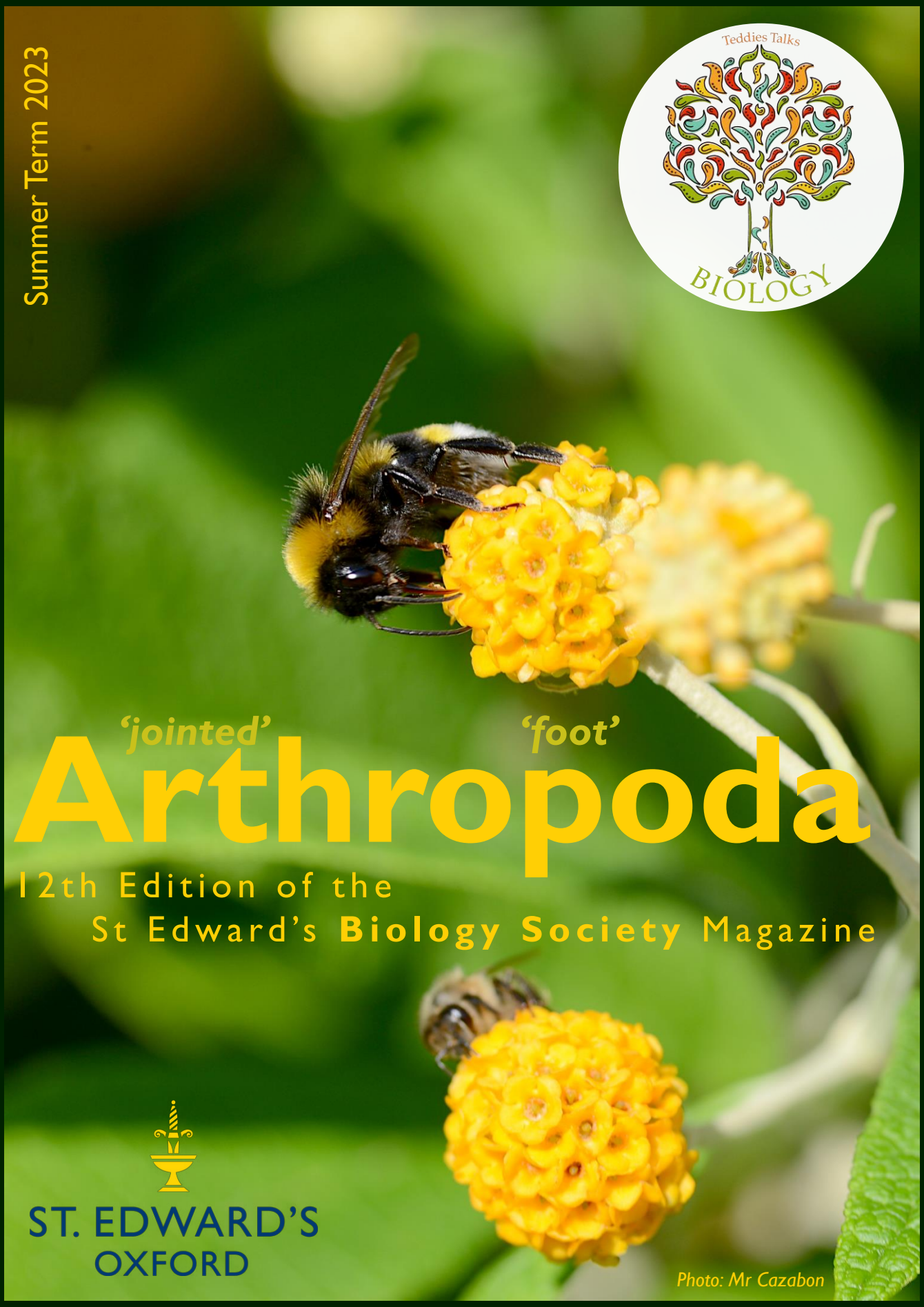
Summer Term 2023

Teddies Talks

BIOLOGY



*'jointed'* *'foot'*

# Arthropoda

12th Edition of the
St Edward's **Biology Society** Magazine

ST. EDWARD'S
OXFORD

*Photo: Mr Cazabon*

# Editorial

Dear Reader,

The Biology Society has worked tirelessly to create this twelfth edition of Teddies Talks Biology magazine since our last publication, Under the Sea. The title of this issue is **ARTHROPODA**, inspired by invertebrate animals which have tough exoskeleton, segmented bodies, and, most famously, jointed legs. 80% of all current animal species are arthropods ranging from microscopic mites to malaria-carrying mosquitoes, and to the ginormous Japanese spider crab with leg spans up to 3.7 metres long!

We dedicate this issue to Dr Andrew Davis who is moving on from Teddies after 22 years of biology education. Dr Davis is an entomologist whose research focused on tree-dwelling beetles that eat dung. His legacy in the world in zoology can be seen in the names of arthropod species he has discovered: *Teutamus andrewdavisi* (a forest spider) and *Onthophagus andrewdavisi* (a scarab beetle). He is truly an inspiration for the biologists at Teddies.

