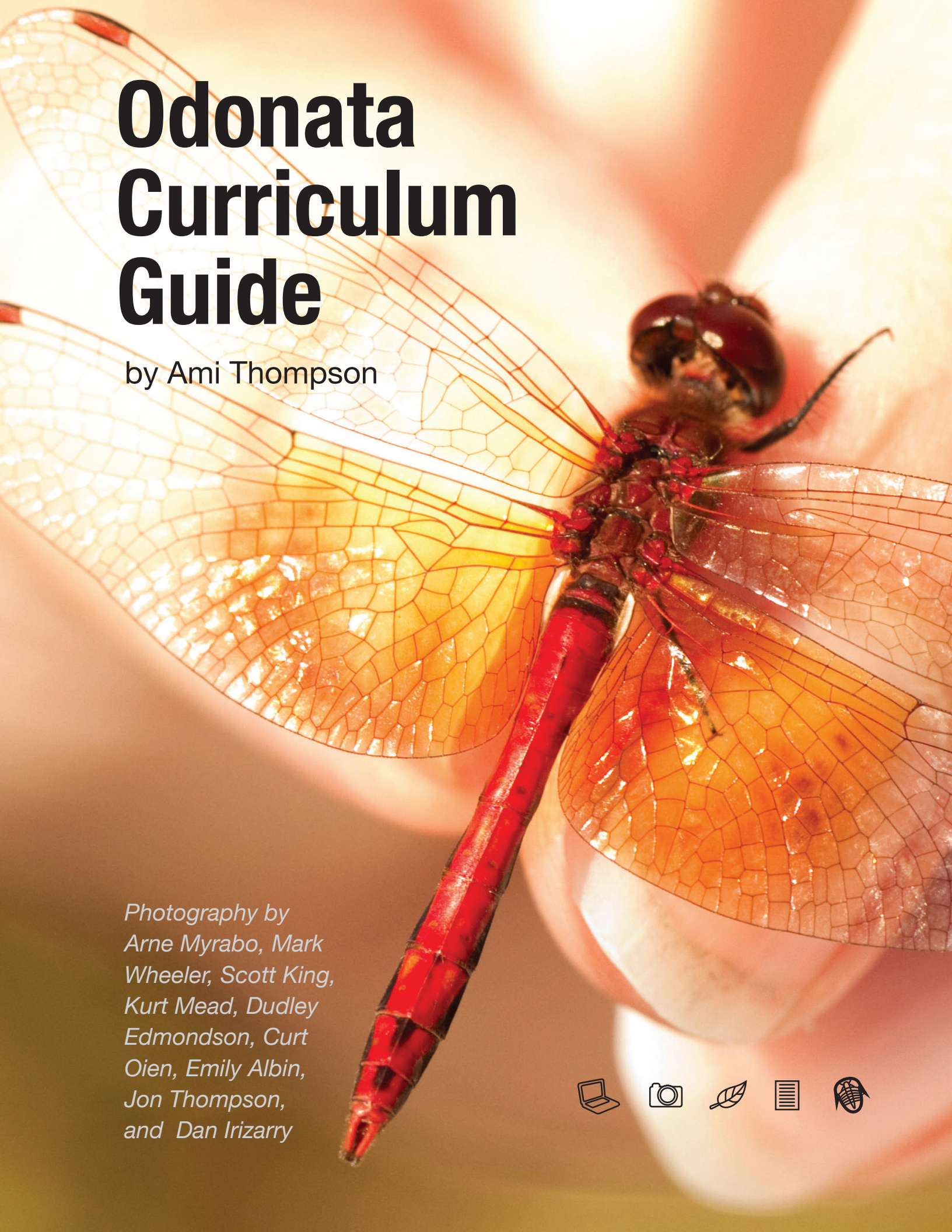
Odonata Curriculum Guide

by Ami Thompson



Photography by Arne Myrabo, Mark Wheeler, Scott King, Kurt Mead, Dudley Edmondson, Curt Oien, Emily Albin, Jon Thompson, and Dan Irizarry

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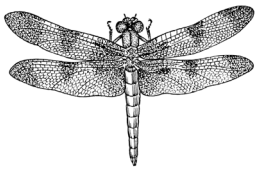

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Cover Photo: Dudley Edmondson

Introduction

A Minnesota Dragonfly Society citizen science training with Kurt Mead (center). (Photo: Ami Thompson)

Welcome to the exciting world of dragonflies! This guide provides instructions for dragonfly and damselfly natural history lessons, outdoor hands-on experiences, and classroom activities.

Notes about Copyright
The amazing photographs and illustrations in this curriculum guide are copyrighted by the creators and were generously donated in good faith. Please respect the copyright of the photographers and illustrators by only using the images from this guide and the associated files for educational purposes.

Terminology
Throughout this guide I use many terms to refer to dragonflies and damselflies. Odonata is the order name for dragonflies and damselflies. When I use the terms "Odonata," "Odonates," or "Odes" I'm referring to the suborders of both dragonflies and damselflies. "Damselflies" always only refers to the suborder of damselflies. "Dragonflies" always includes the suborder of dragonflies. Occasionally, I use "dragonflies" to refer to both suborders.

This curriculum guide uses outdoor observation to fuel science learning. Nearly all the activities engage students in recording their observations in a journal or on a worksheet. The journal could be a special notebook dedicated to an Odonata unit or it could be a portion of a journal that you use for other science topics. Utilize the journaling component in the way that works best for you and your teaching style.

This curriculum guide is a living document and will grow and change. Updated versions of the guide will be available electronically at www.amidragonfly.com and will be accessible with the password "Dragon88".

All supplemental files referenced in this guide are available at www.amidragonfly.com in the resources section and accessible with the same password.

Materials and Sources:
Insect nets: large-diameter fine-mesh aerial nets with a long handle are best for catching dragonflies. BioQuip (http://www.bioquip.com/) sells a sturdy student net for a reasonable price (item number 7615NA).

Hand lenses (item number 1129N) and clear *Odonata specimen envelopes* (item number 1130DP) will also be helpful for students. Both are available through BioQuip Supply.

Dragonfly close-up. (Photo: Dudley Edmondson)

Identification guides: *Dragonflies of the North Woods* (by Kurt Mead) and *Damselflies of the North Woods* (by Bob DuBois) are published in Minnesota by Kollath+Stensaas Publishing. Available through Adventure Publications (http://www.adventurepublications.net/) or on Amazon.

Comparing thorax marks to identify a dragonfly. (Photo: Dudley Edmondson)

If you live outside of the North Woods ecosystem (but are still in the western hemisphere), you may consider purchasing a copy of *Dragonflies and Damselflies of the East* or *Dragonflies and Damselflies of the West* by Dennis Paulson (Princeton University Press).

Outdoor Classroom Management:
Prepare students before they head outside. Introduce the activity they will be doing and the product they will be creating (and be graded on), set very clear geographic parameters, and introduce and demonstrate the audio and visual signals you will give when you want students to return to you or to the classroom. All indoor classroom rules can apply to the outdoor classroom.

Dragonflies and damselflies are most active during sunny warm weather. However, don't be shy about bringing your students outside on rainy, cloudy, or colder days. They will observe first hand that dragonflies are not as readily found during shady, cooler, or wet weather and may discover that other creatures are more active. You can dip-net in the water for nymphs on overcast days and even during rain. The more often you go outside, the more natural and efficient it will become!

Acknowledgements

The USDA Forest Service generously funded the Spanish translation of this guide.

This curriculum guide could not have been created without the help of many intelligent and dedicated people.

Kurt Mead, and all the Minnesota Dragonfly Society members have inspired and supported me at every turn. Particularly, I am grateful to the MDS members who have allowed me to use their truly outstanding photography in this guide: Arne Myrabo, Mark Wheeler, Scott King, Kurt Mead, Curt Oien, Emily Albin, and Dan Irizarry.

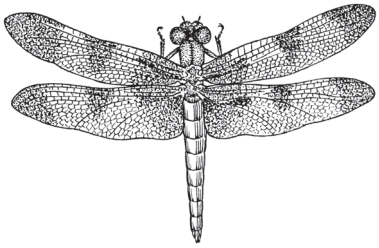
Karen Oberhauser and Lis Young-Isebrand, of the University of Minnesota Monarch Lab, bushwhacked the path for studying insects in the classroom. Their curriculum materials inspired these lessons on dragonflies.

Rick Kollath and Mark "Sparky" Stensaas of Kollath+Stensaas Publishing generously allowed me to use Rick's beautiful Odonata anatomy illustrations from Dragonflies of the North Woods and Damselflies of North Woods in this guide. Jon Thompson drew the illustrations for the paper craft dragonfly and the emerging nymph drawing on the paper fortune teller.

Mary Spivey, Jan Welsh, and Dudley Edmondson have all given me invaluable advice and support. They talked me off a few ledges and guided me around more than a few pitfalls. Dudley has also allowed me to use his amazing photography.

