

AMPLEXUS

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Figure 1. Rainforest_harley (photographer). (2006). Orange-tipped Frogs (*Litoria xanthurus*) in amplexus. April 19, 2021. https://commons.wikimedia.org/wiki/File:Litoria_xanthurus_amplexus.jpg. Copyright 2006. Creative Commons Attribution-Share Alike 2.0 Generic.

During mating season, male frogs and toads perform a reproductive behavior known as **amplexus** to guard females and await the opportunity to fertilize eggs. Imagine the action as a "frog hug" or a "frog piggy back ride". The male clasps his arms around the female at the head (cephalic amplexus), the armpits (axillary amplexus) or the waist (inguinal amplexus) and can remain joined for minutes to months. Amplexus often begins well in advance of the eggs being laid, and in some species can last up to 6 months.

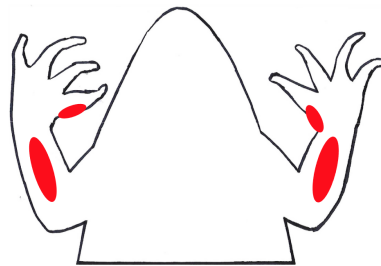
For many species, mating success depends partially on the ability of males to hold onto their mates, especially in areas where competition is high. A behavior of such extended duration requires unique **morphology** (physical traits), and males therefore have specialized adaptations that help them hold on for long lengths of time, including thicker upper body muscles and nuptial pads.

HOW DO THEY HANG ON?

NUPTIAL PADS



Figure 2. Fischer, C. (2010). A male Edible Frog (*Pelodytes punctatus*), caught in the breeding season. April 19, 2021. <https://commons.wikimedia.org/wiki/File:NuptialPad.jpg>. April 19, 2011. Copyright by Creative Commons Attribution-Share Alike 3.0 Unported.



Nuptial pads typically found in these areas

During the mating season male frogs and toads develop nuptial pads. These are spiny areas of skin on the thumbs and/or forearms that contain the protein **keratin**, making them darker, thicker and harder than regular skin. These pads function to improve males' grip on the females and help the mounted male defend against attacks from competing males. They appear just prior to the beginning of the breeding season and disappear after it concludes.

The spiny texture of the pads provide the friction necessary to grip onto the smooth body of the females.

Below the nuptial pads are glands that secrete **pheromones** (chemical substances that influence the behavior of other organisms) and special proteins called **amplexins**. The nuptial pads have a glue-like substance that helps the male maintain his grip on the female.

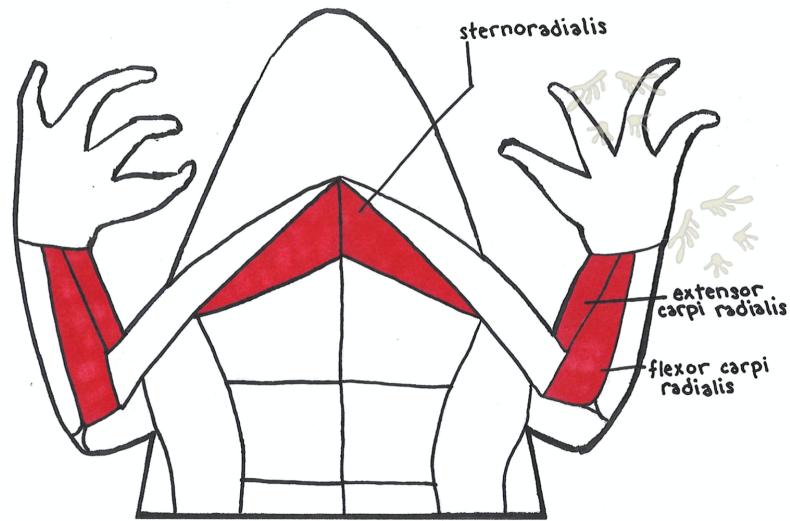


Figure 3. Fredyfish4, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons

AMPLEXUS CONT.

