Bio Factsheet

Number 96

Pollination

The aims of this Factsheet are to enable you to:
- **recognise and name the parts of a typical simple flower;**
- **know and understand the structural features of a named insect-pollinated (entomophilous) flower and a named wind-pollinated (anemophilous) flower;**
- **be able to describe the mechanisms and compare the outcomes of self-pollination and cross-pollination.**

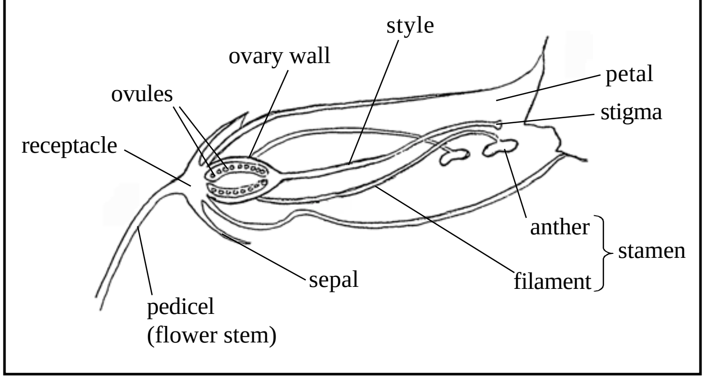
Pollen contains the haploid male nuclei involved in fertilisation. Pollen is formed in anthers. The haploid female nuclei are found in the ovules of carpels. Pollination is the transfer of pollen from an anther to the stigma of a carpel. Self-pollination occurs if the pollen falls on to stigmas of the same plant and this results in inbreeding, which is genetically limiting. Cross-pollination is the transfer of pollen to the stigmas of a different plant of the same species, and it results in outbreeding, which is genetically advantageous.

Remember:- *Fertilisation may not necessarily follow pollination but if fertilisation takes place, pollination must have occurred.*

Flower structure

Fig 1 illustrates the basic structure of a dicotyledonous insect-pollinated flower (a foxglove).

Fig 1. Half-flower diagram of *Digitalis purpurea* (Foxglove)

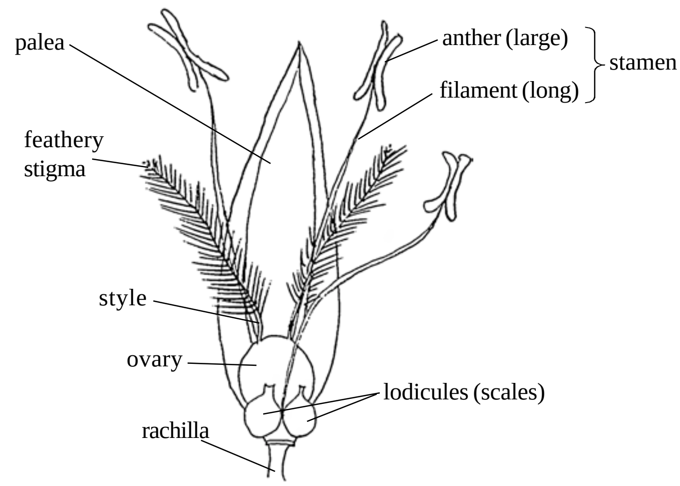


The sepals, petals and ovary are all attached to the receptacle which is the end of the pedicel or flower stalk. In the foxglove, the stamens are attached to the bases of the petals (remember that in most flowers the stamens are attached to the receptacle). The five sepals, making up the calyx, are green and protect the flower when it is still in the bud. The five petals, making up the corolla, are fused at the base to form a tube which is shaped into an upper and lower lip at the entrance. The petals are usually pinkish-purple in colour. There are only four stamens, making up the androecium, (remember that most dicotyledonous flowers have five), two of the stamens have long filaments and two have short filaments.

The carpels, making up the gynaecium, are fused together into the ovary which contains many ovules. The ovary has a long style which supports the stigma near the entrance to the corolla tube. The foxglove has its flowers mounted in large numbers in an erect, unbranched 'spike' arrangement. Each 'spike' (technically it is called a 'raceme') supports between twenty and eighty flowers. The resulting mass of colour is very attractive to the pollinating insects, which in this case are mainly bumble bees and honey bees. To attract bees, the flowers also secrete a sugary nectar from nectaries at the base of the corolla tube and also exude an attractive scent.

In contrast to the foxglove, monocotyledonous grasses, such as *Poa annua*, the annual meadow grass, are wind-pollinated. The floral structure of this grass is shown in Fig 2.