Thank you to all the teachers who reviewed early versions of this guide and attended dragonfly workshops. I made many improvements thanks to their brilliant suggestions.

Close-up of a dragonfly. (Photo: Dudley Edmondson)



1. Catch, Observe, Release

Students catch, examine, record observations about, and release dragonflies and damselflies.

What You'll Need
Student Journals
Insect Nets
Odonata Envelopes
Anatomy Handouts
Access to a Wetland

Skills & Concepts
Recording Observations
Using Tools
Communicating
Asking Questions
Patterns
Structure and Function

We rarely get a good look at dragon and damselflies because they are constantly in motion. The best way to get to know them is by up-close in-hand observation.

Tips for catching dragonflies:

1. Be sneaky. Slowly approach a dragonfly you want to catch after it has landed or patiently wait for it to fly close to you. Start your swing from behind the dragonfly, if possible, so it doesn't see your net coming.

2. Swing the net like a baseball bat—with speed and follow-through.

4. After the swing, immediately flick the end of the net over to trap any captured insects.

5. Don't fret if there is a lot of swinging and missing, that's part of the fun!

To safely take a captured dragonfly out of the net, slide one hand into the net while holding the netting tight around your wrist with your other hand. Grasp the insect by gently folding up its wings from below and pinching them folded above its body. Be careful not to crease the wings.

Removing a dragonfly from the net. (Photo: Jon Thompson)

Once you have a good grasp on the wings, slowly remove the dragonfly from the net. Be attentive to any legs or mouthparts that might be tangled in the netting.

To release the insect, when you are ready, place its legs gently on a plant and let it go.

Dragonflies have mandibles that munch up the insects they catch. They do not have piercing-sucking mouthparts like many biting insects and they cannot sting. Odonata mandibles are generally too small to hurt people and they will only try to bite a human if a finger is placed right at their mouth. Some of the larger darners may be able to scratch with their mouths, but mostly they just pinch.

Dragonflies can be temporarily placed in clear plastic Odonata envelopes for observation. This works particularly well with damselflies because they are so small. In the envelope, they can be closely observed without fingers getting in the way.

Dragonflies have fascinating anatomy. Like all insects, they have a head, a thorax, an abdomen, six legs, and four wings. See the following worksheets for more anatomy details.

Dragonflies are most active when it's sunny and warm during the summer. However, spring and fall can be great times to do this activity. A good exercise would be to compare the different species found at different times of year.

Note of caution: While Odonata do not sting or bite, other insects may. If students catch a bee, wasp, or other stinging insect, they should calmly release it by simply allowing the net to hang wide open. If the offending insect doesn't fly out on its own, a gentle shake of the net to turn it inside out will do the trick.

Activity: Catch, Observe, Release

1. Introduce the activity of going outside to catch dragon- and damselflies in order to observe them. Explain that this activity is about observing dragonfly anatomy by looking closely and recording their observations in a journal.

2. With a large stuffed or paper dragonfly, demonstrate how to safely hold the insect. Allow students to practice on their own paper versions (see activity 2). Explain that Odonata do not sting or bite but that the big ones might pinch.

3. Demonstrate good netting technique as described above. Remind students to make sure that there are no other students nearby before they swing.

4. Lastly, explain that all the inside classroom rules apply outside.

5. Break students into groups depending on how many insects nets you have. Distribute nets, envelopes, and journals.

6. Lead your students to an area near water—a stream, pond, wetland, river, etc. Dragonflies will be along the banks and perhaps flying in adjacent fields or woods. They also often fly in grassy clearings or sports fields. Clearly define for your students where they are allowed to go (and where they are not) and how they will know when they should return to you (bell, whistle, shout, etc.).

7. Send them off! Walk around and observe their collection techniques, giving suggestions if needed. Ask probing questions of the groups—How many wings do they count? Are the wings all the same shape? How would they describe the colors and patterns? How many legs does a dragonfly have? What are the legs used for? Do all Odonata look the same? What are some differences? Encourage them to sketch in their journals.

8. If the dragonflies are not abundant or if someone catches something unique, you can place it in a clear plastic Odonata envelope and show it around to the other groups.

9. Return to the classroom and make a list of the anatomy observations on the board. Allow groups or individuals to report, each adding only their new observations that are not already on the class list. As observations pile up, inform students of the scientifically correct anatomical names. Also make a list of the questions students created while observing. Save this list for future reference; you may discover answers to these questions during future activities.

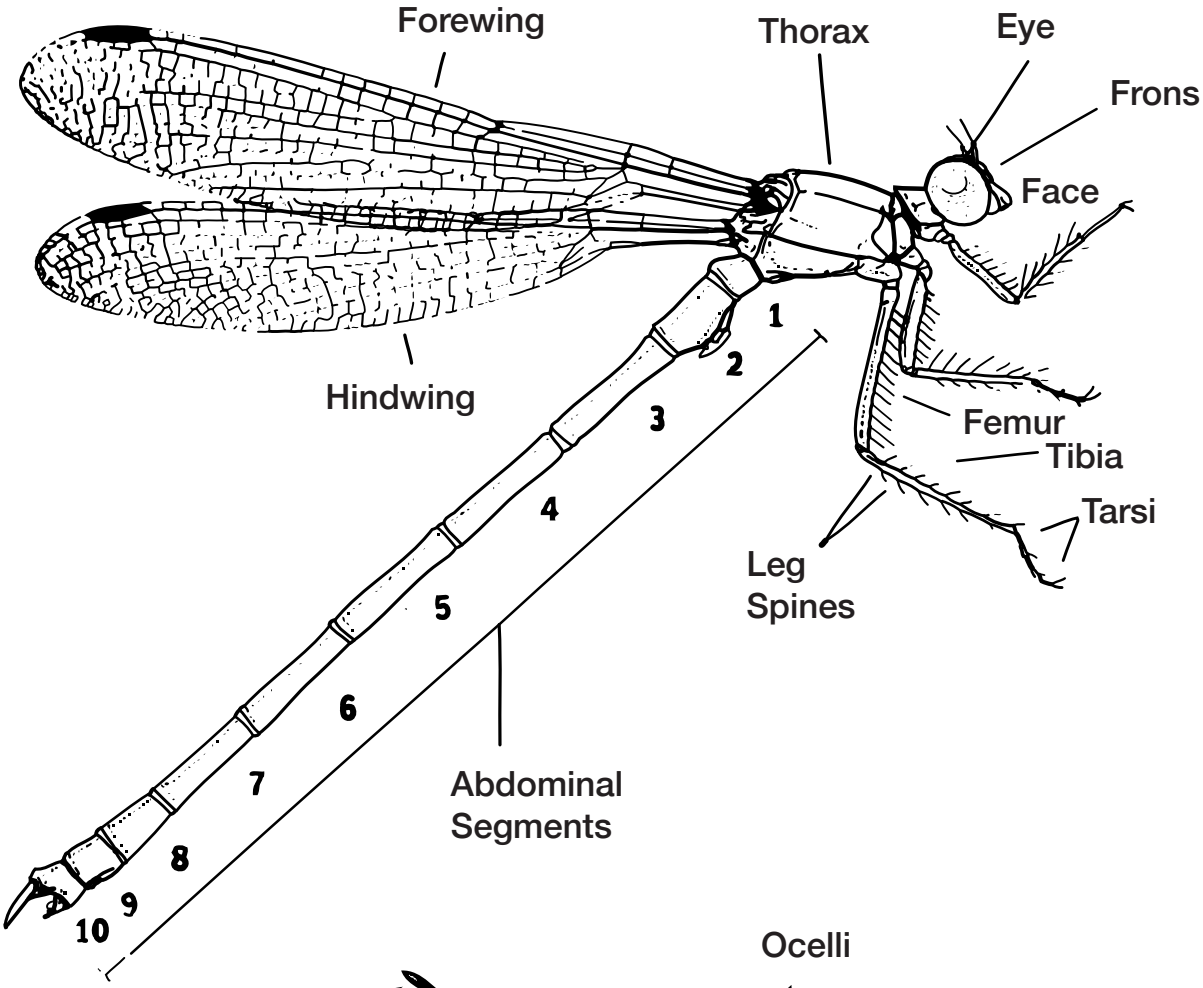
If time allows, ask about any other observations they might have made. Where were the dragonflies easiest to catch? the hardest? Why? Did the dragonflies all look the same?