MUSCLES

The muscles of male frogs show special adaptations that help them maintain their grip and withstand attacks from competing males when grasping their mates. The muscles involved in amplexus in male frogs may show strikingly different characteristics to the corresponding muscles in female frogs of the same species, a phenomenon known as **sexual dimorphism**.



Although female frogs and toads are typically larger than their male partners, with bigger snouts and longer bodies, research shows that the muscles of male frogs in species that display amplexus may have greater mass, length and resistance to fatigue than equivalent muscles in female frogs. In fact, muscles that are **vestigial** (undeveloped/functionless) in females may be quite well-developed in males of the same species!

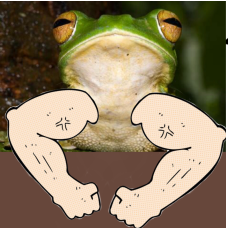
In some species, certain muscles in males may overdevelop as the breeding season approaches, and then return to normal once breeding has concluded. Differences in musculature between males and females is therefore more pronounced during the breeding season, with the the upper body muscles of males able to produce greater force and experience slower relaxation times. This helps the frogs to stay clasped together for long periods of time. These muscles can be found in the forearms (flexor carpi radialis and extensor carpi radialis) and the chest (sternoradialis).

While there are many biological and evolutionary factors that may influence sexual dimorphism, there is evidence that suggests an important influencer of the sexual dimorphism seen during amplexus is the hormone **testosterone**. In studies, muscles in the forearms reacted strongly to testosterone treatment, growing in mass and length.

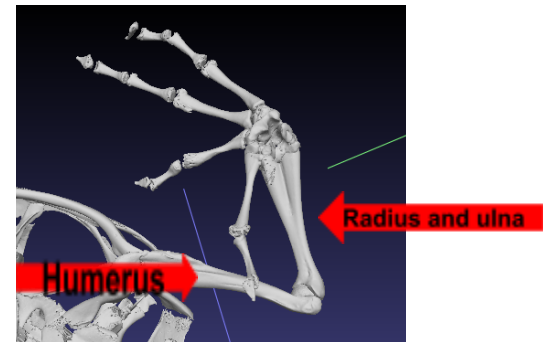
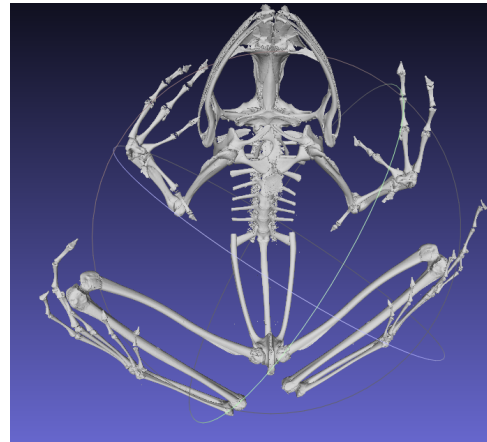
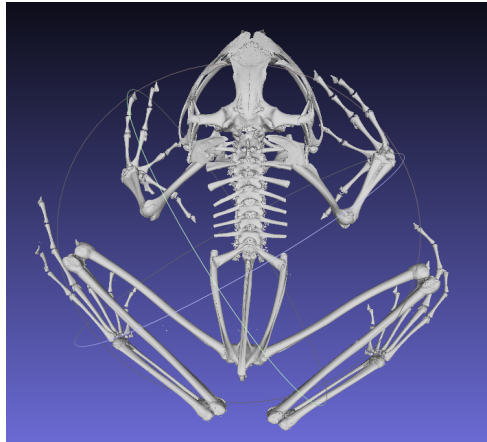
Studies show that more successful males have much thicker forearms than females and less successful males. Such strong sexual dimorphism in musculature is uncommon in **vertebrates** (animals with a backbone) and is just one of the many ways in which frogs have evolved to maintain amplexus and defend their mates against interfering males in the days, weeks, or months they are joined together.

