Insects: Inside and out

Insects are important to the food chain, pollination, honey, wax, silk, food, scavenging, and decomposing. which insects are "good" and which ones are "bad". Are lady beetles good or bad? they are good when they eat aphids, but bad when hundreds collect inside your house.

Are honey bees good or bad? They are good when they pollinate and produce honey, but bad when they sting. Are termites good or bad? They are bad when they eat the wood in your house, but good when they break down dead and fallen trees.

Classification of Insects and writing scientific names: animals are divided into smaller and smaller groups which are: Kingdom, Phylum, Class, Order, Family, Genus, species.

Using the house fly as an example, notice the genus and species is the official scientific name of the animal. This name is valid in any country of the world. This two-word Latin naming system was developed in 1758 and has hardly changed since then. There are some important things to know about it.

- Kingdom- Animal
- Phylum - Arthropod
- Class - Insect
- Order - Diptera
- Family - Muscidae
- Genus - *Musca*
- species - *domestica*

Scientific names are always two words. The first part of the name (Genus) is always capitalized. The second name is always in lower case and is usually descriptive of the insect in some manner. Because these words are in Latin, they are always *italicized*.

Insects' common names.

One problem with common names is that there may be more than one common name for the same insect. Common names often differ between geographical regions.

Important rules govern the use of common names. If the insect truly belongs to the group that the name denotes, then the common name should be two words. For example, a honey bee is a true member of the bees, so honey bee (or bumble bee) is always spelled as **two words** despite what (Honeybee is wrong). Which of the following should be two words?

Butterfly, dragonfly, horsefly, housefly, whitefly, damselfly, fruitfly, mayfly.

Only these insects are **true flies**: Horse fly, house fly, fruit fly.

External Anatomy

Adult insects are known for having three major body regions (Head, thorax and abdomen), six legs, one pair of antennae and usually two pair of wings as adults. Insect's body has fused segments with specific body part associations. The first body region is the head. Insect head can be highly variable, but most possess eyes, antennae and mouthparts. Antennae are used by insects as major sensory devices, especially for smell, and can be adaptive for the insect in many ways. Insect mouthparts are also highly modified for the insect such as Chewing, piercing-sucking. The middle body region is called the thorax and is composed of three fused segments. All legs and wings are located on the thorax.

Like the mouthparts and antennae, insect legs are quite variable in form and function and reflect the insect's lifestyle (digging, sucking, swimming, grasping).

The last body region is called the abdomen. It is composed of many segments connected by flexible sections allowing it great movement.

Insects possess an exterior covering called the exoskeleton. They do not have internal bones. This segmented "shell" is what gives insects shape and can be very hard in some insects. It is often covered with a waxy layer and may have "hairs" called setae.

Internal Anatomy

Inside the insect we find the systems for respiration, circulation, nerves, and digestion, but there is little resemblance to the same systems found in man or other mammals.

1-The Digestive system:

The digestive system is a tube that opens at the mouth and empties at the tail end of the insect. It is divided into three parts called the foregut, midgut, and hind gut. In some insects such as the honey bee, the foregut acts as a crop to carry or hold liquids which can be regurgitated later.

2- The Circulatory system:

The circulatory system is not composed of a central heart, veins and arteries which circulate blood cells and transport oxygen. The insect circulatory system is a simple tube down the back which is open at both ends and slowly pulses body fluids and nutrients from the rear of the insect to the head.

3- The Nervous System:

Insects have a less centralized nervous system than humans. The nerve chord runs along the ventral or bottom aspect of an insect. The brain is divided into two main parts. The largest lobes control important areas such as the eyes, antennae, and mouthparts. Other major concentrations of nerve bundles called ganglia occur along the nerve chord and usually control those body functions closest to it.

4- The Respiratory System:

The respiratory system is composed of air sacs and tubes called tracheae. Air enters the tubes through a series of openings called spiracles found along the sides of the body. The largest spiracles are usually found on the thorax where greater musculature from wings and legs require more oxygen. There are no spiracles on the head.

Life Cycles and Metamorphosis

Post-embryonic development is divided into a series of stages, each separated from the next by a molt. The form that the insect assumes between molts is known as an instar, that which follows hatching or the first molt being the first instar, which later molts to the second instar, and so on until at a final molt the adult. No further molts occur once the insect is adult except in Apterygota.

The periods between molts are called stages.

The many diverse orders of insects have four different types of life cycles. These life cycles are called "Metamorphosis" because of the changes of shape that the insects undergo during development.

It should be noted that because insects are hard-bodied, they cannot grow larger gradually. Instead they grow larger in steps by shedding the hard exoskeleton for a brief period of expansion. The brief periods between or within stages are called molts. Insects are soft-bodied and vulnerable during this time.

1- Without Metamorphosis: Egg ………..Nymphs…………….Adult

Ametabolous insects have no metamorphosis, the adult form resulting from progressive increase in the size of the nymphal stage. This is seen in wingless primitive orders (Apterygota) such as silverfish (Thysanura) and springtails (Collembola). The young resembles adults except for size.

2- Incomplete Metamorphosis: Egg ………………..Naiads…………………Adult

The second type is "incomplete" metamorphosis which is found among the aquatic insect orders such as mayflies (Ephemeroptera) and dragonflies (Odonata). The nymph of these orders called naiad which is an aquatic nymph with a specific nymphal adaptations such as gills which enable the naiads to live in water. While the adult lives outside the water and feed on different type of food.

3- The Gradual Metamorphosis: Egg ………..Nymphs…………….Adult

The third type is "gradual" metamorphosis seen in orders such as the grasshoppers (Orthoptera), termites (Isoptera), thrips (Thysanoptera), and true bugs (Hemiptera). They are insects in which the nymph hatches in a form essentially like the adult apart from its small size and lack of development of genitalia and wings. At each molt the nymph grows bigger and the genitalia and wings develop progressively. Adults and nymphs live in the same habitat. Only adults possess the reproductive capacity and fully wings.

5- The complete Metamorphosis:

Egg………..Larvae………………pupa……………Adult

The fourth type is "complete" metamorphosis found in butterflies (Lepidoptera), beetles (Coleoptera), flies (Diptera), and bees, wasps, and ants (Hymenoptera). The larvae are usually quite unlike the adult and a pupal stage is present between the last larval stage and the adult.

The Biology of T. absoluta

Tuta absoluta is a micro lepidopteron moth with high reproductive potential. There are about 10–12 generations per year. The total life cycle is completed within 30-35 days. **Adults** are nocturnal and hide between leaves during the day time. Adults are 5-7 mm long and with a wingspan of 8-10 mm. Adult females lay eggs on host plants and mature female could lay up to 260 eggs before completing life cycle. The most important identifying characters are the filiform (bead like structure) antenna, silverfish-grey scales and characteristic black spots present in anterior wing. **Eggs** are Small cylindrical, creamy white to yellow 0.35 mm long. Egg hatching takes place 4-6 days after egg lying. Tuta absoluta can overwinter as eggs, pupae or adults depending on environmental conditions. **The Larvae** is cream in colour with characteristic dark head. The larvae becoming greenish to light pink in second to fourth instars. Larval period is most damaging period which completed within 12-15 days. Four larval instars are developed. Larvae do not enter diapause when food is available.

Pupation may take place in the soil, on the leaf surface (inside a cacoon) or within mines.

The Nature of damage

The larvae of *Tuta absoluta* mine the leaves producing large galleries and burrow into the fruit, causing a substantial loss of tomato production in protected and open filed cultivations. The larvae feed on mesophyll tissues and make irregular mine on leaf surface. Damage can reach up to 100%.

This pest damage occurs throughout the entire growing cycle of tomatoes. *Tuta bsoluta* has a very high reproduction capability. There are up to 10-12 generations a year in favourable conditions. The larvae are very unlikely to enter diapause as long as food source is available. Tuta absoluta can overwinter as eggs, pupae and adults. Adult female could lay hundreds of eggs during her life time. Tomato plants can be attacked from seedlings to mature plants. In tomato, infestation found on apical buds, leaves, and stems, flowers and fruits, on which the black frass is visible. On potato, mainly aerial parts are attacked. However damage on tuber also recently reported.

Animal communication

Animal communication is the transfer of information from one or a group of animals (sender or senders) to one or more other animals (receiver or receivers) that affects the current or future behaviour of the receivers. Animals use communications to find mates, locate food, avoid predators, and even gather in groups. When the information from the sender changes the behaviour of a receiver, the information is referred to as a "signal".

1- Visual signals: Love at First Sight (signals which are related to the sense of vision (sight)

Gestures: involves the display of distinctive body parts or movements; often these occur in combination, so a movement acts to reveal or emphasize a body part. A notable example is the presentation of paradise birds.

Facial expression: a facial gesture is a signal of emotion. Dogs, for example, express anger through snarling and showing their teeth. In alarm their ears perk up, in fear the ears flatten while the dogs expose their teeth slightly and squint their eyes.

Colours: animals invest colours to attract or to repel another animal. For example, Butterflies use their bright colours to attract their mates, and the display of peacocks using their colourful feathers.

Bioluminescent communication: Communication by the production of light occurs commonly in vertebrates and invertebrates in the oceans, particularly at depths (e.g. angler fish). Two well-known forms of land bioluminescence occur in fireflies and glow worms. Fireflies may be the most famous insects that flirt using visual signals. Here, the female and male both flash their light in a specific code until they have found each other.

2- Auditory signals: Serenades of Love (signals which are related to the sense of hearing)

Bird calls can serve as alarms or keep members of a flock in contact, while the longer and more complex bird songs are associated with courtship and mating. Many animals communicate through vocalization. Vocal communication serves many purposes, including mating rituals, warning calls, conveying location of food sources, and social learning. In a number of species, males perform calls during mating rituals as a form of competition against other males and to signal females.

