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Squid dissection: a hands-on activity to learn about cephalopod anatomy

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Did you know that a squid's brain is donut shaped, so that the oesophagus can pass through it? Or that squid have three hearts? Explore the fascinating physiology of squid in this hands-on activity.

Introduction

The practice of carrying out animal dissections for educational purposes dates back to the 13th century, and it has been used since then to promote understanding of the functioning of the whole animal body through the analysis of its parts.[1] Dissections can also evoke a sense of wonder; it is much more engaging to see things first hand than to read about them in a book. We ran this squid dissection activity as part of an ocean literacy program, and it was overwhelmingly the students' favourite activity on the feedback forms.

Many alternatives to animal dissections have been developed, from 3D models to more recent digitalised techniques, like videos or computer programs. However, actual dissections can provide more meaningful learning experiences due to their total sensory nature, which removes abstrac-

tion and instead promotes an understanding of the animal's structure, function, adaptation, and diversity, as well as the care of living organisms.[2] The ethical concerns involved in the dissection of the squid can be addressed by taking into consideration that cephalopod populations are increasingly globally in response to changes in the ocean,[3] as well as the fact that the dissection can be planned to incorporate the consumption of the squid if safety regulations allow it.[4] The squid used in our dissections were used to provide food for animals in the aquarium.

Squid dissection

In this activity, students investigate the external features of a squid and then dissect it to examine some if its internal features, while learning how these different features contribute to the functions the squid needs to survive. Squid are invertebrates and have a sophisticated and fascinating anatomy that is very different from that of the vertebrates students may be more familiar with, so it is interesting for them to learn about this very different kind of body construction.

By tweaking the number of dissections used (demonstration or group activity), the level of engagement with the students and the depth of details discussed during the procedure, the activity can be carried out with students between 8 and 15 years old. It should take one lesson to complete.

Materials

- The Squid infosheet
- Fresh or frozen squid (one per class or one per 3–4 students)
- Plastic trays or old newspaper
- Safety scissors
- Gloves (latex free where required)
- Reusable container or bucket
- Dishwashing cloth or kitchen roll
- Antimicrobial surface-sanitizer spray
- Dishwashing liquid
- Rubbish bag

Safety note

It is advisable to wear gloves during the procedure, but the squid dissection can be carried out with bare hands, provided that both squid and hands are washed thoroughly beforehand and afterwards.

After the dissection, collect all the squid remnants and dispose of them following the regulations issued by your local authority, which can vary among countries. (The mantle, arms, and tentacles of the squid are actually edible, while the head and innards should be discarded.)

Squid

Squid belong to the class of molluscs called Cephalopoda, which literally means head foot. In fact, the main characteristic of these animals is that they have arms and tentacles directly attached to their head, whereas the rest of the organs are contained in a muscular sac-like part of the body called the mantle. Most members of the cephalopods have lost their shell (like octopuses of the Incirrata suborder) or have an internal shell that supports the mantle (like squid and cuttlefish); only the chambered nautiluses have maintained an external true shell.

There are over 300 species of squid in the world. Their size can vary from a couple of centimetres, such as the pygmy squid, to the giant squid, which grows to 18 m. Although most squid will live alone, like the rest of their cephalopod relatives, some species of squid live in schools of millions. Certain species are also the deepest-living cephalopods and have been found at depths of more than a 1000 m below the surface of the ocean. However, most squid can be found in the open ocean and shallow coastal waters between the sunlight and twilight zones all around the world.

Caribbean reef squid, BES Islands
Image: Betty Wills/Wikimedia, CC BY-SA 4.0

Carefully sanitize surfaces once the dissection is completed. Wash trays and the scissors used for the dissection with dishwashing liquid.