CT SCANS

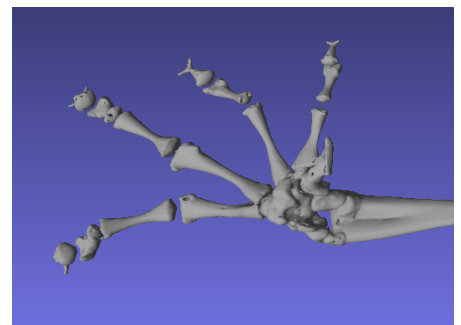
Look at CT scans with the frog-inator!



Dorsal and ventral view (view from the stomach and from the back) of *Stefania scalae*

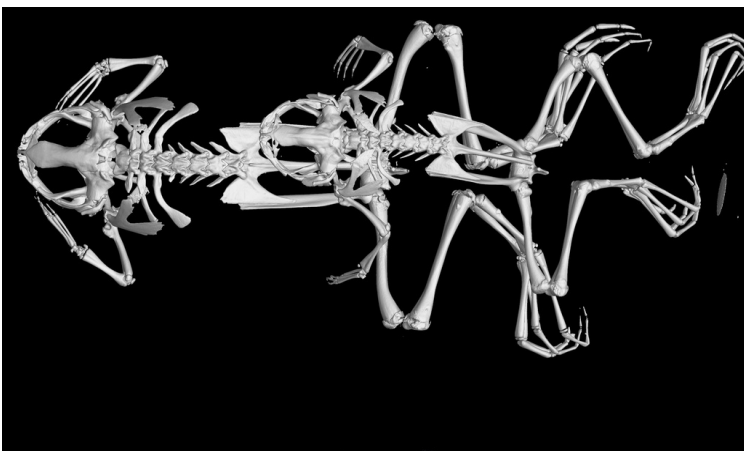


A hand of *Allophryne ruthveni*



Frogs' unique anatomy plays a significant role in enabling them to perform amplexus. CT scans are incredibly beneficial for observing differences in anatomy across different frog species. One drawback is that we cannot view muscles with CT scans, particularly the important forelimb muscles integral to amplexus! Even so, CT scans allow us to observe the radius and ulna, as well as the humerus. These bones serve as the attachment sites for the important muscles without which amplexus would not be able to happen. Below is a CT scan of two frogs in **inguinal amplexus** - observe the male's arms securely wrapped around the waist of the female.

CT scans of two *Xenopus laevis* frogs in amplexus



KIDS ACTIVITY SHEET

You will need:

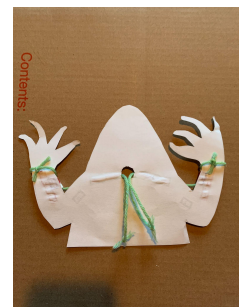
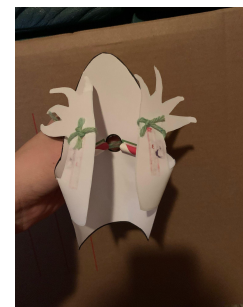
- One frog cut-out
- Two straws
- Yarn
- Tape or glue
- Scissors
- An adult to supervise





Figure 4. Brian Gratwicke, CC BY 2.0
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Instructions:

