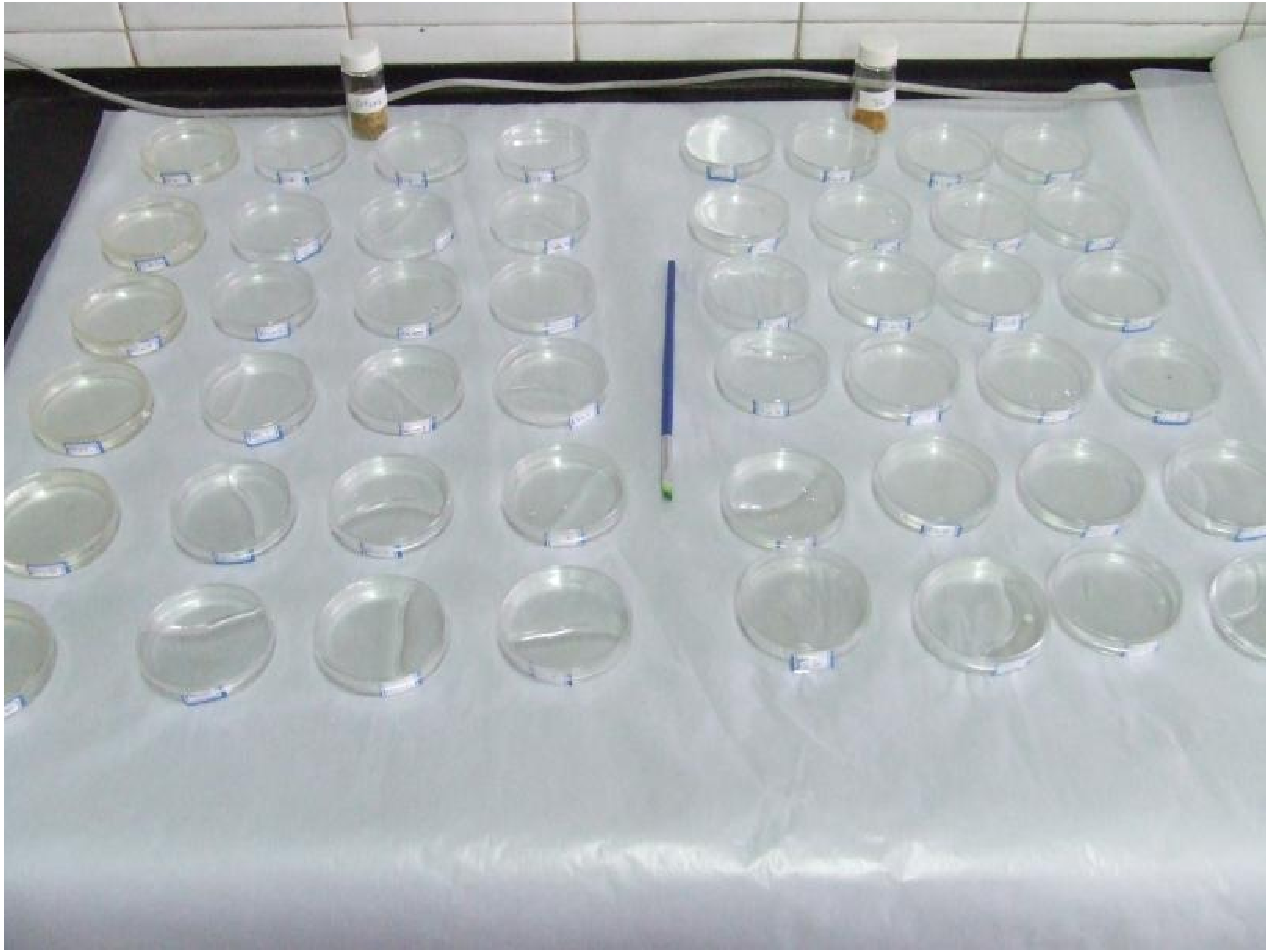
- Double pollination
- In some species when incompatible pollen is applied as a mixture.

a mature, pollen-bearing anther


Hazel Catkins – showering millions of pollen grains in the air


W.P. Armstrong





Methods of Seed Collection, Extraction and Cleaning

Tree Seed Management

Seed Sources, Seed Collection and Seed Handling

Mulawarman, JM Roshetko, SM Sasongko and D Irianto. 2003.

