11-2014

Eight Legged Encounters

Eileen A. Hebets
University of Nebraska-Lincoln, ehebets2@unl.edu

EIGHT LEGGED ENCOUNTERS

By Eileen A. Hebets, University of Nebraska; Funded by NSF

TABLE OF CONTENTS

these questions can be obtained as participants are guided through their own web-weaving exercise.

RESEARCH-RELATED STATIONS

MISCELANEOUS STATIONS

XVI. ACKNOWLEDGEMENTS

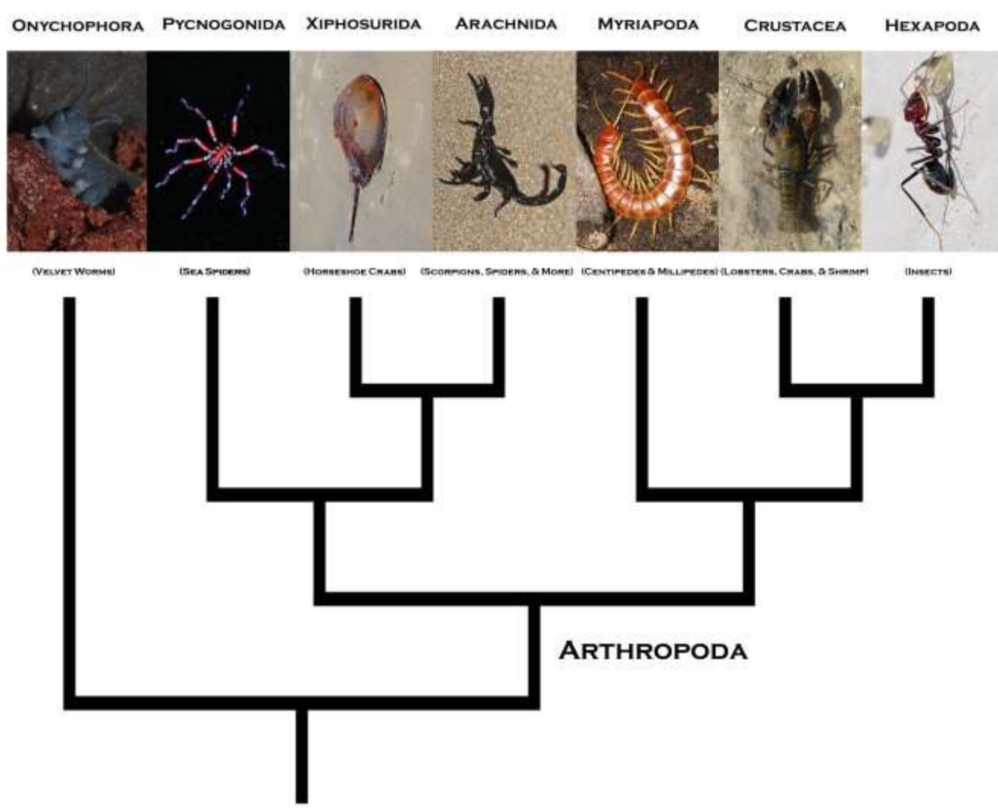
a. This program was funded in part by a National Science Foundation grant (DRL–1241482 to EAH). Material was developed in collaboration with Marie-Claire Chelini, Jessie Rose Storz, Cody Storz, and Malcolm Rosenthal. Steven Schwartz, Jason Stafstrom, Kathy French, Priscilla Grew, and Judy Diamond were all extremely helpful in grant writing, facilitating the first live event, and/or discussions. Pawl Tisdale (artist) was phenomenal to work with on all aspects of the project!

EIGHT LEGGED ENCOUNTERS

I. WHAT IS AN ARTHROPOD?

GOAL: To introduce the arthropods, with a focus on the major groups within this phylum and the basic characteristics associated with each group.

BACKGROUND: Arthropods are invertebrates that have an exoskeleton, a segmented body, and jointed appendages. The Phylum Arthropoda is separated into multiple sub-phyla including the extinct *Subphylum Trilobitomorpha* (trilobites); as well as the extant (or living) *Subphylum Chelicerata* (arachnids, sea spiders, horseshoe crabs, eurypterids), *Subphylum Hexapoda* (insects), *Subphylum Myriapoda* (centipedes and millipedes) and *Subphylum Crustacea* (crabs, lobsters, shrimp).The most recent hypothesized phylogenetic relationships among these groups can be seen in the phylogeny below:



MATERIALS:

- Ideally you would have live representatives of as many of the above groups as possible.
- For the game, you will need the following:
    - 5 large squares outlined in white tape on the floor (one representing each of the arthropod subphyla).
    - Within one of the squares (the one representing the Subphylum Chelicerata), you will need two big squares outlined in blue.
        - (one representing the Class Meristomata and one representing the Class Arachnida)
    - A large tub with numerous plastic animal examples of all of the above groups. On the underside of each animal, place a dot of paint to match the color of the card to which it belongs (e.g. green dots on the bottom of insects, blue dots on the bottom of crustaceans, red dots on the bottom of myriapods, etc.). These colors are seen on the borders of the cards that go with the game and will enable participants to check their “answers”.

PROCEDURE:

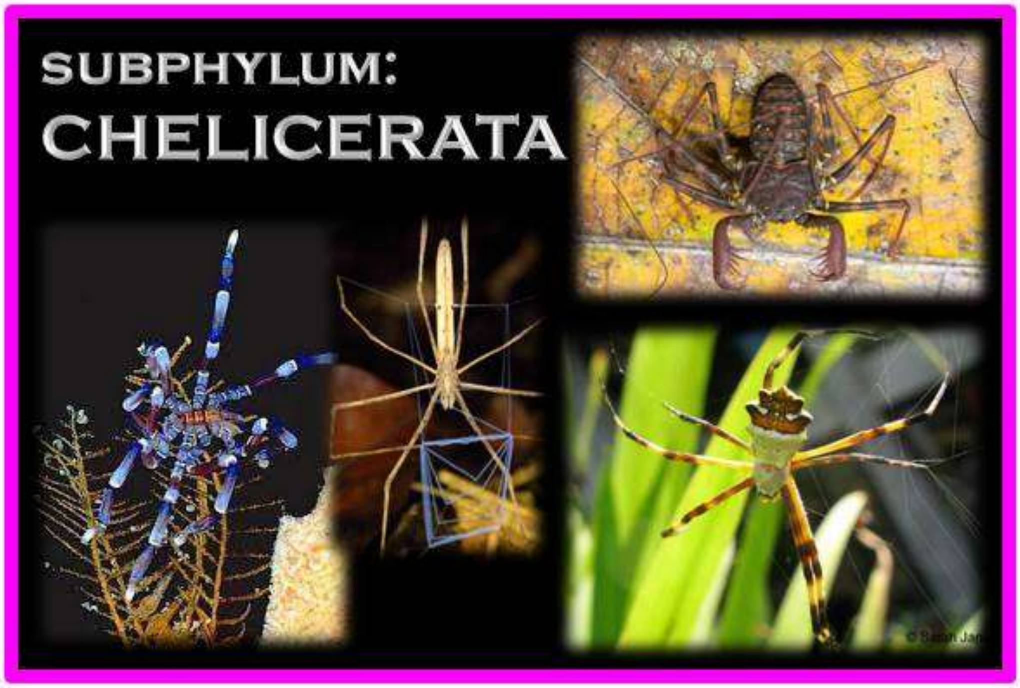
- Place within each square a laminated card with a list of characteristics describing animals that belong in that square.
- Invite participants to go through the bucket of animals on the floor and try to place animals in their appropriate squares.
- When participants feel that they are done, allow them to flip the card over to see pictures of animals that should be represented in each square. Laminated cards also provide taxonomic information regarding each arthropod group.


