

## WHAT IS A BUTTERFLY?

- Some people call them flying flowers or flying jewels. The Ancient Greeks believed that butterflies were the souls of the dead flying to heaven.
- Butterflies are insects, but whereas almost everybody finds a butterfly beautiful, this isn't true of other insects like wasps, beetles or mosquitoes. Unlike these insects, the butterfly has no bite or sting, it is a model of innocence.
- Insects belong to the largest division (or phylum) of the animal kingdom. This phylum is called the Arthropods.
- Arthropods have a segmented body and jointed limbs. Included in this division are: Crustacia (lobsters, crabs, woodlice), Arachnids (spiders, scorpions, mites, harvestmen), and Centipedes.
- Insects, however, are the largest and most richly varied group within this diverse division of the animal kingdom. No less than 70% of over 1 million described arthropods are insects.
- The main features of insects are: **[How many legs?]** 6 legs, 1 pair of antennae, and a segmented body, head, thorax and abdomen.
- Insects are also sub-divided into 30 so-called Orders, mainly based on wing features. These orders include Coleoptera (beetles), Hymenoptera (bees, wasps & ants), Orthoptera (grasshoppers, crickets) and Lepidoptera (butterflies and moths).

## Lepidoptera

- After Coleoptera (the beetles), Lepidoptera form the order with the largest number of species. ***[Guess how many species of butterfly there are?]*** 16,000 have been described, with more still being discovered.
  
- Lepidoptera have always been distinguished into butterflies and moths based on the shape of their antennae.
  
- Lepidoptera with threadlike antennae ending in a small club are butterflies, those with differently shaped antennae e.g. feathery, are classified as moths. ***[Make arms into antennae]***
  
- Most butterflies are brightly coloured and active during daytime, whereas moths have dull colours and are active at night. However, this is a rule with many exceptions.

## **Build - Caterpillar**

- The body of a caterpillar is built very simply. It consists of no more than a head with 13 segments behind.
- The most striking feature of the head is the large jaws which are used to chew and eat large amounts of food.
- Between the jaws are glands that produce a liquid from which silk can be made. On both sides of the jaws are two small antennae with simply constructed eyes, called ocelli.
- The next 3 segments (thorax) have 3 pairs of legs used for grasping the food.
- The remaining segments are those of the abdomen which have 4 pairs of false or pro-legs, which end in a contractile pad surrounded by a ring of hooks. The last segment has the large hind pro-legs or claspers.
- With all these legs the caterpillar can walk very well and hold on tightly to a plant.
  
- On the side of the caterpillar can be seen small holes (spiracles). These are tubes which form part of the caterpillar's breathing mechanism.
  
- Depending on the species, caterpillars have a body which is either bald, hairy, spiny or with tails.

## **Build – Butterflies & Moths**

- Butterflies and moths also have a head, thorax and abdomen. The head contains some remarkable organs. ***[Can you name any organs of the head?]*** The most prominent are the antennae, the proboscis and the compound eyes.
- The antennae on each side of the head contain delicate nerve cells which function as highly sensitive organs of smell.
- The antennae are also used for balancing and as feelers.
- With their sensitive antennae, Emperor Moths can smell a female from a distance of many miles. They have the most sensitive noses in the animal kingdom.
- The proboscis consists of two elongated half tubes which form a tubular sucking and licking organ. Towards the end it forms a narrowing capillary which is split at the tip. When not in use it is coiled in a spiral.
- Because butterflies and moths have no jaws to bite and chew with, they must rely on liquid food, the most important being nectar.
- ***[Can you think of anything else they might like to drink?]*** Some also like the juice of rotting fruit, dead animals, manure and urine.
- Heliconias sometimes collect pollen which sticks to the proboscis. They make the proteins of that pollen soluble and then suck it up

their proboscis. In this way they are able to gain more nutrition and so enabling them to live longer.

- The size of the proboscis varies in size from not even a centimetre to 15 centimetres.
- The compound eyes are made up of between 12 – 17,000 separate optical units called ommatidia. The butterfly sees its surroundings as a mosaic of tiny pictures. They have excellent vision, especially over shorter distances, flying expertly in difficult surroundings, full of obstacles. They can detect a limited number of different colours and are also capable of detecting ultraviolet light.
- The thorax consists of 3 segments largely filled with muscles. The forelegs are attached to the 1<sup>st</sup> segment, middle legs and a pair of forewings to the 2<sup>nd</sup>, and a third pair of legs and hindwings to the 3<sup>rd</sup>.
- The wings are covered with small scales, arranged like roof tiles, are hollow and contain pigments.
- The morphos do not only depend on the pigment but also on the structure and arrangement of the scales. A special form of light refraction is created giving the wings a metallic glow.

