AP® BIOLOGY
2008 SCORING GUIDELINES

Question 4

4. Flowering plants have evolved various strategies for fertilization.

(a) **Describe** the process of fertilization in flowering plants. **(3 points maximum)**

Double fertilization **(2 points maximum)**

- Sperm + egg → zygote (2n)/fertilized egg
- Sperm (n) + 2 polar nuclei (n+n) → endosperm food source (3n)

Pollen tube formation **(1 point maximum)**

- Pollen grain adheres to stigma, absorbs water and germinates; growth of pollen tube (tube nucleus)
- Generative nucleus divides into two sperm nuclei (or pollen grain has two sperm nuclei)
- Development of embryo sac (female gametophyte)

(b) **Discuss** TWO mechanisms of pollen transfer and the adaptations that facilitate each mechanism. **(4 points maximum)**

Mechanism **(1 point for each mechanism discussed <u>with action verb</u>; 2 points maximum)**	**Adaptations** **(1 point for each adaptation appropriate to the mechanism(s) discussed; 2 points maximum)**
Wind (e.g., blows, carries)	Pollen shape (pits) Lightweight pollen Feather-like, sticky stigma High pollen:ovule ratio Male flowers elevated/exposed anther Stem/stamen modification for pollen release
Animal vectors (e.g., transfer, carry)	Barbs, spikes on pollen (attaches) Nectar/fragrance/color/UV patterns Coevolution of animals (specific example) Shape of flower/position of pollen
Water (e.g., transfers, carries)	Lightweight pollen floats on water
Gravity (self-pollination) (e.g., falls, drops)	Anther/stigma mature at same time Anthers above stigma

Some species of flowering plants have evolved mechanisms to prevent self-fertilization.

(c) **Discuss** an evolutionary advantage of preventing self-fertilization. **(2 points maximum)**

- Maintains/increases genetic variability of the population (<u>not at individual level</u>)
- Variability in action—explain or give an example
  (e.g., more material for natural selection, avoids effects of inbreeding, allows population to cope with changing environment)
- Hybrid vigor

Question 4 (continued)

(d) **Describe** TWO mechanisms that prevent self-fertilization. **(3 points maximum)**
1 point for a description of each mechanism as suggested by the bullets below (2 points maximum); 1 point for an appropriate specific example or detailed description

Self-incompatibility

- Pollen fails to germinate (stigma epidermal cells prevent germination of pollen through signal transduction pathway).
- Pollen tube does not complete development (due to destruction by RNAses).
- Sperm fails to unite with egg.
- S-genes must be different (allele incompatibility).
    - If pollen grain and stigma have matching alleles at the S-locus then the male gametophyte fails to begin process of fertilization.

Structural adaptations

- Stigmas are higher than anthers or vice-versa (pin and thrum) (heterostylous).
- Separate male/female flowers (monoecious)/separate sexes/stamens OR carpels (dioecious).
- Temporal separation of maturation of male/female parts (dichogamy/protogyny/protandry).
- Nectar production at different times.
- Mechanical isolation: difference in size of pollen grains and stigma papillae.

4. Flowering plants have evolved various strategies for fertilization.

4A,

(a) **Describe** the process of fertilization in flowering plants.

(b) **Discuss** TWO mechanisms of pollen transfer and the adaptations that facilitate each mechanism.

Some species of flowering plants have evolved mechanisms to prevent self-fertilization.

(c) **Discuss** an evolutionary advantage of preventing self-fertilization.

(d) **Describe** TWO mechanisms that prevent self-fertilization.

Everyone knows what a flowering plant is, but how do they arise? There are two parts to a flowering plant, the male and female structures. The female structure is the carpel, containing the stigma, style, and ovary. The male structure is the stamen with the anther and filament. In fertilization, pollen from another plant lands on the stigma of the plant. Pollen from the other plant came from the male stamen. When the pollen lands on the stigma the pollen tube forms as it begins to be "digested". The pollen travels down the tube of the style and into the ovary where one haploid nucleus is fertilized as the embryo while the other becomes the endosperm. Endosperm will nourish the growing embryo as it becomes a seed. The ovary will develop as the fleshy part of a fruit and encase and protect the seeds. Once the seeds are produced the cycle begins again.