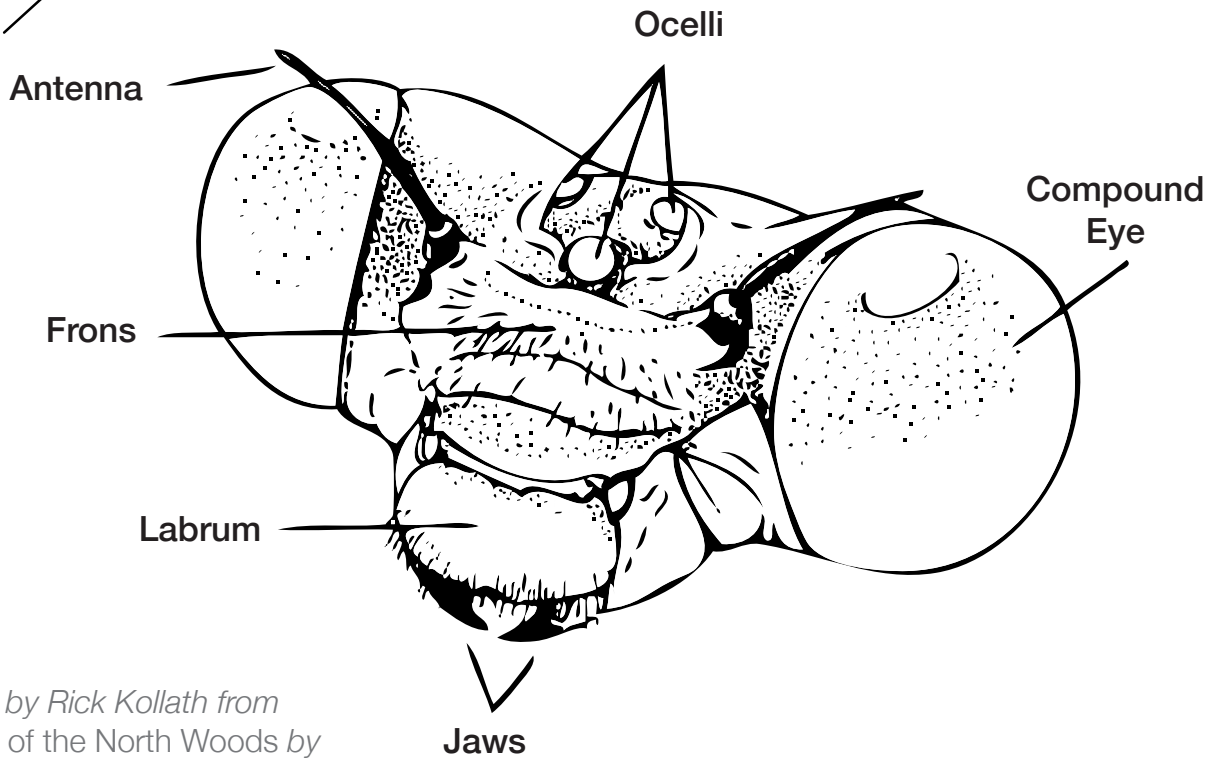
10. Distribute the dragonfly and damselfly anatomy handouts. Or pass out the anatomy worksheets and allow students to complete them alone, in groups, or as homework. Help as needed if you didn't cover all the answers while compiling your class observations list.

Two levels of the dragonfly worksheets and handouts are provided below. Choose the version that best meets your classroom's needs.

Damselfly Anatomy Handout

Name _____ Date _____

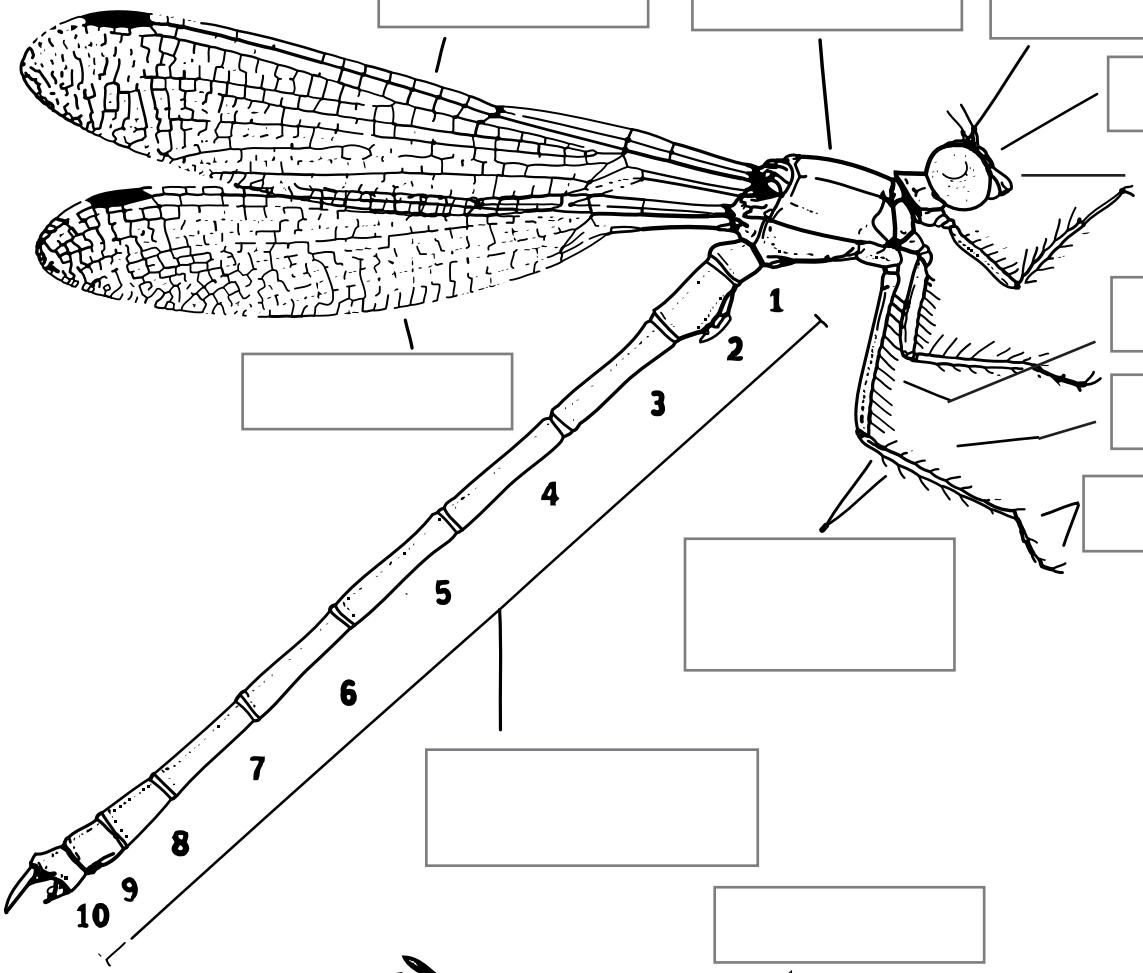




Illustrations by Rick Kollath from Damselflies of the North Woods *by Kollath+Stensaas Publishing*