Procedure

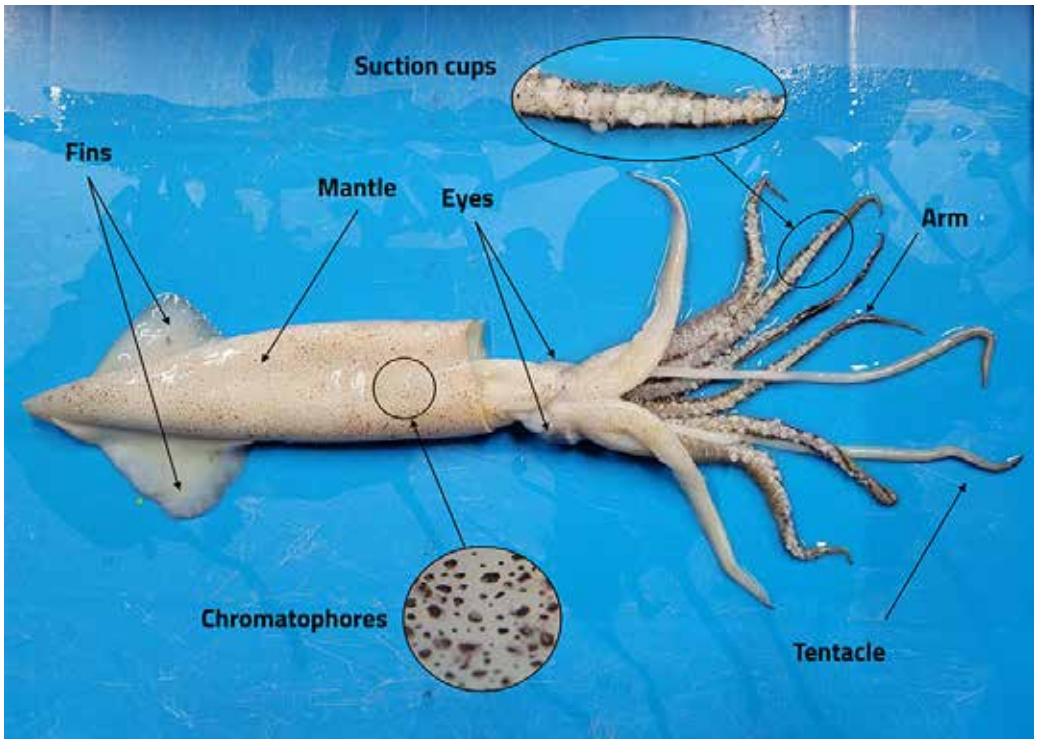
If frozen squid are used, they should be placed in a container and thawed overnight. This process can be accelerated using running water if necessary.

If this is done as a class, the teacher should ideally allow the students to come forward and examine the different features at each step. If the students are doing it themselves, clear instructions need to be given, and it is advisable to go through one step at a time with discussion in between.

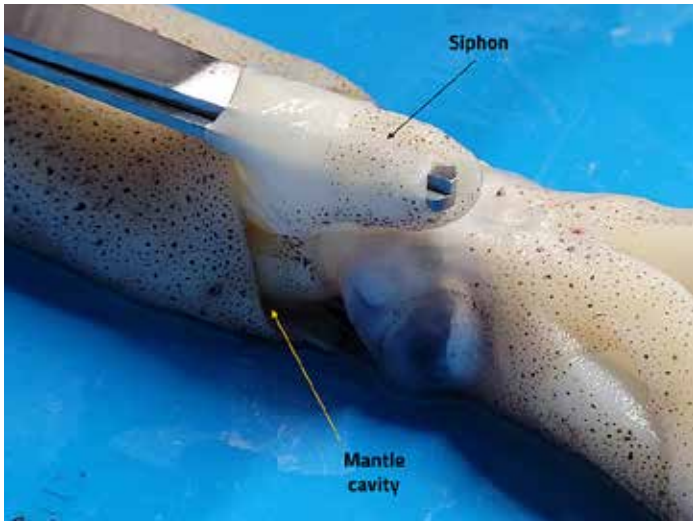
The accompanying Squid infosheet can be used during the activity to learn interesting facts about squid that relate to some of the features examined. It might be a good idea to place the sheets in plastic pockets so that they don't get wet and dirty.