Practical Definitions for Common Tree Seed Terms

- **Germplasm:**
- **Seed:**
- **Seedling:**
- **Seed source:**
- **Seed trees:**
- **Genotype:**
- **Phenotype:**
- **Plus trees (Selected trees):**

3. Seed Quality

Another important term is **seed quality**. Seed quality has a direct impact on tree growth and the success of tree planting activities. Seed quality is comprised of three components.

- **Physical quality**: Quality related to physical characteristics, such as size, color, age, seed coat condition, occurrence of cracks, pest and disease attacks, or other damage.
- **Physiological quality**: Quality related to physiological characteristics, such as maturity, moisture content, or germination ability.
- **Genetic quality**: Quality related to characteristics inherited from the parent trees.

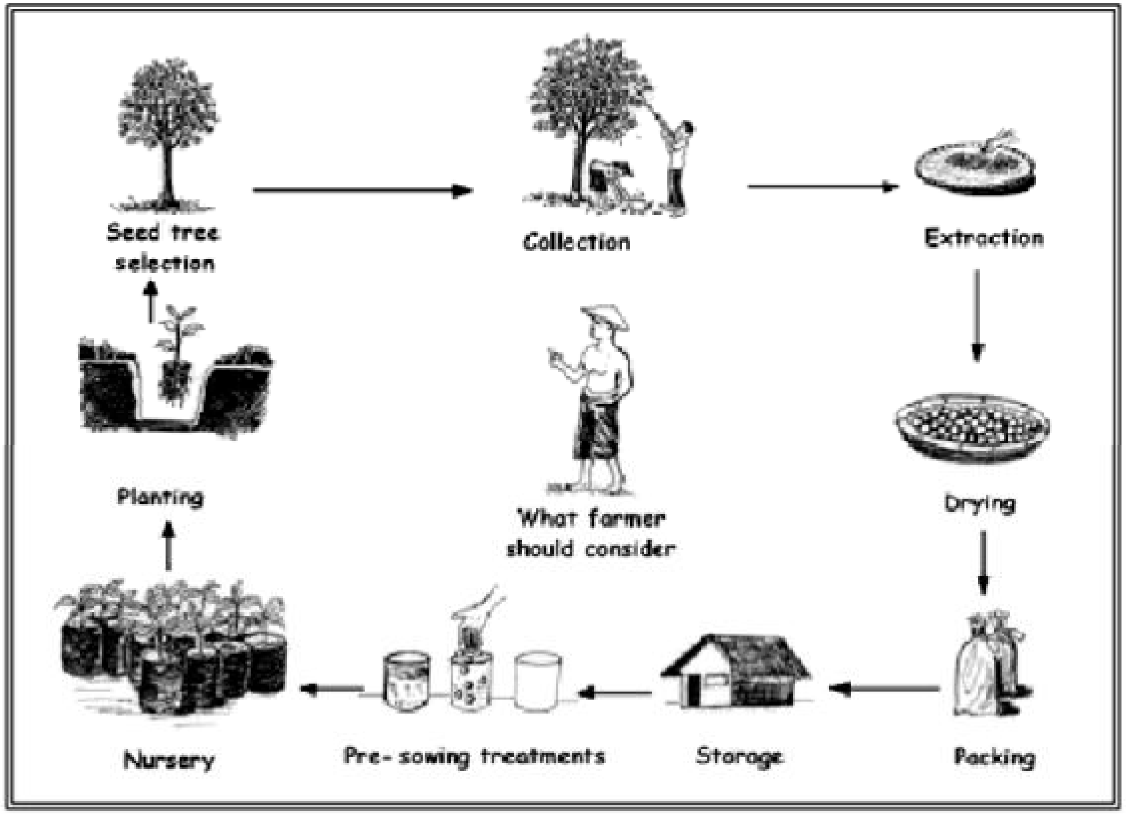


Figure 1. Continuum of activities that influence seed quality and should be considered when planning seed collection and tree planting activities (Adapted from IFSP, 2000).