Damselfly Anatomy Worksheet

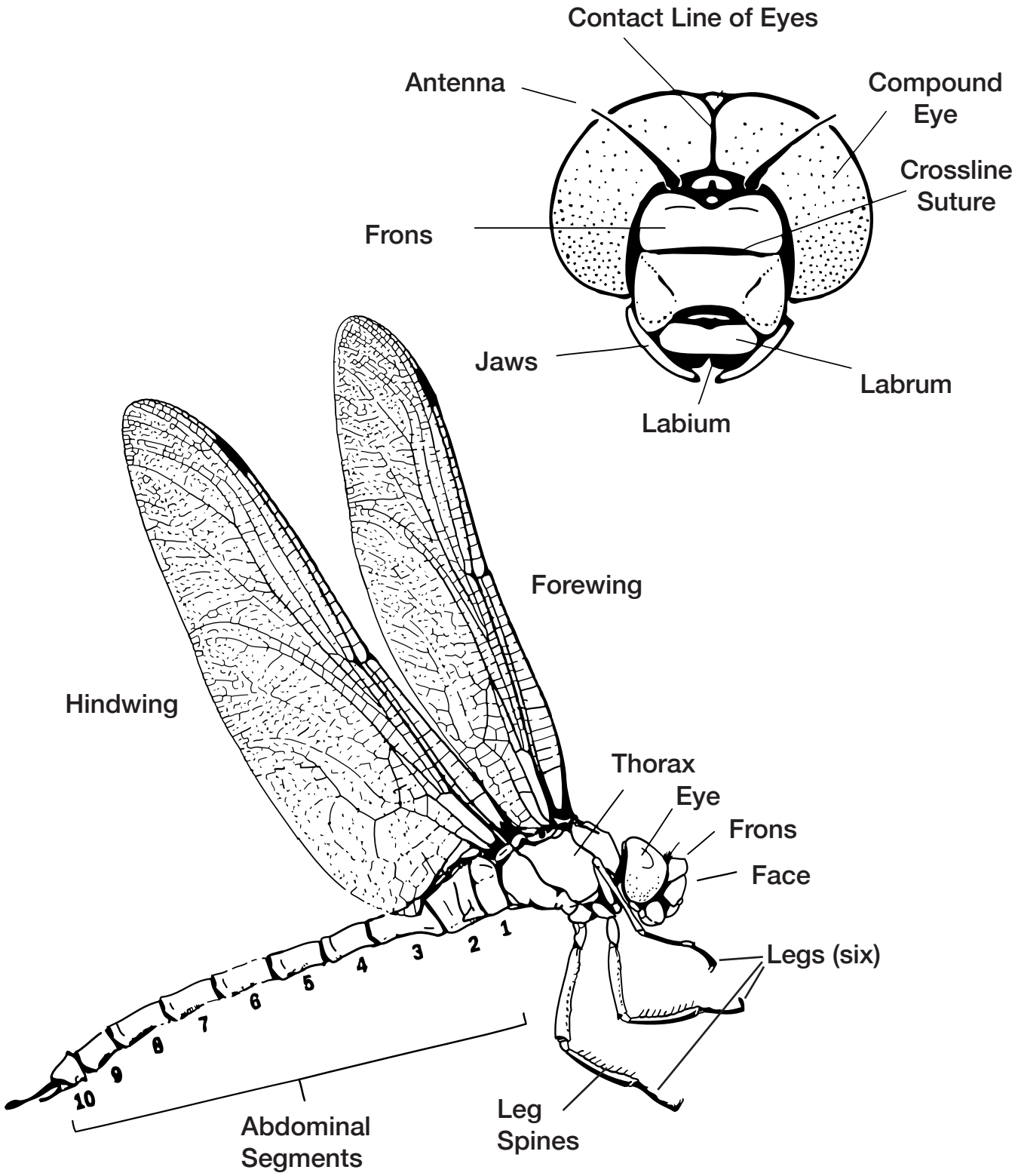
Name _____ Date _____



Illustrations by Rick Kollath from Damselflies of the North Woods *by Kollath+Stensaas Publishing*

Dragonfly Anatomy Handout

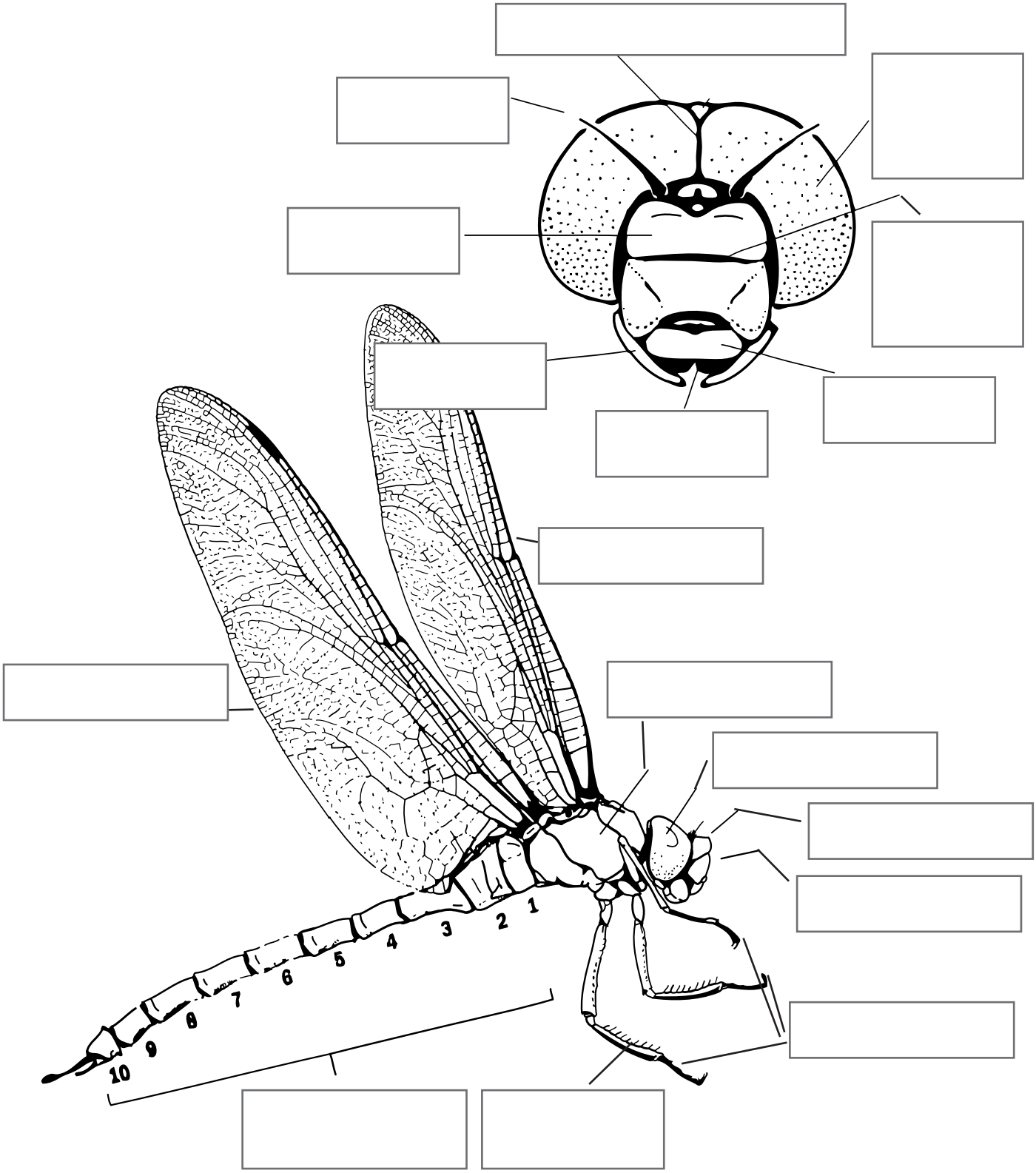
Name _____ Date _____



Illustrations by Rick Kollath from Dragonflies of the North Woods *by Kollath+Stensaas Publishing*

Dragonfly Anatomy Worksheet

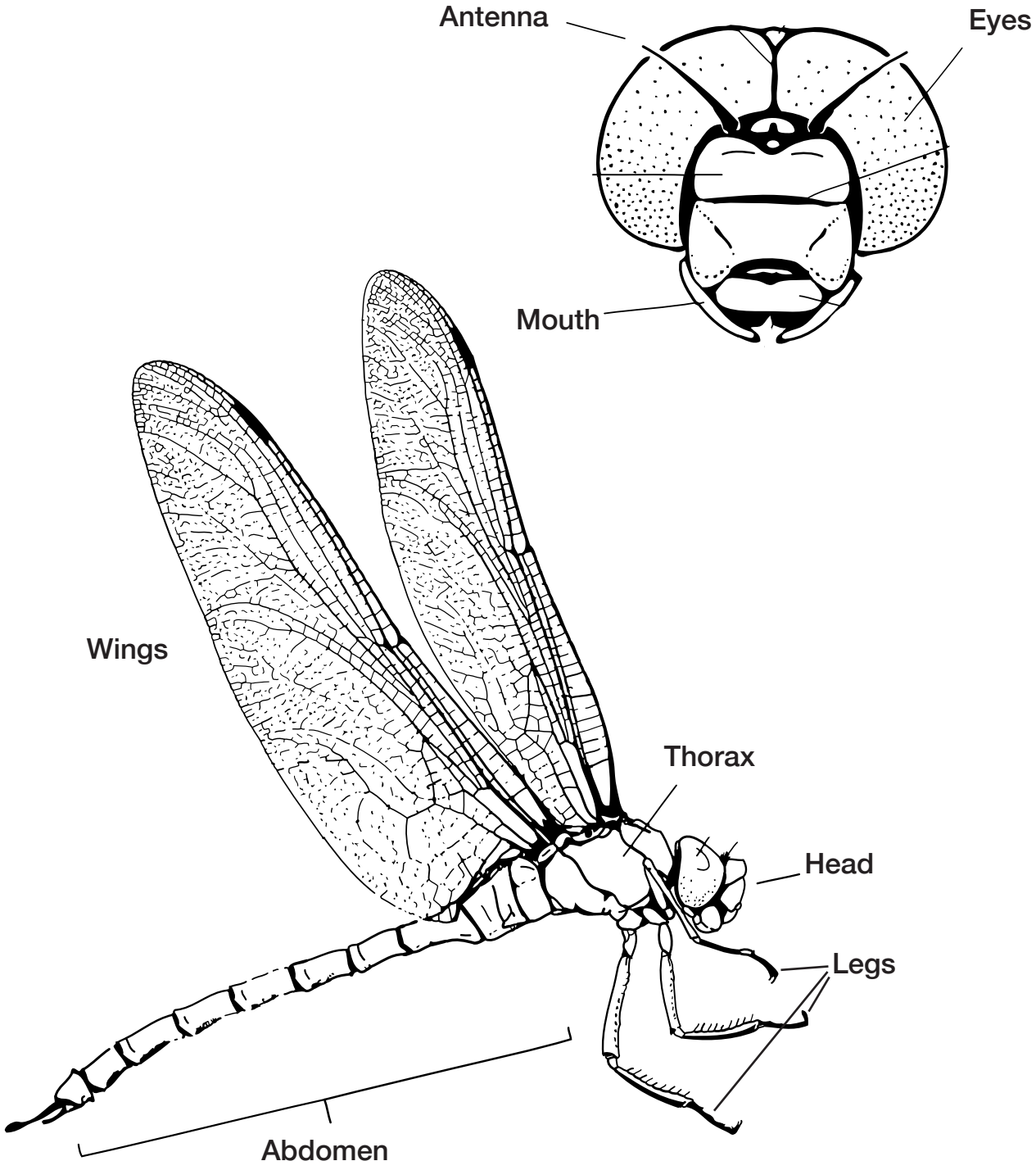
Name _____ Date _____



Illustrations by Rick Kollath from
Dragonflies of the North Woods *by*
Kollath+Stensaas Publishing

