POLLINATORS OR PLANT MUNCHERS?

THE BUTTERFLIES

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Butterflies have always been a source of beauty and wonder. But, what gives these lovely insects their attractive colours? What is the best time to watch them? What do we know about their behaviour? In this article, the author explores the fascinating world of butterflies, sharing some ideas to bring them to life in the science classroom.

From ancient to modern times, butterflies have had a deep impact on the minds of humans. On the one hand, they have been thought of as patron deities in the Aztec calendar, or soothing minstrels that lull you to peaceful sleep by bringing pleasant dreams. On the other, butterflies have been a source for scientific and (nano-) technological research, helping produce efficient light-emitting diodes or paints without toxic pigments. Over centuries, butterflies have shared a warm relationship with humans. Their beauty and colours have inspired poets and painters. Their frequent silent ethereal presence and their life cycle have led ancient cultures to look upon them as spirits of the deceased and modern day humans to welcome them with joy. Butterflies are insects, yet their relationship with humans is never negative. I often wonder whether they are even thought of as insects by humans.

Butterflies can be seen everywhere, even in urban areas, flying among auto-rickshaws, cars and motorbikes, and occasionally even resting on concrete roads. We read about deers and other small mammals being crushed under the wheels of speeding motorists; but, butterflies too are often victims of humans in a hurry. If we attempt to study butterflies more closely, we are likely to find that there are many interesting aspects of science that these insects can help us understand. For example, many concepts taught in physics and chemistry, including those dealing with colour, flight or pressure can become clearer through the observation of butterflies. This article is to help you connect with butterflies in your neighbourhood, as well as to explore some activities that will help your students learn scientific concepts in an interesting way. Welcome to the lepidopterist's world!

Figure 1. Caricature of a lepidopterist.

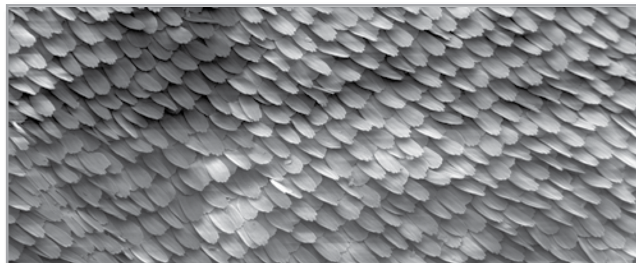

Figure 2b. Another view of micrograph of butterfly scales. Source: SecretDisc, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:SEM_image_of_a_Peacock_wing,_slant_view_1.JPG#/media/File:SEM_image_of_a_Peacock_wing,_slant_view_1.JPG. License: CC-BY-SA.

Lepidoptera

Butterflies, and their more abundant cousins - the colourful Moths, belong to the order Lepidoptera. The word Lepidoptera comes from two Greek words – '*Lepis*' meaning scales and '*pteron*' meaning wings. The defining characteristic of Butterflies and Moths is the presence of scales on their wings, bodies and appendages. If you have ever had the opportunity to pick up a dead butterfly or even the discarded wing of a butterfly, you may have noticed that they leave some coloured dust on your fingers. These are the scales from their wings. These scales are modified hairs that are responsible for the colours observed in these insects.

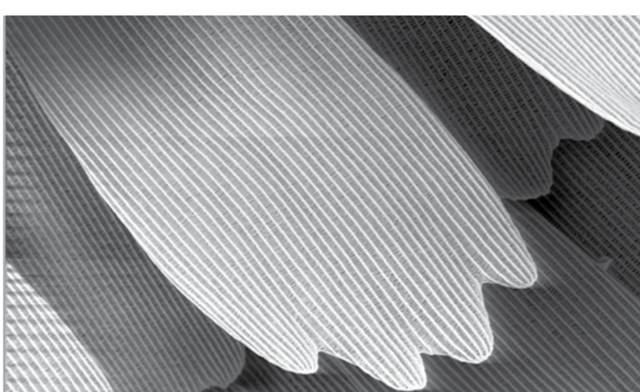

Figure 2a. Micrograph of butterfly scales. Source: SecretDisc, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:SEM_image_of_a_Peacock_wing,_slant_view_3.JPG#file.License: CC-BY-SA. Narayanswamy.