Fig 2. Structure of a single flower (spikelet) of *Poa annua* (Annual meadow grass)



The individual flowers are called spikelets and many are borne together making up an unbranched spike or 'ear'. Fig 3 illustrates the arrangement of the spikelets into a flower head. Each spikelet is attached to the main stem (rachis) of the ear by a short 'rachilla'. Since the flower is wind pollinated, the sepals and petals are reduced in size to allow free wind access and are green or colourless since they do not need to attract insects. For example, the lodicules are small scales which are thought to be the vestiges of petals. The palea is a bract (modified leaf) which encloses and protects the flower during development. The filaments are long and pendulous, holding the large anthers in the wind currents so that the pollen grains can be shaken out into the air. The stigmas are feathery to give a large surface area for catching pollen and also hang out, exposed to the air currents.

Fig 3. Arrangement of a grass flower head

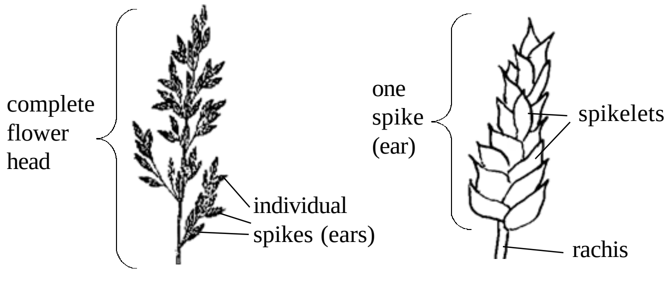


Table 1 below gives comparative details of wind and insect pollinated flowers.

Table 1 Comparison of the features of wind-pollinated flowers and insect-pollinated flowers.

Feature	Wind-pollinated flower	Insect-pollinated flower
Number of flowers per plant	Several hundred small flowers	Fewer, larger flowers-sometimes one only
Plant population growth pattern	Dense populations e.g. grasslands and forests	Small groups, sometimes solitary
Petals	Small, inconspicuous, absent in some species	Large, conspicuous, colourful
Scent and nectar	Not produced	Both may be produced as attractants
Pollen	Large quantity, small grains, smooth, separate, light, aerodynamic, some have air sacs	Smaller quantity, large grains, irregular surface, clumped together
Stamens	Pendulous, long filaments expose anthers beyond the other flower parts into air currents	Shorter filaments, anthers enclosed within the other flower parts
Carpels/ovary	Exposed	Enclosed by petals
Stigmatic surface	Exposed to the air, large, filamentous and feathery, sticky, often branched, forming a net	Enclosed within the other flower parts, flat, lobed, sticky

Exam Hint: *- Examiners often ask questions about comparative features of insect and wind pollinated flowers. Data questions may be set involving flowers that you may not have directly studied – do not panic! – the principles will be the same whatever the example.*

A common error when answering questions on pollination is to include details of fertilisation in flowers. Remember that the process of pollination stops when the pollen is on the stigmas. Do not give details of pollen germination, pollen tubes and double fertilisation, unless asked to.

Remember: *– The main pollinating insects are honeybees and bumble bees. These visit the flowers for food, using pollen as a protein and lipid food source and nectar as a carbohydrate source (which they store as honey). The bees are adapted by having, for example:*
- *hairy bodies to which pollen sticks, long tongues (proboscis) for reaching the nectary and sucking the nectar into their large honey stomach;*
- *pollen baskets on their back legs for carrying large quantities of pollen;*
- *good colour vision for seeing the flowers;*
- *a good sense of smell for sensing the flower scents.*

Self and cross pollination

Flowering plants as a whole show three different arrangements with respect to their flowers.
Any particular species will have one of the following:
1. both sexes in each individual flower (hermaphrodite *flowers*), for example, Buttercup;
2. both sexes as single sex flowers on the same plant (hermaphrodite *plants*), for example, Hazel;
3. single sex flowers on separate plants (male plants and female plants), for example, Holly.

The nuclei present in pollen transferred within an individual hermaphroditic flower will have a similar genetic constitution to the female nuclei present in the ovules. The same will be true when pollination occurs between male and female flowers on an individual hermaphroditic plant. This type of pollination is described as **self pollination**.