Animal	Sound		Animal	Sound
Mosquitoes	Whine		Lions	Roar
Bees	Buzz		Champanzees	Scream
-	-		Dogs	Bark

Also, many arthropods rub specialized body parts together to produce sound, for example, the chirp of a cricket or the song of a cicada. Most insects that make sounds do so for the purpose of mating, and males tend to be the crooners in species that use auditory signals. Male crickets rub their forewings together to produce a raspy and loud song. Additionally, the male cicadas have sound boxes in their abdomens. They make their sound by expanding and contracting a membrane called a tymbal. They both use their sound to attract females. For many insects, a receptor on the antennae called the Johnston's organ collects auditory information. The Johnston's organ is located on the pedicel, which is the second segment from the base of the antennae, (An insect antenna has three segments: scape, pedicel and flagellum). Mosquitoes and fruit flies hear using the Johnston's organ.

3- Olfactory signals: Love is in the Air (signals which are related to the sense of smelling)

The ability to detect chemicals in the environment serves many functions, such as the detection of food. As this function evolved, organisms began to differentiate between chemicals compounds emanating from resources, conspecifics (same species; i.e., mates and kin), and heterospecifics (different species; i.e., competitors and predators).

Organisms produce semiochemicals (A chemical involved in an interaction between organisms), or odour signals, to interact with one another. Organisms also emit pheromones (A chemical that mediates an interaction between individuals of the same species) which dictate organism behaviours. In order to navigate such a scent-filled environment, organisms require a fairly sophisticated system of odour detection. For example, insects possess several types of olfactory sensilla, which collect the chemical signals. Most of these smell-gathering organs occupy the insect's antennae. In some species, additional sensilla may be located on the mouthparts or even the genitalia.

Some of the Functions of Animal communication:

There are many functions of animal communication. However, some have been studied in more detail than others. This includes:

1- Communication during contests: Animal communication plays a vital role in determining the winner of contest over a resource. Many species have distinct signals that signal aggression or willingness to attack or signals to convey retreat during competitions over food, territories, or mates. **For example**, two lions fighting over a piece of land or over a female, they use their legs and teeth to attack the competitor lion.

2- Mating rituals: Animals produce signals to attract the attention of a possible mate or to solidify pair bonds. These signals frequently involve the display of body parts or postures. **For example**, a gazelle will assume characteristic poses to initiate mating. Mating signals can also include the use of olfactory signals or calls unique to a species. Animals that form lasting pair bonds often have symmetrical displays that they make to each other. **For example**, the triumph displays shown by many species of geese and penguins on their nest sites, and the spectacular courtship displays by birds of paradise.

3- Ownership/territorial: Signals used to claim or defend a territory, food, or a mate. **For example**, Hyenas mark their territories by depositing a strong- smelling substance produced by anal glands on the grass along the boundaries.

4- Food-related signals: Many animals make "food calls" to attract a mate, offspring, or other members of a social group to a food source. Perhaps the most elaborate food-related signal is the Waggle dance of honeybees. Pheromones are released by many social insects to lead the other members of the society to the food source. **For example**, ants leave a pheromone trail on the ground that can be followed by other ants to lead them to the food source.

5- Alarm calls: Alarm calls communicate the threat of a predator (scream of monkeys). This allows all members of a social group (and sometimes other species) to respond accordingly. This may include running for cover, becoming immobile, or gathering into a group to reduce the risk of attack. Alarm signals are not always vocalizations. Crushed ants will release an alarm pheromone to attract more ants and send them into an attack state.

What are the five senses?

Sight sense (vision sense), Gustation sense or taste sense, hearing sense, Smelling sense, Touch sense.

Notice: there are four types of pheromones:

Sex pheromones: a message between a male and a female, usually the female releases a sex pheromone to attract the male (the male usually has a bigger and more complicated antenna than the female). For example, moths and butterflies.

Alarm pheromones: released in the time of danger among a social group such as bees and ants in order to prepare them for an action.

Aggregation pheromones: released among a group of insects to let them gather in a group for the purpose of migration (such as locusts) or for the purpose of finding new host such as (bark beetles).

Marking pheromones: some parasitic wasps mark their host when they lay eggs inside them to make sure that other parasitoids wouldn't lay eggs on the same host to avoid competition.

Bee Colony

The nest of a bee colony consists of a number of vertical combs which hang parallel to each other at a distance of about 10 mm. The combs, about 25 mm wide, are composed of hexagonal cells. There are two types of comb cells: the smaller, called worker cells, and the larger, called drone cells. In the worker cells in the lower part of the comb, the bees rear worker brood; in the upper part of the comb, they store pollen and honey. In the drone cells, the bees rear drones. Occasionally they build a third type of cell, the queen cells, in which queens are reared.

Development of the honeybee : The bees develop from fertilized or unfertilized eggs laid by the queen at the bottom of the cells. Fertilized eggs are laid into worker cells and queen cells, and the unfertilized into drone cells. The egg develops in three days. After that time, the female queen and worker larvae hatch from fertilized eggs, and male larvae hatch from unfertilized eggs.

All the larvae are fed during their first two days of life with "royal jelly", produced by the nurse bees, which are young worker bees not yet ready to leave the hive. After that time, worker and drone larvae are fed on a mixed food composed of honey and pollen, while larvae destined to develop into queens are fed on royal jelly during their whole larval life of five days. Thus, queens can be reared from any worker larvae younger than three days.

When a queen disappears accidentally from a colony, the workers reconstruct a few worker cells, containing larvae younger than three days, into queen cells and continue to feed the larvae with royal Jelly. Queen larvae are sealed in their cells by the workers five days after being hatched, worker larvae after six days and drone larvae after seven days.

In the sealed cells, metamorphosis of the larvae creates the pupae. The adult queen emerges from the cell 16 days after deposition of an egg, the worker bee after 21 days and the drone after 24 days.

Drone	Worker	Queen	Differentiated Factor
Unfertilized egg(N)	Fertilized egg (2N)	Fertilized egg(2N)	**Genetic factor**
2 -3 days	3 days	5 – 5.5 days	**Feeding factor (larval stage)** The Period feeding on royal jelly
3- 4 days	2.5 days	-	The period feeding on beebread
Big hexagonal cells 6.5 mm (diameter)	Small hexagonal cells 5.5 mm (diameter)	Royal house 25X10 mm	**Accommodation factor**

The queen: There is only one queen per hive. The queen is the only bee with fully developed ovaries. The queen has a sting but, unlike the aggressive workers, does not use it to fight hive intruders. Her sting is only used to fight rival queens. Five days after the queen emerges from her cell, she starts a mating flights which last about 30 minutes. She flies to an area 6-10 m above the ground where drones have congregated. During a successful mating flight, she is mated by about eight drones.

Three days after her last mating flight, the queen starts to lay her eggs, which are produced in her ovaries. A good queen lays 1500-2000 eggs per day. She lives three to five years, but after two years she lays fewer eggs. When her spermatozoa become exhausted, she also lays unfertilized eggs in worker cells, where drones now develop. Such a queen in called a dronelayer (an old queen which her spermatozoa is exhausted and it only lays unfertilized eggs). The queen has some glands which are highly important to maintain its job in the hive:

The gland	its location	Its function
Hypopharyngeal glands	**The head**	**Secrete the queen substance**
Kochinfikof glands	**Around the sting**	**Release sex pheromones**

The drone: The male bees are kept on standby during the summer for mating with a virgin queen. Because the drone has a barbed sex organ, mating is followed by death of the drone. There are only 300-3000 drones in a hive. The drone does not have a stinger. Because they are of no use in the winter, drones are expelled from the hive in the autumn.

The worker: Workers are the smallest and most numerous of the bees, constituting over 98% of the colony's population. One colony may have as many as 80 000 workers, but 50 000 is a more common maximum. Although they never mate, the workers possess organs necessary for carrying out the many duties essential to the wellbeing of the colony. They have a longer tongue than the queen and drones, and thus are well fitted for sucking nectar from flowers. They have large honey stomachs (crop) to carry the nectar from the field to the hive; they have pollen baskets on their hind legs to transport the pollen to the hive, a well-developed sting permits them to defend the colony very efficiently. Also, worker bees possess some glands to carry on their duties in the hive.

The kind of work performed by the worker depends largely upon her age. In the first three weeks of her adult life, the worker bee is called a house bee (a worker bee younger than 3 weeks and it is devoted to activities within the hive), while after three weeks it is called a field bee. Worker bees live for 6 weeks during the busy summer, and for 4-9 months during the winter months.

The gland	its location	Its function
Hypopharyngeal glands	**The head**	**Produce royal jelly**
Salivary glands	**The thorax**	**Secrete enzymes necessary for ripening the honey**
Wax glands	**The abdomen**	**produce wax for comb construction**

<u>The main duties of the house bee:</u> The duties of a house bee are: **A**: cleaning and ventilating the hive and the comb (at the age of 1 – 5 days), **B**: feeding the brood (at the age of 6 – 11 days), **C**: comb building (at the age of 12- 17 days), **D**: guard duty (at the age of 18- 21 days).

<u>The field bees:</u> **(a** worker bee older than 3 weeks and its activities involve foraging outside the hive) Between the 18th and the 21st day, her hypopharyngeal and wax glands have become too weak to function, so that she cannot produce royal jelly to feed the queen and the young larvae, nor wax to build comb cells. But by this time, she is in perfect condition to fly and knows the geography of the locality. She therefore starts field work, fetching nectar, pollen, propolis or water, but always concentrating her activity on the immediate needs of the colony.

<u>The scout bee:</u> Foragers can take on scout duties as well. The scout bee fly in the early morning and locates food sources and passes on the information to other bees by a series of dance-like movements called the Waggle dance.