Butterflies share the general external characteristics of all insects - namely a body divided into a head, thorax and abdomen; three pairs of jointed appendages; a pair of wings; compound eyes, antennae and mouth-parts in the head. Of the four structures that make up the mouth-parts of an insect, it is parts of the maxillae that are modified to form the proboscis. This is the second most characteristic feature of butterflies – a long tubular proboscis that they use to sip nectar from flowers. The next time you see a butterfly alighting on a flower, observe it closely - you will see it extend a spring-like proboscis, which is usually kept coiled and tucked away under its head, into the corolla of the flower. Watching the coiling and uncoiling of the proboscis is quite a fascinating sight!

Figure 3a. Proboscis coiled up.

Figure 3b. Proboscis extended.

Butterflies are holometabolous insects – in other words, they undergo complete metamorphosis. Eggs hatch to form larvae, which grow to become caterpillars that continuously eat, grow and moult. These finally transform into an externally inactive pupa or chrysalis, which after a period of intensive internal transformations emerges as the adult butterfly. This gradual stepwise change in form and structure of a caterpillar to an adult is called metamorphosis. These stages are extremely significant; since some species of butterflies do not feed at all. The caterpillar is the only feeding stage in the lifetime of such species. The energy required for pupation, transformations and emergence of the adult butterfly, which then finds a mate, copulates and lays eggs, is all derived from what is stored in the body tissues during the caterpillar stage. One can therefore understand why caterpillars feed so voraciously and continuously.

An activity that can be undertaken in classrooms is to discover how much a caterpillar eats, how much of it is (roughly) utilised and what amount discarded. Additional details are provided in the section on learning activities.

Puddling

Puddling or mud puddling is one among the many interesting behaviours exhibited by butterflies (as well as moths and insects from several other groups). Puddling species often congregate in large numbers near puddles, wet patches, over carrion, bird and animal excreta, and even on human sweat.

Figure 4a. Palm Red-eye eggs. Source: Chitra Narayanaswamy.

Figure 4b. Palm Red-eye eggs ready to hatch. Source: Chitra Narayanswamy.

It is believed that a deficiency of sodium in adult butterflies triggers puddling. However, puddling is not a simple phenomenon of obtaining sodium. Puddling butterflies extract a variety of mineral salts - predominantly sodium, as well as certain amino acids, not obtained in adequate amounts from their regular diet. Research into this behaviour has shown that it is only males, especially young males that puddle. Why do females rarely mud puddle? And those that do are mostly older females. Several hypotheses have been put forward to explain this gender bias and need among young males. According to one hypothesis, the intense competition for nectar-feeding may have driven young males and older females to adopt alternate foraging strategies such as puddling for nutrients. According to another, males spend a lot more time flying than females. Since sodium is needed for neuromuscular activities, males may need more sodium. In many species, copulating males transfer sodium to females - sodium is necessary for egg production.

Is it possible to know whether butterflies actually sip fluids from a puddle? The best time to look for pudding butterflies is during the monsoons or post-monsoon season. You will see the gentle movement of the proboscis – a sign of puddling happening. If you observe these butterflies closely, you will notice that as they puddle, some of the fluids taken in are pumped out. You can see droplets of fluids coming out from the anus of the butterfly. In fact, when a butterfly wants its daily dose of mineral and can't find wet patches, it pumps out fluid from its anus onto a rock/stone/soil to wet it, and then extracts the mineral from this surface.

It's quite fascinating to observe mud-puddling. Although more frequently seen in Papilionids and Pierids, butterflies from other families also puddle. Lycaenids (blues) and Nymphalids are more often seen on sources other than wet soil patches for their daily dose of minerals.

Figure 5a. Butterfly sipping a cold sodium drink.

Figure 5b. Butterfly guzzling human sweat.

Figure 6. A butterfly pumping fluid on a rock.

Recognising butterflies

Butterflies differ from each other in many ways. For example, the wing designs and colours of butterflies vary not only between species, but also between the upper- and under-sides of a single species. Thus, several of their features have to be observed carefully for the precise identification of a butterfly species. To help beginners ease into observing butterflies, what we provide in this article is a very simple and elementary family-level description of these insects. It really does not matter if you can't immediately start identifying different species. Continue to observe them using the pamphlet provided with this article. As you become increasingly familiar with the habits and behaviour of butterflies you observe, you will become better at identifying them.

Butterflies are grouped into five large families namely Papilionidae, Pieridae, Lycenidae, Nymphalidae and Hesperidae.

