Beneficial Insects:
Pollinators
Order: Hymenoptera (The ordinal name describes the type of wing in this order, which is membranous or refers to the connection or marriage of front and hindwings by means of hooks (hamuli); from the greek god of marriage Hymeno).
They also have sucking and biting mouthparts.

Suborder: **Apocrita** (wasp, bees, and ants characterized by a wasp waist, a constriction between the first and second abdominal segment).
Subgroup: Aculeata The ovipositor(egg laying device) modified into a stinger with poison to immobilize prey or for protection.
Superfamily: Apoidea They feed pollen and nectar to their young.

Bees are a group of specialized insects that evolved from wasps, specifically from sphecids, which are solitary wasps. Unlike wasp, bees provide pollen as a protein source for their larvae instead of arthropod prey. In order to do this the adult females possess modified structures on their legs or bodies to trap and carry the pollen grains. The modification of behavior and structure allows bees to pollinate angiosperms, plants with showy flowers that are pollinated by animals.

There is strong circumstantial evidence that the first bees appeared during the Cretaceous period 146 to 76 million years ago. At this time the continents had barely began to drift apart, the first true mammals appeared, and angiosperms appeared a pre-requisite for bee evolution.

Malyshev suggested bees evolved from a sphecid, which feed on the honeydew of aphids and psyllids. He believed that it was a small step to go from collecting sweet tasting aphids to collecting the sweet mixture of nectar and pollen of flowers. The adults of modern sphecids feed on the fluids exuding from the bodies of their paralyzed prey and also the energy rich nectar of flowers.

How bees and wasps orient to their nests

They memorize both near and distant landmarks, building up a mental map of the position of the nest in relationship to objects and features of the landscape. A second way they locate their nest is with a sun-compass. A female memorizes the position of the sun in relationship to the nest entrance each time she leaves the nest. She has a built in clock, which takes into account the movement of the sun while she is foraging. When she has finished foraging and begins her return to the nest she can locate it by accounting for the movement of the sun during foraging.
Thirdly, she can find her nest by detecting the direction of polarized light when the sun is obscured by clouds, tall tree, or other obstruction. So long as there is some blue sky the bee can use the direction of polarized light to give her a fix on the position of the sun.

Pollination: It is the process by which the male spores or pollen grains are transported from the flowers of one plant to those of another plant. Bees are the most effective pollinators simply because they and their offspring are entirely committed to a diet of food collected from flowers. Bees make repeated visits to flowers, ensuring a high rate of pollen transport from flower to flower.

Brightly colored petals offer a contrast to the background of green vegetation and allows the plant to advertise their presence to pollinators. This contrast exploits the bees color vision and the ability to learn and remember the location of sources of food.

Color:
The spectrum of colors visible to bees is shifted toward blue making them sensitive to ultra-violet light. Bees are red-blind and see red as black, although some red flowers reflect ultra-violet light and do attract bees. Otherwise bees see blue, green, yellow, and orange.

Scents:
Flowers secrete a scent from special glands, which are usually situated on the petals.

Location of anthers and stigma:
The male and female structures of the flower are so arranged that when the bee scrambles about gathering pollen she becomes dusted with thousands of tiny pollen grains. When the bee visits the next flower of the same species she cannot avoid brushing the stigma with pollen.

Nectar guides: Some flowers have guides, which indicate the direction of the nectaries. They may of may not be visible to the human eye.

Bee Rewards for Pollination:
Pollen is a source of protein
Nectar is a liquid solution of sugars mainly sucrose, fructose, and glucose secreted from nectaries. They are usually located at the base of petals. The position of the nectaries force bees to hunt for them and in so doing brush against the anthers and stigma of the flower. Bees are ver energy efficient and have a fuel consumption of 2 million mpg.

Bee Adaptation to Flowers:
Plumose Hairs:
Almost all pollen collecting bees are densely covered in branched or plumose hairs among which pollen grains are trapped.
Electrostatic Charge:
The effect is enhanced by static electricity. Pollen clings to the bee. A flying bee builds up electrostatic charge equivalent to a potential of 450 volts on its bodies. Most floral structures are well insulated and pollen is attracted to the bee from a distance of 0.5 mm.
Pollen concentration:
Scopa-a patch of modified hairs on the hind leg or underside of the abdomen for carrying pollen.

Corbiculum-pollen basket formed from the slightly concave outer face of the hind tibia fringed by stiff hairs.
Pollen is moved from the body to the collection sites using the front and middle legs. The basitarsi and tarsi are covered with a comb-like array of stiff bristles. The bee rakes off pollen on the head with the foreleg and passes it to the mid-leg and then to the hind-leg. The mid-legs collect pollen from the thorax. All of these pollen manipulations are performed in flight. A lot of coordinated behavior and action for an animal with a supposed little brain.