We hope you enjoy this issue.
Best regards,

**Teddies Talks Biology Editorial Team and Contributors**

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Kene Oreh
Karen Teng
Yukino Watanabe

# Contents



# Metamorphosis

*'change' 'shape'*

**Yukino Watanabe** L6th

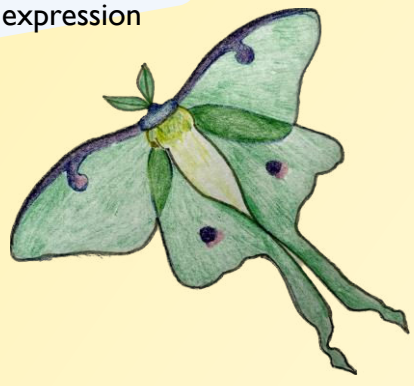
reveals the secret of how insects undergo metamorphosis

Metamorphosis is where an animal physically transforms from a larva into an adult with abrupt changes in its body structure. Many insects undergo metamorphosis including butterflies, bees, ants, beetles, and mosquitos.

Insects can undergo incomplete metamorphosis, with a nymph stage, which is just a smaller version of the adult that gets larger and larger with each moult. These insects do not show distinct changes in form.

Insects that do complete metamorphosis undergo four stages: egg, larva, pupa, and adult. Complete metamorphosis begins when the insect hatches out from its egg into the worm-like larva. Larvae have well-developed organs for movement because a larva has to look for food sources as it is essential that they store energy for later stages. Larvae have voracious appetites and eat several times their own body weight each day. Later, the insect develops a shell, turning into a pupa. At this phase, it stops moving or eating. An astonishing transformation takes place; the insect's structure completely changes, then an adult form hatches out.

How metamorphosis occurs differs by species but it is controlled by hormones. The two most important hormones for metamorphosis in butterflies are ecdysteroids (ECDs), which are similar to testosterone, and juvenile hormones (JHs). ECDs causes changes in gene expression whereas JHs ensure the growth of the larvae and prevent metamorphosis. The role of JH is to delay metamorphosis (keeping them juvenile) until the larva has reached an appropriate size. A drop in JH triggers metamorphosis in insects.



Metamorphosis often means that adult insects exist in a completely different habitat to the larvae. This means that there won't be competition for food between larvae and adults, and it allows the larvae to exploit food resources in the original habitat and still be able to move away to a new habitat when it has fully grown. Living in a new environment with different selection pressures enhances the potential for adaptation and evolution.

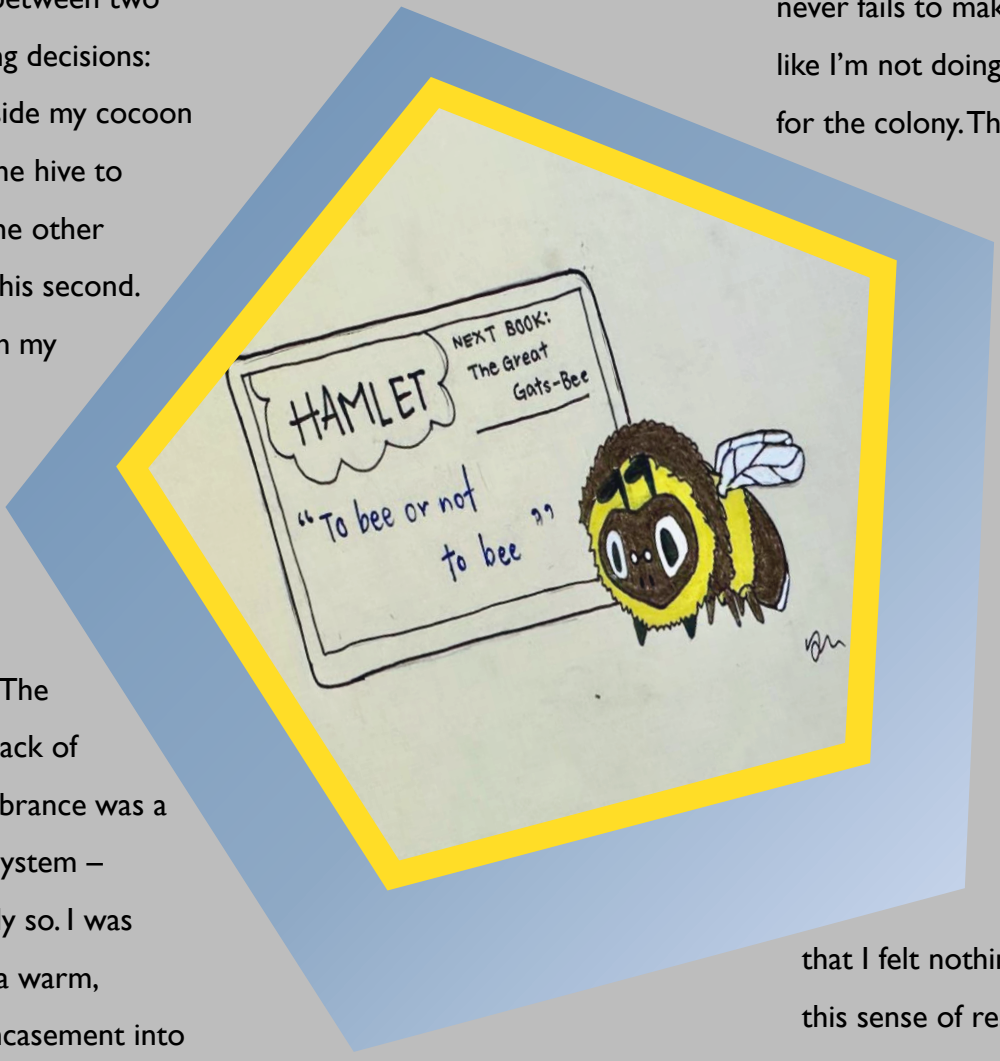
It is with the benefits of metamorphosis that insects are the most diverse and successful group in the animal kingdom■