SUBPHYLUM:
HEXAPODA
© Sarah Jane Rose


SUBPHYLUM:
CRUSTACEA

- 6 LEGS
- 3 BODY PARTS
- 1 PAIR OF ANTENNAE
- COMPOUND EYES
- MANY HAVE WINGS
- COMMON & DIVERSE

- 3 BODY PARTS
- 2 PAIR OF ANTENNAE
- PRIMARILY AQUATIC
- MANY SPECIES HAVE 10 LEGS (5 PAIR)
- COMMONLY EATEN BY HUMANS


SUBPHYLUM:
CHELICERATA


SUBPHYLUM:
MYRIAPODA

- 2 BODY PARTS
- CHELICERAE PRESENT
  (APPENDAGES IN FRONT OF MOUTH)
- PEDIPALPS PRESENT
  (APPENDAGES IN FRONT OF WALKING LEGS)
- 8 WALKING LEGS
- NO ANTENNAE

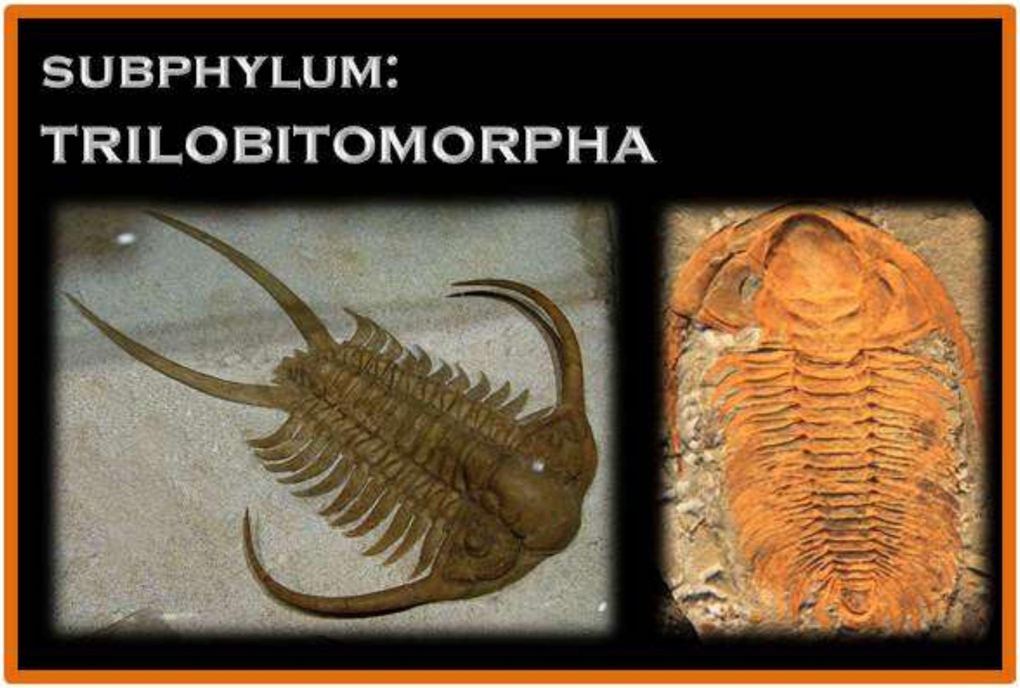
- 2 BODY PARTS
- PAIRED APPENDAGES ALONG LENGTH OF BODY
- 1 PAIR OF ANTENNAE


SUBPHYLUM:
CHELICERATA
CLASS:
ARACHNIDA


SUBPHYLUM:
CHELICERATA
CLASS:
MERISTOMATA

- 2 BODY PARTS; CHELICERAE PRESENT; PEDIPALPS PRESENT; 8 WALKING LEGS; NO ANTENNAE
- NO EXTERNAL SEGMENTATION ON BODY PARTS
- BODY PARTS JOINED BY STALK (PEDICEL)

- UNSEGMENTED CARAPACE (HARD SHIELD)
- SPINELIKE TELSON (TAILPIECE)
- BREATH THROUGH BOOK GILLS


SUBPHYLUM:
TRILOBITOMORPHA

- extinct
- 3 body parts
- Compound eyes
- Common arthropod fossil

II. CREATE A CHELICERATE

GOAL: To introduce the audience to chelicerates and their basic characteristics. Namely: (i) they are composed of two body parts (*tagmata*), (ii) they all have a pair of appendages in front of the mouth termed *chelicerae*, and (iii) they all have a second pair of appendages directly behind the mouth called *pedipalps*.

BACKGROUND: Like all arthropods, chelicerates (a subphylum of the Phylum Arthropods) have segmented bodies with jointed appendages. They have an exoskeleton made of chitin and protein and must molt their skin to grow. The living chelicerate groups include the *Arachnida, Pycnogonida* ('sea spiders') and *Xiphosura* (horseshoe crabs). Chelicerates are an ancient group of animals that likely originated in the Cambrian period (~541 – 485 million years ago). An extinct group of chelicerates, *eurypterids* (sea scorpions), are known from fossils dating back 445 mya. Eurypterids were giant predators of the Paleozoic seas; they represent the largest known arthropods that ever lived, reaching more than 8 feet in length.

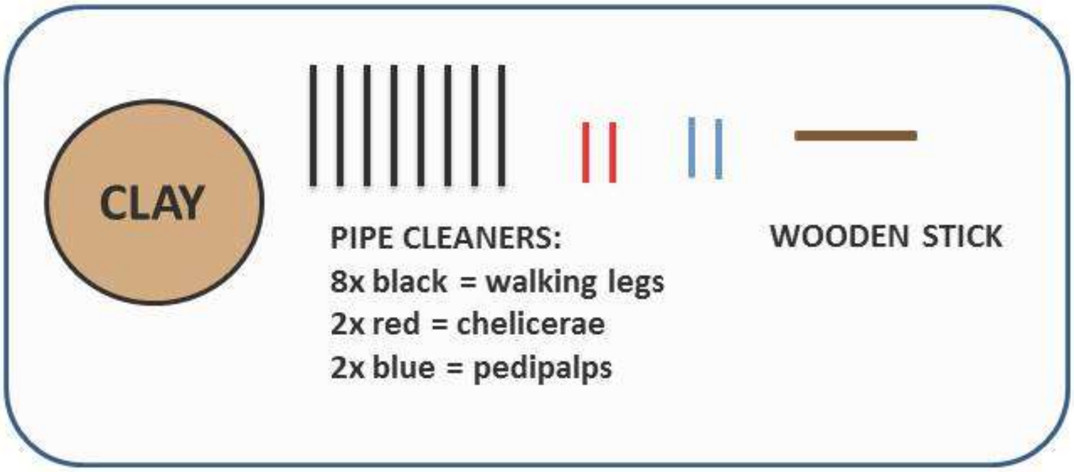
MATERIALS:

Ziplock bags pre-filled with the following:

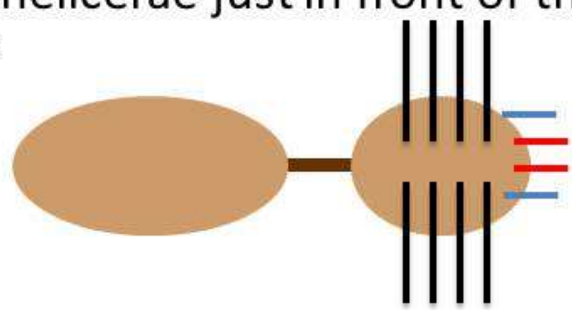
- Small block of air-dry clay
- 8 small cut pieces of black pipe cleaner (representing walking legs)
- Wooden stick to hold two body parts together
- 2 small cut pieces of red pipe cleaner (representing *chelicerae*)
- 2 small cut pieces of blue pipe cleaner (representing *pedipalps*)
- Instruction sheets placed on the table so participants can work independently if they choose.

CREATE A CHELICERATE

IN YOUR ZIPLOCK BAG:



- Separate your clay into 2 pieces.
- Use the wooden stick to connect the 2 pieces (body parts).
- Place 4 legs on each side of the *front* body part.
- Place 2 pedipalps just behind the "mouth"
- Place 2 chelicerae just in front of the "mouth"

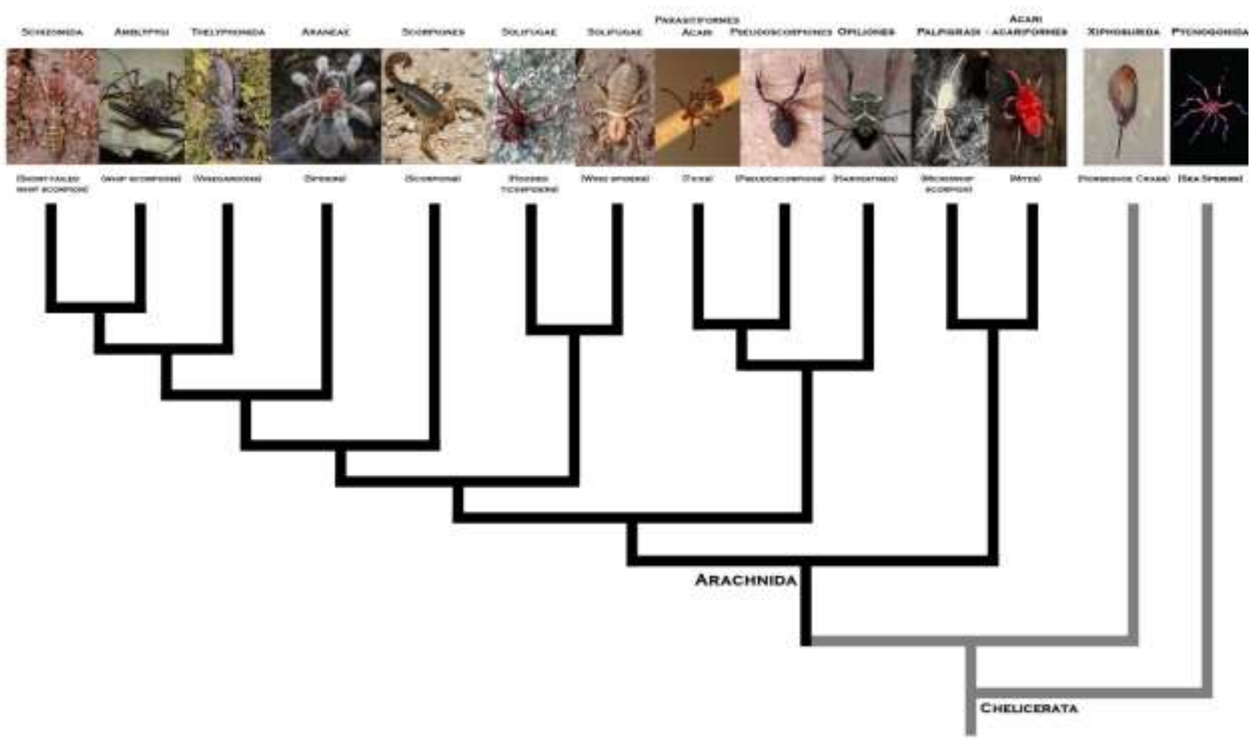


EIGHT LEGGED ENCOUNTERS

III. ASSEMBLE AN ARACHNID

GOAL: To introduce the audience to arachnids and highlight the fact that there are *eleven different* orders of arachnid alive today and they vary greatly in body shape.