Bee Tongue:
This tongue is adapted for imbibing liquid food. These long tongues allow the bee to probe for nectaries.

Crop:
Honey stomach is a distensible crop that allows the female to collect and transport nectar in quantities that exceed her fuel requirements.

Flower Types:

1. **Disk** or open access flower like a buttercup, rose, apple, are radially symmetrical forming a shallow dish which attracts short tongued bees as well as flies, wasp beetles, butterflies, and a wide range of other insects. The stamen, pistil, and nectar at or nearly at the same level (two-dimensional flower). They typically have a low nectar reward for pollinators.

2. **Funnel or Tubular corollas**: Petals fused to form a tube offer more nectar than open access flowers and are considered high reward flowers. Only long tongued bees can reach the nectaries. Flowers exploit a restricted but specialized group of pollinators. The bee is reward by selective access to flowers with larger amounts of nectar, which is unavailable to short tongue bees. Examples of long tubed flowers from temperate regions are the primroses, lungworts, deadnettles, salvia, gentian, larkspur, columbine, honeysuckle, and pentstemmon. The long tongued bees that pollinate them are mainly ***Bombus*** and ***Anthophora.*** Long tongued bees are larger and faster flyers than short tongued bees and this is in a large part due to the higher nectar contents (energy) of the tubular flowers that has allowed for this adaptation.

3. **Bell or Trumpet Flowers**: These are inverted funnels with the bell opening pointing toward the ground. The insect must crawl inside to feed and pollinate. This is adaptation to the body form of the pollinator rather than the length and type of mouthparts. Examples include; heather, lilies. fritillaries, field bindweed (morning glory), Bees and flies are the chief pollinators,

4. **Zygomorphy**- flowers that are bilaterally symmetrical. Zygomorphic flowers have evolved independently in many different families of flowering plants. In a radially symmetrical flower an insect can take up any one of a number of positions in relation to the axis of the flower. In a bilaterally symmetrical flower

an insect takes up a single position. This allows a much more precise adaptation of the flower to the pollinator. These flowers are usually placed horizontally on the plant as opposed to radially symmetrical flowers. The stamens and styles may be so placed that come in contact with the underside (sternotribic) or the upperside (nototribic) of the pollinator. Examples of sternotribic flowers are those found in the Fabaceae (pea family). Examples of nototribic flowers are found in the figwort family (Scrophulariaceae).

5. **Some other types**.

a. **Lip Flowers**: The lower lip of these flowers offer a good landing pad for pollinators. This is an upper lip and a lower lip. Monkshood, and many orchids such as lady's slipper are lip flowers.

b. **Butterfly flower**: So named not because they are only visited by butterflies but by the flower shape. The corolla has five free petals of which the upper most petal is known as the standard. The two below are the wings, and the two remaining petals below and between the wings are pressed together and folded over one another to form a boat shaped structure the keel. The stamens and pistil are hidden by the keel. These flowers are visited by bees and bumblebees, which possess devices to push out or expose the pollen as the insect lands on the wings or keel.

c. **Head of basket flowers**: Dense head-like inflorescenes, which are assemblage of many flowers. As is common in many Asteraceae, the florets on the edge of the inflorescence are sterile and only there for display. A number of families of flowering plants have a broad, flat, or doomed inflorescences of numerous white flowers creating a much more conspicuous floral display than scattered single flowers. Basket flowers are rewarding because the food containers are densely packed. The dense packing means that the flowers are tall thin tubes so a long proboscis is needed to reach food. A prime example of this type of floral display are plants in the Apiaceae (Umbellifers). These plants are visited by a diverse array of insects that include flies, beetles, social and solitary bees. A total of 334 species of insects belonging to 37 families were recorded visiting carrot flowers in Utah.

d. **Stalked-plate Flowers**: They are a disk shaped flower set on a tubular stalk. The primrose are an example of this type of flower. Only insects with a long thin proboscis can reach the nectar at the base. Generally pollinated by butterflies.

Flowers specifically adapted for bumblbee pollination have their nectaries at the end of a long tube. Columbine, monkshood, and 100 or more species of lousewort, (foxgloves).