Part 1: External features of the squid

1. Place a squid on each tray carefully, spreading all the arms and tentacles, and being sure that the siphon faces upwards.
2. Invite the students to observe the torpedo-like shape of the squid and to point out any parts of the body that they can identify.
3. The mantle is the main part of the body. It contains most of the organs, namely, gills, digestive system, hearts, reproductive organs, and ink sac.
4. Point out the colourful spots on the surface of the mantle and the rest of the body. These are the chromatophores, which are the cells that contain the pigments that allow the squid to change their colour faster than a chameleon! Squid use the colouration not only for camouflage, but also to communicate with each other.
5. The two triangular-shaped elements at the side of the top of the mantle are the fins. The squid can use them to swim, but their main function is to help the squid to steer, and therefore, to change direction in the water.
6. At the base of the mantle is the head of the animal, and on top of it sits a structure shaped like a funnel called a siphon, which allows the squid to swim like a jet ski. Water gets drawn into the cavity of the mantle, and then it is squirted out through the siphon, so that the squid can swim backwards with very fast movements (in fact, squid are the fastest invertebrates).



Some of the external features of the squid. The species represented in this picture, and the following ones, is the California market squid (Doryteuthis opalescens).
Image courtesy of the authors

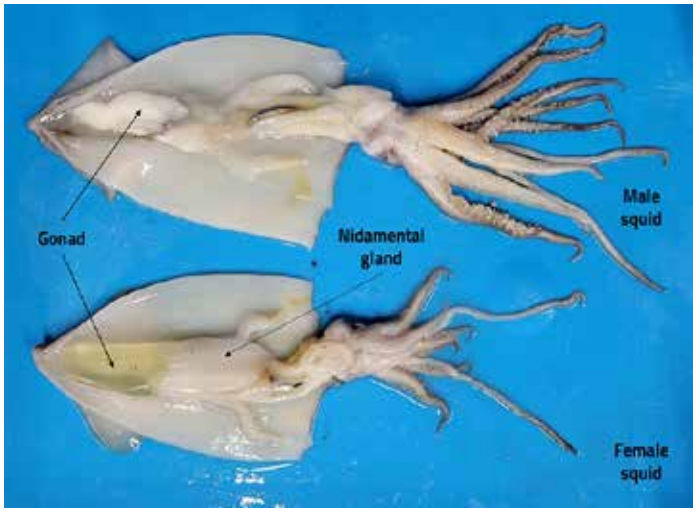


Close-up of the siphon. The mantle cavity represents a conspicuous space: large quantities of water can be drawn into it, which explains the speed of the squid as it swims.
Image courtesy of the authors

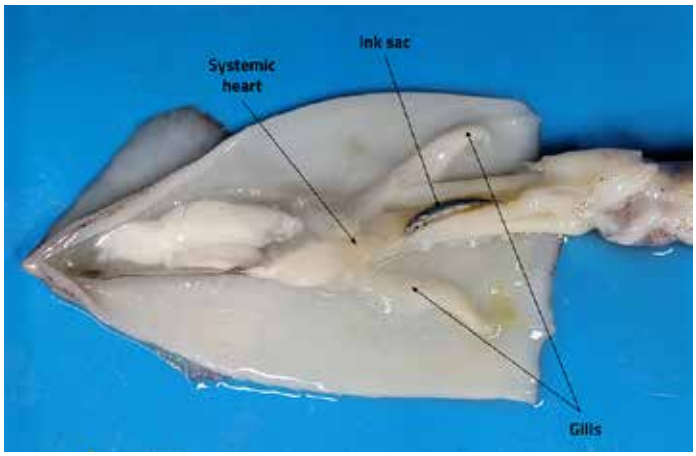
7. At the base of the head, among the arms, is the location of the buccal cavity, which contains the beak of the squid. It is composed of two parts, like the beak of birds, and it is made of a molecule called chitin, which is a common component of mollusc shells. This explains why the beak of the squid is extremely hard!
8. It cannot be shown during the dissection, but it is now time to point out that the brain in these animals is shaped like a doughnut because the oesophagus has to pass through it.
9. At the two opposite sides of the head are the eyes, which are very big in relation to the size of the squid, when compared with terrestrial vertebrates. Thanks to their location of the eyes, the squid can have a panoramic view around them, but since their eyes have only one kind of photoreceptor, they cannot see colours in the way humans do.
10. Squid have ten arms in total: the two longest ones are called tentacles and are especially adapted to grab prey, whereas the other eight arms hold it. For these purposes, all along the arms, and on the extreme ends of the tentacles, the squid have multiple suction cups that help capture prey.
11. Now it is time for the students, if they want, to pick the squid up and have a close look at all the different body parts described so far.
12. Ask the students to consider the squid's texture, feel, and temperature. You can encourage students to consider five words to describe the squid, maybe all beginning with the letter S.