# Can you Bee-lieve it?

**Kene Oreh** U6th illustrates an anthropomorphic view from the perspective of a bee in colony

Dear Diary,

I only just emerged from my cocoon a week ago, and now I'm hovering between two equally enticing decisions: crawl back inside my cocoon or head out the hive to swarm with the other drones right this second. Emerging from my cell was an extremely disorienting experience to put it mildly. The Immediate attack of Colour and vibrance was a shock to my system – understandably so. I was thrust out of a warm, comforting encasement into a world where my senses are continuously stimulated. Towering golden heights of eerily perfect cells surrounded me and established themselves as my whole world – a world that values order and efficiency above all. The noise of the worker bees bustling from one comb of the hive to the other with various tasks to complete never fails to make me feel like I'm not doing enough for the colony. This sudden urge to do anything for the sake of our colony's survival bloomed so suddenly that it's strange that I felt nothing close to this sense of responsibility while I was pupating. Since my emergence it consumes my every waking thought. It becomes increasingly hard not to feel a deepening sense of



# A Day in the Life of a Bee

incompetence as I watch the foragers zip past and waggle at one another while I wait patiently for the nurse workers to come and feed me and the other drones. I usually try to comfort myself with the affirmation of my more respectable qualities: my large eyes, extra sensitive antennae, dependable flight muscles and large build – I may not be as impressive as the queen, but I've got the worker bees beat in terms of size. One could argue (in an attempt to demolish my confidence) that these features are useless unless utilized. However, the time to put them to use is fast approaching.

I've heard some whispers from several reliable sources that a virgin queen will be close to the hive tomorrow as she carries out her nuptial flight, so all the drones within the colony will have to fly upwards to the drone congregation area to form a cloud and wait for her. Thousands of drones from various colonies will be there as

well but with the competitive nature of our gathering hanging over our heads, I doubt we will be able to get along that well. The pressure is nothing if not suffocating; this is finally my chance to do something important for the hive's development and future survival and development. Despite how attractive this all sounds, I'm not naïve enough to believe that there's room for forgiveness if I fail at the one thing I was made for. The one thing I was born for. There are merely two options that await me now: I'm lucky enough to gain the queen's favour amidst the swarm, mate successfully and plummet to my blissful death or I fly back to the hive overwhelmed by the undeniable feeling of failure and shame to await my eventual expulsion from the colony come autumn. Only ten to twenty of us will succeed so here's to hoping my next day is my last■

**Lucy Evans L6th** at the end of a productive and busy year asks an important question on (many) of our minds...

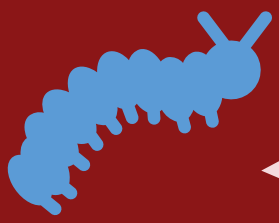
# Do arthropods sleep?

Sleep: we know what it is, but what about other animals? It turns out all animals including arthropods spend some time during a 24-hour cycle where they move very little, which we think is sleep. The main benefit of sleep in mammals is for consolidating memory: by selectively strengthening or clearing synapses, needed for learning. When asleep, insects are immobile and less responsive to external stimuli, which was first discovered in the honeybee. In sleeping bees, neurons in a part of their brain don't respond to light patterns that they would be able to normally respond to. Measuring sleep in insects poses many challenges as it can be difficult to differentiate between true sleep and sleep-like states. For example, butterflies rest in the late afternoon by hiding under leaves, but it is unknown if they actually sleep. Without adequate rest, they don't forage well and females lay eggs on the wrong plants for their caterpillar offspring to eat. Research in fruit flies show similar genes activated during sleep as in mammals and, like us, sleep deprived honeybees have impaired dancing skills, which can prevent bees from getting home. Fruit flies carrying mutations in circadian clock genes no longer sleep in one major phase but rather sleep in multiple chunks. Energy is still required during sleep due to the protein synthesis and repair which occur. As no food is consumed and heart rate decreases, other Process have to take over to supply the brain with sugar but not much is known about this. To conclude, it appears that insects and other arthropods do sleep, and in many ways their form of sleep is similar to mammalian sleep, however it is difficult to detect this biological process. Fruit flies, as well as honeybees, have been instrumental in developing our understanding of this scientific realm■