The honey bee hive is perennial. Although quite inactive during the winter, the honey bee survives the winter months by clustering for warmth. By self-regulating the internal temperature of the cluster, the bees maintain 93 degrees Fahrenheit in the centre of the winter cluster (regardless of the outside temperature).

Some Bee products:

Honey: Honey is the complex substance made when the nectar and sweet deposits from plants and trees are gathered, modified, and stored in the honeycomb by honey bees as a food source for the colony.

Beeswax: Worker bees of a certain age secrete beeswax from a series of glands on their abdomens. They use the wax to form the walls and caps of the comb. As with honey, beeswax is gathered by humans for various purposes.

Pollen: Bees collect pollen in their pollen baskets and carry it back to the hive. In the hive, pollen is used as a protein source necessary during brood-rearing.

Bee bread: Worker bees combine pollen, honey and glandular secretions and allow it to ferment in the comb to make bee bread. The fermentation process releases additional nutrients from the pollen and can produce antibiotics and fatty acids which inhibit spoilage. Bee bread is eaten by nurse bees (younger workers) who then produce the protein-rich royal jelly needed by the queen and developing larvae in their hypopharyngeal glands.

Propolis: Collected by honeybees from trees, the sticky resin is used by the bee to seal cracks and repair their hive.

Royal Jelly: Royal Jelly is the substance that turns an ordinary bee into the Queen Bee. It is a chemical secreted from a gland in the nursing bee's heads. The” royal jelly" is fed to all the larvae for the first two days of their lives.

Articles and citation

A scientific article is written by scientists for a scholarly audience. A reviewed journal article means that the article's scientific quality has been checked by other scientists before publication.

A scientific article contains the following elements:

1- **Abstract** - a brief summary of the article that addresses purpose, methods, results and conclusion.

2 **Introduction** - background information, aim and problem statements.

3- **Materials and Method** - describes the method used, so precisely that it is possible for the reader to follow and repeat the research process.

4- **Results** - presentation of the results in text and optionally with tables, charts and figures.

5- **Discussion** - this section discusses the research results and the principles, relationships, or generalizations which are certified by the study's results. Possible weaknesses in the study are discussed here.

6- **Reference list** - all the documents that the author referred to shall be included in the reference list.

There are three different types of scientific articles:

1- **Original articles** where the author describes the empirical studies, and for the first time, describes the results of a research work.

2- **Review articles** are critical evaluations, in which the author organizes, integrates and evaluates previously published studies.

3- **Theoretical articles** where the author, based on existing research, presents a new theory, analyse or criticize existing theories.

كيفية توثيق المقالات: عند استخدام أي فكرة من أي مقالة علمية لابد من ذكر مصدر هذه الفكرة ، و يشار لها في النص (التوثيق ضمن النص) وأيضا يشار لها في نهاية المخطوطة التي يتم كتابتها (التوثيق في قائمة المراجع) حيث تذكر قائمة بكل المراجع التي أخذت منها الأفكار الموجودة في هذه المخطوطة سوء كانت (مشروع تخرج، رسالة ماجستير أو دكتوارة ، مقالة علمية أخرى) ويتم ترتيبها حسب التسلسل الأبجدي في نهاية هذه المخطوطة.

1. **<u>In-text citations</u>** (التوثيق ضمن النص) are used when directly quoting or paraphrasing a source. They are located in the body of the work and contain a fragment of the full citation. For example, **(Fitzgerald, 2004)**.

التوثيق ضمن النص: يكون موجود ضمن نص المخطوطة المكتوبة ويذكر فقط **<u>اسم عائلة Surname</u>** المؤلف أو مؤلفي المقالة التي أخذت منها الفكرة وتاريخ **<u>نشر هذه المقالة</u>** وتوضع هذه المعلومات ما بين قوسين في نهاية الفقرة وبوجود فاصلة بينها كما في الجدول أدناه.

In- text citation	**التوثيق ضمن النص**
1- One author	(Vinson, 1970)
2- Two authors	(Gu and Dron, 2000)
3- Three authors or more	(Turlings *et al*, 2014)
في حالة التوثيق ضمن النص و الفقرة المراد توثيقها قد تكلمت عنها أكثر من مقالة: يتم الترتيب حسب التاريخ (الأقدم في البداية) ويفصل بينها بفاصلة منقوطة	
More than one article for the same idea	(Vinson, 1976; Turlings *et al*, 1990; Dicke, 1994)
More than one article for the same idea with some articles at the same year	(Vinson, 1976; Turlings *et al*, 1990; Dicke, 1994; Du, 1994)

2- **<u>Reference Lists(التوثيق في قائمة المراجع)</u>** are located at the end of the work and display full citations for sources used in the assignment. For example **: Fitzgerald, F. (2004). The great Gatsby. New York: Scribner.**

التوثيق في نهاية المخطوطة أو قائمة المراجع: يكون موجود في نهاية المخطوطة المكتوبة ويحتوي كافة المراجع مرتبة ترتيبا هجائيا و مع تفاصيل تختلف عن التوثيق ضمن النص وتشمل هذه التفاصيل:

1- surname of author (s) اسم أو أسماء عائلات المؤلفين
2- Year published سنة نشر المقالة (ملاحظة : لا يؤخذ بعين الاعتبار تاريخ قبول المقالة)
3- Title of the article عنوان المقالة
4- Name of the journal which published the article. اسم المجلة التي نشرت فيها المقالة

5- The volume of the journal رقم المجلد الذي نشرت فيه المقالة (يكون رقم)
6- The range of the pages of the article مدى صفحات المقالة ضمن المجلة التي نشرت بها

توضع هذه الفقرات بترتيب معين كما هو مبين أدناه.

Last name (surname), First Initial. (Year published). Title of article. *Name of Journal*, Volume: Pages

Citations are listed in alphabetical order by the author's last name. If there are multiple sources by the same author, then citations are listed in order by the date of publication.

Examples for **articles**”

- Dismuke, C. and Egede, L. (2015). The Impact of Cognitive, Social and Physical Limitations on Income in Community Dwelling Adults with Chronic Medical and Mental Disorders. *Global Journal of Health Science*, **7**: 183-195.
- Ross, N. (2015). On Truth Content and False Consciousness in Adorno’s Aesthetic Theory. *Philosophy Today*, **59**: 269-290.
- Wang, Q., Gu, H. and Dorn, S. (2003). Selection on olfactory response to semiochemicals from a plant- host complex in a parasitic wasp. *Heredity*, **91**: 430-435.

ملاحظات هامة في التوثيق: 1- في التوثيق ضمن النص يذكر فقط: اسم عائلة المؤلف وعام نشر المقالة، بينما في التوثيق في قائمة المراجع: يذكر اسم عائلة المؤلف (الكنية) والحرف الأول فقط من الاسم الأول للمؤلف.

2- في بعض المقالات يتم ذكر اسم المجلة كاملا أو الاسم المختصر لها مثلا :

Global Journal of Health Science (Global. J. health. Sci)

4- في بعض الأحيان قد تنشر المجلة الواحدة أكثر من عدد في نفس السنة و في هذه الحالة يشار إلى مجلد المجلة برقمين: الأول هو رقم المجلد لهذه السنة ثم رقم عدد هذه السنة (يكون دائما الأعداد 12.....,1, 2,4,5) مثلا هذا الرقم (2) 40 :يشير إلى المجلد 40 و العدد الثاني من هذه السنة.

5- قد تصادف طرق مختلفة لكتابة أسماء المؤلفين في المقالات والمجلات المختلفة ولكنها تتفق في شيء واحد وهو: لا يمكن أن يكون اسم عائلة المؤلف مختصر. مثل:

P.E. Brown	Pop E Brown
P. Brown	Brown P
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Pop E. Brown	Brown, P.

Some Examples:

Molecular Phylogenetics and Evolution
Vol. 16, No. 1, July, pp. 29–36, 2000
doi:10.1006/mpev.1999.0768, available online at http://www.idealibrary.com on

Phylogenetic Relationships of World Populations of *Bemisia tabaci* (Gennadius) Using Ribosomal ITS1
Paul J. De Barro, Felice Driver, John W. H. Trueman,* and John Curran

التوثيق ضمن النص: (De Barro *et al*, 2000)

التوثيق في قائمة المراجع:

De Barro, P., Driver, F., Trueman, J. and Curran, J. (2000). Phylogenetic Relationships of World Populations of *Bemisia tabaci* (Gennadius) Using Ribosomal ITS1. *Molecular Phylogenetics and Evolution*, **16**: 29- 36.

Pest Management Science, 56:861-866 (2010)

Insecticidal activity of surfactants and oils against silverleaf whitefly (*Bemisia argentifolii*) nymphs (Homoptera: Aleyrodidae) on collards and tomato

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التوثيق ضمن النص: (Liu and Stansly, 2010)

التوثيق في قائمة المراجع:

Liu, T. and Stansly, P. (2010). Insecticidal activity of surfactants and oils against silverleaf whitefly (*Bemisia argentifolii*) nymphs (Homoptera: Aleyrodidae) on collards and tomato. *Pest Management Science*, **56**: 861- 866.

Sains Malaysiana 43(1)(2014): 31–36

Insecticide Susceptibility of *Bemisia tabaci* to Karate® and Cydim Super® and its Associated Carboxylesterase Activity

S.W. AVICOR*, V.Y. EZIAH , E.O. OWUSU & M.F.F. WAJIDI

التوثيق ضمن النص: (Avicor *et al*, 2014)

التوثيق في قائمة المراجع:

Avicor, S., Eziah, V., Owusu, E. and Wajidi, M. (2014). Insecticide Susceptibility of *Bemisia tabaci* to Karate® and Cydim Super® and its Associated Carboxylesterase Activity. *Sains Malysiana*, **43**: 31- 36.