WHERE SHOULD SEED BE COLLECTED?

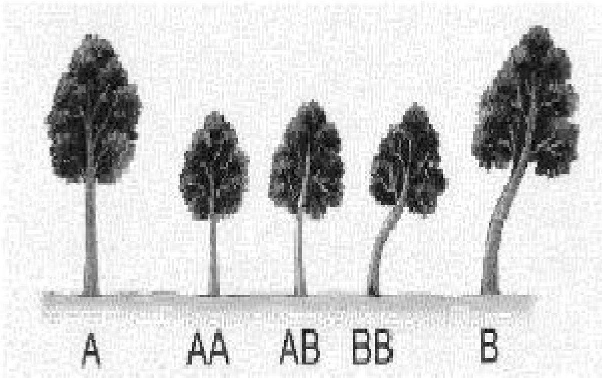
I. Seed Sources

- Seed orchards
- Seed production areas
- Seed stands
- Seed trees

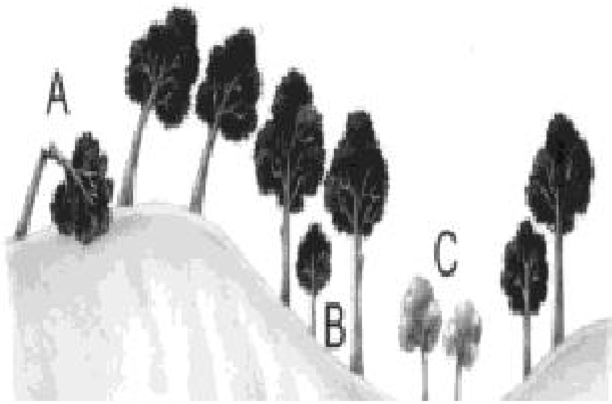
Table 1. Characteristics of various seed sources.

Characters	Seed sources				
	Seed orchards	**Seed production areas**	**Seed stands**	**Seed trees**	**Unselected seed sources**
Planting purpose	Seed production	Not for seed production	Not for seed production	Not for seed production	Not for seed production
Seed origin	Identified	Identified or Unidentified	Unidentified	Unidentified	Unidentified
Quality of mother trees	Selected and tested trees	Selected stands, thinned, untested	Selected stands, unthinned (or thinned), untested	Selected trees from unselected stands	Unselected trees from unselected stands
Seed quality	Very good	Good	Fairly good	Intermediate	Poor
Level of Management	Very Intensive	Intensive	Intermediate	Some	None

Seed tree selection



a. Homogeneous site – appropriate for seed tree selection.



b. Heterogeneous site - inappropriate for seed tree selection.

Figure 3. Sites for seed tree selection (IFSP, 2000).

Criteria for seed trees selection

Seed tree selection criteria differ for various tree types.

- Timber tree criteria
  - Above average tree height and stem diameter
  - Straight stem form
  - Long, clear merchantable bole
  - Uniform crown, without heavy branches or double-stem
  - Free of pests and diseases
  - Good quality timber
  - Mature tree that produces ample quantities of seed
- Fodder trees and living fences
  - Rapid growth
  - High leaf production
  - High nutritive values of leaf
  - Good coppicing ability
  - Tree stature and shape that fits the intended planting system and site
  - Free of pests and diseases
  - Drought resistance
  - Mature tree that produces ample quantities of seed
- Fruit trees[1]
  - Good growth
  - Abundant, sweet, and big fruits
  - Uniform crown with low branches
  - Free of pests and diseases
  - Mature tree that produces ample quantities of seed