Insects are diverse, making up almost 80 % of all species in the Animalia kingdom. Insects belong to the Animalia kingdom, Arthropoda phylum and Insecta class based on the hierarchical system. They can be distinguished from other animals based on their morphology (studying the phenotypic characteristics) and molecular phylogeny (studying their DNA or mRNA sequences and the amino acid sequences). Insects have an exoskeleton, which makes them part of the phylum Arthropoda. Besides a segmented body consisting of a head with antennae, thorax, and abdomen, their other features include compound eyes, grinding mouthparts, three pairs of legs, and one to two pairs of wings attached to their thorax.

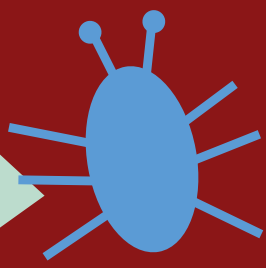
# Insect or not insect?

Khanh Luong L6th analyses the different features of insects, revealing their fascinating nature

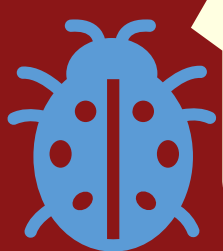


Some animals in the Arthropoda phylum may be mistaken for insects, such as spiders and crabs. Spiders have a segmented body and an exoskeleton but have only two body parts, no wings, and four pairs of legs. In contrast, crabs have compound eyes, antennae, and an exoskeleton but possess more leg pairs and a divided body of a cephalothorax and abdomen. These features differentiate insects from these similar-looking creatures.

Insects are fascinating creatures that have unique characteristics. They respire through spiracles, which are openings in their exoskeletons that allow air to flow into their tracheae. Insects also have eardrums on both sides of their bodies, grinding mouthparts for chewing food, and some have a proventriculus, like a gizzard, that helps break down their food. Throughout their life cycles, insects can undergo incomplete or complete metamorphosis. As seen in a grasshopper, incomplete metamorphosis occurs when an insect is born looking similar to its adult stage but smaller. In contrast, complete metamorphosis involves a complete change from birth to maturity, such as in the case of a butterfly.



With an estimated population of 10 quintillion, insects have a remarkable ability to survive and thrive. Their high reproduction rate allows them to rapidly increase their population and genetic diversity, facilitating quick and effective adaptations to harsh conditions. Insects have evolved specific phenotypes, such as their strong exoskeletons and exceptional camouflage abilities, which protect them from predators and help them transport heavy objects. Due to their large population size, insects play a critical role in food chains and reproduction of other organisms. Therefore, it is essential to prioritize insect conservation efforts to maintain the ecological balance.



Insects are truly intriguing creatures that continue to capture the imagination of scientists and nature enthusiasts alike. Their unique characteristics, such as their respiratory system, hearing abilities, and metamorphosis, make them some of the most adaptable and resilient animals on the planet. As climate change continues to threaten the delicate balance of our planet's biodiversity, it is crucial to recognize the importance of insect conservation efforts. Protecting insects and their habitats is vital for a healthy and sustainable future.

# Marine Insects

**Konnie Culshaw-Markham** L6th explores the nature of marine insects and their captivating adaptations

Marine insects spend part of their life cycle in the marine environment. Researchers estimate that there are over 5 million different insect species. Only around 3 % of the described insect species are aquatic or have aquatic stages during their lifetime. 9,000 of these species complete all their life stages under or on water, and they are mostly bugs and beetles. Around 30,000 species are aquatic during their larval stage, including flies and mosquitoes. To date, we do not know of any marine insects that can stay submerged throughout their whole lives.

Even though there are many species that have spent part of their lifecycle in coastal environments, there is only one official marine insect: the water strider or sea skater. There are over 40 species, and they are in the genus Halobates. Most sea skater species are coastal and are usually found in sheltered marine habitats.

Also known as water striders, sea skaters are small insects with an adaptation to their legs which allows them to "walk on water". Their legs are long and hydrophobic, meaning they repel water, so they can stay above the surface. Water acts differently on its surface. It is polar, meaning that molecules are attracted to one another, providing water with a high surface tension and a membrane which is possible to walk on.

Through time and natural selection, many insects have specifically adapted to live around coastal environments. Some species trap air between the hairs covering their bodies, which prevents them from drowning. Other marine insects have adaptations to their tracheal system including different types of physical gills ■

**Image courtesy of berniedup, via Flickr, CC**

# A Day in the Life of an **Emerald Swallowtail**

**Bilegt Gantulga** L6th takes us to the enchanting world of Emerald Swallowtails

Enchanting and vibrant, the emerald swallowtail is a unique butterfly, possessing black wings with iridescent, emerald-green streaks running diagonally along the edges. Native to the tropical countries of South-east Asia, it is relatively large with an impressive wingspan of up to 10 cm!