Archives of Insect Biochemistry and Physiology 58:216–225 (2005)

Biotypes B and Q of *Bemisia tabaci* and Their Relevance to Neonicotinoid and Pyriproxyfen Resistance

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التوثيق ضمن النص: (Horowitz *et al*, 2005)

التوثيق في قائمة المراجع:

Horowitz, A., Kontsedalov, S., Khasdan, V. and Ishaaya, I. (2005). Biotypes B and Q of *Bemisia tabaci* and Their Relevance to Neonicotinoid and Pyriproxyfen Resistance. *Archives of Insect Biochemistry and Physiology*, **58**: 216- 225.

في حالة تم أخذ معلومات من كافة المقالات السابقة لكتابة فقرة في مشروع تخرجك فكيف يتم توثيقها في نهاية الفقرة المكتوبة؟ وكيف يتم ترتيبها في قائمة المراجع في نهاية مشروع تخرجك؟

التوثيق ضمن النص: De Barro *et al*, 2000; Horowitz *et al*, 2005; Liu and Stansly, 2010; (Avicor *et al*, 2014)

التوثيق في قائمة المراجع:

1- **A**vicor, S., Eziah, V., Owusu, E. and Wajidi, M. (2014). Insecticide Susceptibility of *Bemisia tabaci* to Karate® and Cydim Super® and its Associated Carboxylesterase Activity. *Sains Malysiana*, **43**: 31- 36.

2- **D**e Barro, P., Driver, F., Trueman, J. and Curran, J. (2000). Phylogenetic Relationships of World Populations of *Bemisia tabaci* (Gennadius) Using Ribosomal ITS1. *Molecular Phylogenetics and Evolution*, **16**: 29- 36.

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4- **L**iu, T. and Stansly, P. (2010). Insecticidal activity of surfactants and oils against silverleaf whitefly (*Bemisia argentifolii*) nymphs (Homoptera: Aleyrodidae) on collards and tomato. *Pest Management Science*, **56**: 861- 866.

BASIC TERMINOLOGY AND DEFINITIONS IN PLANT PATHOLOGY

There is a very impressive and extensive number of terms and definitions used in plant science, many of which you will not come in contact with. With interest, study and practice, terms and names will come to light and become familiar to you. When you start out, don't worry too much about the scientific names of pathogens and diseases; but also don't be afraid of them. The more exposure you have to the subject the more comfortable you will be when dealing with your peers and the public.

For the accurate identification and diagnosis of plant disease and plant problems a foundational knowledge of terms and definitions is essential for developing concepts, doing research, discussing and communicating issues and providing clarity to your work. The following terms and definitions are basic to the study of plant pathology. They are, however, just a brief introduction to the vocabulary of the science. However, your vocabulary and skill will develop through exposure to diagnostics, experience and correct use of the appropriate terms.

Plant pathology (gr., path -"suffering"- "ology", the science of) is the study of plant diseases and the abnormal conditions that constitute plant disorders. **Etiology** is the determination and study of the cause of disease. **A pathogen** can be living or non-living, but usually refers to a live agent. **A pathogen** is an organism which causes a disease. **Pathological** is a condition of being diseased. **Pathogenic** is having the characteristics of a pathogen and **pathogenicity** is the capability of a pathogen to cause a disease.

A plant disease is an abnormality in the structure and/or function of the host plant cells and/or tissue as a result of a continuous irritation caused by a pathogenic agent or an environmental factor. **A disease** is not static; it is a series of changes in the plant. All plants, to some extent, are subject to disease. **Plant disease** is the result of an **infectious**, or **biotic** (a living component of an ecosystem) agent or a **non-infectious**, or **abiotic** (nonliving, physical and/or chemical component) factor.

Plant injury is an abrupt alteration of form or function caused by a discontinuous irritant. Plant injury includes insect, animal, physical, chemical or environmental agents.

A causal agent is a general term used to describe an animate or inanimate factor which incites and governs disease and injury. **A causal organism** is a pathogen of biotic origin. When a pathogenic agent is **virulent** (the relative aggressiveness of a pathogen) it can cause disease and if the agent is **avirulent** it is a variant of a pathogen that does not cause severe disease (non-virulent is the preferred synonym to avoid confusion with "a virulent").

A parasite (gr. "parasitos", one who eats at the table of another) is an organism which lives on or in another organism and obtains its nutrition there from. An **obligate parasite** is an organism which is wholly dependent for its nutrition on another living entity. Obligate parasites are **biotrophs** (gr."bio", life - "troph", "nourish, feeder") which also depend entirely on a living host for its nutrition. **An autotroph** ("auto", self - "troph, nourish, feeder") is a plant that can make its own food through photosynthesis. A **facultative** parasites has the ability, or "faculty" to adapt to an alternative mode of living (i.e.: parasite or saprophyte) **saprophytes** (gr. sapro, "rotten"- "phyte", plant) are organisms that gain their nourishment by digesting dead organic material. Keep in mind that a parasite is defined by how the organism secures its nutrients and a pathogen is defined on the basis of causing abnormalities. **Environmental disease** includes such factors as extremes in weather, nutrient deficiency or excess, toxic chemicals and other nonliving agents.

A host is an organism (eg.: a plant) that is harboring a parasite or pathogen from which it obtains its nutrients. The **host range** refers to the various kinds of host plants that a given pathogen may parasitize. A host is considered **resistant** when it has the ability to exclude, hinder or overcome the effects of a given pathogen or other damaging factor. A plant may be resistant to one pathogen or condition but not others. **Tolerance** is the ability of a plant to be colonized by a pathogen or exposed to an abiotic factor without dying or demonstrating disease symptoms. **Susceptibility** is the antithesis of resistance.

Symbiosis is the mutually beneficial association between two or more different kinds of organisms. The **organisms** in this association are referred to as **symbionts**. An example of symbiosis is demonstrated in the beneficial relationship between **mycorrhizal** fungi and the roots of over 85% of the plants in nature.

The signs and symptoms of plant disorders are the appearance or manifestation of changes in the normal form and/or function of the plant. Signs and symptoms are usually the first indication you will notice in plant problems. **Signs** are the appearance and/or physical evidence of the causal factor of the plants abnormality. Signs are the physical evidence of damage caused by biotic or abiotic agents such as the pathogen itself, pests, spores, fruiting bodies, chemical residue, bacterial ooze and so forth. **Symptoms** are the visible response of a plant to biotic and/or abiotic factors that result in a change or abnormality in the plant. Symptoms can take form as galls, chlorosis, ring-spots, wilt, rot and so on. A **syndrome** is the totality of the effects demonstrated in a host by one disease, whether simultaneously or successively, and whether visible to the unaided eye or not. **Diagnostics** is the determination of the nature and/or cause of a disease or disordered condition.

For a **biotic disease** to occur, the environmental conditions must be conducive to the survival of the pathogen. This is especially true with moisture and temperature. Environmental factors can encourage or discourage the susceptibility of the host and the pathogenicity of the pathogen. The **environmental** conditions can also effect the interaction between the host and the pathogen. Environmental diseases are caused by persistent unfavorable environmental conditions. These conditions include temperature, moisture, wind, light, soil pH, soil structure, host nutrition, herbicides, chemicals and air pollutants. Nutrient deficiency and excess also can greatly affect the susceptibility of plants to disease and disorders. The four fundamental elements required for disease in plants are: a susceptible host, a pathogen capable of causing disease, a favorable environment and adequate time. This is referred to as the "disease **quadrangle**".

The **life cycle** of an infectious disease is the sequence of distinct events, such as sexual reproduction, that occur between the appearance and reappearance of the causal organism. The stages of the **disease cycle** are the appearance, development and perpetuation of a pathogen and the effect of the disease on the host. Because advancement of the disease involves the host, the pathogen and in some cases biological vectors, the life cycle of the pathogen as well as environmental factors are involved in the disease cycle. **Propagules** are any structure, fragment or part of an organism that can propagate the organism. The propagules, such as spores, sclerotia etc. that overwinter or oversummer and initiate an infection are referred to as **primary inoculum**. **Secondary inoculum** is produced by infections that take place during the same growing season. **Inoculation** is the process of applying inoculum to a host. **Inoculum** must be on a part of the host that can be invaded, this is the **infection court**. **A repeating cycle** is a series of secondary infections that continue for a specific period of time during the growing season. A **polycyclic** disease is one that completes two or more life cycles in one year. A **monocyclic** disease is one that has one life cycle in one year.

Pathogens are transmitted, **disseminated** and **spread** by many factors, which include biotic, abiotic and environmental factors. **Transmission** usually implies active transfer by means of grafting, insects, mechanical factors, animals and so on. To **disseminate or spread** means to disperse or distribute. Disseminate usually refers to long-distance distribution, and spread usually refers to local distribution. **Vectors** are active agents of transmission such as insects, mites, nematodes and other animals. The dissemination of pathogenic organisms can also be accomplished by wind, rain, irrigation, contaminated seeds and transplants. A few pathogens have the ability to move short distances on their own. Nematodes, zoosporic fungi, oomycetes and some bacteria can move from host to host if they are close enough to one another and the conditions are favorable.

Infection is the establishment of a parasite on or within a host cell or tissue. The **infection court** is a certain part of a given plant that is susceptible to a particular pathogen or pathogens. Successful infections usually result in the appearance of disease symptoms. **Colonization** of a host results from the establishment, growth and reproduction of the pathogen on or in infected plant. **Infestation** refers to the establishment (or “running over”) on the surface of a host by a large number of insects or other animal pests. With infestation there is no implication that infection has occurred.