BACKGROUND: Arachnids are a Class of arthropods grouped together based upon the following characteristics: (i) 2 body parts, (ii) chelicerae and pedipalps, and (iii) eight pair of walking legs (although in some groups these are modified into a purely sensory and non-locomotory function). Most living arachnids are terrestrial, and most are predatory. The current hypothesis regarding the phylogenetic relationship among the living arachnids can be seen below:

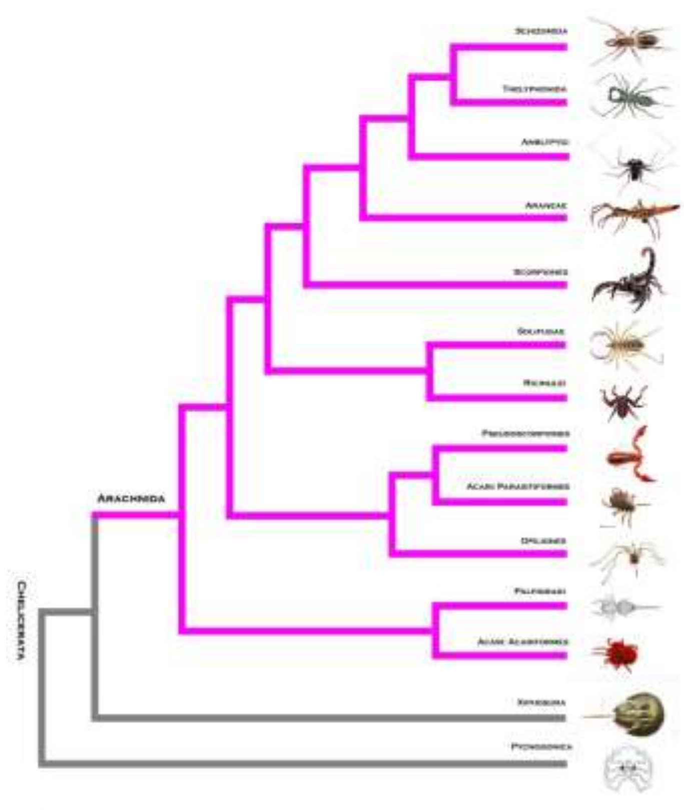


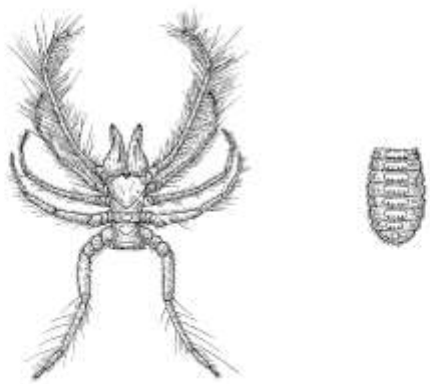
MATERIALS:

- Pre-cut front and back body parts representing each arachnid order. Be sure these are in random order in separate piles.
- Tubs of crayons.
- Age-appropriate scissors.
- Tape.

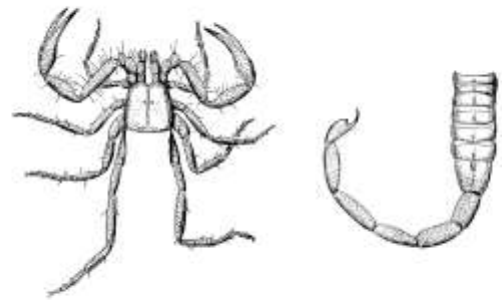
PROCEDURE:

- Allow participants to choose one front body part and one back body part to color.
- After completing the coloring, participants are asked to cut out each body part and to tape them together to create their own unique animal.
- Participants can look at the key provided to figure out which two arachnid orders went into creating their animal.

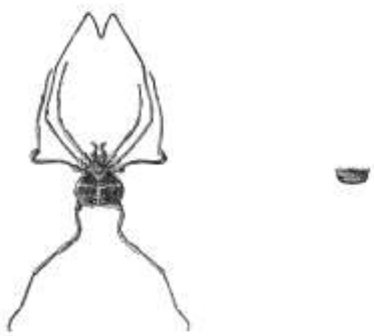




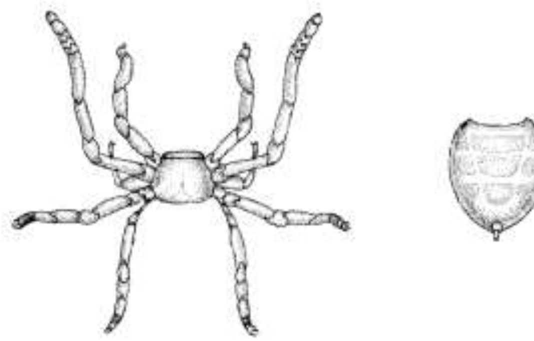
Order Solifugae



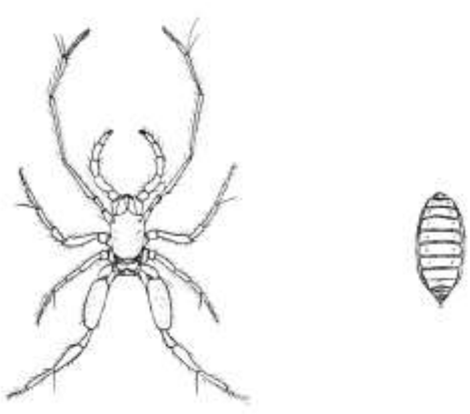
Order Scorpiones



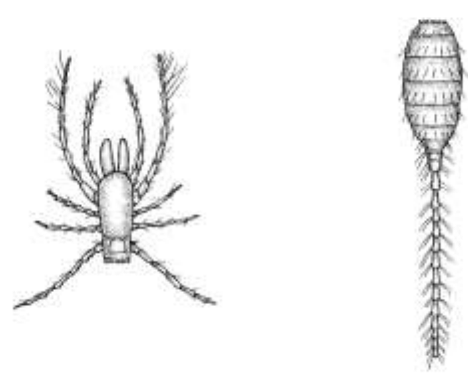
Order Opiliones



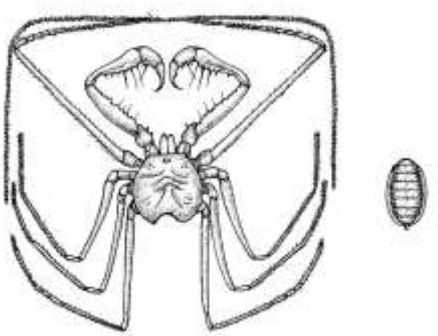
Order Ricinulei



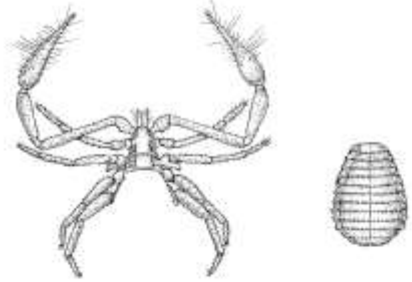
Order Schizomida



Order Palpigradi



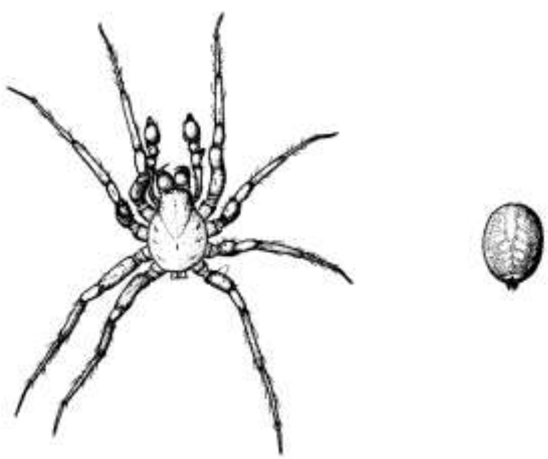
Order Amblypygi



Order Pseudoscorpiones

Order Thelyphonida

Order Acari



Order Araneae

EIGHT LEGGED ENCOUNTERS

IV. BUILD A BURROW

GOAL: To learn about the history of spiders and their silk. Specifically, this activity highlights the fact that spiders have been around and using silk before insects took to the air.