Part 2: Internal features of the squid

1. Place the squid carefully back on the trays in the same position as before.
2. Cut open the mantle of the squid with the safety scissors from the middle of the lower edge, just behind the siphon, to the tip. Keep the scissors pointing upwards, so that no inner organs are damaged.
3. The organ at the very top of the mantle cavity is the gonad or reproductive organ: by looking at it, it is possible to distinguish the female squid from the male. The gonad in the female is see through and granular in aspect (it contains the microscopic eggs), whereas in the male it is white and stringy.
4. Another difference between female and male squid is the nidamental gland, which is the white organ that sits at the bottom of the gonad in the female, but is absent in the male. The nidamental gland secretes the jelly capsules in which the fertilised eggs are laid.
5. The small, peachy-coloured organ located around the centre of the mantle cavity is the systemic heart, which controls the blood circulation in most of the body of the squid, except the gills. It is good to highlight at this point that the blood of the squid is blue, instead of red, because it does not contain the oxygen-carrier molecule haemoglobin, but another pigment called haemocyanin.
6. The gills can be observed at the two sides of the body. They can be recognised by their feathery appearance and are white in colour. On top of each gill, there is a small heart that controls the blood circulation within it (the gill or branchial hearts). Yes, squid have three hearts!



Different appearances of the gonad in male and female squid. The female gonad is often greenish in colour and normally more conspicuous than the male gonad due to the presence of the eggs. The nidamental gland is bright white in colour and quite massive; it often covers the systemic heart completely and sometimes even the ink sac.
Image courtesy of the authors

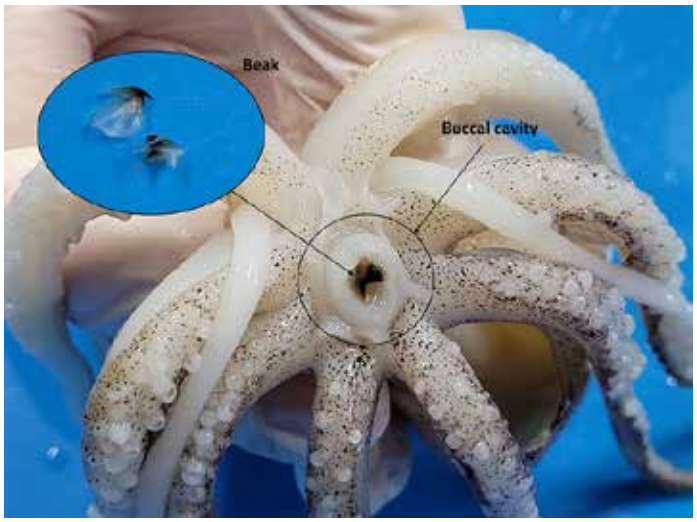


Location of the systemic heart, ink sac, and gills inside the mantle cavity. Students often think, at first, that the ink sac is a small fish eaten by the squid that has not been digested! The systemic heart, and even more, the gill hearts, is very faint in colour and in many cases not easy to spot; therefore, students might need particular support with this step of the procedure.
Image courtesy of the authors

7. The organ that looks like a small silvery fish is the ink sac. The ink is black because it contains melanin, and it is released in the environment to create a cloud when the squid feels under threat or wants to hide. The ink sac can be cut out of the rest of the body easily using the safety scissors.
8. Grab the head of the squid and gently pull the organs away from the mantle. You will be able to see that underneath there is the gladius pen, that is, the internal shell of the squid, which gives support to its body. The gladius pen looks like a piece of plastic, but it is also made of chitin, as already seen with the beak.
9. A nice suggestion for the students, once they have isolated the pen, is to dip it in the ink sac and see if they can write something on a piece of paper!