An epidemic is the unarrested, widespread increase of an infectious disease, usually limited in time. An epidemic may extend over a single season or many years and over a wide or relatively small area. An endemic disease is one that is permanently established in a moderate or severe form within a defined area. **Endemic diseases** usually become indigenous following initial introduction of the pathogen. **Epidemiology** is the study of factors affecting the outbreak and spread of infectious disease. The **epidemic rate** is the increase or decrease per unit or time in a given plant population.

The **classification** of a disease can be categorized by the pathogen, the host, the age of the host, the name of the disease, a plant part, symptoms, location, causal agent, geography or by order of importance within a given location. **Taxonomic** classification is the systematic ordering of plants and animals.

Insect pests of field crops

<u>Principles of field crop insect control</u>

A knowledge of insect classification, growth and development, and life cycles is a requisite to the conduct of control programs. Life cycle data are essential in the timing of controls. One of the most familiar principles of insect control is that of the "weakest link". Only through a thorough knowledge of a pest's life cycle can one hope to aim control measures effectively at its most vulnerable stage.

Crop value, or the unit value of an agricultural crop, is an important consideration. Control of pest insects is usually justifiable when the increase in marketable yield produced is worth more than the cost of control. In the case of low-unit-value crops, such as certain forage crops, the feasibility of controlling pests is difficult to determine. Costly controls can be applied more logically to floral crops and fruit crops than to field crops and cereals.

Preventive control measures can be applied when one knows through experience that a certain insect pest or pests will develop to a damaging degree in a given area year after year. It is often true that early season applications are more efficient than later ones. Early treatments tend to control a pest species before it has reached its maximum rate of development and reproduction; and before the crop foliage has grown to the point where it is difficult to penetrate with sprays, granules or dusts. In contrast, one should generally wait until a certain pest population level is reached before treating field crops.

<u>Causes of insect outbreaks</u>

Outbreaks or epidemics of insect pests are usually caused by one or more of the following:

1. Large-scale culture of a single crop.

2. Introduction of a pest into a favourable new area without its natural enemies.

3. Favourable weather conditions for rapid development and multiplication of a pest; these same conditions may also be unfavourable to natural enemies.

4. Use of insecticides which kill the natural enemies of a pest, exert other effects favourable to a pest, or reduce the competing species of a pest while allowing it to multiply in low levels or only partially controlled.

5. Use of poor cultural practices which encourage buildup of pest infestations.

6. Destruction of natural biotic communities which otherwise provide regulation of insect population levels.

Types of control

A. Biological control can be defined as the action of parasites, predators, or pathogens on a host or prey population, producing a lower population level than would prevail in the absence of these agents.

Biological control has a number of distinct advantages, three of which are permanence, safety, and economy. Once biological control is established, it is relatively permanent and has no side effects, such as toxicity, environmental pollution, or use hazards. There are three main kinds of traditional biological control:

1. The introduction of exotic species of parasites, predators and pathogens.

2. Conservation of parasites and predators.

3. Augmentation of parasites and predators.

The use of insect pathogens, such as fungi, bacteria, and viruses, is another one of the techniques employed in the biological control of insects.

From the practical standpoint, it should be noted that natural enemies should be able to play a role in most crop ecosystems. One factor which may impede their effectiveness is climate. Other reasons their activity may be inhibited include environmental factors such as dust, competitors, drift of pesticides from adjoining agriculture, or necessary pesticide use within the crop.

B. Mechanical control is the reduction of insect populations by means of devices which affect them directly or which alter their physical environment radically. These methods are often hard to distinguish from cultural methods. Hand picking, shingling, and trapping are familiar mechanical methods of insect control. Screens, barriers, sticky bands, and shading devices represent other mechanical methods.

C. Legal control is the lawful regulation of areas to eradicate, prevent, or control infestation or reduce damage by insects. This involves mainly the use of quarantines and pest control procedures.

D. Cultural control is the reduction of insect populations by the utilization of agricultural practices. It has also been defined as "making environments unfavourable for pests". The method more or less associated with agricultural production usually involves certain changes in normal farming practices rather than the addition of special procedures.

The principle of the "weakest link" or most vulnerable part of the life cycle usually applies. The environment is changed by altering farming practices at the correct time so as to kill the pests or to slow down their multiplication.

Several types of cultural control practices are:

1. Rotation 2. Trap Crop 3. Location 4. Tillage 5. Clean Culture
6. Timing 7. Resistant Plant Varieties.

E. Reproductive control is the reduction of insect populations by means of physical treatments or substances which cause sterility, alter sexual behaviour, or otherwise disrupt the normal reproduction of insects.

F. Chemical control is the reduction of insect populations or prevention of insect injury by the use of materials to poison them, attract them to other devices, or repel them from specified areas.

Chemicals are still our first line of defence in the management of most pests, despite adverse publicity. They are highly effective and economical, and can be applied quickly to have an immediate impact on a pest populations. When pest populations approach economic levels, and natural controls are inadequate, pesticide applications are the only hope to save a crop so that it can be marketed. One of the advantages of the use of insecticides in many crop ecosystems is that more than one major pest may be controlled with a single application. It seems clear that pesticides must and will continue to be used in a major way in integrated pest management.

Insecticides do have certain well known limitations which can be briefly listed as follows:

1. Development in many cases of strains of pests that are resistant to pesticides.

2. Only temporary control effects on pest populations, often necessitating repeated treatment.

3. Presence of residues of the pesticide in the harvested crop.

4. Outbreaks of unleashed secondary pests, resulting from the destruction of their natural enemies.

5. Undesirable side effects on non-target organisms, included a) parasites and predators; b) fish, birds and other wildlife; c) honey bees and other necessary pollinators; d) man and his domestic animals, and e) the crop plant.

6. Direct hazards in the application of certain insecticides.

G. Integrated control is the management of insect populations by the utilization of all suitable techniques in a compatible manner so that damage is kept below economic levels. It is an approach that not only avoids economic damage but also minimizes adverse effects. Principal considerations of the integrated approach to pest management are the agro-ecosystem, the economic threshold, and the least disruptive program.

Parts of the plant

The parts of a plant can be divided into two groups, sexual reproductive parts and vegetative parts. Sexual reproductive parts are those involved in the production of seed. They include flower buds, flowers, fruit, and seeds. The vegetative parts include leaves, roots, leaf buds, stems.

Stem: Stems are structures which support buds and leaves and serve as conduits for carrying water, minerals, and sugars. The three major internal parts of a stem are the xylem, phloem, and cambium. The xylem and phloem are the major components of a plant's vascular system. Stems may be long, with great distances between leaves and buds (branches of trees), or compressed, with short distances between buds or leaves (fruit spurs, crowns of strawberry plants). Stems can be above the ground like most stems with which we are familiar, or below the ground (potatoes, tulip bulbs). All stems must have buds or leaves present to be classified as stem tissue.

An area of the stem where leaves are located is called a node. Nodes are areas of great cellular activity and growth, where auxiliary buds develop into leaves or flowers. The area between nodes is called the internode.

Modified Stems:

The modified stem	Examples	Location	Characters
1- Crown	Strawberries, dandelion, African violet	Near the surface of the soil	Compressed stem with leaves and flowers on short internodes
2- Spur	Fruit trees such as pears, apple and cherries	Side stem that arise from the main stem	Compressed fruiting stem, short and stubby
3- Stolon	Strawberry runners	Horizontal stem along the top of the ground	Fleshy and semi-woody stem. Forms a new plant at one or more of its nodes

4- Tuber	Potato tubers	Enlarged underground stem	The node on a tuber is called an eye. Each eye contains a cluster of buds.
5- Rhizome	Iris rhizomes	Grows horizontally just below the soil surface	Compressed fleshy stem acts as means of storage organ and propagation.
6- Bulbs	Tulips, lilies and onions	Shortened, compressed, underground stem	Bulbs are surrounded by fleshy scales that envelop a central bud located at the tip of the stem. Most bulbs need a period of low temperature before they begin to grow again.
7- Corms	Gladiolus and crocus	Solid, swollen underground stem	Corms are not surrounded by fleshy scales, those scales have been reduced to a dry, leaf-like covering.

1- **Leaves:** The blade of a leaf is the expanded, thin structure on either side of the midrib. The leaf blade is usually the largest part of a leaf and it is responsible for the absorbing of sunlight. The leaf is supported away from the stem by a stem-like appendage called a petiole. The base of the petiole is attached to the stem at the node. The small angle formed between the petiole and the stem is called the leaf axil. An active or dormant bud or cluster of buds is usually located in the axil. The principal function of leaves is to absorb sunlight for the manufacturing of plant sugars in a process called photosynthesis.

2- **Buds:** A bud is an undeveloped shoot from which embryonic leaves or flower parts arise. **A leaf bud** is composed of a short stem with embryonic leaves, and bud primordia in the axils and at the apex. Such buds develop into leafy shoots. Leaf buds are often less plump and more pointed than flower buds.

A flower bud is composed of a short stem with embryonic flower parts. Flower buds are plump with more rounded shape than the leaf buds.

Types of Buds: Terminal or apical buds are those which are located at the apex of a stem (responsible for vertical growth). Lateral or axillary buds are existing on the sides of the stem (responsible for horizontal growth).

3-Roots: Roots typically originate from the lower portion of a plant or cutting. They possess a root cap, have no nodes and never bear leaves or flowers directly. The principal functions of roots are to absorb nutrients and moisture, to anchor the plant in the soil, to furnish physical support for the stem, and to serve as food storage organs. In some plants they may be used as a means of propagation.

Type of Roots: A primary (radicle) root originates at the lower end of the embryo of a seedling plant. A taproot is formed when the primary root continues to elongate downward. The taproot of carrot, parsnip, and salsify is the principal edible part of these crops.