BACKGROUND: Spiders and their relatives are among the earliest animals known from the fossil record. *Attercopus fimbriunguis* is a 380 million year old (Devonian) fossil that was originally believed to be a spider. Although scientists contend that *Attercopus* produced silk, it is not considered a spider because it did not have spinnerets; it may have been the ancestor of today's spiders or at least a close common ancestor. Among the living spider, the oldest Mesothelae fossil is 290mya (Permian).

Mesothelae have remained unchanged for ~300my. As such, examining the living Mesothelae may give us insights into spiders of the past. There is only one family of living Mesothelae (Liphistiidae) with 5 genera and ~89 species. They are restricted to Southeast Asia, China, and Japan and are the most basal of all living spiders. They are morphologically distinct because of the segmented plates on their abdomen and the location of their spinnerets - in the middle of their abdomen. They also have 8 spinnerets.

Living Mesothelae dig burrows in moist soil and line their burrows with silk. They then build a trapdoor using soil protein to glue various materials together. They hide in the burrows, which offer protection from predators and prey. Their trapdoor also creates a membrane between underground and above-ground air which moderates humidity and even protects from short-term flooding.

Mesothelae are entirely nocturnal. Some keep at least one foot in their door, waiting to sense and capture prey. Others use silk to extend their hunting ground beyond their doorstep. They lay down 6 – 8 'trip lines' that radiate a few centimeters from their door. These lines are slightly raised and passing prey "trip" on these lines, sending a vibration back to the spider so that it knows when and where to pounce.

Mesothelae also use silk for egg protection.

The oldest Mygalomorph fossil is 240mya (Triassic) and the oldest Araneomorph fossil is 225mya (Triassic).

MATERIALS:

- Door hangers
- Foam strips
- Pre-cut pieces of fishing line
- Glue
- Tuning forks

PROCEDURES:

- Choose one doorhanger.
- Choose one foam strip.
- Roll the foam strip up into a circle and place it so that it rests within the opening of the door hanger (use glue if necessary). Make sure the strip sticks above the doorhanger – this is your burrow's turret.
- At *each* opposite corner of the doorhanger (the corners opposite the hole), make a small (~.5cm) cut diagonally towards the center so that each corner has an identical cut.
- Take two pre-cut pieces of fishing line and make a small knot at one end of each of them.
- Lodge the knot underneath the cut and pull the fishing line tight so that the fishing line is captured.
- Pull the non-knotted end of the fishing line through the burrow opening.
- Hold each of your fishing lines (*i.e.* silk strands) in between the fingers of each of your hands underneath the "burrow".
- Close your eyes and ask someone to use a tuning fork to touch one of the silken trip lines.
- Can you tell where the vibration is coming from? Do you think you would successfully capture your prey?

EIGHT LEGGED ENCOUNTERS

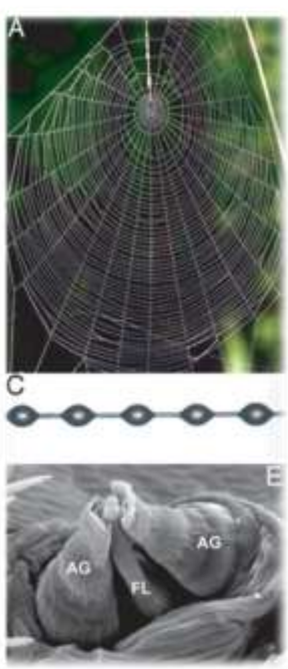
V. CRIBELLATE VS. ECRIBELLATE SILK

GOAL: To learn about the two different ways in which spiders have evolved to improve the efficiency of prey capture with their webs.

BACKGROUND:

Tens of millions of years before the orb web evolved, spiders used major *ampullate silk* in various forms (lampshades, tangles, sheets, funnels, etc.). The first webs were horizontal and were not orbs. Currently, scientists believe that orb web evolved only once. Cribellate silk is produced from numerous tiny silk glands underneath a specialized spinning organ called the *cribellum*.

The cribellum is derived from spinnerets (the anterior median spinnerets) and its surface is covered by hundreds-thousands of tiny, elongate spigots which each produces an extremely thin single fibril of cribellate silk (~0.00001mm thick). All spigots act together to produce a single cribellate thread made up of thousands of silk fibrils. All araneomorph spiders were once cribellate, but the cribellum has been lost numerous times.



Cribellate spiders also possess a row of toothed bristles – the *calamistrum* – on the metatarsal segment (2nd to last) of the last leg (4th walking leg). These bristles are used to comb out the cribellate fibrils.

The combination of *flagelliform* silk threads and *aggregate* silk protein glue ~136 mya represents a major explosion in spider species numbers. Spiders that combine flagelliform and aggregate silk proteins are in the superfamily *Araneoidea*. In these spiders, a sticky liquid silk is carried on fibrous silk support lines.

In summary, cribellate (wooly) and ecribellate (sticky) catching silks increase the prey holding efficiency of webs that act as snares or traps. They represent completely different evolutionary solutions to the same problem.

MATERIALS:

- Pre-cut pieces of yarn
- Eyebrow brushes/combs
- Glue
- Confetti (or something small and light with lots of points)

PROCEDURE:

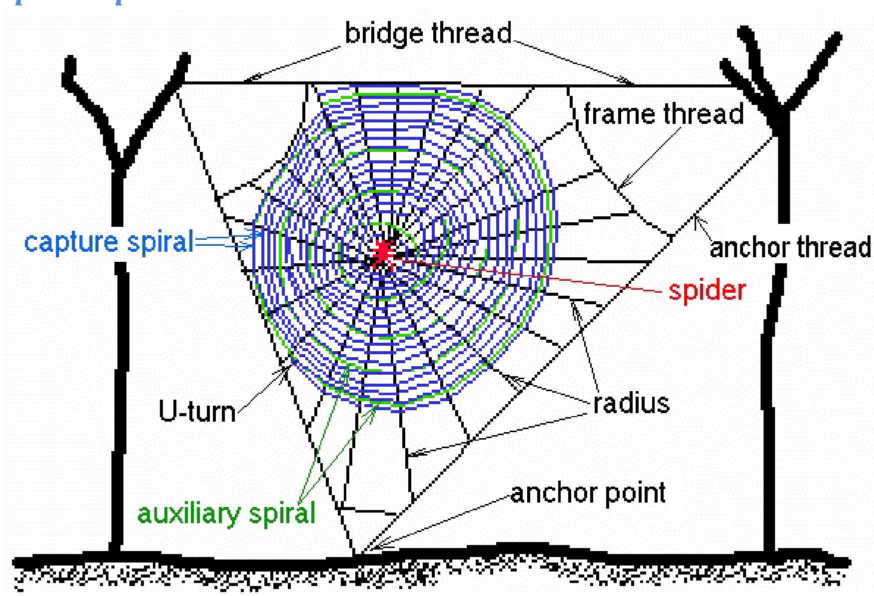
- Take a piece of pre-cut yarn.
- Pick up one piece of confetti.
- Toss the confetti at the yarn…does it stick?
- On ½ of the yarn, add droplets of glue and toss the confetti at the yarn…does it stick?
- On the other ½ of the yarn, comb it out using the eyebrow brush.
- Once the yarn is combed out, toss a piece of confetti at it…does it stick?

VI. WEAVE A WEB

GOAL: This station invites participants to think about how orb-weaving spiders go about building their web and how web structure and use of silk from specific glands might facilitate prey capture.

BACKGROUND: Not all spiders construct webs, but they all use silk in one way or another (*e.g.* dispersal, nest lining/construction, diving bell construction, guide lines, cocoons, etc.). Spiders can have up to seven different types of silk glands (*Major Ampullate gland, Minor Ampullate gland, Flagelliform gland, Aciniform gland, Tubuliform gland, Pyriform gland,* and *Aggregate gland*), each of which produces silk or glue with distinct properties.

Orb-weaving spiders are hypothesized to share a common ancestor (*i.e.* the orb web is *monophyletic*), with an ancestral orb web consisting of a horizontal orb constructed out of *cribellate* silk. The evolution of *flagelliform silk* (core silk produced by *flagelliform glands* coated with sticky droplets produced by *aggregate glands*), along with a vertical web orientation, is suggested to be a *key innovation* in the diversification of the Araneoid spiders. An orb web consists of ***bridge, anchor***, and ***frame threads***; a non-sticky ***radius***, an ***auxiliary spiral***, and a ***capture spiral***.