Pollen transfer can occur in two ways. The first and most widely known way is by insects like bees. Flowering plants provide a food source for animals like bees. When an insect lands, pollen is stuck to it. Upon traveling to another flower pollen rubs off from other flowers, fertilizing the new plant. Another mechanism is by water. Some plants have adapted evolutionarily to favor environments with much water. There is a reason for this. Evolution may have selected for a plant whose readily accessible pollen

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4A2

travels well in water. The water transports pollen to other flowers, pollenating them. One evolutionary adaptation that facilitates pollen transfer is pollen location. Instead of stored inside a flower, pollen exists on the anther, easily accessible by animal or water.

If a flower self-fertilizes, all genetic information will remain the same. In an evolutionary sense this is no good. Genetic variation is what evolution is based on; if no variation existed, evolution could not select viable organisms. By preventing self-fertilization, genetic diversity is preserved. Genetic diversity can give rise to possible characteristics that may benefit an organism. By introducing new traits, natural selection can advance a species rather than rendering a population unchanging.

In order to prevent self-fertilization, a physical adaptation and a chemical process are employed. The first mechanism to prevent self-fertilization is a physical inhibition. In some plants, the location of pollen in relation to the stigma is not conducive to fertilization; in other words the pollen is in a location lower than the stigma. The simple employment of gravity lessens the chance of self fertilizing by sheer isolation. A second mechanism to prevent this is a chemical reaction. Much like the neutralizing of an acid by adding a base, the combination of self pollen and haploid nuclei renders the resulting embryo non-viable. Certain plants have innate reactions that occur upon self-fertilization that make it impossible for a viable offspring to be produced.

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4. Flowering plants have evolved various strategies for fertilization. 4B,

(a) **Describe** the process of fertilization in flowering plants.

(b) **Discuss** TWO mechanisms of pollen transfer and the adaptations that facilitate each mechanism.

Some species of flowering plants have evolved mechanisms to prevent self-fertilization.

(c) **Discuss** an evolutionary advantage of preventing self-fertilization.

(d) **Describe** TWO mechanisms that prevent self-fertilization.

A. In flowering plants, pollen from the anther is transported by some mechanism to pollinate the eggs in the female ovule.

B. In order to attract insects which can carry pollen, flowers are usually brightly colored and sweet smelling. When an insect such as a bee lands in the flower, it is often coated in pollen by the anthers and then flys to another flower spreading the pollen.

Many plants also use the wind to carry their pollen by having it on the protruding anthers. The pollen is picked up in the wind and lands everywhere, sometimes another flower.

C. By preventing self fertilization, plants are able to avoid the mutations which they may have encountered. Random fertilization makes it so that disease, which may have plagued this plant, has a 50/50 shot of plaguing the offspring rather than a 100% chance.

D. Flowers which only exhibit one sex cannot self pollinate because they need a flower with the opposite sex to fertilize.

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4B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

Another way that plants can avoid self fertilization is through the male and female parts being fertile at different times. This allows the pollen to be spread and the eggs to be ready at diffrent times, therefore preventing a flower from pollinating itself.

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4C1

4. Flowering plants have evolved various strategies for fertilization.

(a) **Describe** the process of fertilization in flowering plants.

(b) **Discuss** TWO mechanisms of pollen transfer and the adaptations that facilitate each mechanism.

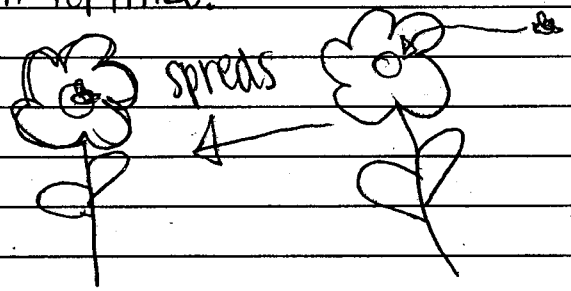
Some species of flowering plants have evolved mechanisms to prevent self-fertilization.