A lateral, or secondary root is a branch root which arises from another root. A fibrous root system is one in which the primary root ceases to elongate, leading to the development of numerous lateral roots. These then branch repeatedly and form the feeding root system of the plant.

Flowers: The crucial function of the flower is sexual reproduction. Its attractiveness and fragrance have evolved to ensure the continuance of the plant species. Fragrance and colour are devices to attract pollinators that play an important role in the reproductive process.

Parts of the Flower: the flower contains the male part and/or the female part plus accessory parts such as petals, sepals, and nectar glands.

The pistil is the female part of the plant. It is generally shaped like a bowling pin and located in the center of the flower. It consists of the stigma, style, and ovary. The stigma is located at the top, and is connected to the ovary by the style. The ovary contains the eggs which reside in the ovules. After the egg is fertilized the ovule develops into a seed.

The stamen is the male reproductive organ. It consists of a pollen sac (anther) and a long supporting filament. This filament holds the anther in position so the pollen it contains may be disbursed by wind or carried to the stigma by insects, birds or bats.

Sepals are small green, leaflike structures on the base of the flower which protect the flower bud. The sepals collectively are called the calyx.

Petals are highly colored portions of the flower. They may contain perfume as well as nectar glands. The petals collectively are called the corolla.

How does a seed form? : Pollination is the transfer of pollen from an anther to a stigma. This may occur by wind or by pollinators. The stigma contains a chemical which stimulates the pollen, causing it to grow a long tube down the inside of the style to the ovules inside the ovary. The sperm is released by the pollen grain and fertilization typically occurs. Fertilization is the union of the male sperm nucleus (from the pollen grain) and the female egg (in the ovule). If fertilization is successful, the ovule will develop into a seed.

3- Fruits and seeds: Fruits are developed from the ovary after fertilization. It protects the seeds and help in seed dispersal. On the other hand, seeds, or matured ovule are made up of three parts. The embryo, endosperm and the seed coat.

Reproduction in Plants

Reproduction is the process by which a living organism is able to produce more of its own kind. The continuity of life on earth, from its origin to the present day, has been possible only because of reproduction. Living organisms reproduce in two ways: asexual and sexual reproduction.

1- Asexual reproduction:

Asexual reproduction involves the production of an offspring from body parts other than reproductive organs. It is a common process of reproduction in lower plants and animals.

Basic features of asexual reproduction:

i) It involves only one organism i.e. different sexes are not involved.

ii) The cell divisions during this type of reproduction are either mitotic or amitotic.

iii) New individuals produced are genetically identical to the single parent.

iv) It is a fast mode of multiplication.

2- Sexual reproduction:

Sexual reproduction is a type of reproduction in which two sexes, the male and the female, are involved. This type of reproduction occurs both in plants and animals.

Basic features of sexual reproduction:

i) It is the production of offspring by the fusion of egg and sperm, which are the sex cells or gametes.

ii) Upon fertilization, the male and female gametes unite to form a zygote, which develops into a mature organism.

iii) It results in the combination of genetic material from two parents.

Reproduction in plants

Like animals plants also reproduce both asexually and sexually. Asexual reproduction in plants is either by fission, budding, fragmentation and regeneration, spore formation or by vegetative propagation or vegetative reproduction of plant parts. Sexual reproduction is by fusion of male and female gametes and it occurs in flowering plants.

1- Asexual reproduction:

1. Fission: Fission is of two types:

*- Binary fission: In binary fission, two individuals are formed from a single parent. This type of reproduction is found in organisms like bacteria, yeast and Amoeba.

*- Multiple fission: In multiple fission, many individuals are formed from a single parent. This type of reproduction by multiple fission occurs during unfavourable conditions.

2. Budding: In this type of reproduction, a bulb-like projection or outgrowth arises from the parent body known as bud, which detaches and forms a new organism. For example, Hydra reproduces by budding.

3. Regeneration or Fragmentation: In this type of reproduction, the body of an individual breaks up into two or more parts and each part develops into a complete individual. Examples: Spirogyra, and Planaria.

4. Spore formation: In lower forms of life like the alga, Chlamydomonas, the protoplast of the cell divides to form 4–8 spores. These being motile are termed as zoospores. When spores are released in the surrounding medium they develop into new plants.

5. Vegetative reproduction in plants: Vegetative reproduction is a form of asexual reproduction in plants in which a bud grows and develops into a new plant. In this type of reproduction, any vegetative part of the plant body like leaf, stem or root develops into a complete new plant. Vegetative reproduction can take place by two methods—natural and artificial.

<u>A) Vegetative reproduction by natural methods:</u>

This type of vegetative reproduction can involve roots, stem or leaves. Some common modes of vegetative reproduction are given below:

i) By roots: The roots of sweet potato and mint bear adventitious buds. When these roots are planted in the soil, new plants are produced

ii) By stem: In many plants the stem develops buds on it. The part of the stem that bears buds serves as an organ for vegetative multiplication, e.g. the modified parts of stem, such as runners of grass, suckers of mint, bulbs of onion and tulip, rhizomes of ginger, corms of gladiolus, and tubers of potato, etc.

iii) By leaves: In some plants, e.g. in Bryophyllum and Bigonia, adventitious buds are developed in the margins of their leaves. When the leaf falls on moist soil, these buds develop into small plantlets, which can be separated and grown into independent plants.

<u>b) Vegetative propagation by artificial methods:</u>

Some plants can be propagated artificially. The methods of artificial propagation include grafting, layering, cutting and tissue culture.

i) Grafting: It is the method of obtaining a superior quality plant from two different plants, taking the root system of one plant and the shoot system of another plant. The plant whose root system is taken is called stock. The plant whose shoot system is taken is called scion. The ends to be grafted, of the stock and the scion, are cut obliquely and placed face to face and are bound firmly with tape. The stock supplies all the desired nutrients to the scion. This technique has been used in raising superior quality plants of mango, apples, roses, rubber and citrus..

ii) Cutting: In some plants like rose, sugarcane, Bougainvillaea, etc. this method is used quite frequently. Stem cuttings with nodes and internodes are placed in moist soil which give rise to adventitious roots, and grow into new plants.

iii) Layering: Layering is the development of roots on a stem while it is still attached to the parent plant. The stem or the branch that develops adventitious roots while still attached to the parent plant is called a layer. It is a means of reproduction in black raspberries, jasmine, Magnolia, etc.

iv) Tissue culture: This is a modern technique of vegetative propagation. In this technique, a small piece of tissue is cut from a plant and is transferred to a container with nutrient medium under aseptic conditions. The tissue utilizes nutrients from the medium, divides and re-divides, and forms a callus. Small portions of this callus are transferred to another medium which induces differentiation and plantlets are produced. These plantlets are transplanted in soil to form an adult plant. Orchids, Chrysanthemum, Asparagus and many other plants are now being grown by using plant tissue culture technique.

2- Sexual reproduction:

In flowering plants, flower is the reproductive part of a plant. Most flowers have both male and female reproductive organs. A typical flower has four sepals, petals, stamens and carpels. The stamens and carpels are directly concerned with sexual reproduction.

The stamens is the male part of the flower. Each stamen has anther and a filament. Each anther possesses many pollen grains, which are the male gametes in pollen sacs. Carpels is the female reproductive part of a flower. The female part contained in this whorl is called pistil.

Each pistil consists of three parts—an upper flat stigma, a medial, long, cylindrical style, and a lower, swollen ovary.

• The stigma receives pollen grains during pollination.

• The style bears the stigma at a suitable position to receive the pollen grains.

• The ovary contains ovules that are found attached to the placenta. Ovules are the structures in which embryo sacs develop, and mature into seeds after fertilization. The arrangement of ovules in the ovary is called placentation.

Pollination

Pollination is the process of transfer of pollen grains from the anther to the stigma of a flower. It is of two types:

i) Self-pollination: If the pollen grains from the anther of a flower are transferred to the stigma of the same flower, it is termed as self-pollination or autogamy (auto: self; gamy: marriage) e.g. pea and china rose.

ii) Cross pollination: If the pollen grains from anther of one plant reach the stigma of a flower on another plant of the same species, then this is called as cross pollination or allogamy (allos: other; gamy: marriage). Cross pollination has the advantage of increasing the chances of variations.

How do plants get pollen from one plant to another?

Because plants are rooted in the ground, they must use different strategies:

Wind pollination; Animals pollination (Insects, Birds, Mammals, Even some reptiles) ; **Coevolution pollination**

Coevolution – interactions between two different species as selective forces on each other, resulting in adaptations that increase their interdependency.

Fertilization

i. After pollination, the pollen grains germinate on the stigma to produce a pollen tube.
ii. This tube grows down through the style and finally reaches the ovule.
iii. The ovule contains the egg cell inside the embryo sac.
iv. The tip of the pollen tube ruptures in the ovule and discharges two male gametes into it.
v. One of the male gametes fuses with the egg to form the zygote. This fusion is called fertilization.
vi. The other male gamete fuses with the diploid secondary nucleus and forms the endosperm nucleus.
vii. The zygote that is formed as a result of fertilization divides several times and gives rise to an embryo. The endosperm nucleus grows to form the endosperm of the seed. Following fertilization, the sepals, petals, style and stigma degenerate and usually fall off. The ovary wall ripens and forms the pericarp of the fruit. Each ovule develops into a seed. The seed contains a potential plant or embryo. The whole ovary after fertilization changes into a fruit.

Types of Crops

A crop is a plant or plant product that can be grown and harvested for profit or subsistence. By use, crops fall into six categories: food crops, feed crops, fiber crops, oil crops, ornamental crops, and industrial crops.