Basic Dragonfly Anatomy Handout

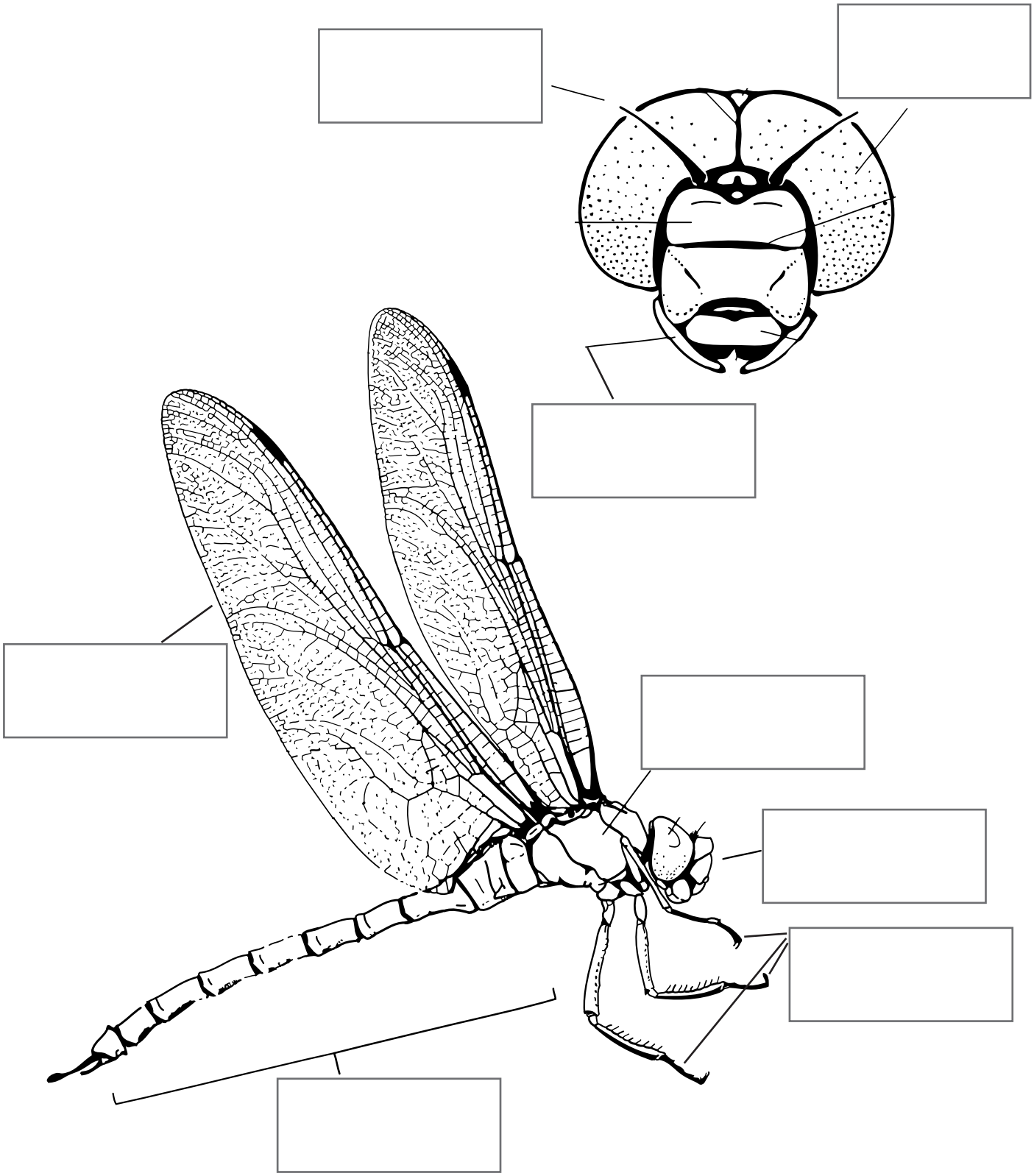
Name _____ Date _____



Illustrations by Rick Kollath from
Dragonflies of the North Woods *by*
Kollath+Stensaas Publishing

Basic Dragonfly Anatomy Worksheet

Name _____ Date _____



Illustrations by Rick Kollath from
Dragonflies of the North Woods *by*
Kollath+Stensaas Publishing

2. Paper Dragon Practice

Practice safely holding dragonflies using paper craft.

What You'll Need
Scissors
Papercraft Handout

Skills & Concepts
Human Impacts
Systems and Models
Communicating
Asking Questions
Structure and Function

Dragonflies and damselflies can be easily caught, examined, and released without harm if handled correctly.

There are two ways to hold a dragonfly.

1. Pinch the wings together above the thorax. Sweep the wings up and together between your thumb and pointer finger, from below.

Dragonflies will try to flap their wings while you are holding them; it will feel like a vibrating cell phone. Just hold tight—you are not hurting the insect when you hold it this way.

This is a great way for students to hold a larger dragonfly if they are afraid of being pinched by the mouthparts.

Damselfly wings can be delicate. If you hold one for a while by the wings, be gentle when you release your grip as their wings may stick to your fingers.

2. The second way to hold a dragonfly is by the legs.

Hold the legs between your thumb and pointer finger. Pinch the entire length of the legs snug up along the thorax; not just the distal ends of the legs. Be sure you are holding at least three legs, or the insect may fly away leaving a leg behind in your hand!

This is great way to hold an Odonate if you want to get a good look at the wings.
When holding a dragonfly by the legs, the mouthparts will be on top of your pointer finger. Dragonflies will express their displeasure about being captured by pinching your finger with their mandibles. All but the very largest of the dragonflies are only able to pinch, not scratch.

Holding a dragonfly by the wings. (Photo: Jon Thompson)

Holding a dragonfly by the legs. (Photo: Jon Thompson)

Activity: Paper Dragon Practice

1. Hand out the paper craft dragonfly sheet. Choose either the basic or more complicated version.

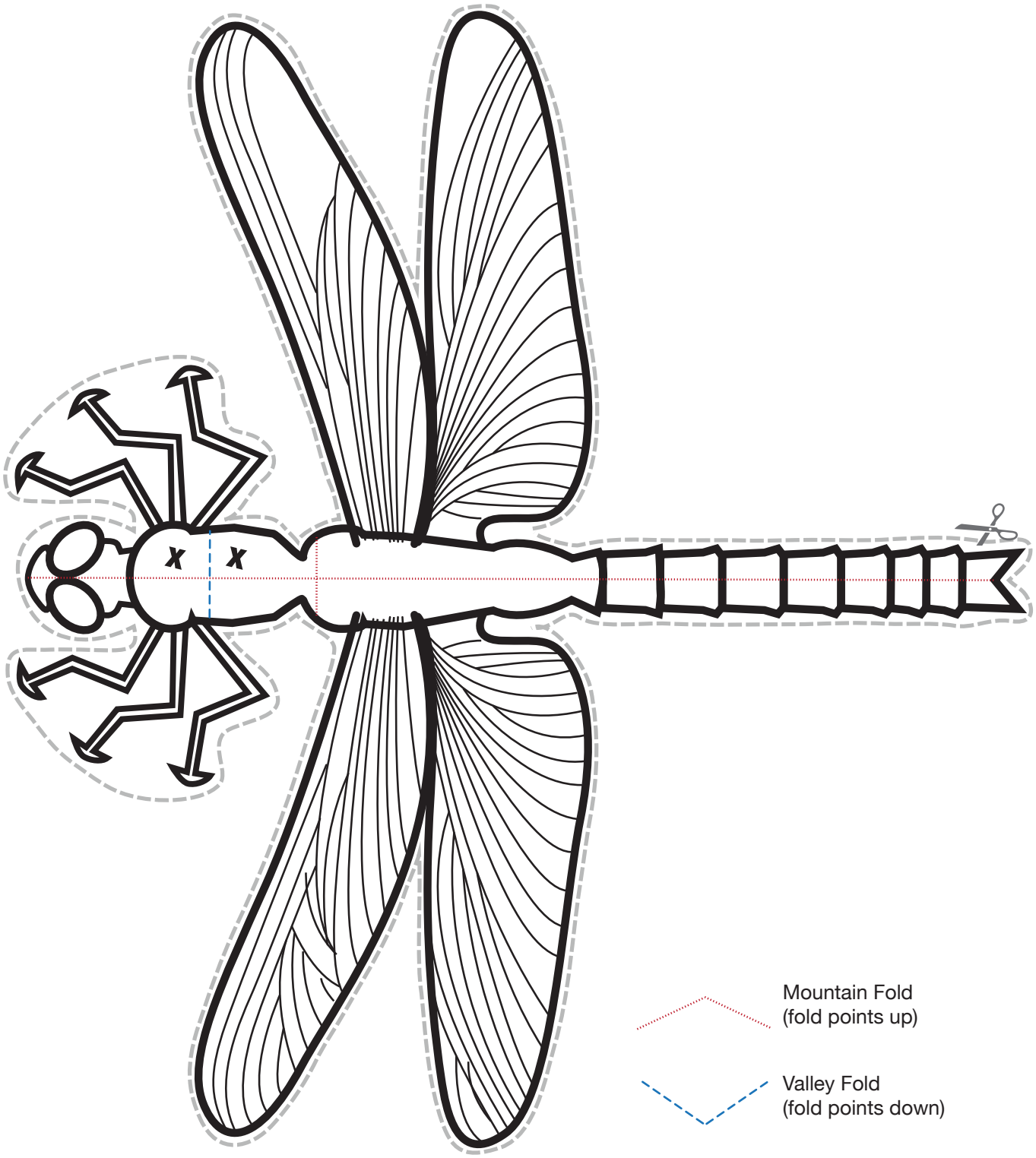
2. Students should cut out the paper dragonfly as instructed on the handout.