A gladius pen isolated from the mantle. Students are always surprised by its look and texture – so similar to plastic!
Image courtesy of the authors

10. Using the tips of the scissors, it is possible to isolate the beak of the squid. Locate the buccal cavity in between the arms, gently squeeze the base of the arms so that the beak is exposed, and carefully scoop out each half of the beak.



The buccal cavity and the two parts of the squid beak. The brown part of the beak is the hardest one, where most of the chitin is concentrated.
Image courtesy of the authors

11. Finally, students can dissect the eyes to look for the lens. Squeeze one eye very gently and use the scissors to create a small cut on the surface. Keep applying pressure on the eyes with the fingers; this will force the lens to come out. Take care to point the eye downwards while doing this, as the eye contains optic fluid that can shoot out as the eye is being cut.

Shaped like a pearl, the lens of the squid is used to focus on movement, similarly to the automatic lens of a camera or telescope. In comparison, a human lens is oval and is used to focus on colour and shape instead.
Image courtesy of the authors

Discussion

The squid dissection is a simple activity to help students learn about the functions of an animal's body, and to compare it to how the human body works. A few questions might prompt the students to think about the reasons behind some features of the squid's body and inspire them to deepen their knowledge about the biology and ecology of these animals, for instance:

1) Why are the eyes so big relative to the size of the body?
2) Which type of organisms do you think they feed on?
3) Why is the brain shaped like a doughnut?
4) What is the advantage of using ink as a self-defence strategy?

To learn more about squid, many other interesting activities can be carried out, for instance, letting students research their favourite squid species; comparing squid with their predators or to us human beings; or imagining how a human body would be if it integrated the features that make cephalopods so unique, such as the suckers or chromatophores. Finally, the students can have fun creating their own flying squid and competing to see which one travels fastest or furthest using maths and measurements to find a winner. More reaching resources and ideas for cephalopod science can be found on the Marine Institute Explorers Education Programme website. «

References

[1] Hart LA, Wood MW, Hart BL (2008) Why dissection? Animal use in education. Greenwood, Westport, CT.

[2] The National Association of Biology Teachers' position statement on the use of animals in biology education: https://nabt.org/Position-Statements-The-Use-of-Animals-in-Biology-Education

[3] Doubleday ZA et al. (2016) Global proliferation of cephalopods. *Current Biology* **26**: R406–R407. doi: 10.1016/j.cub.2016.04.002

[4] Cephalopod recipes in four languages from the Cephs & Chefs Project: https://www.cephsandchefs.com/wp-content/uploads/2021/03/Recipes_horizontal_r23_web.pdf

Resources

- Check out the Marine Institute Explorers Education Programme website for a range of ideas and resources to carry out a complete cephalopod science investigation with your students.
- Discover what Daphnia can teach us about biology and ecology: Faria HM, Fonseca PA (2022) From drugs to climate change: hands-on experiments with Daphnia as a model organism. *Science in School* **58**.
- Dissect a chicken from the supermarket and discover the system that enables birds to fly: Hui E, Blackshaw F, Talbot A (2017) How do birds fly? A hands-on demonstration. *Science in School* **41**: 38–43.
- Investigate how the heart pumps with this hands-on (literally) activity: Hui E, Taplin A (2013) From the bottom of our hearts: a hands-on demonstration of the mammalian heartbeat. *Science in School* **27**: 20–27.
- Explore the effect of carbon dioxide on ocean chemistry with practical activities: Ribeiro CI, Ahlgren O (2021) An ocean in the school lab: carbon dioxide at sea. *Science in School* **55**.
- Read about how shark skin has inspired designers and engineers: Wegner C, Dumcke R, Tönnesmann N (2017) Design inspiration: the secrets of shark skin. *Science in School* **41**: 19–23.
- Dive into the European Atlas of the Seas and find a user-friendly interactive educational tool on the ocean: Van Isacker N (2023) The European Atlas of the Seas: an interactive tool for ocean literacy. *Science in School* **61**.

AUTHOR BIOGRAPHY

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