Food crops, such as fruit and vegetables, are harvested for human consumption. Grains, such as corn, wheat, and rice, are the world's most popular food crops.

Food crops were the first crops to be harvested through agriculture. Agricultural development and the growth of civilizations led to the diversity of other types of crops.

Feed Crops

Feed crops, such as oats and alfalfa, are harvested for livestock consumption. These crops contain nutrients that animals need to develop. They are grown in agricultural fields but can also be found in natural meadows and pastures.

Forage crops are important for livestock farming. Animals feed directly on forages, such as grasses. Forages that are cut and fed to livestock while they are still fresh are called green chop. Alfalfa is a popular crop fed to livestock as green chop.

Some forages are cut, allowed to dry in the field, and stored. These are called hay crops.

Another type of forage crop is silage. Silage crops are harvested, then stored under conditions that allow the forage to break down (ferment) into acids. The wet, acidic silage is fed to livestock such as cattle.

Principle feed crops include corn, barley, wheat, and oats. Each of these crops has different properties that are better suited for some animals' diets over others. Barley, which is harder to digest, is most often fed to beef and dairy cattle because they have a tough, four-chambered stomach. Hull-less barley, which is easier to digest, is fed

to swine and poultry.
The production of feed crops has risen dramatically with increased demand for meat worldwide. Increased production of feed crops has changed the agricultural landscape.
The Food and Agriculture Organization (FAO) says 33 percent of arable land on Earth is used to produce food for livestock. This limits the production of crops for human consumption, especially for the world's poorest people.
Forests have been cleared to create pastures where livestock can graze. Almost 70 percent of land cleared from the Amazon rainforest, for instance, has been turned over to grazing.

Fiber Crops

Fiber crops, such as cotton and hemp, are harvested for textile and paper products. Textiles, or cloth, are made from the dried and processed fibers of certain plants. Most fibers used to make textiles are taken from the stem or roots of plants such as flax. Flax is used to make linen. Other parts of a plant can be harvested for fiber. Cotton, the most popular fiber crop in the world, is harvested from the light, fluffy "boll" of fiber that surrounds the plant's seeds. Textiles made from bamboo are manufactured from the pulp of bamboo plants.
Pulp from other fiber crops can be used in a variety of products. Fiber pulp may be used instead of wood pulp to manufacture paper products.
The hemp plant is an interesting and controversial example of a fiber crop.
The fibers of the hemp plant are strong and durable, perfect for products such as paper, textiles, ropes, nets, and sailcloth for ships. Hemp advocates see the plant as a versatile and ecological source of fiber.
But some varieties of the hemp plant are used to make marijuana, a psychoactive drug. Marijuana is illegal to grow and use in many parts of the United States. (The drug is legally grown and sold for medical or recrecational use in some places). Opponents of hemp argue that increased harvesting of hemp crops will lead

to increased production and use of marijuana.

Oil Crops

Oil crops, such as canola and corn, are harvested for consumption or industrial uses. Technologies developed in the past century have enabled crops to be processed and broken down into their primary components, including oil. Soybeans, for example, represented 61 percent of world oilseed production and 79 percent of all edible oil consumed in the United States in 2000.

Oil crops are harvested for use in cooking, such as olive oil and corn oil. Oil crops are also harvested for industrial use, such as oil paints, soaps, and lubrication for machinery.

Fuel made from oil crops is called biofuel. The demand for biofuels has grown in recent years. Rising gas prices, concerns about global warming, and a desire for energy self-sufficiency have led governments and businesses to invest in biofuel research.

There are two main types of biofuel that use oil crops: bioethanol and biodiesel. Bioethanol is an alcohol made from fermented materials that come from sugar and starch crops. These crops include sugar cane, corn, and wheat. Bioethanol can be used as a fuel for vehicles, but it is usually used as a gasoline additive to improve vehicle emissions. Bioethanol is used widely in the United States and Brazil, where an abundance of corn and sugar cane crops facilitate its production.

Biodiesel is made by combining vegetable oils with alcohol. Nuts, such as coconuts, macadamias, and pecans, are excellent sources of oil used to manufacture biodiesel. Biodiesel can be used in diesel engines, such as those used by buses. Brazil, the United States, and the European Union (particularly Germany) manufacture and use biodiesel on a large scale.

Biofuels provide almost three percent of the world's transport fuel. Many scientists and economists predict that number will rise as oil production decreases in the next century.

Ornamental Crops

Ornamental crops, such as dogwood and azalea, are harvested for landscape gardening. Ornamental crops are most often grown in nurseries, where they are purchased for residential or commercial settings. Ornamental crop production has deep historical roots. The tulip crop of the Netherlands, for example, has become a symbol of that country.

Today, ornamental crop production is an important economic activity in many developing countries. Kenya, for example, is a major exporter of roses and carnations. Kenyan flower growers have situated their greenhouses near the shores of Lake Naivasha and Lake Victoria, where the soil is fertile and the water is abundant and fresh.

Kenya's huge flower operations, however, are having a negative impact on lake ecosystems. Growers irrigate their flowers with lake water, dramatically lowering supplies of freshwater available for consumption and hygiene. Growers also apply heavy amounts of fertilizers and pesticides so their flowers can maintain their beauty throughout the export process. These chemicals often runoff into the lakes, endangering aquatic animal and plant life.

Industrial Crops

Industrial crops, such as rubber and tobacco, are harvested for their products' use in factories or machines. Industrial crops include all crops used in the production of industrial goods, such as fiber and fuel products.

Rubber is produced naturally from a wide variety of plants, but predominantly from the *Hevea* tree indigenous to the Amazon region. Rubber is harvested for its latex. Latex is an extremely tough fluid found in the inner bark of the *Hevea* tree. Latex is obtained by tapping—cutting or shaving the bark with a sharp knife—and collecting the latex in cups. When mixed with chemicals, latex creates solid rubber blobs, called curds. Rubber curds are pressed between rollers to remove excess moisture and to form sheets. The sheets are packed and shipped for use in tires, machine belts, shoe soles, and other products.

Rubber has been used by civilizations for thousands of years. One of the earliest uses of rubber was to create balls for use in games in the Olmec Empire in what is today Mexico. Today, rubber is still used to manufacture durable toys, as well as boots, flooring, balloons, and medical supplies.
Hevea trees transplanted to southern Asia now produce most of the world's rubber. The countries with the largest rubber crops are Thailand, Indonesia, and Malaysia. Industrialization around the world has increased the global demand for rubber. High demand for natural rubber has increased the environmental degradation of forests in southern Asia.

Harvesting Crops

Methods for growing and harvesting crops have developed over thousands of years. The earliest crops were grown in Mesopotamia around 5500 B.C.E.
These crops, indigenous to an agriculturally rich area called the Fertile Crescent, were grown near local sources of freshwater so they could be irrigated relatively easily. Wheat, barley, and figs were among the first crops.

The development of agriculture led to more sophisticated methods of harvesting crops. Crop rotation was the most significant innovation.
In crop rotation, one crop is planted one year, then a different crop is planted the next year on the same land. This helps preserve the soil and reduce the chance for disease. Crop rotation and fertilization, which makes soil more productive, allowed farmers to grow more crops on less land. These innovations also allowed crops to be grown in areas where they might not grow naturally. Improved engineering allowed rivers to

be dammed and diverted to provide water for crops. All of these developments increased the abundance of crops, which could be used for trade and industrial use.

Today, agriculture is the largest industry in the world. Millions of people harvest crops for subsistence or business purposes. Some tools used to harvest crops have not changed in a thousand years—plows, rakes, sickles. Most of all, harvesting crops still relies on human labor.
The tools and machinery used to harvest crops have grown much more complex and expensive, however. Fertilizers, which many farmers need to be economically competitive, cost more than many farmers in the developing world can afford. Machinery, such as tractors and plows, can cost hundreds of thousands of dollars.

GMOs

Genetically modified organisms (GMOs or GM foods) are common throughout the developed world. Biotechnology allows scientists to alter the DNA of microbes, plants, and animals. Businesses sell farmers genetically modified seeds. With these seeds, farmers can use toxic chemicals without harming the crop. Farmers who grow GM foods increase production with less labor and less land. Vegetables and fruits last longer and are less likely to bruise.

The heavy reliance on chemicals has disturbed the natural environment, however. Helpful species of animals may be killed along with harmful ones. Chemical use may also pose a health hazard to people, especially through runoff entering local aquifers and other water supplies. Critics argue that GM foods have less nutritional value and decrease biodiversity.
Organic and free-range food industries have grown in opposition to industrial farming. Agricultural scientists are looking for safer chemicals to use as fertilizers and pesticides. Some farmers use natural controls and rely less on chemicals.

Seed Banks

In order to preserve biodiversity, seed banks have been created around the world to store seed samples. Seed banks may specialize in a specific crop or in the crops of a region. The International Potato Center, based in Lima, Peru, houses 150 wild potato species and other tubers of Andean origin.

Native Seeds, founded in the southwestern United States, helps Native Americans locate seeds for growing traditional crops, such as orach, or “mountain spinach,” and amaranth, once widely used for food and fiber in Mexico.

The Svalbard Global Seed Vault, the world’s most diverse seed bank, was established in 2008. The Norwegian government built the Seed Vault into the side of a permafrost-covered mountain on the island of Spitsbergen, part of the Svalbard archipelago about 1,030 kilometers (620 miles) from the North Pole. The vault is designed to safely store the seeds of hundreds of thousands of plant varieties from crops grown throughout the globe. The Seed Vault offers “fail-safe” protection for the world’s agricultural inheritance against any natural, social, or economic disaster.

Today, the Seed Vault stores about one million seed samples. It has the capacity to hold 4.5 million samples.