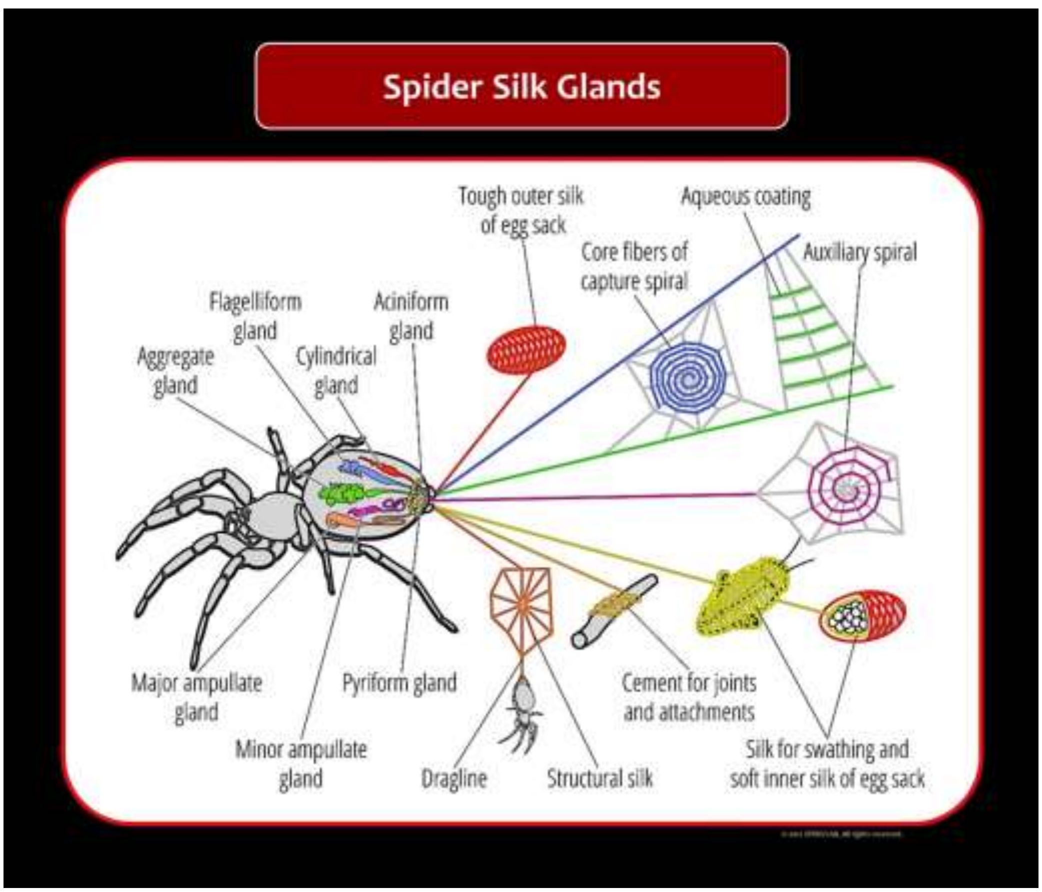
Orb-weavers use four distinct types of silk to construct an orb web. The **anchor and frame threads** are produced by the **Major Ampullate glands**. This silk has high tensile strength and absorbs kinetic energy well. **The temporary capture spider, or auxillary spiral**, is produced by the **Minor Ampullate glands**. This silk is highly elastic. The core silk for the **capture spiral** is produced by the **flagelliform glands** and coated with sticky droplets produced by the **aggregate glands**. Finally, the **pyriform glands** produce a type of glue that is used to attach silk strands together during web construction.

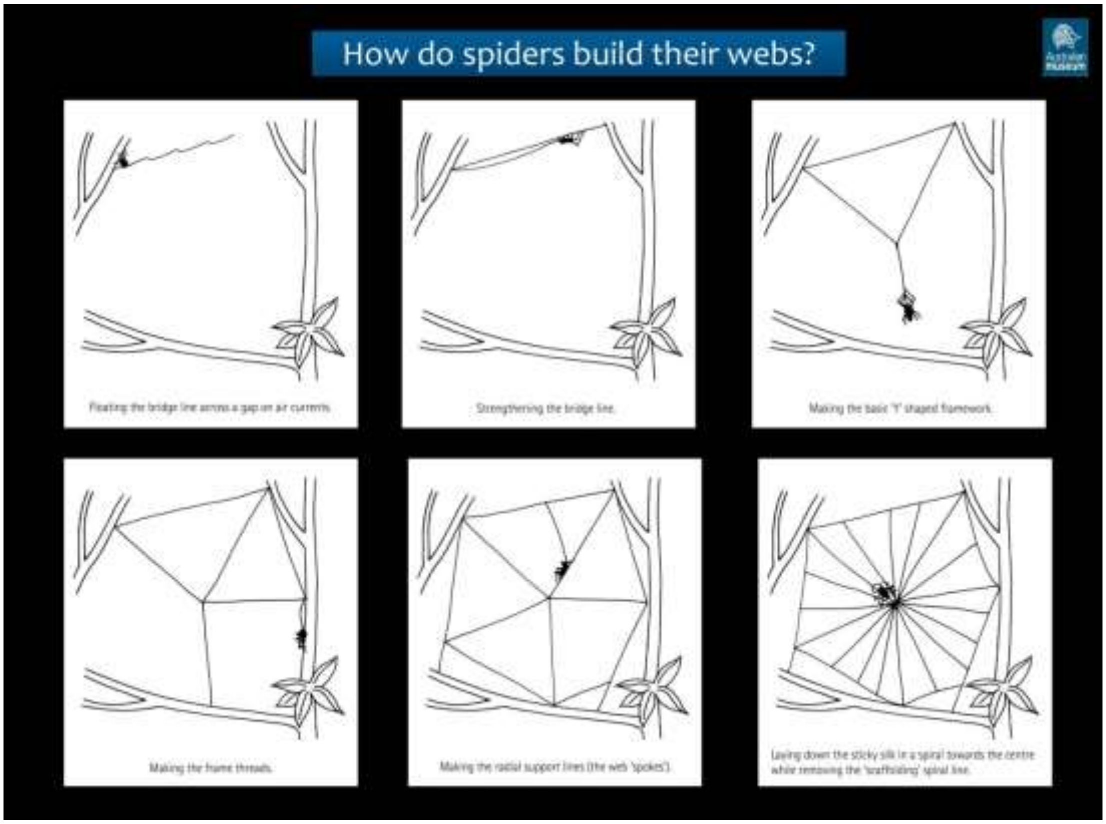
MATERIALS:

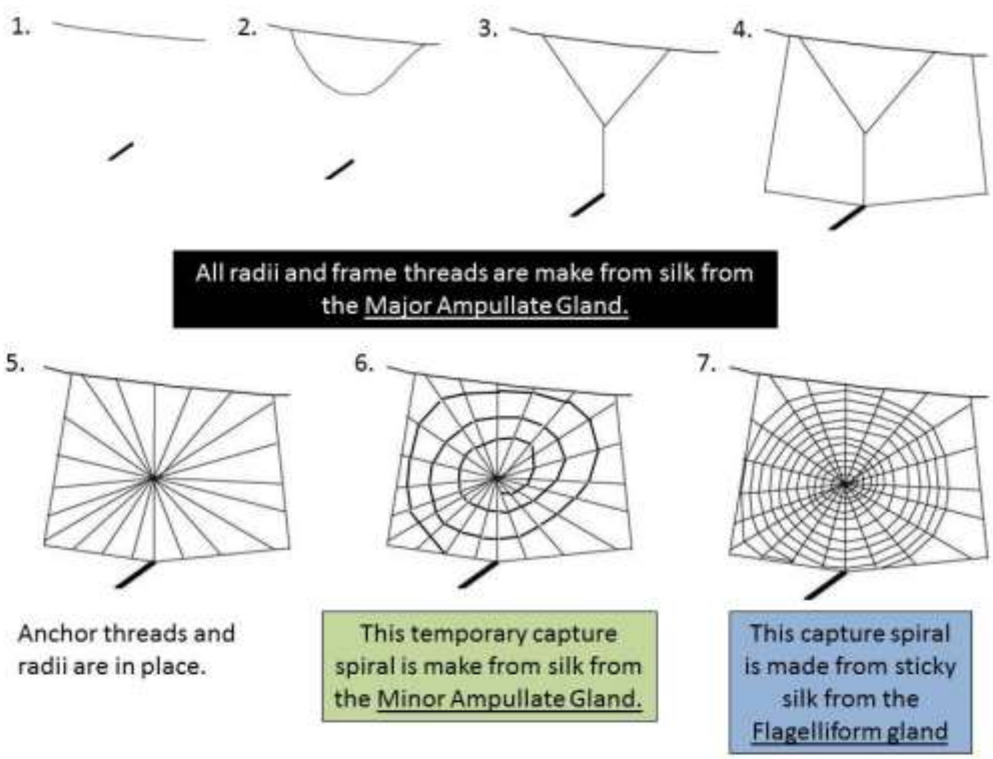
- Sheets of plastic canvas
- Plastic children's sewing needles
- Black yarn
- Green yarn
- Blue yarn

PROCEDURE:

- On the tabletop, make available numerous diagrams depicting how orb-weaving spiders construct their webs.
- Ask participants to think about how they might get their first strand of silk from one tree to another.
- Invite them to use different colored yarn to represent the different types of silk that an orb-weaving spider uses in constructing their web.