As the sun rises, it luxuriates in the warm, morning rays before spreading its wings and taking flight. It needs to eat. The emerald swallowtail nimbly flutters from flower to flower, sucking the sugar rich nectar using its long proboscis – an elongated mouthpart. Glucose is an energy source for activities such as movement and metabolism.

The emerald swallowtail plays a pivotal role in the sexual reproduction of plants. They carry pollen on their bodies from the anther in the stamen of a flower to the stigma in the carpel of another flower, allowing pollination. Pollen grains have a pollen tube cell which elongates down the style, through the micropyle into the embryo sac, allowing the cell to fertilise the egg. Yes, unbeknownst to the emerald swallowtail, it is encouraging the births of millions of flowers!

As afternoon arrives, the emerald swallowtail is tired. It relaxes on a nearby branch, brushing off any pollen on its body. Next begins the search for a mate.

Like many other butterflies, they display courtship dances to indicate that they are looking for a mate. The male butterfly begins with intricate aerial displays, shimmering their emerald-green markings in the sun. Next, they glide down, gently fluttering around the female butterfly so that pheromones – compounds that attract the right type of mate - waft towards and impress her in hopes she might join the male in their graceful performance of courtship.

As the sun sets, the butterfly looks for branches and leaves to rest in. Tucking in its wings and camouflaging to avoid predators, the emerald swallowtail falls asleep, revitalising its body for the next morning! Zzz…

# Arthropod World Records

**Rhinoceros beetle**
*Megasoma actaeon*

The heaviest beetle! These fellas can weigh up to 200g in their larval stage and up to 100g in their adult stage!



**Bullet ant**
*Paraponera clavata*

These ants have the most painful sting in the world! While not lethal, it will leave you in intense, agonising pain for about 12 - 36 hours after the sting.

**Hercules beetle**
*Dynastes hercules*

The largest beetle! These beetles can reach up to 19 cm long, their horn giving them an advantage over the close second - the titan beetle.


Giant chinese stick insect
*Phryganistria chinensis*
This is the longest insect in the world! It measures 640mm with its legs fully outstretched!
Goliath Birdeater
*Theraphosa blondi*
The largest spider in the world! Their body can measure up to 12 centimetres, and their leg span up to 28 centimeters!
Fairyfly
*Dicopomorpha echmepterygis*
This is the smallest insect in the world! The smallest flying fairyflies are 0.15 - 0.19mm. The males measure 0.127mm and are wingless and blind.
Australian tiger beetle
*Rivacindela hudsoni*
These beetles are the fastest runners! They can run at speeds up to 2.5 $ms^{-1}$ (9 mph)!
Drawings (and everything else) by: Anna Kolobova

# Wasp or not a wasp?

**Grace Baffoh Botchway** L6th

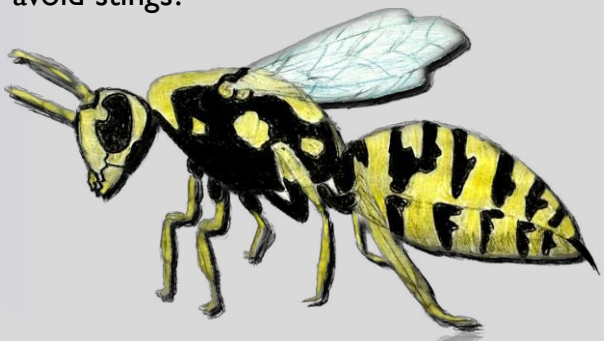
discusses wasp identification and how to avoid wasp stings!

Wasps are in the same insect family as ants and bees, including over 30,000 species. They have a slender, long yellow and black/brown body with two pairs of clear veiny wings and a distinctive narrow waist separating their thorax and abdomen.

Most wasp species can sting multiple times because the stinger is smooth, unlike the barbed stingers of honeybees, who can only sting once. The stinger is used for self-defence, but it is mainly used to subdue prey like spiders and insects. Lots of wasps feed on nectar and kill food for their young, but some wasps are parasitoid. They lay their eggs inside their prey's bodies, so the larvae feeds on the host's body from the inside out, providing a steady source of food. Some species use mimicry to deter predators.

One species of parasitoid wasp uses chemical mimicry to their advantage, to mimic the scent of ants when they are avoiding attack by guarded colonies.

One fascinating fact about wasps is that they tend to live in organised groups. Some species like yellowjacket and hornets build large paper nests in trees which can house hundreds to thousands of individuals. You may think wasps are pests, but they are vital for the ecosystem as they help to regulate insect populations and pollinate flowers. So how can you avoid stings?



So how can you avoid stings?