A) Family Papilionidae: Since the hind wings of many members are extended into a tail, butterflies of this family are generally referred to as Swallowtails. Not all Papilionids sport this feature. Close to 100+ species of Swallowtails are found in India. Since the underside of the wings of many of these butterflies is dull coloured, you may miss seeing them till they open their wings. However, the brilliant colours of the upper side will make you gasp in surprise and joy - such is their beauty! It is these brilliant colours that make them favourites with butterfly collectors, and hence these species are frequently smuggled. In fact, some rare ones, like the Bhutan Glory and Kaiser-i-Hind found in the North and North-eastern parts of our country, are fast becoming scarce due to excessive collection and habitat loss. Apollo, Helen, Mormon, Jay, Mime, Bluebottle, Gorgon, Swordtail, Dragon tail, Swallowtail, Peacock, Lime, Rose, Windmill, Spangle, Raven and Zebra are some of the fanciful common names of butterfly species from this family. Look out for their caterpillars on Citrus trees, Curry-leaf tree and Aristalochia; you will surely find them. A few species of this family are described below.

Birdwings

The black and yellow Southern Birdwing, *Troides minos*, with a wing-span of 140-190 mm is endemic to the Western Ghats.

The female of this species is the largest butterfly of India. Two other species found in other regions of India are the Common and Golden Birdwing. All three species may be found in forested regions and are generally found flying above tree tops.

Figure 8a. Southern Birdwing. Source: Suresh Elamon.

Figure 8b. Common Birdwing (female).

Figure 8c. Golden Birdwing.

Mormons

The second largest butterfly from India is also a swallow tail – the Blue Mormon *Papilio polymnestor*, which is not restricted to forests and therefore more visible than the birdwings. It is found frequenting gardens, especially post monsoon.

Common Mormons, like several other Papilionids, are great mimics. The female of the Common Mormon mimics two other Swallowtails - namely the Common Rose and the Crimson Rose. The Crimson Rose is avoided by birds because it accumulates bitter chemicals in its body. The Mormon, though, is much more palatable to birds and hence protects itself by mimicking the wing pattern of the Rose (see the attached pamphlet for images). You can tell the original one from the mimic by observing their body colour. Mormons are black bodied, whereas Roses are red-bodied butterflies.

Figure 7a. Five-bar Sword Tail

Figure 7b. Red Helen

Figure 7c. Tailed Jay

Figure 9. Blue Mormon.

B) Family Pieridae: This family of sun-loving butterflies are commonly referred to as whites and yellows, as these are colours that are often seen on their bodies. There is no one defining feature that can help identify a Pierid. Familiarity through observation of various features, such as the wing colour, patterns and venation, is the only way to know them. Like the Papilionids, the Pierids also mud puddle, much to the delight of lepidopterists who wish to observe them closely or photograph them. You can often see them basking in the sun with their wings open. Some members of this family, namely the Emigrants and Albatrosses, are seasonal migrants. Many members, such as the Common Jezebel, accumulate distasteful chemicals in their bodies, and thus avoid predation. Recent research has shown that the Great Orange Tip butterfly produces a neurotoxin similar in composition and effect to that produced by the Cone Snail found in our oceans. Scientists quote this as an example of convergent evolution where two completely dissimilar species seem to secrete a similar chemical. Grass yellow, the various coloured tips (Crimson tip, Orange tip, Yellow-orange tip etc.), Arab, Albatross, Puffin, Gull, Pioneer, Psyche, Cabbage white, Jezebel, Wanderer and Sawtooth are some examples of Pierids.

Figure 10a. Emigrant

Figure 10b. Grass Yellow

Figure 10c. Great Orange-tip

C) Family Lycaenidae: Many of these butterflies are unmistakable for the attractive shades of blue on their wings. Commonly called the Blues, Lycaenids make up the second largest family of butterflies. As many as 521 Lycaenid species are found in India and, like the Papilionids, consist of species with fancy names such as Coppers, Sapphire, Silverline, Royal, Imperial, Forget-me-not, Cupid, Cerulean, Pierrot, Flash, Quaker, Onyx, Yamfly, Apefly, Hairstreak and Gems. Male Lycaenids have only two pairs of functional legs. Their forelegs are reduced, with the tips being fused and without claws. The females do not possess this feature. Several blues have small hair-like extensions from their hind-wings, forming small tails, not similar to those seen in Papilionids. The lives of these butterflies are closely associated with ants. Some of their caterpillars feed on aphids and scales, while some caterpillars of other Lycaenid species produce a sweet fluid as a reward for the ants that protect them. The smallest butterfly from India, called the Grass Jewel, can be seen throughout the year fluttering at ground level among grasses. The second smallest butterfly, called the Tiny Grass Yellow, is also a blue and shares the habitat of the Grass Jewel.