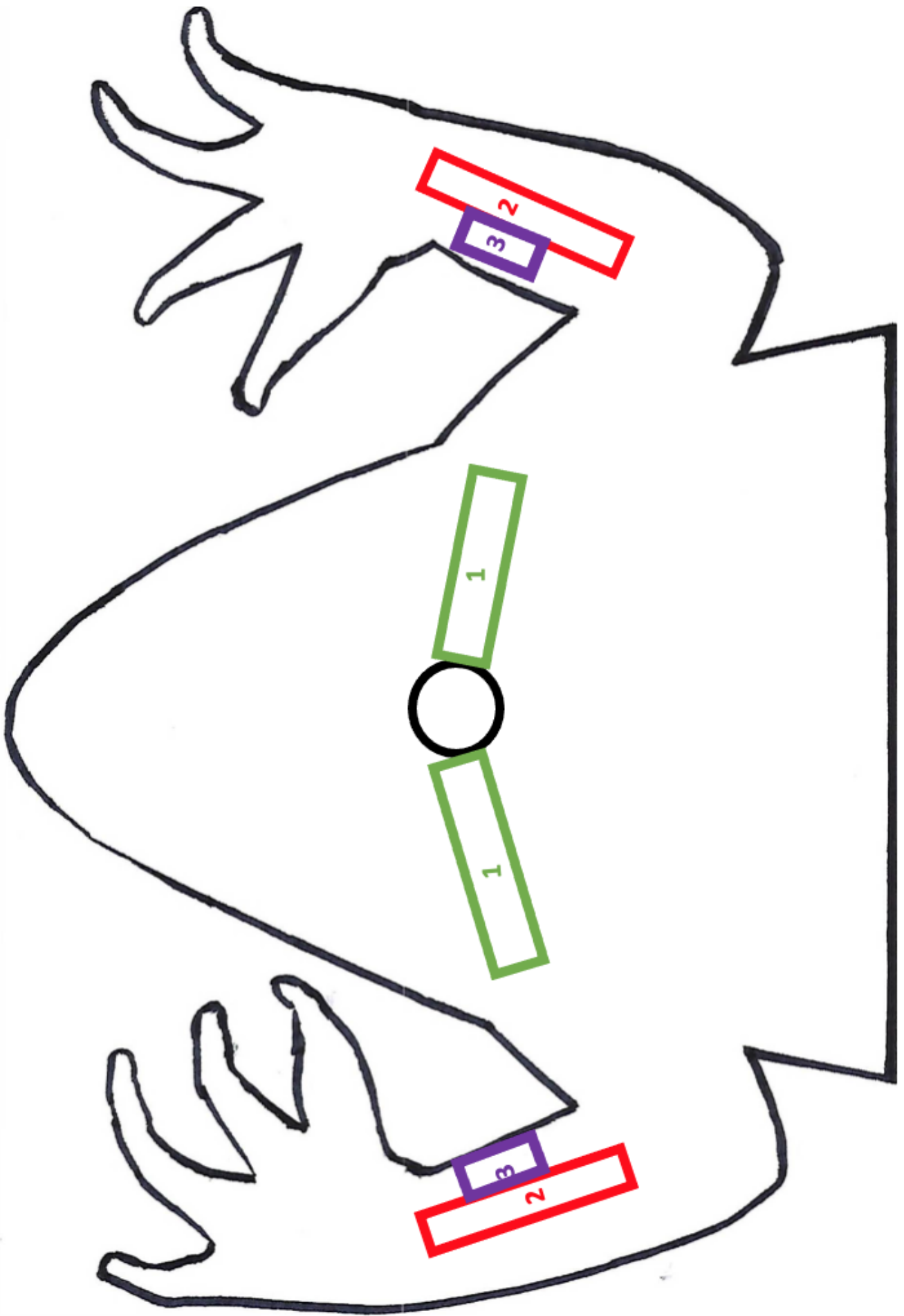
1. Cut out the frog outline (Optional: Add some color to your frog for fun using pencils or crayons)
2. Cut out the circular hole in the center of the frog.
3. Cut four pieces of yarn to a length of 10cm each and separate into two groups of two.
4. Cut the straws into six segments using the lengths of the boxes indicated on the frog diagram.
5. Tie the ends of two of the strings together.
6. Pass those two pieces of thread through the straw meant for box labelled 1 on the diagram.
7. Separate the pieces and thread one strand of yarn through box 2 and the other through box 3.
8. Then tape the straws to the boxes on the diagram.
9. Tie the string around the frogs wrist into a knot and tape the it to keep it in place.
10. Repeat instructions 5-9 for the other side of the frog.
11. Place the ends of the strings through the hole in center.
12. Pull the strings in the center directly back and see how the frog moves his muscles to cling onto his partner!



KEY:  Flexor carpi radialis

 Extensor carpi radialis

 Sternoradialis



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