Flowers exploit the bees three dimensional mental maps of their surrounding: Bees must work in the dark and three dimensional spaces of their nests so they must develop complicated maps of this surroundings. Deadnettles, monkshood, and louseworts exploit this behavior by forcing the bee to learn the complicated structure of the flower to harvest

nectar. Having learned the structure of the flower it pays the bee to continue to visit this species until the rewards are no longer worthwhile. This association greatly increases the likelihood that the bees next visit will be another flower of the same species and that cross-pollination will occur.
Flower constancy: Temporary specialization on one flower species for nectar and pollen. Worker bumblebees and honeybees show the same behavior. An individual honeybee worker may spend 12 days working one plant species.

Oligolecty: this is a permanent affair unlike flower constancy where a species of bee, not just an individual bee, will specialize on one plant species or a group of related plant species. Adult emergence is timed to the flowering period of their pollen plant. These bees are typically solitary and highly seasonal. This is common in species of ***Colletes*** and ***Andrena***. In North America some evening primroses and sunflowers are pollinated by oligolectic bees. The extreme specialization of oligolecty is an efficient way to harvest pollen in unpredictable and extreme climates. Thus more than 60 percent of the bees in the deserts of North America are oligolectic. Of course major shifts in climate or the flora could be fatal. (Global Warming)

Flower robbing: Some short tongue bumblebees often bite a hole near the base of the tube to gain access to the nectar. An example of this is a bumblebee that bites into the long nectar spurs of columbine. Other bees often use these holes to obtain nectar for themselves.

Oil Collecting Bees:
Some flowers provide oil instead of nectar to encourage bees to pollinate flowers. The flowers produce oil in specialized thin walled glands that the bee ruptures with pads of hairs and or spines on the underside of the foretarsi. Some bees have the underside of the abdomen armed with paired pads of specialized hairs, which she waggles from side-to-side to rupture the oil glands. In one bee species in Africa the front legs are modified and elongated so that the bee can stick the front leg into the floral tube and collect the oil.

Pollination and Bees
Eighty percent of the plants in the PNW are pollinated by insects. About 15% of our diet consists of crops pollinated by bees. The meat and other animal by products we consume are ultimately derived from bee pollinated forage crops and account for another 15% of our diet. The annual value of crops dependent on bee pollination is estimated to be worth ($1590 million) $1.6 trillion.

Polllination of and acre of apples requires 300 to 400 hornfaced bees or about 250 female blue orchard bees or 20,0000 or more honey bees.

Many fruits cannot develop full flavor and filled out flesh unless they are fully pollinated. For example an apple with three seeds will probably drop in June. A high quality apple requires 8 to 10 seeds. In a study conducted in Michigan a McIntosh tree was screened from bees while the rest of the trees in the orchard were visited by bees. The screened tree produced 25 apples while its nearest neighbor produced 1200 apples.

Bees are vital to the survival of native habitats and ourselves. As pollinators of crops and natural vegetation they occupy key positions in the web of relationships which sustain the living architecture of our planet.

The Pollinators:
The chief pollinators of flowers belong to four insect orders.

1. Hymenoptera (bees, wasps, sawflies, and ants)
2. Diptera (flies)
3. Lepidoptera (butterflies and moths)
4. Coleoptera (beetles)
5. Others (thrips, stoneflies, true bugs, scorpionflies)

Hymenoptera:

1. **Eusocial Bees**- Honeybees and Bumblebees
   Bumblebees have longer tongues and are stronger than honeybees so they can reach nectar in deep tube flowers and can force their bodies in tightly closed corolla tubes.
   Eusocial wasps and Solitary wasps feed larvae animal material for the most part. The Masaridae, a close relative of the Vespidae (Yellowjackets and Hornets) feed their larvae nectar and pollen. They are mainly a tropical wasp.

2. **Solitary Bees- Short Tongued Bees**, (Jugal lobe of hind wing ¾ the length of the vannal lobe, 2 or 3 submarginal cells in front wing)
   a. **Colletidae**. These are short tongued bees with one subantennal suture. These are the yellow-faced and plasterer bees. Females line their brood cells with a liquid mixture of chemicals called macrocyclic lactones. These chemicals dry to form clear, transparent, cellophane like membranes, which are waterproof and resistant to fungal attack. These chemical are secreted by a large gland in the abdomen called the Dufour gland. The family occurs worldwide and there are two cosmopolitan genera ***Hylaeus*** and ***Colletes.***
   Hylaeus is a relatively hairless bee lacking a pollen scopa. Females swallow pollen and transport it in their crop. Most species are black, nearly hairless bees, with conspicuous yellow or white markings, especially on the face. .A few are red or orange marked. They resemble small wasps but the few hairs they have are branched or plumose while wasps have straight, unbranched hairs. The bees in this Genus have 2 submarginal cells in the front wings, a pre-episternal suture present on the mesothorax (the side of the middle segment of thorax), and the apex of the marginal cell terminates on the wing margin. Many species nest in plant stems, plant galls, beetle borings, or in nest in the ground
   Colletes is a more or less robust hairy bee with conspicuous bands of appressed hairs fringing the abdomen. The front wing has 3 submarginal cells and 2nd recurrent vein is recurved. The basitibial plate is absent and pre-episternal is suture present. Many species are oligolectic, specializing

in collecting pollen from one or a few closely related species of plants. All species are solitary and nest in the soil.