Figure 11a. Metallic Cerulean UN

Figure 11b. Metallic Cerulean UP

Figure 11c. Tiny Grass Blue

Figure 11d. Red Pierrot

D) Family Nymphalidae: All butterflies of this group have a stunted, much reduced pair of forelegs covered by hair and looking like brushes. Commonly called brush-footed butterflies, Nymphalids make up the largest family of butterflies, containing an assorted list of species that were earlier categorised into other family groups. This group can be easily identified - look out for butterflies that stand on only four of their legs. The stunted fore-legs, held beneath the head, are too small to be of any use to the butterfly, which perches using only its remaining two pairs of legs. This feature is common to both males and females except in a group of Nymphalids called Beaks. The reason for this feature is yet to be thoroughly understood. The leading belief is that the hairy forelegs are used for a variety of behaviours that may be seen among this group. These butterflies show wide variations in shape, design and colour at all stages of their lives - eggs, larvae, caterpillar, pupa to adult. The Monarch, famous milkweed butterfly whose migration has been extensively studied, belongs to this family. Another globally-seen and migratory butterfly from this family is the Painted Lady. Raja, Prince, Nawab, Begum, Caliph, Emperor, Courtesan, Joker, Jester, Archduke, Duke, Duchess, Baron, Baronet, Earl, Viscount, Commander, Commodore, Pasha, Sergeant, Sailer, Constable, Map, Maplet, Popinjay, Brown, Crow, Tiger, Panther, Faun, Nymph, Oakleaf, Palmfly and Pansy are imaginatively named Nymphalids that you would enjoy observing. Many of them can be seen in forested regions, but several can be observed even in urban spaces. Food plants for caterpillars and adults of Nymphalids include common hedge plants, such as Oleanders, Lantana, Duranta; the most common wild plant, namely the Calotropis; and the cultivated flowering plants of family Compositae.

Figure 12a. Orange Oakleaf

Figure 12b. Common Evening Brown

Figure 12c. Green Commodore

Figure 12d. Popinjay

E) Family Hesperiidae: Their common name – ‘Skippers’ – describe their habitual quick darting flight. Small, stout and hairy, many butterflies of this group are often mistaken for moths, with which they are more closely related than other butterfly families. You can recognise Skippers by their hook-shaped or comma-shaped antennae that are distinctly different from the club-shaped antennae of most other butterflies. Many may be observed at dawn and dusk, although some can be spotted even during the day. Several of them are pests of cultivated plants such as bananas and rice. In fact, a large number of banana plants in southern India were destroyed in a recent outbreak of the Torus Banana Skipper *Erionota torus* (also called as Banana Leaf Roller or Palm Red Eye). Awls, Darts, Swifts, Flat, Angle, Ace, Skipper, Hopper, Flitter, Demon, Bob, Ace, Redeye, are some examples of the approximately 321 Skipper species found in India.

Figure 13a. Pale Green Awlet

Figure 13b. Common Red Eye

Figure 13c. Chestnut Angle

Butterflies in the classroom

Butterflies are best studied by undertaking a field trip. Some of these studies can then be continued in the classroom.

1) Butterfly conservatory in the classroom

Observe butterflies inside the class: You can invite butterflies into your classroom if you are willing to put in some time and effort. This is not very difficult. You need to set up a few potted plants in your classroom. Students may enjoy setting up these plants and looking after them.

Visit the nearest nursery to get the necessary materials such as flower pots, soil manure and few plants saplings. Kalanchoes are succulents that don’t need much looking-after once they are planted in a pot. All they need is sunlight, warmth and occasional watering. Kalanchoes are food plants for the commonly noticeable Red Pierrot. Since they are like Bryophyllum, you can use these plants to teach vegetative propagation also. While at the nursery, choose a *Nerium* plant and grow it in a large or at least medium sized pot. These too can stay in your classroom. *Nerium* will soon attract Tiger butterflies, especially the Glassy Blue Tiger or even the Plain Tiger. If you want more species, then consider growing *Tridax procumbens* and *Crotolaria sp*, both of which may be found growing in wastelands or by the road side. You could also grow *Aristolochia sp*., a beautiful plant with basket-like fruits, which is the favourite food plant of Swallowtails. If butterfly visitors don’t arrive within a month, then you may have to take your students for a field trip to go caterpillar hunting.