3. Then they can follow the folding directions to construct the paper craft dragonfly. Provide a finished example for them to examine as a problem-solving technique.

4. When the paper craft is completed, use it to practice the two different dragonfly-handling techniques.

5. As students work out how to fold the dragonfly, allow them to help each other by explaining the directions in different words or by demonstrating the different types of folds.

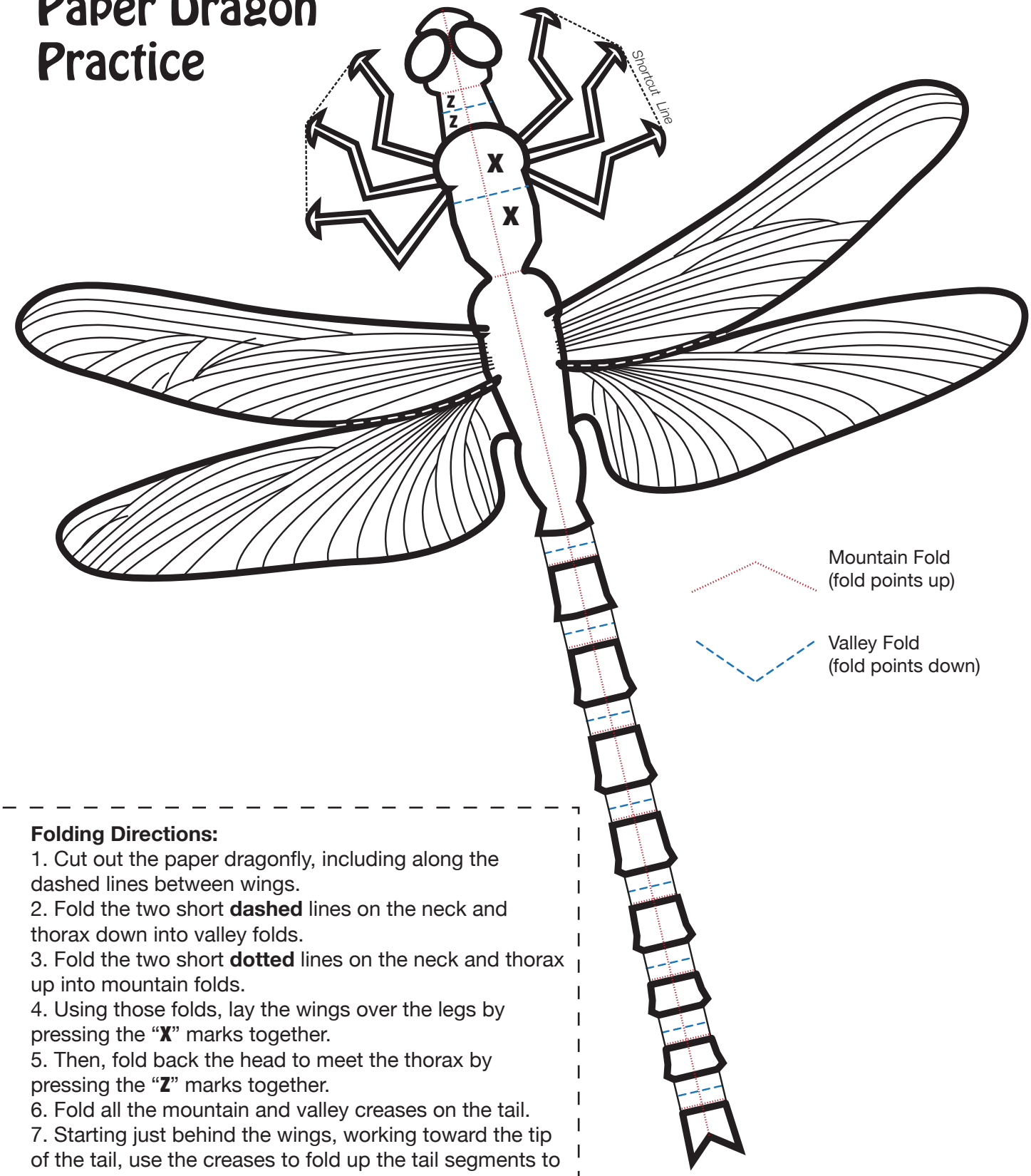
Basic Paper Dragon Practice



Directions:

1. Cut out the paper dragonfly along the outside dashed line.
2. Fold the dashed line by the legs down into a valley fold so the “X” marks touch.
3. Fold the dotted line in front of the wings up into a mountain fold.
4. Use those folds to lay the wings over the legs by pressing the “X” marks together.
5. Fold the dragonfly the long way, from head to tail, along the mountain fold line, pushing the wings down.
6. While holding the legs together, press up on the wings and gently crease them at the body to make them stick out.

Paper Dragon Practice



Folding Directions:

1. Cut out the paper dragonfly, including along the dashed lines between wings.
2. Fold the two short **dashed** lines on the neck and thorax down into valley folds.
3. Fold the two short **dotted** lines on the neck and thorax up into mountain folds.
4. Using those folds, lay the wings over the legs by pressing the "**X**" marks together.
5. Then, fold back the head to meet the thorax by pressing the "**Z**" marks together.
6. Fold all the mountain and valley creases on the tail.
7. Starting just behind the wings, working toward the tip of the tail, use the creases to fold up the tail segments to meet. Each segment tucks under the one in front of it.
8. Crease the entire dragonfly, from head to tail, along the long mountain fold dotted line, pushing the wings down. This crease will hold the head, legs, and tail in place.
9. While holding the legs together, press up on the wings and gently crease them at the body to make them stick out.

3. Dragon vs. Damsel

Discover the differences between dragonflies and damselflies.

What You'll Need
Nets
Hand Lenses
Odonata Envelopes
Journals
Access to a Wetland

Skills & Concepts
Recording Observations
Using Tools
Communicating
Asking Questions
Patterns
Structure and Function

Dragonflies and damselflies both belong to the order Odonata. Dragonflies are in the suborder Anisoptera; meaning "not equal wings." Dragonfly forewings are shaped differently than their hind wings. Damselflies are in the suborder Zygoptera; meaning "even wings." All four damselfly wings are the same shape.

Differences between the two suborders include:

1. Eyes: Dragonfly eyes almost always touch (except in the clubtail family). Damselfly eyes are always well separated by a distance that more than the width of one of their eyes.
2. Wings: Dragonfly wings are always held straight and out level when perched, like an airplane. Damselfly wings are held up over their backs or out at a slight angle.
3. Bodies: Dragonfly bodies are thick and meaty, and damselfly bodies are thin and petite.
4. Flight: Dragonflies have strong, purposeful flight. Damselflies are more erratic and fluttery flyers.

Note that size is not a defining difference; there are large damselflies and small dragonflies (even though dragonflies are often larger).

Activity: Which Ode Are You?

1. Break students into small groups and hand out a stack of photos of dragonflies and damselflies. You can gather your own photos or download photos from www.amidragonfly.com (A "Photos of Odes" PDF is available in the resources section). Tell students to organize the photos into different groups based on any characteristics they choose.