➤ The abdomen is composed of 10 segments, the last 2 or 3 are fused together as a genital organ. Males have pincer shaped projections with which they grasp the female while mating. Females have an ovipositor with which they lay eggs. The females also have glands in the abdomen that produce sex pheromones used to attract males.

➤ Some butterflies have special colour varieties. These can be mutants that lack a certain colour pigment, eg where a butterfly has white wings instead of orange. A very special anomaly is the gynandromorphy. This means the left half of the insect is male and the right half is female. The development occurs in the fertilised egg. This can contain two nuclei, a male and a female, or a cell with one nucleus in which an error has occurred during one of the first cell divisions. The end result being a gynandromorphy. Such butterflies remain hidden from the human eye when the wings of the male and female are the same, but for those butterflies where the male and female have their own colour pattern, a gynandromorphy can be spotted immediately. The frequency of this happening has so far been determined as 1 in 90,000.

## Life Cycle

- Butterflies and moths belong to the winged insects. These can be divided into two large groups: insects with an incomplete metamorphosis and insects with a complete metamorphosis.

➤ The incomplete metamorphosis is where the larvae which has hatched from the egg already looks like a mature adult. They are just smaller and in the larval stage do not yet have wings. The larva grows with each skin change or sloughing and at the final sloughing, gets its wings and is now a fully grown adult. There is no distinct pupae stage. Grasshoppers, stick insects and dragonflies have a similar life cycle.

- The complete metamorphosis is where the larvae crawl from the egg and do not look like the mature adult at all. Think of a maggot which becomes a fly and of course the caterpillar which becomes a butterfly or moth. The larva sloughs several times and gets bigger each time. At the final sloughing it becomes a pupa. At this stage the insect goes through the metamorphosis from a larva to a mature winged adult. Beetles, wasps and flies also belong to this group of insects.

- So the life cycle is as follows: **[Ask?]**

Butterfly/moth --- egg --- caterpillar --- pupa --- butterfly/moth --- etc

## Attraction

- **[How long do you think they live?]** The lives of butterflies and moths are very short. Most only live 2 or 3 weeks. In this short time they must produce offspring.
- The first step is to find a mate. This may not be easy as there are more than 160,000 different species which are often very similar.

➤ So, to find a mate the female sits in a strategic spot and releases an aromatic substance called sex pheromones.

- Each species has its own characteristic odour. Butterflies recognise each other first of all by their external appearance, and in a certain place such as a hilltop, a single tree or an open space in the woods, males fly madly about throwing themselves at females that resemble its own species. When it finds a suitable candidate the courtship begins.

➤ Some males fly under the female, other hover and dance above the female. While dancing he waves sex pheromones at his partner. The female is only stimulated to mate by the scent of the male of her own species. If another species should try she would take on a defensive attitude with her abdomen.

- If the male and female have made it clear by scents and colours that they belong to the same species then they begin to mate. They start with the coupling of the external sex organs. They can stay together for many hours, even a whole day. During copulation the male passes on sperm cells and also certain proteins to the female. She uses them for the production of her eggs. The male may also give off an aromatic substance as well, so making the female less attractive to any passing males.

## Egg

- Mating finished, the males go after more females and the freshly mated female goes in search of a plant on which to lay her eggs.
- Butterflies have a strong preference for plants belonging to a certain species. These 'host' plants are recognised by the female with the aid of the sensilla on her legs. She may gently tap the leaves of the plant or simply walk on them and can judge whether the plant is a suitable food plant and start egg laying.
- The size of the eggs varies from a few tenths of a millimetre to almost half a centimetre. Some are laid singly, some in groups, rows, ringlets and chains.
- The egg shell is hard and can be smooth or have ridges, and are ball, cone, cylindrical or disc shaped. The embryo develops in the eggs. This can take a few days to sometimes weeks.
- Eggs often change colour just before hatching. The eggs are usually laid under the leaf (but not always). They are glued to the plant with a sort of collagen (gelatine). They are now safe from the rain and cannot be washed off.
- ***[What other dangers face the eggs?]*** Perhaps their biggest enemy at this stage are ants who can remove them and take them off to their nest.