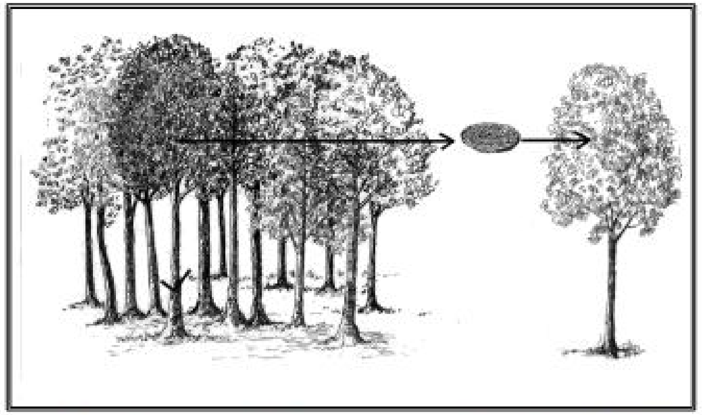


Figure 5. When the seed (mother) tree is surrounded by other good quality trees the progeny will demonstrate good quality (Wiyono, 2002).

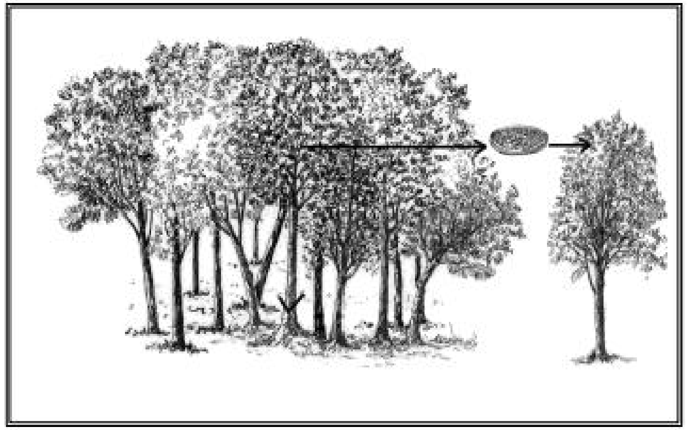


Figure 6. When the seed (mother) tree is surrounded by good to fair quality trees, most of the progeny will demonstrate good to fair quality (Wiyono, 2002).

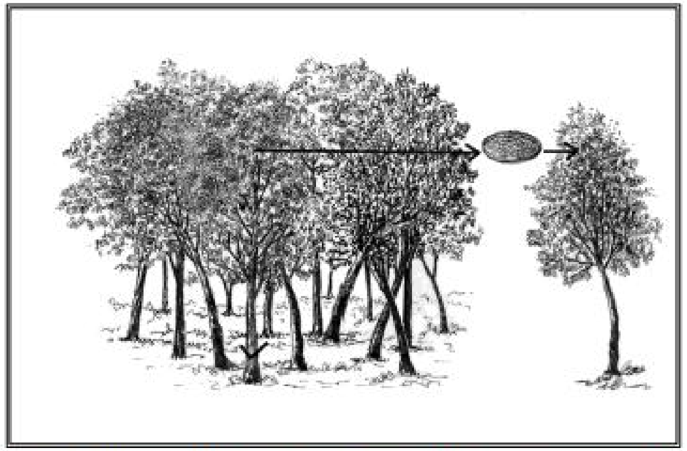


Figure 7. When the seed (mother) tree is surrounded by many poor quality trees, the progeny will demonstrate poor quality (Wiyono, 2002).