1. Wasps are attracted to sugar, so avoid wearing sweet-scented perfumes
2. Shut windows and doors and block holes with caulk or weatherstripping
3. Use harm free wasp traps
4. Hire a professional to deal with nests
5. Avoid swatting wasps as it makes them feel threatened and more likely to sting. Instead, stay calm and move away slowly■

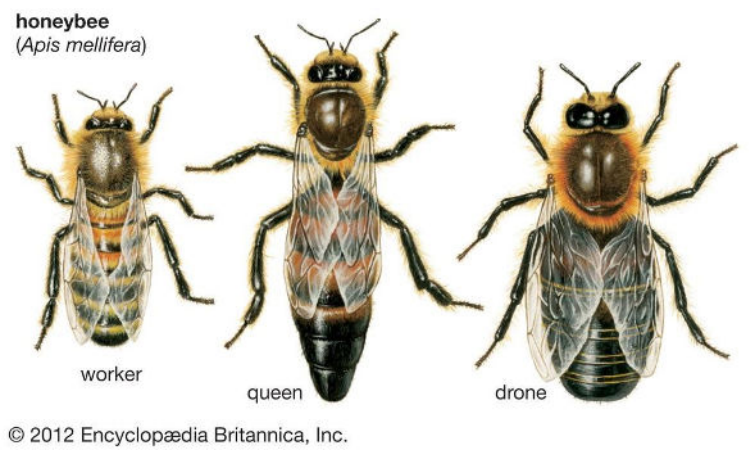
# What do honeybees even eat?

**Jennie Chennells**, Oxford fellow and bee nutrition expert, shares her research findings

Honeybees live in organised colonies with one queen and thousands of workers. Workers feed, clean and protect the colony. As bees age, they progress through different jobs. Working life begins in the hive, and they eventually go out to forage. The colony aims to rear healthy brood and provide the young with the right nutrition.

What is a healthy diet for a bee, and how do they get one? I am an Oxford University DPhil (PhD) student, and this is one of the questions I am studying. Bees balance their intake of different foods, so they eat optimum amounts of protein, fat, carbohydrates, and micronutrients. We can research what foods bees need, and what happens when required nutrients are unavailable.

Foragers collect pollen from flowers in their pollen baskets. This is where the phrase "bee's knees" comes from! Next time you see a bee, see what colour pollen they have collected, as it differs between plant species. They use their tongues to collect sugary nectar and store it in their honey stomach. They offload pollen and nectar in the hive and the work to store these as bee bread and honey begins.




Nurse bees feed the colony mouth-to-mouth or with specialised glands. You will have heard of royal jelly, but bees also produce jelly for regular worker bees. Did you know, if you feed a young larva with royal jelly, you can change its fate? It will develop into a queen bee rather than a worker bee!

As they age, bees eat less pollen and more honey to give them energy to fly and waggle dance on their foraging missions. Beekeepers put extra frames inside beehives that the queen cannot lay eggs on, so there is space to make honey. This is how we take honey from bees without depleting their stores!

Image courtesy of Charles J Sharp, CC

# Which arthropod is the smartest?

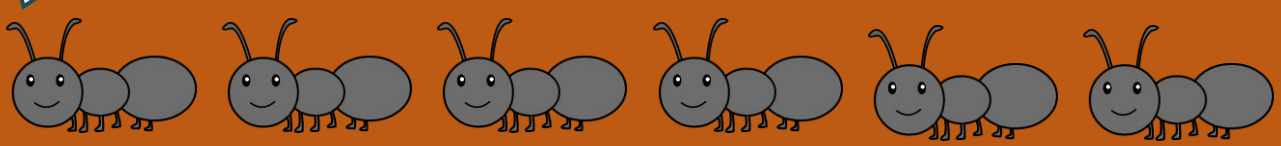
Ants, the most abundant insects on earth. Researchers estimate that there are over 20 quadrillion individual ants at this very moment on earth! We see them almost every day, wandering around a classroom or strolling across the field side pitches. Little did you know, ants are one of the most intelligent insects in the world.

One study proved that ants use tools, displaying sign of intelligence. The ants were presented with diluted honey and pure honey along with a plethora of other items that can be found in the wild like twigs, pine needles and grains of soil. There were also artificial items like paper and sponges. The ants were observed using the grains of soil to soak up the diluted honey and used the sponge to soak up the much more viscous pure honey.

They even tore up the sponge into smaller pieces to make transportation more efficient. This shows that ants can differentiate the properties of diluted honey and pure honey, then construct an efficient way to transport both substances using the items in their surroundings.

One very specific species is called the Fungus-growing ant. As you can tell, they can grow fungi. They carry pieces of grass and leaves into their nests. The humidity and decomposition of the leaves and grass creates ideal growing conditions for the fungus. The ants feed on the fungus which provides the colony with additional food sources. This is extremely helpful as the ants do not have to rely on one food source.

**Hayden Lai** L6th believes ants are the smartest



Dragonflies are one of the most unique creatures this planet has to offer, with their iridescent colours and aerial abilities. Not only are they beautiful, but they are extremely useful, as the main insect predators of mosquitoes. They help keep those disease-spreading nuisances in check. The agility of these creatures has intrigued scientists, prompting study into their adaptations for flight, and applying their natural wing mechanics to modern aeronautical inventions.