How do spiders build their webs?
Floating the bridge line across a gap on air currents.
Strengthening the bridge line.
Making the basic 'Y' shaped framework.
Making the frame threads.
Making the radial support lines (the web 'spokes').
Laying down the sticky silk in a spiral towards the centre while removing the 'scaffolding' spiral line.


1.
2.
3.
4.
All radii and frame threads are make from silk from the Major Ampullate Gland.
5.
6.
7.
Anchor threads and radii are in place.
This temporary capture spiral is make from silk from the Minor Ampullate Gland.
This capture spiral is made from sticky silk from the Flagelliform gland

VII. CATCH A MOTH

GOAL: This game illustrates one of many unusual hunting strategies exhibited by spiders and highlights the diversity of ways in which spiders can use silk.

BACKGROUND: Bolas spiders are orb-weaving spiders that no longer build typical orb webs. Instead, these spiders have evolved a unique hunting strategy that involves placing a sticky drop of silk at the end of a silken line (referred to as a 'bolas'; thus their name). This sticky droplet contains chemicals that mimic the pheromones of moths, thus luring unsuspecting males to their ultimate death! As a male moth approaches, looking for what it believes to be a mate, the spider swings it bolas and lassos the moth out of the air! One species of bolas spider, *Mastophora hutchinsoni*, has been shown to even adjust its pheromone blend in line with the activity patterns of two local moths: (i) the bristly cutworm moth and (ii) the smoky tetanolita moth. The spider produces components of both species' pheromones at all times, but as the bristly cutworm moth becomes less active over the course of the night, the spider decreases its emissions of that species' pheromone blend! The young of *M. hutchinsoni* neither build orb webs nor use bolas, but instead ambush prey from the underside of leaf margins.

MATERIALS:

- A horizontal strand of fishing line string between two poles (~10 ft across, depending on how many participants you want to be able to play at a time).
- Homemade "moths" attached by fishing line, hung at various heights, along the horizontal strand.
- Moths can be made from foam pieces, "noodles", pipe cleaners, cloth, etc. and need only have a piece of Velcro on their underside.
- The opposite piece of Velcro should be attached around a Ping-Pong ball (*i.e.* the droplet of sticky silk), which should be attached to a thicker white string creating the spider's bolas.
- A line of colored tape can be placed on the floor a few feet from where the moths are hanging.
- On display near this activity, or associated with this activity, it would be ideal to have a video loop of spiders using silk in different ways to capture prey.

PROCEDURE:

- Participants are given a bolas (Ping Pong ball attached to a string) and are instructed to stand with their toes behind the colored tape line.

- Using *only underhand* movements, participants swing their bolas and try to capture a moth.
- Successful participants can be given a prize (*e.g.* a small plastic spider).

VIII. TISSUE PAPER FLOWER

GOAL: To introduce some cool facts about spiders. Specifically, some spiders can change color! Building from this cool fact, we can learn something about camouflage.

BACKGROUND: Many species of crab spider (Family Thomisidae) sit motionless atop a flower waiting in ambush for an unsuspecting pollinator to drop in. The crab spider *Misumena vatia* commonly hunts atop goldenrod and can be yellow or white, depending upon the color of the flower upon which they are hunting. These spiders can actively change their color by secreting a yellow liquid pigment into their outer cell layer. This pigment can then be moved closer to, or further from, the outside of the body enabling the spider to change its color. If the pigment is transported to the spider's lower cell layers, the white guanine that fills the inner glands becomes visible and the spider turns white. To turn back yellow, the pigments are transported closer to the surface again.

MATERIALS:

- Pre-cut squares of yellow, white, and red tissue paper.
- Green pipe cleaners.
- Age-appropriate scissors
- Pre-cut crab spiders printed on white or yellow paper.
- Double-stick tape and/or glue sticks.

PROCEDURE:

- Participants can follow the instructions on how to make their own tissue paper flower.
- Once their flower is finished, they can choose a crab spider to place atop their flower.
- Does their spider blend in or does it contrast with the flower? How might this influence the spider's foraging success?
- You may reward participants who successfully camouflaged their spider (*e.g.* providing jelly beans to represent foraging success).

How to Make a Tissue Paper Flower

(1) Take *three* pieces of tissue paper (any combination of colors you like) and place them *directly* on top of each other.

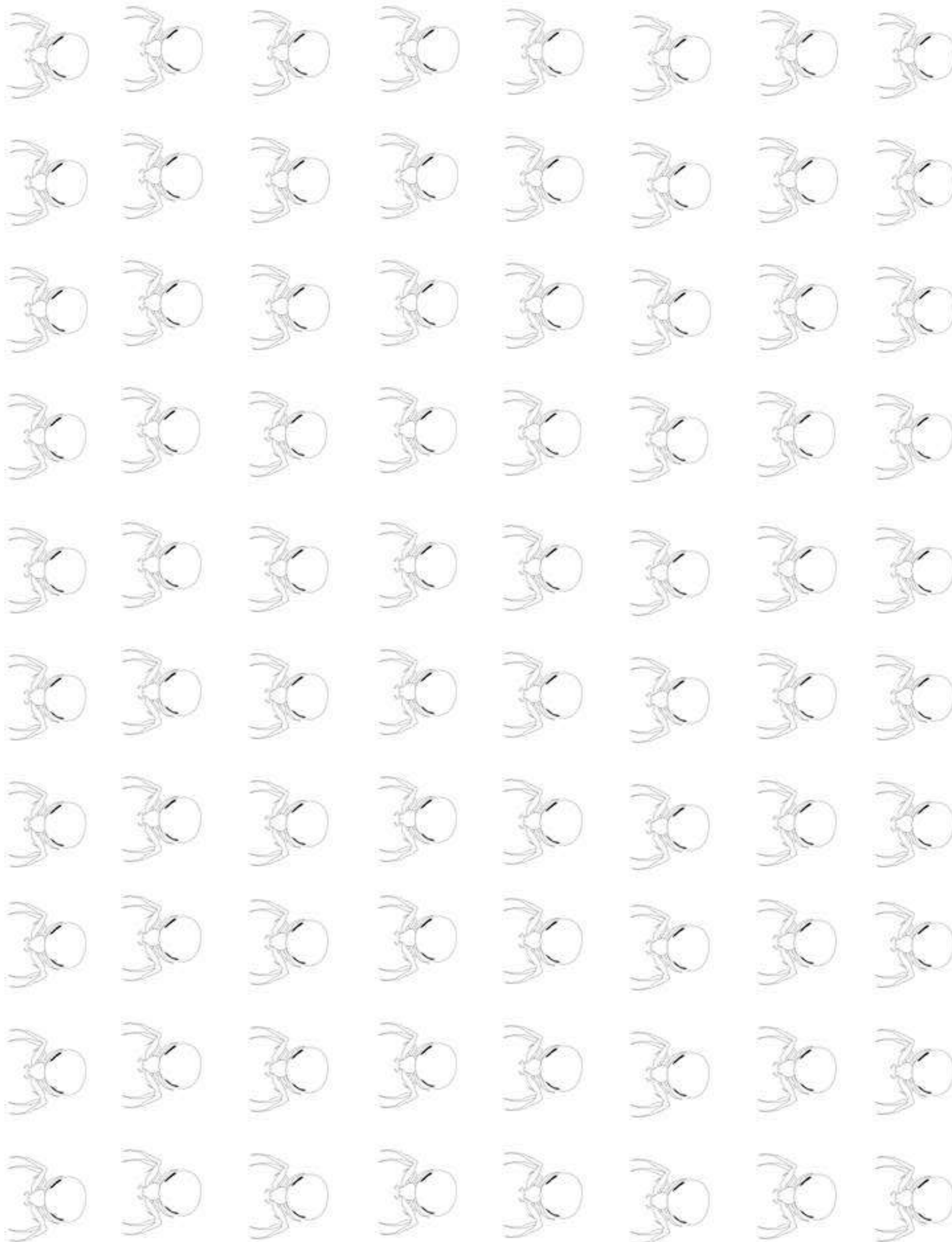
(2) Fold the papers like an accordion.

(3) Tie a pipe cleaner around the center.

(4) Cut the ends so they are rounded.

(5) Gently separate each layer pulling upwards toward the middle of the flower. Do the second side.

(6) Choose a crab spider and tape it atop your flower!