## Caterpillar

- On emerging from the egg the caterpillar will eat the eggshell. They will then continue to eat the plant they are on.
- Despite their huge appetite, caterpillars are extremely choosy. If they cannot find the correct food plant they would starve rather than try another plant. The caterpillar eats large amounts of leaves.
- To be able to grow the caterpillar sheds its skin a number of times, because the skin is not elastic. **[Think of the Incredible Hulk – his clothes split when he grew bigger!]** It gorges itself and at a certain stage will need a wider jacket. The caterpillar seeks a sheltered spot and spins a silk thread and fastens its abdomen to the plant. Its skin tears open at the front and the caterpillar walks out of its old skin. A new skin a few sizes bigger has already been formed. When the new skin is dry it continues to feed.
- Within 2 or 3 weeks the caterpillar can reach a weight that is a few thousand times its birth weight.
- Most caterpillars slough 4 or 5 times.
  
- At the last sloughing a caterpillar does not appear but **[what?]** a pupa. For this the caterpillar spins a silk pad onto the plant. It then hooks its back legs into this pad and hangs. Some make a girdle around their middle as well.
  
- Caterpillars are a great snack for many insectivores, so the caterpillar has a range of tricks.
- Some blend into the background of the plant they are on **[What is this is called?]**, others look like a twig.

- Because birds do not eat their own droppings, swallowtail caterpillars during the first few sloughings resemble bird poo. When it gets too big for this, it changes into a small, striking green monster with false eyes.
- Another defence they use is a forked organ behind the head which spreads a penetrating odour. This organ is called the osmaterium.

## Pupae

- Metamorphosis takes place in the pupa. The pupa is extremely vulnerable. It cannot run away and hide, so a safe place to pupate is of great importance.
- Pupae of butterflies are beautifully camouflaged by form and colour. Some appear plant-like - they resemble a shrivelled leaf, a fruit or a broken twig. Some moths, however, wrap a silk thread around the caterpillar to form a cocoon. Inside this safe cocoon the caterpillar pupates.
- The pupa stage sometimes lasts about 10 days, but can also last 3 years. This depends on the species and external circumstances such as temperature and humidity.

## Adult

- When the metamorphosis is complete, the butterfly or moth crawls out, the wings all crumpled up. It finds a spot to hang and develop its wings.
- It pumps blood from the enlarged body into the veins of its wings. These become bigger and bigger until they reach full size. It then hangs there for a few hours to dry. When they have hardened they pump the blood back out of their wings leaving them light and strong.
- Any stored up liquid is ejected from the rear, this thin pink or orange liquid is called meconium. The butterfly is now ready to take flight.
- Most butterflies hatch in the morning, when the air is still humid.

## Temperature

- Lepidoptera need [*what?*] warmth to fly. Most species prefer a body temperature of 30° to 35°.
- Lepidoptera are cold blooded, so are the same temperature as their surroundings. So butterflies are highly dependent on warmth. To become a little active, a minimum temperature of 15° is necessary.
- The butterfly crawls out to warm itself in the sun, using the wings as solar panels to collect warmth and transporting it to the flight muscles.
- If it gets too hot they retreat to a spot in the shade. If they cannot find shade, they close their wings above their body and turn towards the sun. In that way the smallest area is warmed by the sun.
- Moths too can only fly with warm muscles. They do this by rapidly beating their wings without taking flight. All this muscle work provides energy to warm the flight muscles.

## Food

- ***What do butterflies drink from flowers?***
- Most Lepidoptera need nectar for energy. Females need energy for egg development.
- Rotting fruit can also serve as an energy source.
- Water is also indispensable. Many drink from dew on the leaves or from mud puddles and river banks.
- The plant gives nectar to the butterfly and other flower visiting insects as a kind of reward for their help in pollination.
- The form of a flower is often adapted to a certain group of insects. The feature of a flower adapted for butterflies and moths are deep trumpet-shaped flower heads that can only be reached into by the long thin proboscis of a butterfly or moth. Bees and flies simply cannot reach the nectar.
- However, nectar and sweet juices are not the only diet. Some species suck sap from wounded trees, sharing the feast with beetles, flies and hornets.
- Some species also show a preference to foul smelling matter such as dung, carrion and rotting plant material.

