Definition: Two or more species having a close ecological relationship evolve together such that one species adapt to the changes of the other, thereby affecting each other evolution.

1) Coevolution is the the mutual evolutionary influence between two species (the evolution of two species totally dependent on each other).

2) Each of the species involved exerts selective pressure on the other, so they evolve together.

3) Coevolution is an extreme example of mutualism. Some examples of coevolution include:

**Yucca moths and yucca plants:**

4) Yucca flowers are a certain shape so only that tiny moth can pollinate them. The moths lay their eggs in the yucca flowers and the larvae (caterpillars) live in the developing ovary and eat yucca seeds.
Flowering Plants and Pollinators:

Another example of beneficial coevolution is the relationship between flowering plants and the respective insect and bird species that pollinate them. In this respect, flowering plants and pollinators have developed co-adaptations that allow flowers to attract pollinators, and insects and birds have developed specialized adaptations for extracting nectar and pollen from the plants (shown below).

Research indicates that there are at least three traits that flowering plants have evolved to attract pollinators:

- **Distinct visual cues**: flowering plants have evolved bright colors, stripes, patterns, and colors specific to the pollinator. For example, flowering plants seeking to attract insect pollinators are typically blue or ultraviolet, whereas red and orange are designed to attract birds.

- **Scent**: flowering plants use scents as a means of instructing insects as to their location. Since scents become stronger closer to the plant, the insect is able to hone-in and land on that plant to extract its nectar.

- **Some flowers use chemical and tactile means to mimic female insect species to attract the male species**: For example, orchids secrete a chemical that is the same as the pheromones of bee and wasp species.
When the male insect lands on the flower and attempts to copulate, the pollen is transferred to him.

- **Colour of flower**: the colour of flowers are the important character for the pollination, mostly the pollinators should be attracted towards the bright coloured flower.

**Angiosperms, in general**

1) Coevolution is often seen in a number of species of flowering plants that coevolved with specific pollinators (insects, bats, etc).

2) The pollinator gets a reward such as nectar for pollinating the plant.

3) Moth-pollinated plants often have spurs or tubes the exact length of a certain moth’s “tongue.”

   For example, Charles Darwin predicted the existence of a moth in Madagascar based on the size and shape of a flower he saw there.

4) The moth was actually discovered about 40 years later. The common snapdragons that many people plant in their gardens are designed for a bumblebee of just the right weight to trip the opening mechanism.

**Nectaries, color, and a folded carpel to enclose seeds**

1) Next to occur would have been the evolution of nectaries, nectar-
secreting structures, to lure the pollinators.

2) Development of white or brightly-colored, conspicuous flowers to draw attention to the nectar and/or other food sources would also have occurred.

3) The carpel (female reproductive structure) was originally leaf-shaped. It became folded on itself to enclose and protect the ovule from being eaten by the pollinators (hence Angiosperms).

4) Plants with protected ovules would have been selected over ones with ovules that got eaten.

**Further modification of flowers to attract pollinators:**

Violet with “nectar guides” Monarch feeding on clustered, small, tube-shaped flowers
1) By the beginning of the Cenozoic Era (65 mya), the first bees, wasps, butterflies, and moths had evolved.

2) The significance in this is that these are insects for which flowers are often the only source of nutrition for the adults.

3) From this point on, certain plant and insect species have had a profound influence on one another’s evolution.

4) A flower that attracted specific pollinators on a regular basis had an advantage (less wasted pollen) over flowers that attracted “promiscuous” pollinators.

5) It is also an advantage for the pollinator to have its own “private” food source because there is, thus, less competition.

6) The varied shapes, colors, and odors of flowers allowed sensory recognition by pollinators and excluded unwanted, indiscriminate pollinators.

7) Today, over 65% of Angiosperms are insect-pollinated and 20% of insects, at least at some stage, depend on flowers for their food.

Flower-Pollinator Relationships:

For pollination to work, to be effective, a relationship must be established between the pollinator and the blossom to be pollinated, involving:

Pollinator must visit regularly.

1) The pollinator should visit this particular blossom regularly. These visits
(whatever the cause) should constitute a regular part of the life activities of the animal.

2) The visitor must perform or at least try to perform certain tasks that are tied in with the structure and function of the blossom.

3) Insects that happen to visit a couple flowers and transfer pollen don’t count as pollinators of that species unless they regularly visit that species of plant for some specific reason.

**Plants must provide and advertise a reward:**

The plant must supply:

1. Some kind of reward (food?) for the pollinator (nectar, pollen)

2. Some kind of attractant to advertise the presence of the reward. This could be a direct attractant such as odor, color, shape, or texture, or an indirect attractant such as providing prey for predators.

3. While the exact role as pollinators played by such visitors is unclear, the possibility exists that a more direct insect-blossom relation may develop out of such a behavior.

4. This may be true of hummingbirds. They eat small insects and spiders and may have originally been attracted to flowers to eat the insects on
5. A means of putting pollen onto the pollinator such that it is effectively transferred to the next flower visited.

**Matching Flowers to Pollinators**

Adaptations of flowers depend on the type of pollinator on which they depend.

**Bees:**

1) Bees don’t see red, but do see yellow, blue, and UV. Thus, bee-pollinated flowers are mostly yellow or blue with UV nectar guides (landing patterns) to guide the bee.

2) They usually have a delicate, sweet scent, and a small, narrow floral tube to fit the tongue-length of that species of bee.