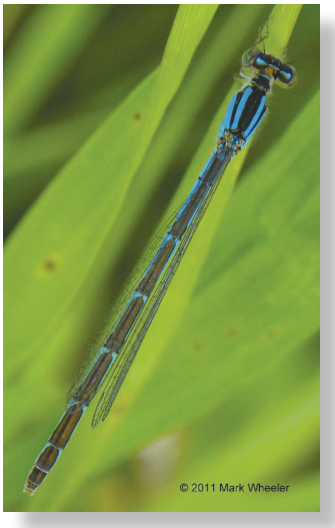
2. After they have completed their task, ask the groups to share the criteria they used for grouping the Odonata photos. List them on the board. If a group shares a characteristic that is used to differentiate dragonflies and damselflies (touching/not touching eyes, wing orientation, or body type), place a star next to it.

3. Tell students they will be comparing and contrasting dragonflies and damselflies outside; they have already discovered some of the differences between them. They will be going outside to discover more.

4. Prepare students for going outside. They will need to bring nets, hand lenses, and their journals. Using the criteria they discovered already, they should be able to tell dragonflies and damselflies apart. During this outdoor observation, they should observe all the differences, including flight styles, and record notes in their journals

5. Back in the classroom, compile a list of all of the observed differences and boil it down to the major differences listed above. Facilitate discussion about which differences are best to use to differentiate between the suborders. Encourage discussion and argumentation based on observed evidence.

Dragonfly eyes touch (except in the clubtail family). (Photo: Mark Wheeler)



Most Damselflies hold their wings folded up over their backs. (Photo: Mark Wheeler)

4. Who's Who?

Identifying Odes is not difficult, but it requires attention to detail and close observation.

What You'll Need
Handouts
Crayons/Markers
Photos of Odes

Skills & Concepts
Recording Observations
Sorting and Grouping
Communicating
Asking Questions
Patterns
Structure and Function

Most Odonata are easy to identify to family, genus, and species and have common names that describe their morphology, behavior, or habitat.

The trick to identifying dragonflies is paying close attention to detail.

The difference between two species could be a solid line of color along the abdomen versus a dotted line, yellow legs versus black legs, or the presence or absence of colorful wing veins. Male dragonflies are often easier to identify than females due to their brighter markings.

All of these things are easily observable, but you need to know to look for them. Identification guides are excellent at pointing out what to look for.

Students will be able to identify all the Odonata they catch to at least the family level (see activity 5, "Ode to Family"). Older students can learn to use a hand lens to observe the shapes of the reproductive parts of both male and female dragonflies. This will allow them to identify Odonata to the species level.

The skills of sorting, grouping, and observing dragonflies and damselflies are much more important than becoming an expert at identification. If you misidentify or can't identify all the way down to the species level, it's nothing to lose sleep over; the process itself is a valuable learning experience.

The Halloween Pennant dragonfly is easy to identify with its vibrant orange-and-brown wings. (Photo: Mark Wheeler)

Activity #1: Which Are the Same?

1. Hand out the matching game worksheet. Photocopy the following two 8.5 x 11 in (215.9 x 279.4 mm) worksheet pages side-by-side onto one 11 x 17 in (279.4 x 431.8 mm) page if possible. This is a version of the comparison games commonly found in activity books. It might be a little more difficult than those, but that's part of the point of the activity; what seems difficult at first becomes easy once you know what to look for.

Note: The worksheet dragonfly images are not representative of specific dragonfly species, just demonstrative of common variations.

2. Allow students to work independently at first, recording the differences they find between the dragonfly images as they search for the two that are exactly the same.

3. After a bit of time, if they are still searching, allow students to work together in groups to figure out which two dragonfly drawings are the same.

4. After most or all groups have discovered the answer, confirm the correct answer to the entire class. Review the differences they observed.

5. Discuss which differences were easy to find and which were harder. At first glance, did all the dragonflies look the same? Do they all look the same now? Now that they know what to look for the differences should be obvious.

6. Explain that the skills they used in the matching activity (close observation and comparison) are the same skills that scientists use when they are identifying Odonata.

Activity #2: What's Your Name?

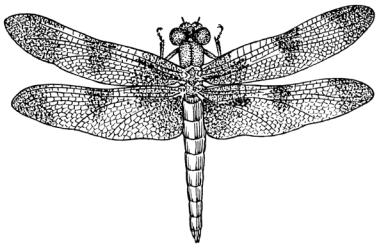
1. Project photos of dragonflies (See the "Ode Name Game PDF" from the resources section at www.amidragonfly.com) one at a time so all students can see. For each photo, ask students to raise their hand and share a made-up name for the Odonate based on something they can observe in the photo (morphology, habitat, behavior). Ask students to explain the reasoning behind their suggested names.

2. Then reveal the real common name for each photo. Were any of the guessed names correct? Discuss where they think the inspiration for the common name came from.

3. Hand out the "What's Your Name?" worksheet. Students should color the dragonfly's body, draw its habitat in the background, and give it a name. This activity could be expanded into a larger descriptive creative writing assignment if you desire.

This female ruby meadowhawk has black legs. It also has fairly large black triangles on its abdomen and no markings on its thorax. (Photo: Emily Albin)

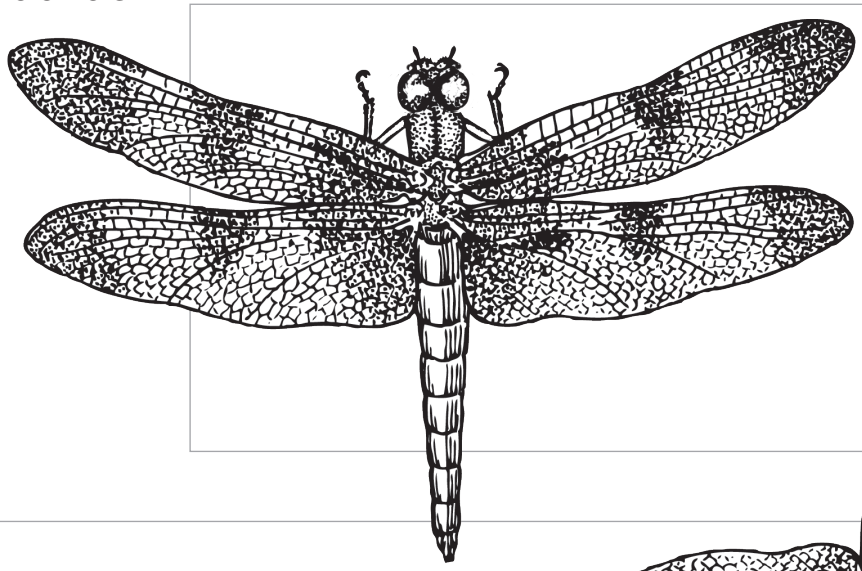
Note the light yellow/brown legs on this female autumn meadowhawk. Other similar meadowhawks have black legs. (Photo: Emily Albin)



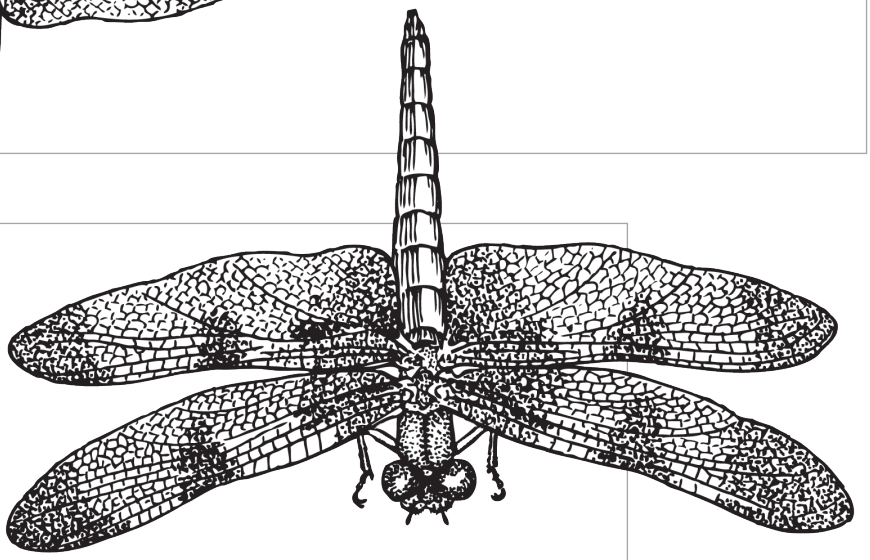
Which Are the Same?