Establishment of Small-Scale Seed Orchard

Site selection for seed orchard

Germplasm selection for seed orchard

Seed orchard size

Seed orchard establishment

Seed orchard design

Seed orchard management

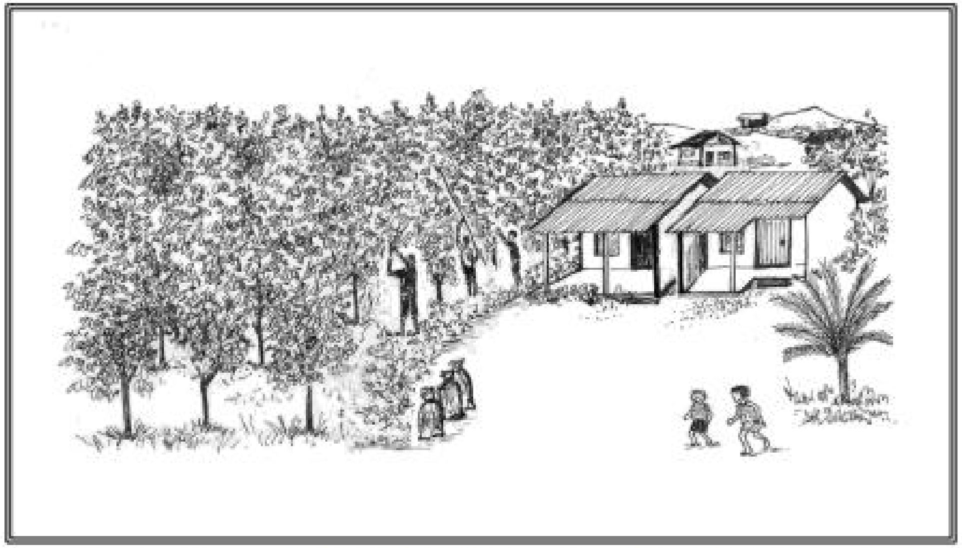
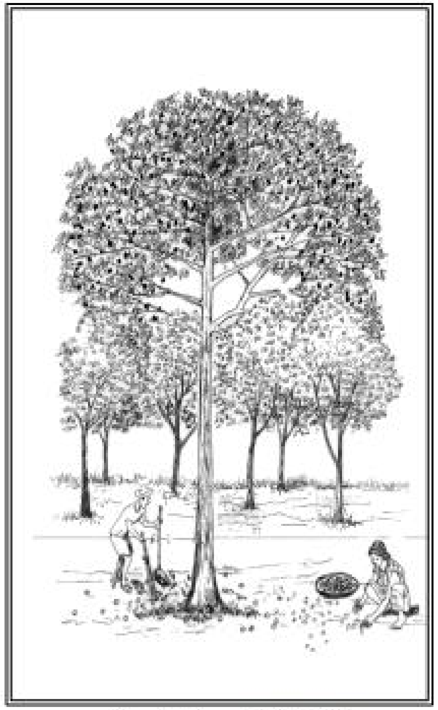


Figure 8. Small-scale seed orchard on farm or community land (Wiyono, 2002).

HOW SHOULD TREE SEED BE COLLECTED?

Seed Collection

Collecting seed from the forest floor



a. Adapted from IFSP, 2000.

b. Adapted from Chamberlain, 2000.

Figure 9. Seed collection from the forest floor.

Seed collection directly from trees (without climbing)

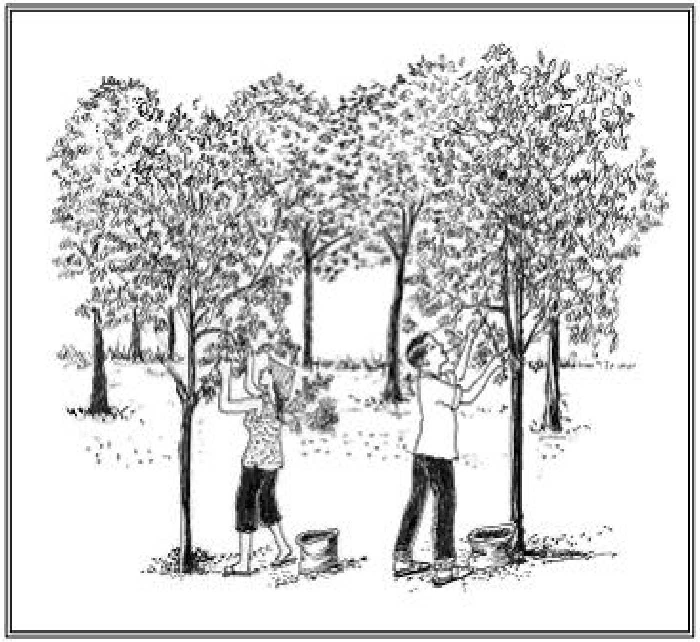


Figure 10. Seed collection directly from trees (Adapted from Chamberlain, 2000).