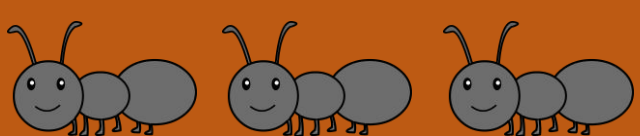
**Yann-I Liew** 4th believes dragonflies are the coolest insects

# Ants or Dragonflies?

Flying up to 54 km/h, dragonflies can propel themselves in all directions, with their most impressive feat being their ability to hover mid-air. They use wing muscles at the wing base, creating a rowing movement in the air by pivoting their wings up and down from a single pivot point. This is called direct flight. Each wing can be controlled independently, giving them a higher degree of flexibility in flight and the ability to make swift changes in direction mid-air.

Moreover, dragonflies can ambush prey by hovering in the air for more than a minute, catching their prey off-guard. They place their body horizontally and push their wings back and down, feathering and slicing up and forward at the end of the stroke. The wings beat out of phase, supporting their weight with the upward drag, reducing the overall drag and aerodynamic power expended, and enhancing the force of the wings.

The morphology of the dragonflies' wings also plays a major role in their aerodynamic abilities. Up close, the cuticle and chitin create an iridescent and translucent pattern, making it flexible and strong. Additionally, the corrugations of the wings act as stiffening elements due to a high second movement area, reducing bending during flight■



# What has Fruit Fly ever done for Science?

**Karen Teng** U6th

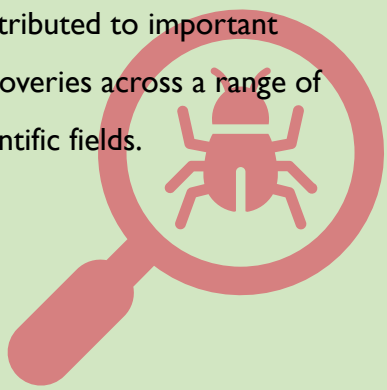
evaluates the contributions of fruit fly tests to various area of science

Fruit flies have been used as model organisms for scientific research for over 100 years. Their tiny body, short lifespan, and high reproductive rate make them ideal for genetic research. Research using them has contributed to medical development as fruit flies and human genomes have similarities. 75% of genes causing human diseases are found in fruit flies (Aungst, 2022).

Many scientific breakthroughs were aided by tests on fruit flies. They have been used to study adaptation, speciation, inheritance and other evolutionary processes. Darwin's theory of evolution and Mendel's rule of heredity were widely known. However, Thomas Hunt Morgan, an evolutionary biologist and geneticist was not convinced. He won the Darwin Medal in 1924 for his work with fruit flies which confirmed the theory of inheritance: 'genes are located on chromosomes like beads on a string, and that some genes are linked (meaning they are on the same chromosome and always inherited together)' (Nature Educator, 2014). Drosophila have also been used for studying organ and tissue development. Meier-Gorlin syndrome (MGS) causes dwarfism, missing patella, and other skeletal abnormalities (Balasov et al, 2020). MGS is caused by mutations in human genes. Scientists can use fruit flies to detect the mutation locations and functions by introducing mutant human genes into fruit flies. Thus, treatments can be developed directed to these mutations.

In 1947, fruit flies were the first animals to go to space! NASA studied the genetic effects of cosmic radiation on living organisms. When the rocket descended, all flies survived, with no genetic mutations (Mancini, 2018).

Great amounts of invaluable insights into evolutionary biology, disease developments, and medical treatments are owed to Drosophila tests. Fruit flies have been a workhorse of scientific research and contributed to important discoveries across a range of scientific fields.



# A Life of **S**ervice, **E**xcellence, and **S**cholarship in the Life Sciences

**Cosimo Gualandi** 4th

Interviews Teacher of Biology, Dr Andrew J Davis on his career and passion for beetles

**Q. Why did you want to be a teacher?**

When I was young, I never thought about becoming a teacher, but it has always been a part of my interest. After ten years of research, I just wanted a change and what I went on to do was teaching. It proved to be the right thing choice as I've enjoyed my time at Teddies very much. Research is quite narrow and specific on one group of animals, whereas teaching is much broader: it's drawing more of your other interests such as DofE, sports and it's a more sociable community. I was in 'the large animal group' in Cambridge. Though I enjoyed my research, I felt out of place; we would go to lunch and all they'd talk about is their own animals! I thought it was time for a change.

**Q. What was your PhD research about?**

I had the serendipity to do a final year project and wanted to do a life gorilla research at London, but my supervisor told me to do dung beetles because it was what he spent his life studying. So, I decided to try researching dung beetles, luckily for me my PhD teacher was a rainforest ecologist.

So, I applied for money to do the research and brough a one-way ticket to Borneo. The actual research was to do with deforestation and its impact on dung beetles such as extinction and loss of biodiversity because of certain logging practices.

If I could go back, I would still do research again because it is easy to capture and research them; much easier than a bigger animal.