Remember: *- pollen transfer between plants that have been produced asexually as part of a clone, i.e. genetically identical, will also be a case of self pollination despite the fact that the pollen transferred may come from a different plant.*

Pollination is described as **cross-pollination** when it takes place between different plants of the same species that have different genetic constitutions. For some plant species, self-pollination is the norm and no doubt occurs quite frequently in many others. Self-pollination limits the amount of genetic variation that can occur since it does not introduce any new alleles. Some variation is possible also by random mutations which can occur naturally in any plant population. Some of these may be advantageous in terms of evolutionary fitness. Others may be disadvantageous. Self pollination limits the establishment of new combinations that might be of survival value for the species. However, self-pollination enables a plant to set seeds when it is isolated or when there is a lack of suitable pollinators. Therefore survival of the genes is ensured when the parent plant dies. Cross-pollination brings together gametes containing a wide variety of alleles from genetically different parents. This leads to genetic diversity and increases survival chances.

Many mechanisms have evolved that decrease the chance of self-pollination and increase the probability of cross-pollination. One mechanism prevents self-pollination (see later).

Remember : *- 'Nature' tends to promote outbreeding and reduce the incidence of inbreeding.*

Mechanisms that reduce the chance of self pollination

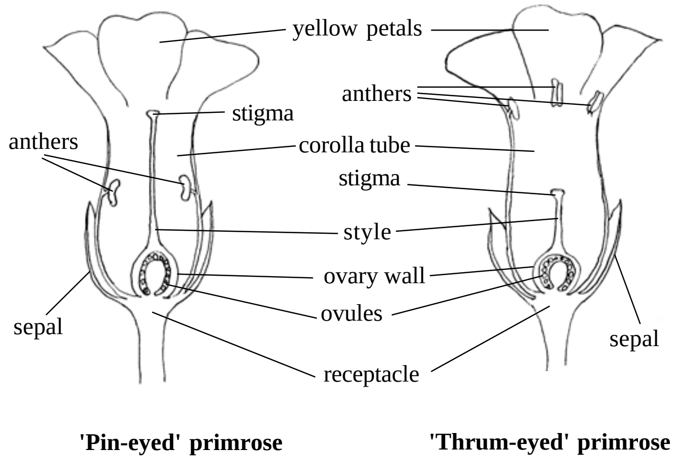
1 Many plant species have male and female sex organs on the same plant. These plants are said to be **monoecious**. Their sex organs may be organised in separate male and female flowers, or within hermaphrodite flowers. Pollinators visiting hermaphrodite flowers are likely to transfer pollen within the inflorescence and therefore self-pollinate but mechanisms exist that reduce the probability of this leading to fertilisation (see below). Equally, pollinators are likely to visit both sexes of flower on those plants with single sexed flowers but the chance of self-pollination is less than it would be with hermaphrodite flowers.

2. Stamens and carpels within the same flower of some species may mature at different times. Flowers where the stamens mature earlier than the carpels are called **protandrous.** Thus the pollen that is released must be transferred to another flower of the same species containing a stigmatic surface that is ready to receive it. Other species have carpels that are mature before the stamens. Consequently by the time pollen is released, the carpel should have been successfully pollinated by pollen from another flower of the same species. Such flowers are described as **protogynous**.

> ***Remember:*** *- Different flowers on the same plant are likely to be of different ages and at different stages of maturity. Some flowers open earlier than others and therefore self pollination is still a possibility.*

3. Some species of plant produce different growth forms (**polymorphism**). For example, the primrose *Primula vulgaris* is a dimorphic plant. This particular example of polymorphism is known as **heterostyly** (styles of different lengths). Approximately half the plants have 'pin-eyed' flowers, the other half having 'thrum-eyed' flowers. These features provide structural incompatibility and so reduce the chance of self pollination. These features are illustrated in Fig 4.

Fig 4. Half-flower diagrams of primrose flowers



The stamens of a 'thrum-eyed' flower are found at the mouth of the corolla at roughly the same height as the stigmatic surface of a 'pin-eyed' flower. The stamens and stigma of a 'pin-eyed' flower and a 'thrum-eyed' flower respectively are found at approximately the same position, halfway down the corolla tube. When visiting insects such as bees force their way into the corolla tube to reach the nectar at the base, they are most likely to effect transfer of 'thrum' pollen to 'pin eyed' stigmas and vice versa. Physical incompatibility between the pollen grains and the nature of the stigmatic surface also reduces the chance of thrum-eyed pollen that accidentally falls onto its own stigmas from germinating successfully.

4. Some species of plant posses self-incompatibility genes. These enable the tissues of the stigma and style to recognise proteins associated with the surface of pollen grains. Chemical processes in the tissues of the stigma and style prevent the plant's own pollen grains from germinating there or inhibit the growth of the pollen tubes.