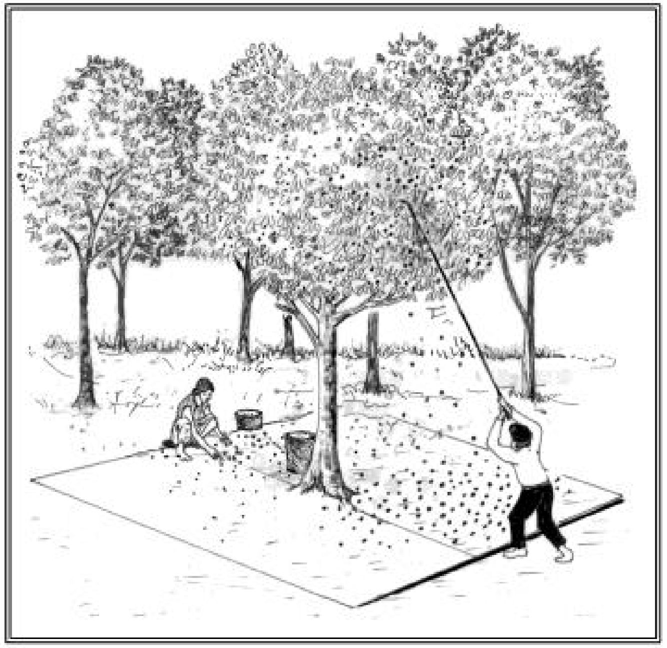
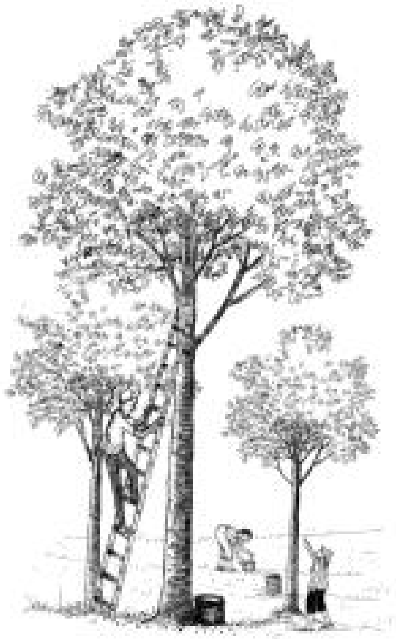


Figure 11. Seed collection from tree using pole tools (Adapted from IFSP, 2000).

Seed collection by climbing tree



a. Climbing a tree using a ladder (Wiyono, 2002).

b. Climbing a tree without using tools or equipment (Wiyono, 2002).

Figure 12. Seed collection by climbing trees.

General comments concerning seed collection

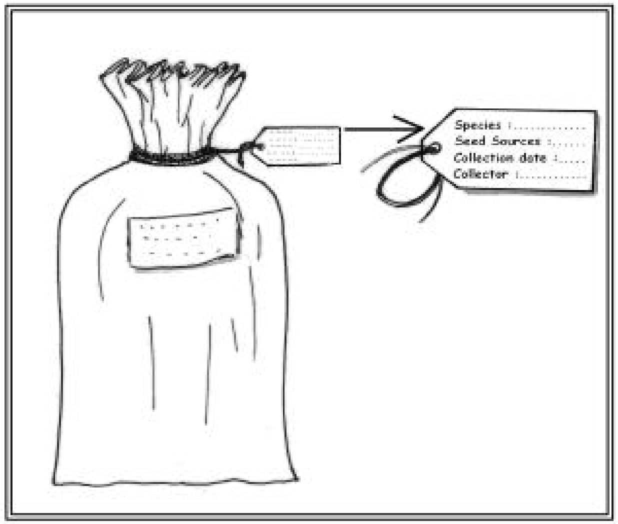


Figure 13. A sack of seed properly labeled (IFSP, 2000).