b. **Halictidae**. These are short tongue bees with one subantennal suture. The basal vein in the front wing is strongly arched. This is a very large family of small to medium sized bees found in all parts of the world. Many species are metallic in coloration and apart from the honey bee they are among the most common bees visiting flowers. This family displays almost the whole range of social behavior from solitary to primitively eusocial. Most species excavate nest in the soil, but a few use rotten wood. The females in the subfamilies Nomiinae and Halictinae line their brood cells with a mixture of lactones that do not form a transparent membrane that is easily detachable from the soil, as in the Colletidae, but hardens to a shiny varnish like finish that impregnates the soil. There are some very beautiful metallic colored bees in this family especially in the subfamily Halictinae. Bees in this subfamily are often called sweat bees because in hot weather they are attracted to human perspiration, which they lap up probably for the salts.

c. **Andrenidae.** These are short tongued bees with two subantennal sutures. The subfamily Andreninae has 3 submarginal cells in the front wing and are dark brown to brownish black,while bees in the subfamily Panurginae have only two and are usually reddish brown. In this family the basal vein in the front wing is straight or nearly so. Members of this family live in all continents except Australia. All species nest in the soil. Many species are solitary but a few species nest in dense aggregations. A few species are communal with two or more females using parts of a nest.
In the Andreninae the majority of the species belong to the genus ***Andrena***. These bees are often commonest in spring. Many species are oligolectic. The females line their brood cells with terpenes and farnesyl esters secreted by the Dufour's gland, which impregnate the cell walls with a waxy finish.

3. **Solitary Bees-Long Tongued Bees** (Jugal lobe ½ or less in length of the vannal lobe, 2 submarginal cells in front wing)

d. **Megachilidae**-. These are the Leafcutting and Mason bees. They are stout bodied, dark, colored, 10 to 20 mm (1/3 to 4.5") in length. The front wings have 2 nearly equal sized submarginal cells. Pollen is carried on the underside of abdomen. Many leafcutting bees nest in the ground or in some natural cavity with mud, resin, or leaf pulp as a cell liner.

3. **Solitary Bees-Long Tongued Bees** (Jugal lobe ½ or less in length of the vannal lobe, 3 submarginal cells in front wing)

a. **Anthophoridae**-This is a very large family or subfamily depending on who is doing the classification. Many are robust and resemble bumblebees. Species nest in the ground, in plant stems, or solid wood. Most pollen collecting species have a rapid darting flight. Ground nesting species line their brood cells with triglycerides. A large number of species have become cuckoo or social parasites of other bees. Many resemble bumblebees with the 2nd submarginal cell smaller than the first and triangular in shape.

4. **Social Bees- Long Tongued Bees** (Jugal lobe ½ or less in length of the vannal lobe, 3 submarginal cells in the front wing).

a. This is the family Apidae, which includes the Honeybees and Bumblebees. Both are social insects or eusocial. Bumblebees and honeybees have 3 caste, queens, workers, and drones (males). Bumblebee colonies are generally annual, the queens over-winter and start a new colony in the spring. Most nest in the ground and abandon mouse holes are favorite nesting sites. Honeybee colonies are perennial surviving the winter in the hive.

Bumblebees are common,well known and loved insects. They are robust, generally very hairy insects, marked with yellow (rarely orange) and black, and 15 to 25 mm (2/3 to 1") in length. The 2nd submarginal cell is more or less rectangular and about as long as the first. They are gentle giants, generally non-aggressive and not suppose to be able to fly according to one engineer.

Honey bees, there is only one species in North America with several races that vary slightly in color and sizes. They differ from other bees in having the eyes hairy, lack an apical spur on the hind tibia, and have a characteristic venation. The marginal cell in the front wing is narrow and parallel-sided, and the third submarginal cell is oblique. They are extremely valuable insects for pollination, honey, and beeswax. These bees nest in human constructed structures or hollow trees. Their ability to orient to polarized light, round and waggle dance for communication of pollen and nectar sites, and caste determination is well studied.