Crops have a wide variety of uses and are an integral part of our existence and development. While advancements in crop science and technology have increased the production of some of our most basic foodstuffs, they also have had wide-ranging impacts on the environment.

The production of crops does not have to harm the environment. By protecting the land, water, and air, and by sharing knowledge and resources, people may find solutions for the problems of world hunger and global energy scarcities through the sustainable use of crops.

FAST FACT

Crop Circles

Crop circles are enormous, intricate patterns in cultivated fields of grain, such as wheat or corn. They may have circular, linear, or complex patterns. Crop circles often appear overnight and to the surprise (and financial disappointment) of the owner of the field.

When they were first reported in the 1970s, some people thought the beautiful, mysterious crop circles were created by unusual weather phenomena or even extraterrestrials. Crop circles are actually created by teams of people working together with basic toolsropes, cut-out patterns, and flat boards used to crush the crops.

Although more than a dozen countries have reported crop circles, most of the patterns have appeared in southern England.

Worms?

Traditionally, worms have been raised for fishing bait as well as a protein and enzyme source for various products, including animal food and biodegradable cleansers. Worms have also been used to manage agricultural wastes such as dairy manure. They convert waste into worm manure (also known as worm castings), a nutrient-rich, biologically beneficial soil product.

Vermicomposting is the use of worms as a composting method to produce vermicompost. Vermiculture is worm farming for the production of worms. In recent years, worm farming has been practiced on both a small and large scale with three complementary goals in mind: waste diversion, vermicomposting, and vermiculture.

What is vermicompost?

Vermicompost, or castings, is worm manure. Worm castings are considered by many in horticulture to be one of the best soil amendments available. The nutrient content of castings is depends on the material fed to the worms–and worms commonly feed on highly nutritious materials, such as food waste and manures.

Worm castings provide a variety nutrients helpful to promote plant growth and in a form readily available for plant uptake. The biology of the worm's gut facilitates the growth of fungus and bacteria that are beneficial to plant growth. In addition, many chemical compounds are found in castings that are thought to promote plant growth.

Much of the content of worm castings and their effects on plants are still being studied. Nonetheless, farmers and soils blenders know the benefits of worm castings from their actual effect on plants and product sales, even when the worms are fed low-nutrient materials such as paper fiber.

What kind of worms are used for vermicomposting?

Most worm farms raise two main types of earthworm: Eisenia foetida and Lumbricus rubellis. These worms are commonly used to produce vermicompost, as well as for fish bait. Both are referred to by a variety of common names, including red worms, red wigglers, tiger worms, brandling worms, and manure worms. These two species are often raised together and are difficult to tell apart, though they are not believed to interbreed. While several other species have been successfully bred in recent years, this fact sheet focuses primarily on the use of these species.

The night crawler (Lumbricus terrestrius) is also harvested and sold for fishing bait. This species does not breed well in captivity and is generally harvested from wild stock.

What do worms need?

Worms can survive a wide variety of temperatures, but they thrive best at temperatures between 55 and 77 degrees Fahrenheit (13–25 degrees Celsius). They need a moist, organic substrate or “bedding” in which to live. They will eat the bedding and convert it into castings along with other feed. Moisture and oxygen are vital and bedding should be about as damp as a wrung-out sponge. A worm’s skin is photosensitive and therefore they need a dark environment.

Because worms have no teeth, they need some type of grit in their bedding that they can swallow and use in their gizzard to grind food, much like birds do with small stones. A little soil or sand will work, but it should be sterile so that no foreign organisms are introduced. Common additives used include rock dust or oyster flour (ground up oyster shells).

Since oyster flour is basically calcium carbonate, adding too much will raise the pH in the worms’ environment. Worms prefer a slightly acidic pH level of about 6.5. For a typical worm bin, no more than a tablespoon of grit is needed, which should not significantly alter the pH.

What will worms eat?

Worms will eat a wide variety of organic materials such as paper, manure, fruit and vegetable waste, grains, coffee grounds, and ground yard wastes. While worms will eat meat and dairy products, it is best not to feed these materials or oily foods to worms, due to potential odor and pest problems. Worms will consume limited amounts of citrus scraps, but limonene, a chemical compound found in citrus, is toxic to worms, so it is best to limit or avoid feeding them this material.

Since worms have no teeth, any food they eat must be small enough to swallow, or soft enough for them to bite. Some foods may not be soft enough initially for them to consume, but they quickly degrade so that the worms can consume them.

Where should you keep worms?

Worms can be raised on a small or large scale, depending on your goals. If you are trying to manage food scraps for yourself or your family, a small 12-to 20-gallon worm bin should be adequate. The bin should be dark and opaque and should, have a lid, drainage, and aeration holes in the bottom. Small 1-inch legs and a tray underneath the bin are also helpful.

If you are trying to manage larger amounts of organic materials or produce large amounts of worms or vermicompost, worms can be managed in low-mounded rows called worm beds or “ricks,” or in large in-vessel continuous-flow systems available from suppliers. Worms burrow into the bedding to protect themselves, and they will not come out to sunlight unless bedding conditions are intolerable.

How do you harvest worms and vermicompost?

Large-scale worm farmers using worm beds generally use harvesting equipment to separate worms and castings. In-vessel “continuous flow” systems are generally designed to produce vermicompost. They rely on the surface-feeding tendency of red worms to incorporate a casting harvest mechanism on the bottom of the system, below the active feeding area. Food and additional bedding are added to the top, encouraging the worms to continue feeding upwards.

Smaller scale worm bins are harvested in a variety of ways. In all cases, harvesting should begin when the bedding and consumed food has turned a rich dark brown, with a consistency of coffee grounds. Waiting longer can result in a sludgy material that is difficult to harvest and may become anaerobic and odorous.

One commonly used method of harvesting is to dump the bin onto a tarp in bright light, allowing the worms to burrow down to escape the light. Castings can then be separated by slowly scraping them away, pausing periodically to let the worms burrow further. Eventually, you are left with a pile of worms.

Some will harvest by placing new bedding in one half of the bin, and feed exclusively on that side. Eventually (sometimes over a period of several weeks) most of the worms will move to the side with the new bedding, and the finished compost can be harvested.

One simple method is to place a large amount of food in one area of the bin. Within a few days to a week, this should become a writhing mass of feeding worms. By turning a plastic bag inside out over your hand, you can then “reverse harvest” the worms by simply grabbing the mass of worms and turning the bag right-side out. You then have enough worms to start your bin again. Some worms and egg cases will be left in the castings. This should be no problem if the castings are used soon for indoor potted plants. Castings should be cured before outdoor use.

Harvested castings can be mixed into potting soil soon after harvest for best effect on indoor plants. If they are to be stored or used for outdoor plants, they should be cured in an aerobic environment to dry, eliminate the potential to introduce new species and prevent mold.

Will I need to buy more worms?

Red worms are hermaphroditic, but they need two worms to procreate and exchange DNA. A small egg case, usually amber in color, is produced which can contain from 2 to 20 baby worms.

Worms will regulate their own population according to the conditions of their environment. These conditions include space, moisture, pH, temperature, bedding material, and amount of food available. A typical household worm bin might start out with one pound of worms (approximately 1,000 adults), which will soon multiply to 2,000–3,000 in favorable conditions. Conversely, if one or more of the above conditions are not provided, the worms may crawl out leaving the bin or die off.

What other organisms live with worms?

Worms do not live in isolation. In addition to microscopic organisms like bacteria and some fungi, you may notice several other creatures, such as springtails, mites, pot worms (small white worms often mistaken as baby red worms), and an occasional fungus gnat. These organisms generally stay in the bin, live in harmony with the worms and cause little problems. Consistently burying the food in the bedding will minimize the attraction of unwanted species.

Keeping the bin moist and stirring the castings and bedding periodically will minimize the growth of fungi and the potential of fungal spores. If the bin is not stirred, full-sized mushrooms can grow.

If a bin is kept outside, the number of organisms that find their way into a bin greatly increases. Slugs and snails, ants, spiders, soldier fly larvae, fruit flies, pill bugs, centipedes, even frogs, salamanders and some small rodents have found their way into outdoor worm bins. Rarely will more than three or four of these cohabitants occupy a bin. Most do not hinder the functioning of a bin, and they are not bothersome. It is best to keep outdoor bins outside to prevent the introduction of unwanted animals into your house.

The most common "pests" in worm bins are ants and fruit flies. Keeping the bin moist, stopping feeding for a week or two, and stirring the bin every day can eliminate ants. Fruit flies can be more problematic, and sometimes can only be eliminated by starting over. Short of that, stopping feeding for a couple weeks and using flypaper or other fly traps can work if the population of flies is not too high.

Worms raised in worm beds can also attract predators such as birds and moles. Birds can be deterred in traditional ways such as placing scarecrows near the beds, or the beds can be covered with cardboard or other material. Moles can breed quickly and can eat a lot of worms. They can be deterred either by raising the worms in an in-vessel system, on a cement pad, or placing a wooden or plastic barrier several inches into the soil around the beds. The barrier should stick out of the soil an inch or two to prevent the moles from finding a way over it.

Are vermicomposting facilities regulated?

Vermicomposting is defined as an "excluded activity" from California solid waste regulation. However, an "exclusion" recognizes that a given activity is involved in solid waste handling and therefore must comply with fundamental health and safety codes.

According to California food and agriculture regulations, worms can be considered livestock, much as cows are livestock in a ranching or dairy operation. Within reason, certain organic wastes can be viewed as feed. However, the handling of compostable material prior to and after use as a growth medium is subject to regulation under solid waste regulations.

If a large worm operation becomes a nuisance by taking in more waste than can be effectively fed to and processed by the worms (resulting in odors, for instance), the activity could be viewed as a solid waste facility. Concerns about a particular circumstance should be directed to a community's environmental health department.