EIGHT LEGGED ENCOUNTERS

V. MICROSCOPE MADNESS

GOAL: It is not very often that people get the opportunity to take a close look at animal body parts; especially body parts of relatively small animals that cannot easily be seen with the naked eye. This station provides an opportunity for participants to see how variable spiders can be. It invites them to look for similarities and differences among different groups of spiders and to think critically and creatively about what this variation might mean in terms of an animal's lifestyle, habitat, evolutionary history, etc. It also highlights differences between female and male spiders.

BACKGROUND: Although most spiders do not rely heavily upon vision for gathering information from their environment, many spiders non-the-less possess eight eyes. Others, however, have two, or four, or six eyes. Spiders in some families have a single pair of eyes that are much larger than the other pairs – what might this tell you about how important vision is for these animals? In terms of other sensory systems, spiders are excellent at detecting vibrations that travel through substrates, or surfaces upon which they rest (e.g. webs, leaves, etc.). They use specialized sensory structures called *slit sensilla* or *lyriform organs* to detect these vibrations. These structures are best observed under high powered magnification such as a scanning electron microscope (SEM). However, *tricobothria*, or air-particle movement detectors, can be seen under a dissecting scope. Tricobothria are extremely long, thin hairs that are very sensitive to air particle movements and are thus incredibly important in prey capture. Spiders also rely heavily on chemical information from their environment. They can detect chemical cues through sensory hairs located at various places on their body. Sensory hairs that "taste" chemicals on a surface typically have a single pore at the very tip. On what body parts might you expect chemosensory hairs to be common?

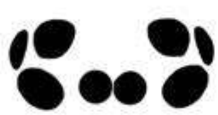
Spiders also have specialized structures for spinning silk (*spinnerets*), combing out silk (*calimistrum*), and capturing and immobilizing their prey (*fangs with venom glands*). Many of these structures are readily seen under a dissecting scope.

MATERIALS:
- Dissecting microscopes with lights
- Petri dishes to hold specimens
- Squeeze bottles of alcohol
- Soft forceps
- Preserved specimens

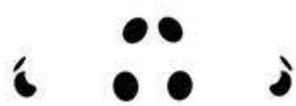
PROCEDURE:
- At each microscope have a bundle of color-coded vials that represent good specimens to examine for each of the observation sheets provided (*i.e.* eye arrangements, crazy structures, male or female).
- Ideally, have other pictures available to show lyriform organs, contact chemosensory hairs, tricobothria, etc.
- Allow the participants to get out the specimens and manipulate them under the microscope.

What family is this?

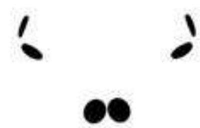
Look at the eyes of the spider you have under the microscope. Can you identify its family based on these examples of eye arrangement?



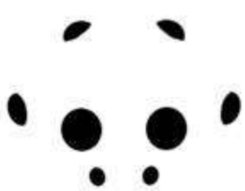
Pholcidae
Cellar spiders



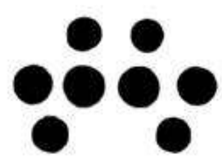
Araneidae
Orb-weaver spiders



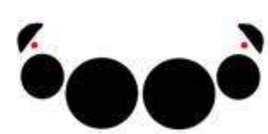
Scytodes
Spitting spiders



Oxyopidae
Lynx spiders



Agelenopis
Funnel-web spiders

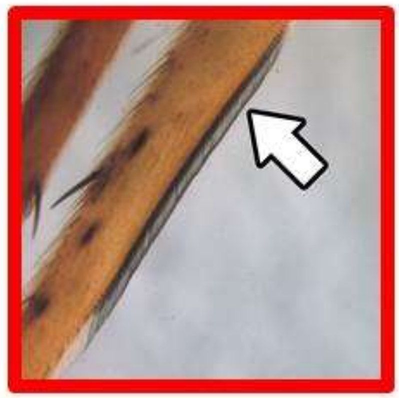


Salticidae
Jumping spiders

Crazy structures!

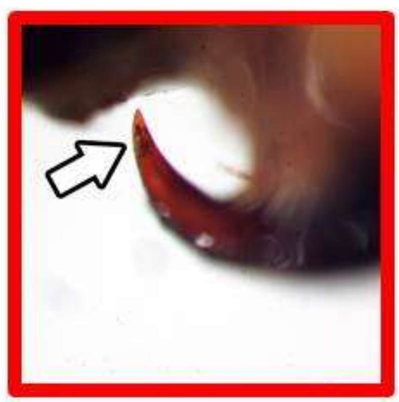
Can you find these structures on the specimen under your microscope?

Spinnerets (used to extrude the silk)



Calimistrum (used to pull the silk from the spinnerets)

Cheliceral teeth (look in front of the head!)



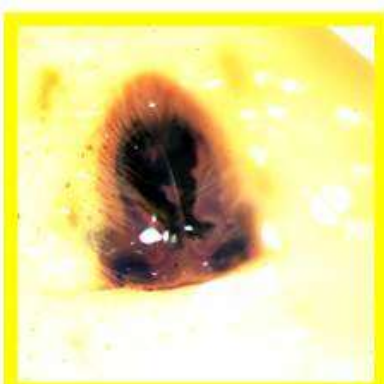
Venom gland opening (in the chelicerae)

Male or Female?

Can you determine if your specimens are males or females? Look at these pictures and figure it out!

Female pedipalp
(look in front of the
1st pair of legs)

Male pedipalp
(specialized for sperm transfer)



Female epyginum, (genital
opening, on the abdomen)

Male abdomen
(with no epyginum)

EIGHT LEGGED ENCOUNTERS

VI. COMMUNITY EXPERIMENT

GOAL: The goal of this station is to engage the participants in a hands-on foraging experiment that allows them to:

(i) Learn how to eye-shine for wolf spiders
(ii) Catch their own spider
(iii) Conduct a portion of an actual experiment
(iv) Enter data into a spreadsheet
(v) Watch the results real-time
(vi) Think about the evolution of sensory systems and associated communication.

OVERVIEW: You will need a darkened room with soil-filled plastic tubs scattered throughout. In each tub, place ~30 juvenile wolf spiders (these are very common throughout North America and can be collected easy at night during the warmer months using eye-shines to locate individual spiders). Participants are given a head-lamp, vial (pre-labeled with a green or blue sticker), and clipboard with background information, experimental instructions and data sheet, and a pencil. They are guided into the darkened room and shown how to use eye-shines to find wolf spiders. They are introduced to the fact that spiders, like many nocturnal mammals, have a retina (a light reflecting layer) that aids in night vision. Each participant will use their vial to collect their own spider.

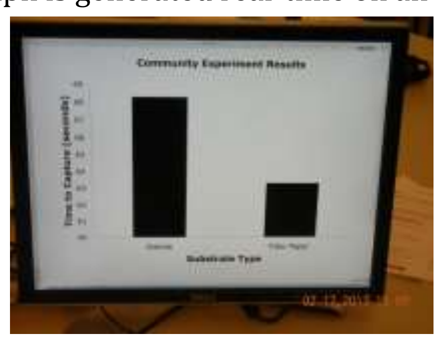
Upon exiting the darkened room with their spider, participants will be guided to their appropriate station based upon their treatment group. Their collecting vial should already have a colored sticker on the lid, which informs them of their experimental treatment group (blue = granite/vibrations absent; green = filter paper/vibrations present). Stations for each treatment should already be set up. Upon arriving at their assigned station, participants follow the instructions on their data sheet.

After completing their experiment (see below), they enter their data into a computer which is hooked up to 2 monitors – the second of which has a data graph where they can watch the graph change in real-time as data are entered. The background material, hypothesis, and can be found on the following pages:

MATERIALS:

- A dark room in which plastic tubs filled with potting soil, moss, and live wolf spiders can be placed. If this activity is done during warmer months, participants can go outside at night to collect their own spider.
- Snap cap plastic vials pre-labeled with green or blue small stickers representing the experimental treatments.
- Head-lamps.
- Clipboards with instructions and a pencil attached.
- Stations set up with the following:
    - Plastic enclosures with no bottoms that can placed upon either (i) a piece of white granite, or (ii) a piece of white filter paper. These correspond to the blue dots on the collecting vials.
    - A container full of crickets (mealworms or some other prey items could probably be substituted).
    - Soft forceps for transferring the prey item.
    - A stop watch.
    - Squirt bottle of alcohol and cotton swaps for cleaning containers.
    - Fresh filter paper for green stations.

- A computer set up with 2 monitors. An excel file should already be started with appropriate columns in which participants can readily sit down and enter their data. The program should be set up such that a graph is generated real-time on an adjacent monitor.



COMMUNITY EXPERIMENT

HOW do spiders communicate with one another and **WHY** would they need to communicate?

WHAT sensory channel(s) do they use for communication?

- vision (sight)
- audition (sound/vibrations)
- chemical (smell/taste)
- mechanical (touch)

WHY might closely related species use different sensory channels for communicating?

WHAT factors could most influence the **EVOLUTION** of spider communication?