## Butterflies and Ants

- Most Lepidoptera are usually considered to be victims that cannot defend themselves. A number of species belonging to the family of the blues have developed a relationship with ants, who protect them.
- The caterpillars are taken underground by worker ants to the underground nest. The caterpillars feed on the ant larvae and food offered by the ants.
- The ants are not aggressive towards the caterpillars because they have organs which secrete a sweet protein-rich substance that the ants love. The worker ants also protect the caterpillars from parasitic flies and wasps. During the winter they are safe in the ants nest.

## Dangers

- Lepidoptera are in danger from many insectivores in all stages of their life cycle.
  - ***What creatures would make a meal of a butterfly or caterpillar?***
  - For many vertebrates, especially birds, butterfly and moth caterpillars are a nutritious meal.
  - When the birds have young the parents search for hundreds of caterpillars to feed the ever-hungry chicks.
  - Bats go after moths using echo-location. They emit a high frequency sound that bounces off the moths and the bat can then locate it and immediately grab the victim.
  - Some moths have evolved to have a densely coated body of hairs, effectively soaking up the sounds the bat emits.
  
  - The many invertebrates are an even greater threat. Spiders, dragonflies, praying mantis and predatory flies go after butterflies and moths, while beetles, ants and parasitic wasps prey on caterpillars.
- Digger wasps and ichneumon wasps lay their eggs in or on the caterpillar. The wasp larva emerge from the egg and start to eat the caterpillar. The horrible part is that they do not kill it but eat it to death. Sometimes 80 to 100 little wasps crawl out of one caterpillar and go in search of a new victim.

## Colours and self-defence

- Lepidoptera protect themselves in many ways with the colour or pattern of their wings.
- Some disappear from sight by using camouflage colours. This is true of many moths, which as long as they remain still during the day will escape attention.
- Butterflies have brightly coloured tops but dull colour patterns underneath. In an emergency the butterfly darts between leaves, closes its wings and disappears.
- Large eye spots are used to mimic the head of larger animals which is reason enough for small insect-eating birds to leave them alone.
- The Atlas moth has a snakeshead on the tip of each forewing to make them look frightening.
- In contrast others have really bright colours like bright red or yellow. Such colours usually indicate that the butterfly is poisonous or distasteful. Once eaten the predator becomes ill and once they've had this experience it is engraved in their memory and they leave them well alone in future. These bright butterflies are usually not shy and don't fly away.
- A large number of caterpillars feed on poisonous plants. They also are usually brightly coloured. They store this poison in their bodies and it's kept even after pupation.
- Some butterflies and moths which are not poisonous, copy the colours of the inedible varieties and are left alone, because the similar colours bring back bad memories to the birds. In many species it is only the females that are protected by mimicry patterns.

## Winter

- Butterflies and moths from temperate regions are faced with winters. Even in tropical regions there are periods of drought.
- To survive these extreme periods of time, butterflies undergo a rest period called the diapause in which development stands still and reserves are used as efficiently as possible.
- The stage of lifecycle during the diapause differs from species to species.
- Some over-winter as eggs, others as caterpillars who retreat to a clump of shrivelled grass in the autumn. While others pupate just before the winter.
- Some adults seek a cool and protected spot in the autumn and hang there motionless until spring.

## Migration

- Many European butterflies and moths are born in the Mediterranean and migrate north as far as Sweden as the weather warms, such as painted ladies and clouded yellows and hummingbird hawk moths.
- These insects die in the autumn without providing a generation that survives the winter.
- Some species migrate to find a place to spend the winter. They do not go to really warm places but to where the temperature remains above freezing.
- The most famous migrating butterfly is the monarch. They fly from Canada to Central America. After summer, the monarchs migrate from all over the continent over distances of more than 3000 kilometres to the south. They fly at speeds of up to 35 kph via fixed routes to a few forests in countries including Mexico. Millions hang in the trees. The climate here is ideal – high humidity and a temperature which is constant and does not drop below freezing. In the spring the monarchs leave the forest and make their way north. They lay their eggs from which a new generation emerges. The butterflies that survived the winter are no longer alive and during the summer one generation after another appears going north to Canada. Then in the autumn all those butterflies migrate south once again.