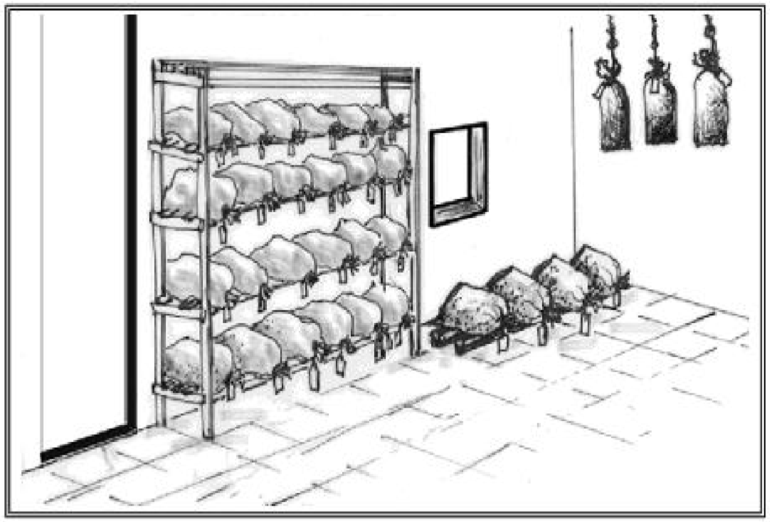
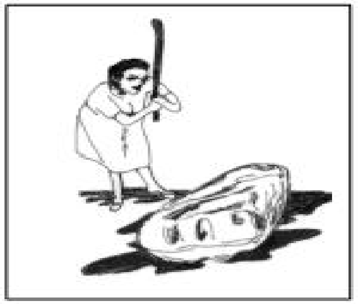
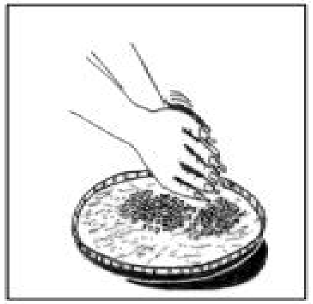


Figure 14. Temporary seed storage (Wiyono, 2002).

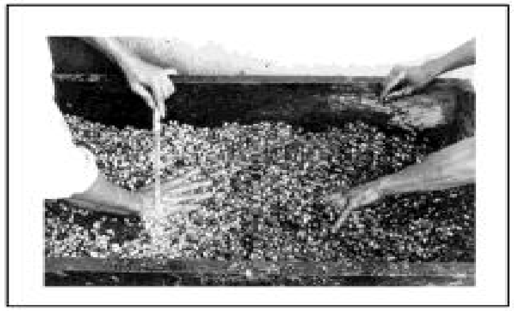
HOW SHOULD SEED BE PROCESSED?



a Beating fruits to facilitate seed extraction (IFSP, 2000).

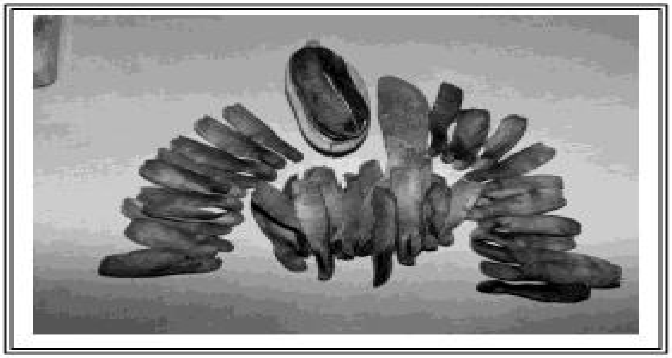


b Scrapping fruits with abrasive material to facilitate seed extraction (IFSP, 2000).



c Scrubbing and washing fruits to remove fleshy material from seeds (IFSP, 2000).

d Breaking open fruit to extract seed (Photo, Mulawarman).



e Seed extracted from fruit (Photo, Mulawarman).

Figure 16. Common seed extraction methods.





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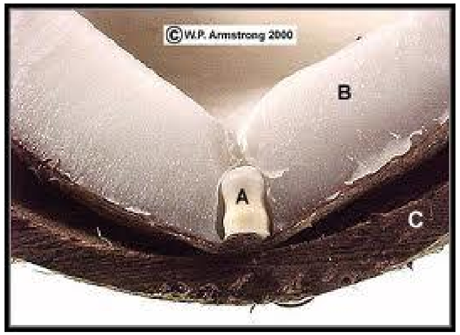
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