(c) **Discuss** an evolutionary advantage of preventing self-fertilization.

(d) **Describe** TWO mechanisms that prevent self-fertilization.

Fertilization in flowering plants is very important for reproduction. Without it, we would no longer live on a green planet. Fertilization is what you do when you plant seeds in the ground water them and wait for them to grow. However, their are many factors that come into the picture like, water, light, energy, space, soil, etc.

Two mechanisms of pollen transfer I think of is bees and wind. Bees help flowers transfer pollen everywhere. Without bees flowers would have a very hard time of spreading. Also the wind often helps blow pollen to different places, so it can grow and it to can fertilize.



One evolutionary advantage of preventing self-fertilization is that it allows their to be more diversity. Self-fertilization will most likely produce the same kind. Also, if their are so many of 1 which have the same gene, it is more likely that it will not survive because if something happens, and theirs no diversity, none will survive. like the example of the tree trunks turning black and all the moths dieing, if their weren't any black already, tons would die because they would no longer be camoflouged.

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Question 4

Overview

The biological theme of this question was evolution. First, the question asked students to describe the process of fertilization in flowering plants. The second part of the question asked students to discuss two mechanisms of pollen transfer and the adaptations (evolution) that facilitate each mechanism. The third part of the question required students to discuss an evolutionary advantage of preventing self-fertilization. Finally, the fourth part of the question asked students to describe two mechanisms that prevent self-fertilization.

Sample: 4A
Score: 9

Two points were earned in part (a). One point was earned for describing how a haploid nucleus travels and "is fertilized [to form] the embryo." Another point was earned for stating that the other haploid nucleus "becomes [part of] the endosperm."

For part (b) the student earned all 4 points. One point was earned for discussing the adaptation that facilitates the mechanism of pollen transfer by animals when the student describes how "[f]lowering plants provide a food source for animals." The pollen transfer occurs when the animals come to feed on the plant and pollen "rubs off" onto their bodies, and then they carry the pollen as they travel from one flower to another. This earned a second point. Another point was earned with the discussion of how "pollen travels well in water." The last point from this section was earned for discussing the adaptation that facilitates this type of pollen transfer (pollen is "readily accessible" and "exists on the anther").

In part (c) a point was earned for discussing how "genetic diversity is preserved" by preventing self-fertilization by "introducing new traits" into the population.

In part (d) the student describes two mechanisms that prevent self-fertilization. One point was earned for describing how "the pollen [can be] in a location lower than the stigma." A second point was earned for a chemical (self-incompatibility) mechanism where "the combination of self pollen and haploid nuclei renders the resulting embryo non-viable."

Sample: 4B
Score: 6

No points were earned for the response in part (a) of this question.

For part (b) the student earned a point for discussing how insects get "coated in pollen by the anthers" of the flower and then fly "to another flower spreading the pollen." A point was earned for the discussion of how "flowers are usually brightly colored . . . to attract insects." A third point was earned for discussing the adaptation of "sweet smelling" flowers that could also attract the insects. A final point was earned for discussing wind as a mechanism to carry the pollen.

No points were earned in part (c) since an evolutionary advantage that prevents self-fertilization is not clearly discussed.

In part (d) the student received a point for describing how flowers that "only exhibit one sex cannot self pollinate" as a mechanism to prevent self-fertilization. A final point was earned for noting that plants "avoid self-fertilization . . . through the male and female parts being fertile at different times."

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Question 4 (continued)

Sample: 4C
Score: 3

No points were earned for part (a) since the response does not contain a description of the process of flowering plant fertilization.

In part (b) 1 point was earned for the discussion of how "[b]ees help flowers transfer pollen everywhere." Another point was earned for the discussion of how "the wind often helps blow pollen to different places."

One point was earned in part (c) for the discussion of an evolutionary advantage of preventing self-fertilization, which allows for "more diversity." The student discusses how having plants with the same genes might make it harder for them to "survive . . . if something happens" to the population.

No points were earned in part (d) of this question since the student does not describe any of the mechanisms that prevent self-fertilization.