Figure 14. Common food plants for butterfly caterpillars - a) *Crotolaria sp.*, b) *Calotropis* sp., c) *Nerium sp.*, and d) *Aristolochia sp.* e) *Tridax procumbens*

2) In search of a caterpillar

The best time to set up a butterfly conservatory is a couple of weeks before the monsoon. The search for caterpillars can take place anytime, but you are bound to see them during the monsoons. Look for caterpillars underneath leaves of plants. If your school has a garden, then you can search for caterpillars within the campus. If you are lucky, you might even chance on butterfly eggs. Try to get caterpillars that are generally found on Calotropis or Curry-leaf plants for they will not be fussy about changing their diet to *Nerium* sp.

3) Rearing caterpillars to watch the emergence of butterflies (this activity is common in schools but I have made it quite integrated)

I. This is in case you have chosen a caterpillar from a plant other than the ones I have mentioned before.

Materials needed: A well aerated box with a perforated cover to house the caterpillar. Make a small glove out of a clean plastic bag to handle the caterpillar. Some tissue paper to clean the box. A weighing scale. A tabulated sheet to record daily observations.

II. If you have collected caterpillars from the plants I have mentioned above or find that the caterpillars you have collected feed on *Nerium*/Oleander leaves, then the materials described before are not really necessary.

You can use this opportunity to teach a few math concepts. Record the weight of the caterpillar before you introduce it into the box/plant. Weigh leaves in the box to know how much a caterpillar eats/day. Since leaves may be very light, discuss with students how they can be weighed, especially without a sophisticated electronic balance (Hint: Add some heavy materials to the leaves to weigh. Subtracting the mass of the heavy materials will give you the mass of the leaves).

Make a record of as many features as you can of the caterpillar, including its length and colour. Observe how the caterpillar chomps away the leaves. As it eats, it also defecates. If you want, collect the droppings and weigh them. This will give you a rough idea of how much of leaf has been utilised by the caterpillar and how much has been egested. These are only rough calculations to give you a sense of food requirements.

Caterpillars will moult at least three to four times before pupation. Make a note of the same. Collect the moulted skin and carry out a few chemical tests – for example, you can take small bits of the moulted skin and perform tests of starch, sugar and proteins.

You can run similar tests with the droppings of the caterpillar. In fact, some droppings can be tested for the presence of chlorine, sulphur etc.

Keep track of the growth and any noticeable changes in the caterpillar. If you see it starting to eat less and becoming more sluggish, you can be certain that it is preparing for pupation. If the caterpillar is in a box, provide a small sturdy stick for it to pupate on. Keep observing the pupa for any noticeable changes.

Now wait for the emergence. If the species is a Tiger or a Crow, then the wait may not be for more than a week or two.

What can you teach through this activity?

Use data to revise concepts on measurements and units of mass.

Chemical analysis.

Metamorphosis.

Discuss the significance of the difference in foods consumed by the caterpillar and the adult to the survival of the species.

4) In search of the butterfly

While you are out looking for caterpillars, you may also try a few tricks to attract butterflies. Butterflies feed not only on the nectar from flowers, but also, as mentioned earlier, on carrion. If you leave a few dead fish, crabs or shrimps at a spot which is moderately sunny - you will soon find several Nymphalids arriving to feed on them.

Figure 15. Common Nawab feeding on a fish.

Observe the feeding butterflies from a distance. If you happen to be doing this near a wooded area or in a hilly region you will surely see the Raja, Earl, Nawab, Yeomen, and even some Papilionids visiting the meat. While observing them, shift your position so that you can see the light falling on their wings at different angles. You will see how the colours on the wings change their hues based on the light falling on them. Make notes and drawings, and once back in class, use the references quoted in this article to understand more about what you have observed.

5) Observing scales under the microscope

For this activity you will need a small piece of a dead butterfly's wing. If you can't find a dead one, you may use a net to trap a butterfly, and then, very gently, pass a soft paint brush over its wings. Don't try to catch the butterfly with your bare hands – you will harm its wings. Release the butterfly once you are done.

Dust the brush over a glass slide and add a drop of glycerine over it. Place a cover-slip over the glycerine. Use a filter paper and wipe away any excess of glycerine that flows from the edges of the cover-slip.

Figure 16. Scales of a butterfly wing under 10X magnification. Source: Dr. Thomas G. U.S. Fish and WildlifeService Headquarters, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Butterfly_scale_pattern_(6293105393).jpg. License: CC-BY.

Take a compound microscope and set it up with a 10X magnification. Place the slide you have just prepared on the platform and focus. Observe and you will see the scales of the butterfly.