**Photo: Dr Narajos**

# To find out more…

# Scan the QR code!

Insect or not Insect

Marine Insects

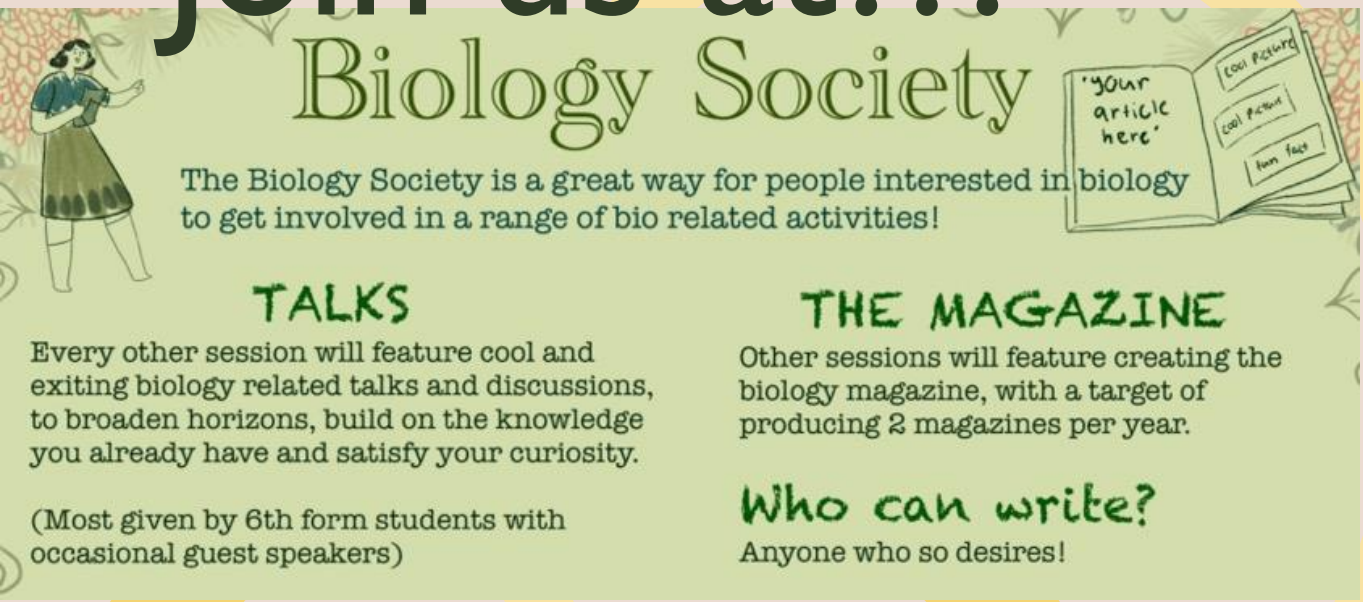
Metamorphosis

Dragonflies

What has the fruit fly ever done for science?

# Love **Biology?**

# Join us at…




*Crossword puzzle and answers: Anna Kolobova U6th*


*Photo: Dr Narajos*

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**Deputy Editors:** Bilegt Gantulga & Lucy Evans
**BioSoc President:** Karen Teng
**BioSoc Vice-President:** Khanh Luong
**Editorial support from:** Alexey Antonov Grantcharov, Judy Li & Yann-I Liew

**Teachers-in-charge:** Mr Joseph Cazabon & Dr Marco Narajos Ms Jennie Chennells

**Crossword puzzle and answers (overleaf):**
Anna Kolobova U6th

## Across:

5. A butterfly that tricks ants into taking care of it as a caterpillar. (5,4)
7. A caterpillar that freezes in winter without dying and defrosts when it gets warmer. (6,4,11)
8. A wasp that lays eggs in nests of other wasps and bees. The young eat the rightful occupants. (6,4)
9. An arachnid that lives in deserts and is known to chase people's shadows to hide from the desert heat. (5,6)
12. An arachnid that camouflages inside of flowers to prey on bees. (4,6)
14. An ant species known for farming mushrooms. (10,3)
15. Small terrestrial crustaceans that can roll into a ball and can be found just about everywhere. (5,4)
17. A female bee with fully developed reproductive organs. The mother of most if not all other bees in the hive. (5,3)

## Down:

1. A spider so rare it doesn't have a common name. Discovered by and named after one of the biology teachers here at Teddies. (8,12)
2. An arachnid commonly kept in cranberry bogs as pest control. (4,6)
3. A parasite that highjacks its host's nervous system, making it seek water, then burrows out of the body, killing the host. (9,4)
4. An arachnid that escapes parasitic wasps by flipping onto its side and cartwheeling down sand dunes. (5,6)
6. Males of this arachnid species have colourful abdomens which, along with the third pair of legs, are raised for display to impress females. (7,6)
10. An insect most commonly used as a model organism in genetics. (5,3)
11. A tiny crustacean found in fresh water that swims in a hopping and sinking motion. (5,4)
13. A big, fuzzy polinator that doesn't make honey. The queen hibernates underground in winter. (9)
15. A female bee that doesn't breed, builds and does tasks around the nest and outside of it. (6,3)
16. A male bee that lacks a stinger, doesn't work and doesn't make honey. (5,3)