Adult males of some wolf spiders **SING** and **DANCE** to convince females to mate with them. **Ornamented** males wave, arch, and tap their fancy legs during their courtship dances (visit the *Spider Dance Disco* to see this in action). Males with **No Ornamentation** tend to have less active courtship displays; but **ALL** males "sing".

LISTEN to the songs of wolf spiders (visit the *Sound Station* if you haven't already). All *Schizocosa* wolf spiders **SING** to their potential mates. They have different ways to produce **VIBRATIONS** that travel through the surface of leaves, grass, twigs, pine needles, or any other surface on which they might court.

WHY do some species use **VISUAL** AND **VIBRATORY** courtship displays to impress females while others use only **VIBRATORY** displays?

ORNAMENTATION

1st walking leg of an ornamented male wolf spider.

NO ORNAMENTATION

1st walking leg of an un-ornamented male wolf spider.

WHAT sensory system do wolf spiders rely upon most for foraging or detecting prey?

LEFT - Wolf Spider face showing all eight eyes.

BELOW – Lyriform organs used by spiders to detect surface vibrations.

IMAGINE that one species uses **VIBRATIONS** for detecting prey while another species relies more on **VISION**.

The reliance on different sensory systems in one context – like foraging – could influence the evolution of sensory systems used in another context – like courtship signaling.

If true, we **predict** that species that use primarily vibrations for prey detection have courtship displays made up of primarily vibratory signals.

Together, let's **TEST** this idea using the wolf spider *Schizocosa floridana*, which we already know relies predominantly on vibratory signals during courtship**!!!**

<u>HYPOTHESIS</u> – An unornamented wolf spider, *Schizocosa floridana*, which we relies predominantly on **vibrations** for courtship, also relies heavily on **vibrations** for foraging.

<u>PREDICTION</u> – Spiders will take longer to attack prey in the absence versus presence of vibratory cues.

<u>GENERAL PROTOCOL</u> – Together, we will record the time it takes spiders to attack crickets on two different substrate types: (i) granite, which cannot transmit cricket vibrations, and (ii) filter paper, which transmits cricket vibrations well.

EXPERIMENTAL PROCEDURE

READ through each step BEFORE you begin!!!

STEP 1. Collect your spider

- **PUT ON** your headlamp, grab a collecting vial and **LEARN** how to find spiders from the reflection of their eyes. Catch a spider!

STEP 2. Determine your experimental treatment

- **LOOK** at the colored sticker on your collecting vial:
    - **BLUE** = granite substrate (NO Vibrations/Visual only – vibrations associated with the cricket's movements are unable to transmit through this granite).
    - **GREEN** = filter paper substrate (Vibration + Visual).

- Locate an appropriate and available experimental arena.

STEP 3. Release your spider

- **RELEASE** your spider into the arena and start your stopwatch (this will be your practice for using your stopwatch). Let the spider get used to the new environment for at least **2 minutes**.

- During this 'acclimation' period for the spider, turn over this sheet and fill in the top information.

- After 2 minutes, **PLACE** the vial gently over the spider to contain it.

Turn Over

NAME(S):

EMAIL ADDRESS:

EXPERIMENTAL TREATMENT (circle): **granite** **filter paper**

TIME OF DAY:

LOOK at the data sheet below before continuing!!!

STEP 4. Collect your prey item

- **GRAB** a single cricket from the container using the forceps provided & **PLACE** the cricket in your arena.

STEP 5. Observe foraging behavior

- Practice using your stopwatch. Once you feel comfortable, lift the vial off the spider to release it and *immediately* **START** the stopwatch!

- **STOP** the stopwatch ***as soon as*** the spider attacks the cricket. **RECORD** your time to attack on the sheet below. Observe for as long as you like.

TIME TO FIRST ATTACK (min, sec):

 # OF ATTACKS:

OBSERVATIONS/NOTES:

STEP 6. Collect your spider and Clean your arena

- **COLLECT** your spider back into your collecting vial & return it to a volunteer.
- If relevant, remove your filter paper from your arena.
- **GRAB** a squirt bottle of alcohol and squirt a little onto a cotton ball. Use the cotton ball to wipe down the edges and bottom of the arena thoroughly.

STEP 7. Enter your data in the computer!!!

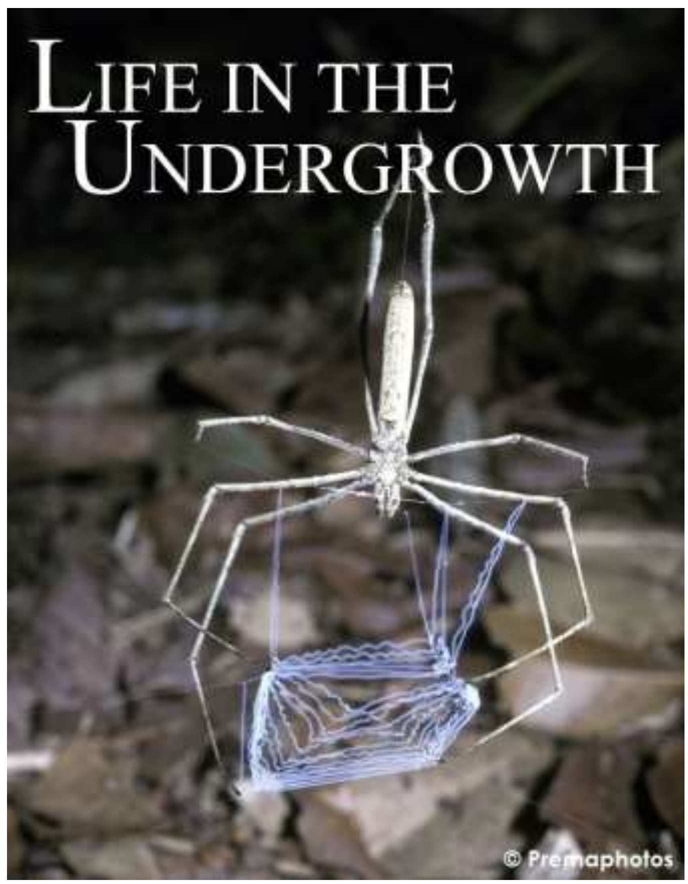
EIGHT LEGGED ENCOUNTERS

IX. SILKEN SPINNERS

GOAL: This station is to provide some quiet rest time, during which participants can learn about silk through the narration of David Attenborough and the incredible footage the BBC in “Silken Spinners” from *Life in the Undergrowth*.

MATERIALS:

- A screen attached to a DVD player
- The DVD for *Life in the Undergrowth*
- Bean bags and/or chairs for the audience to sit on



PROCEDURE:

- Have this DVD on a loop for participants to stop and stay for as long as they like.

X. SOUND STATION

GOAL: This station introduced the audience to the fact that spiders can "sing".

BACKGROUND: Spiders have multiple sound-production mechanisms. For example, they can use stridulatory structures (a file and scraper on two different body parts that are rubbed together…imagine the sound produced by a plastic knife running along the teeth of a comb) often located on their pedipalps to produce vibrations that they couple to a surface. They can also use tremulation of muscles or percussion, involving hitting body parts onto a substrate. These sounds are frequently species-specific and may be coupled to particular movements during courtship.

MATERIALS:

- Headphones attached to a device that plays spider courtship songs on a loop.
- Copy of the spider sounds loop.

PROCEDURE:

- Simply have head phones available on a tabletop along with the sound station instructions (see below).

XI. SPIDER DANCE DISCO

GOAL: To introduce the audience to some of the fascinating courtship dances that spiders perform. This station also enables participants to move about freely and unconstrained - facilitating a full body experience.

MATERIALS:

- Computer Projector with Speakers
- Copy of the "Spider Dance Disco" created by the Hebets' Lab 2013.*
  *Note that the videos and music used to create this video were borrowed from the web for this educational purpose.

PROCEDURE:

- Simply set up a room with a disco ball, a large screen upon which the video can be projected, some strobe lights, and possibly some balloons on the floor and let the audience cut the rug!

EIGHT LEGGED ENCOUNTERS

XII. READ ALOUD

GOAL: This station is designed for either self-directed play/reading or active listening during read alouds.

MATERIALS:

- Wooden puzzles, stuffed animals, plastic animals, puppets (all arachnid-related)
- Scientific arachnid books (non-fiction)
- Arachnids story books (fiction)

PROCEDURE:

- Set up an area with blankets and spider bean bags. A few tubs can be set out that have various arachnid and insect puppets and stuffed animals to play with (scorpions, tarantulas, crickets, ticks, etc.). Additionally, have some wooden puzzles of arachnids and insects as well as numerous plastic arachnids and insects. Also provide a plethora of children's books for kids to look through – mostly focused upon both arachnids and evolution.
- At set times, there will be a spider-related story read aloud. We suggest the following 5 stories:

- "The Very Busy Spider"
- "Be Nice to Spiders"
- "Sophie's Masterpiece"
- "The Spider and the Fly"
- "Anansi the Spider: A Tale from Ashanti"