Figure 17. Individual scales when the 'dust' is focused under 40X or 60X magnification. Adapted from photo by Jan Homann, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Mottenfl%C3%BCgel_in_Mikroskop.jpg. License: Public Domain.

Observe the slide under higher magnification. Play with it by changing the amount of light falling on the specimen. At the end of the class, discuss the importance of scales on the wings both with respect to flight and colour. This will also be a good opportunity to discuss concepts related to wavelengths of light, colour, refraction and reflection.

In case you manage to find a piece of dead butterfly wing, investigate its colour by doing one of the following:

1. Carry out activity 5 with it instead of trying to catch a butterfly. Dust it on a glass slide to get some scales, and follow instructions given above.

2. Take it out in the sun and tilt it in any which way you want. Do you see any difference in colours? Do you observe iridescence?

Scales and colour

What looks like dust on your fingers when you touch the wings of a butterfly are actually its scales. The arrangement of scales on butterfly wings is responsible for both their colour and patterns.

How? The colours that you see are the result of two different mechanisms - one resulting in 'normal' colour, and the other in 'iridescent' colour. 'Normal' colour is produced as a result of the simple process of absorption and reflection. Pigments present on the butterfly wings absorb some of the wavelengths of light and reflect others which we see as say yellow, green or red etc. 'Iridescent' colours are produced as a result of interference of light falling on the scales due to multiple reflections. The iridescent colour your eyes see on the wings depends on where you see the wings from. Since this iridescence depends on the arrangement of scales on the wings, these colours are also called 'structural' colours. Butterfly wing colour could also be produced as a combination of the two. If there is a pigment that can reflect yellow present on the iridescent surface, then the resulting colour could well be a 'normal' i.e., non-iridescent green

Figure 18. Indian Purple emperor showing change in shades of colour.

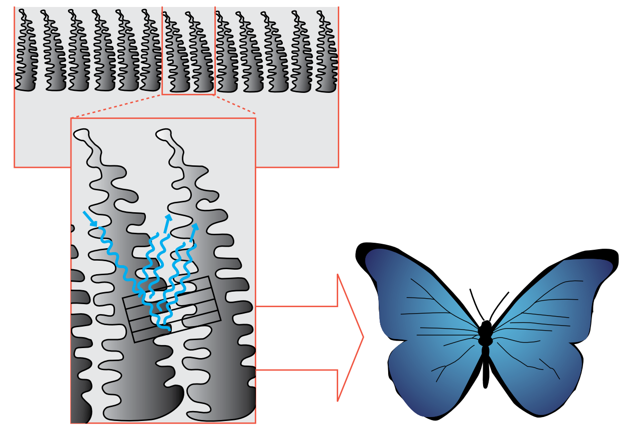

Figure 19. The nano-scale structure of butterfly wings. The tree-like structures are the arrangement of scales. The 'tree' and the air in between are the two materials with different refractive indices that facilitate constructive interference[12].

Structural colours

Even in the absence of pigments, some brilliant colours can be produced simply as a result of optical effects such as refraction, diffraction or interference. Examples of these include the colours reflected off the shining surface of a CD or in a soap bubble. Since these colours depend on the way physical structures interact with light, they are called structural colours.

In butterfly wings it is the arrangement of scales that produces structural colour. While details of the arrangement of scales are beyond the scope of this article, in simple terms, these scales are arranged in a highly ordered fashion but in layers with air gaps between them. This arrangement allows for interference to operate. The light waves strike the scales in one layer and while some light waves get reflected, others continue to travel to the next layer and the following one, striking the scales of each layer to get further reflected. So light gets reflected numerous times. These light waves may not be in phase; the scales and the air gap between them are materials with different refractive indices; thus resulting in 'constructive interference' that strengthens the reflection. The collective effect is the iridescence. When the angle at which light strikes the wing changes, the constructive interference also changes – thus, resulting in different hues of a colour.

Conclusion

Butterflies need not remain part of your science class only. They can also be part of a language or art lesson. Share this poem with the class as you finish the lesson on butterflies.

WANT TO GET STARTED?

Check out our cool pocket-size butterfly pamphlet on the back-cover of this issue!

POEM

Butterflies go fluttering by
On coloured wings that catch the eye.
On wings of orange, and silvery blue,
On wings of golden yellow, too.
Butterflies float in the air,
Making their homes most anywhere:
The rainforest, field, and prairie land,
On mountaintops, and desert sand.
If winter brings the cold and snow,
To warmer climates, off they go!
Returning home the following spring,
Beautiful butterflies on the wing!

– Author Unknown

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