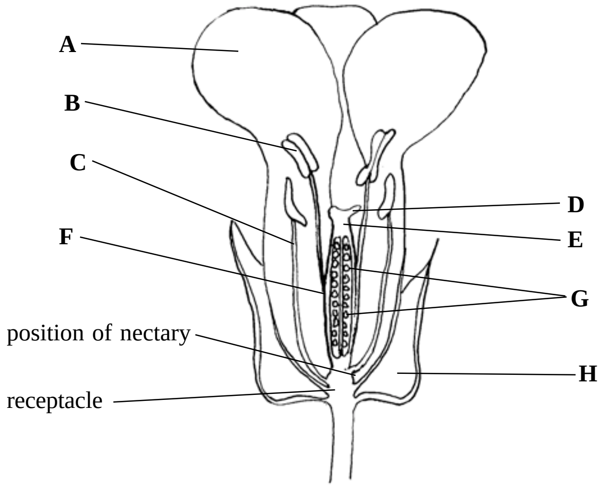
> ***Remember:*** *- Self-sterility is common in fruit trees such as apples, plums and pears. This is why certain varieties will only set fruit if different varieties of the same species exist locally to provide pollinators with a supply of compatible pollen.*

Mechanism for preventing self pollination

Dioecious species of plants produce male and female flowers on different plants. This means that there are different sexes of plant. Self pollination is therefore impossible. Examples of dioecious plants include maize, oak and holly.

Practice Questions

1. The following half-flower diagram shows the structure of an insect pollinated flower.



(a) Label features A to H shown in the flower above. 8

(b) List five features of a wind-pollinated flower that would be different from this flower. 5

(c) Explain how these differences are adaptations related to wind pollination. 5

2. Distinguish between the following pairs of terms:

(a) pollination and fertilisation. 2

(b) self-pollination and cross-pollination. 2

(c) protandry and protogyny. 2

(d) monoecious and dioecious. 2

3. (a) Name one condition that is shown by some species of plants that makes self-pollination impossible 1

(b) Outline one mechanism shown by a **named** flowering plant that prevents self-fertilisation from following successful self pollination. 4

4. Bees often visit primrose flowers. The insect pushes its head into the mouth of the corolla and extends a long proboscis (honey-tongue).

(a) What factors are likely to have attracted the bee to a primrose flower in the first place? 3

(b) Which part of the bee's body is likely to come into direct contact with the stamens of
(i) a 'thrum-eyed' primrose flower? 1
(ii) a 'pin-eyed' primrose flower? 1

(c) Suggest how, having collected pollen from both forms of the flower, this insect is likely to bring about cross pollination. 4

Answers

1 (a) A = petal/corolla; B = anther; C = filament; D = stigma; E = style; F = ovary wall; G = ovules; H = sepal/calyx; 8

(b) smaller/absent/colourless petals/sepals; no nectaries/scent; anthers pendulous; large quantity of pollen/small grains/aerodynamic/air sacs; stigma net-like/branched/feathery; 5

(c) colour/nectar/scent not required as an attractant;
reduced sepals/petals enables more exposure to wind/pollen more likely to be released into the wind; long filaments and large dangling anthers enables pollen to be shaken out into the wind; indiscriminate dispersal of pollen means that large quantities are required to ensure success;
low weight of pollen grains aids dispersal/smooth or aerodynamic to ease wind transport/air sacs increase buoyancy;
feathery stigma provides large surface area to trap pollen; 5

2. (a) pollination involves transfer of pollen from anther to stigma; whereas fertilisation involves the fusion of gametes; 2

(b) self-pollination involves the transfer of pollen between stamen and stigma of the same flower or flowers on the same plant;
cross-pollination involves the transfer of pollen between stamens and stigmas of flowers on different plants of the same species; 2

(d) protandry is the condition where stamens mature before carpels;
protogyny is the condition where carpels mature before stamens; 2

(e) monoecious plant species have both sexes present in the same plant;
dioecious plant species have separate male plants and female plants; 2

3. (a) dioecious/having separate male and female plants 1

(b) apple/pear/cherry; self sterility genes; cause synthesis of pollen grain proteins;
stigmatic/stylar tissue recognises the proteins;
produce chemicals to inhibit the germination of pollen grains or growth of pollen tubes; max 4

4. (a) yellow petal colour; scent; nectar; 3
(b) (i) head; 1
(ii) 'mid' proboscis; 1

(c) if bee next visits 'thrum' the stigma it contacts is in 'mid' position of corolla tube;
therefore 'pin' pollen grains adhering to 'mid' proboscis are transferred;
if bee next visits 'pin' the stigma it contacts is in the 'mouth' of the corolla tube;
therefore 'thrum' pollen grains adhering to its head are transferred; 4

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