3) The flowers are sturdy and irregularly-shaped with a specifically-designed landing platform.

For example, snapdragons will only open for a bee of the right weight.
Hummingbirds:

Hummingbirds are another type of pollinator that have coevolved for mutual benefit. The hummingbirds serve as pollinators and the flowers supply the birds with nutrient-rich nectar. The flowering plants attract the hummingbirds with certain colors, the shape of the flower accommodates the bird’s bill, and such flowers tend to bloom when hummingbirds are breeding. Coevolution of such flowering plants with various hummingbird species is evident by the distinct shape and length of the flower’s corolla tubes, which have adapted to the shape and length of the hummingbird bill that pollinates that plant. The shape of the flower has also adapted such that the pollen becomes attached to a particular region of the bird while it consumes the nectar from the flower (shown below).

Butterflies:
1. Butterflies are diurnal and have good vision (can see red) but a weak sense of smell. They are perching feeders.

2. Butterfly-pollinated flowers are brightly-colored but odorless. Often, these flowers occur in clusters (Compositae, milkweed) and/or are designed with a “landing platform.” Butterflies walk around on flower clusters probing the blossoms with their tongues. Each flower has a tube of suitable length for the butterfly’s tongue.

**Moths:**

1) Moths are nocturnal, have a good sense of smell, and are hover-feeders.
2) These flowers are white or pale colors so they are visible at night, and may only be open at night.

3) Typically, these flowers have a strong, sweet scent (again, maybe only at
night) and deep tubes to match the length of the appropriate moth’s tongue. The petals are flat or bent back (recurved) so the moth can get in.

**Birds:**

1) Birds, especially hummingbirds have good eyes which especially can see red but poor senses of smell.

2) These flowers are brightly-colored, especially red, but have no smell, and have recurved petals so they are out of the way.

3) Hummingbirds are hover-feeders, and these flowers (for example, columbine or fuchsia) are designed to dust the bird’s head (and back) with pollen.

**Bats:**

1) Bats are nocturnal with a good sense of smell. Those bats which are pollinating species also have good vision and a long, bristly tongue.

2) These flowers are open at night, and are white or light-colored with a musty odor like the bats in order to attract the bats.

3) These flowers must be large and sturdy to withstand insertion of a bat’s head.

**Flies and/or ants:**
1. Flies are attracted to rotting flesh. These flowers may be nondescript or may be brownish-red with a bad, rotten smell as their main attractant. Some flowers, near the ground, are pollinated by ants or ground beetles.

Coevolution and Pollination:

1. The coevolution of flowering plants and their animal pollinators presents one of nature's most striking examples of adaptation and specialization.

2. It also demonstrates how the interaction between two groups of organisms can be a font of biological diversity.

3. Flowering plants are adapting to their pollinators, which are in turn adapting to the plants. Each of the participating organisms thus presents an evolutionary "moving target." 

4. The relationship between these distantly related taxa is symbiotic in the broad sense that characterizes life and that gives rise to the high degree of complexity and diversity that we perceive in nature.

5. If the rule in nature is "whatever works," our observations are that many things work, and that what works keeps changing. Our
understanding is that each species evolves to its own benefit; in coevolution, these two self-interests collide, and remarkable things happen.

**Pollinators and flower types**

The table below presents some of the general characteristics of the most common pollinators and the plant characteristics that have coevolved with them.

<table>
<thead>
<tr>
<th>Pollinator</th>
<th>Pollinator characteristics</th>
<th>Typical flower types</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hummingbirds</td>
<td>Long bills, highly developed ability to perceive red, high metabolic needs, ability to hover.</td>
<td>Red or reddish flowers, long broad tubes, often pendent or horizontal, large nectar rewards.</td>
<td>Honey currants, salmon, coltsfoot.</td>
</tr>
<tr>
<td>Bees, including bumblebees, honey bees, and solitary bees</td>
<td>Perception of bilateral symmetry, blue and yellow colors and ultraviolet light; dexterity at manipulating plant parts, ability to strongly vibrate by buzzing, need for both nectar and pollen.</td>
<td>Flowers with bilateral symmetry, often in shades of blue or yellow, nectar guides in the ultraviolet spectrum, flowers that require dexterity to open, sometimes bell-shaped flowers.</td>
<td>Lupine, orchid, pens, erica, buzz pollination.</td>
</tr>
<tr>
<td>Butterflies</td>
<td>High nectar needs, require sunlight for flying, long tongues</td>
<td>Bright colors, often tubular flowers, nectar rewards.</td>
<td>Phlox sunflower.</td>
</tr>
<tr>
<td>Moths</td>
<td>Often fly at night, sensitive to fragrance, ability to hover.</td>
<td>White or pale flowers which may open at night and close during the day, releasing fragrances, pendant or horizontal flowers</td>
<td>Cats, stick-to-bat, toba.</td>
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<tr>
<td>Flies, including mosquitoes</td>
<td>Attracted to odors (sometimes unpleasant to humans), generalists.</td>
<td>Generally open accessible flowers, often releasing odors flies find attractive.</td>
<td>Many sand, mustard, lomas.</td>
</tr>
</tbody>
</table>

(a) Zinnia and butterfly  
(b) Hibiscus and hummingbird  
(c) Saguaro cactus and bat
Thank you ..... 

References; 1) www.biological discussion.com

2) www.biology notes

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