Name _____ Date _____

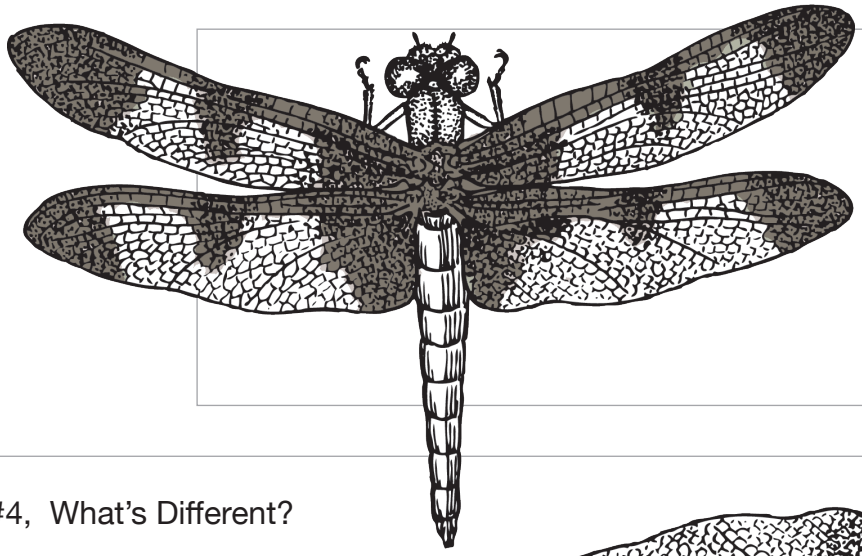
Directions: Find which two dragonflies are the exact same and explain what's different about the others.



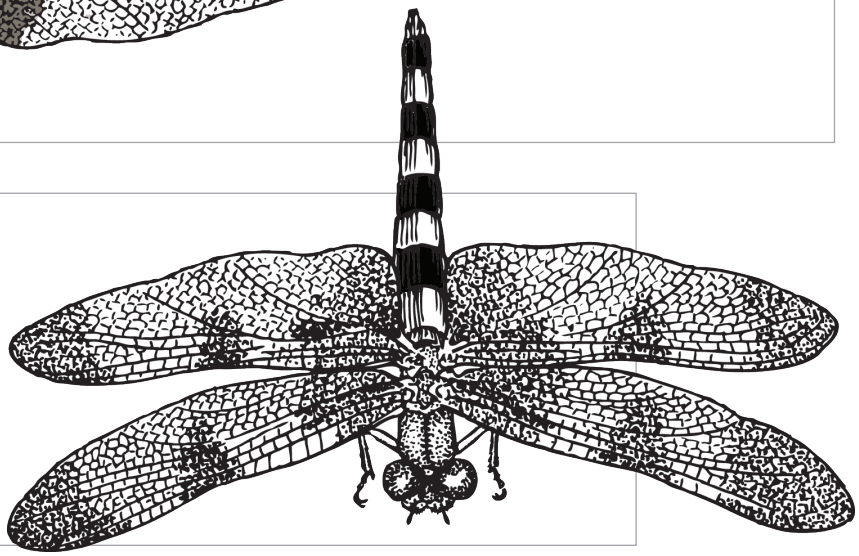
#1, What's Different?



#2, What's Different?

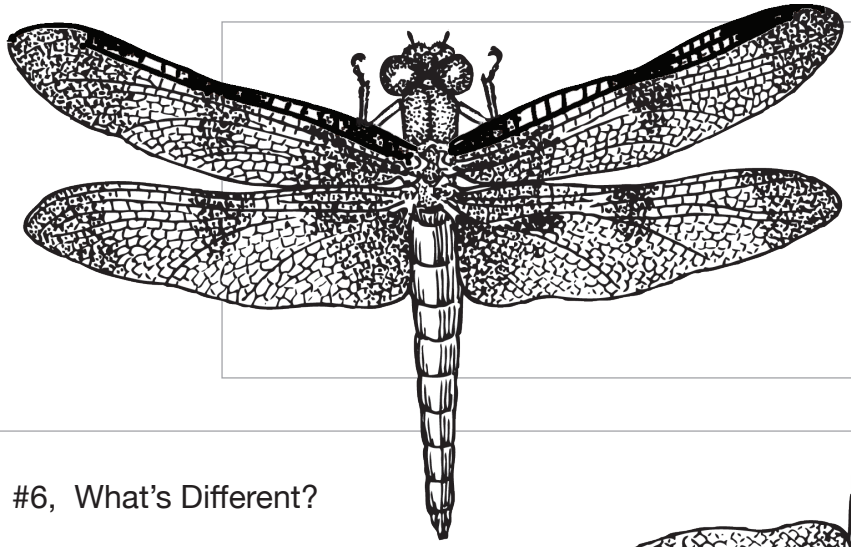


#3, What's Different?



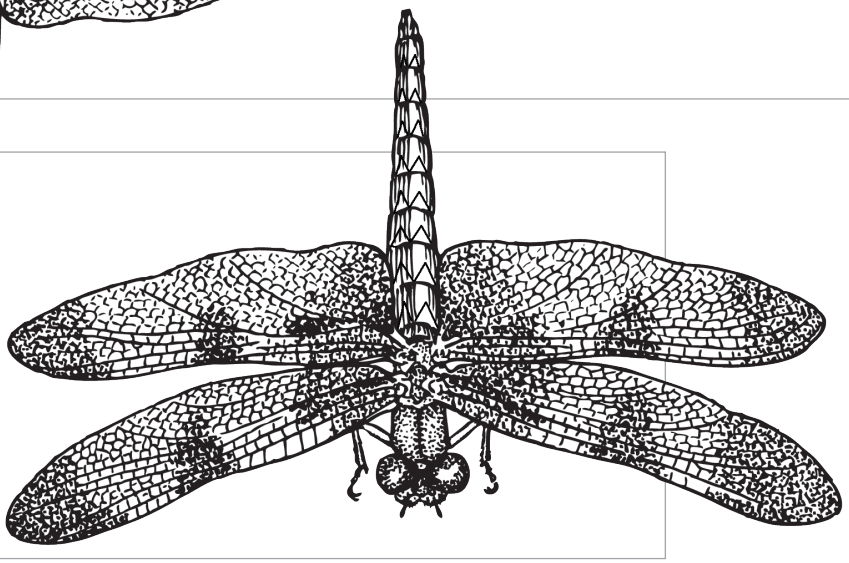
#4, What's Different?

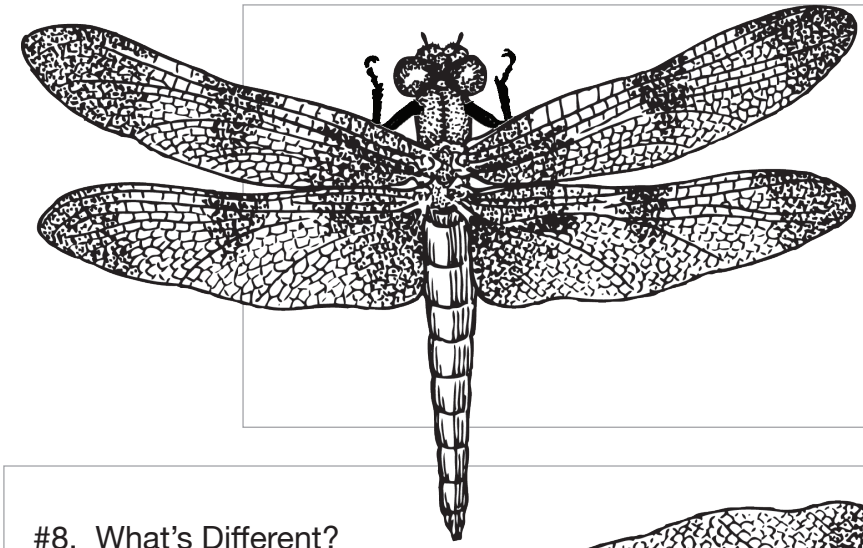
Name _____ Date _____



#5, What's Different?

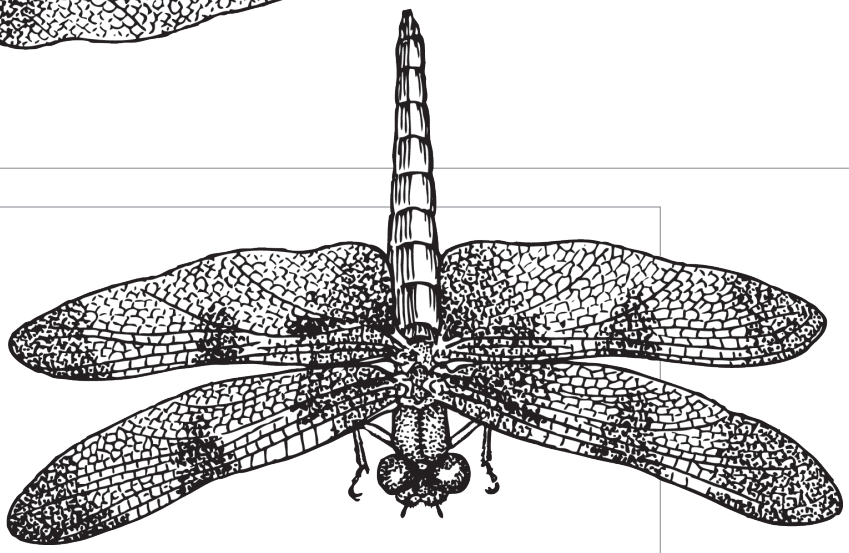
#6, What's Different?





#7, What's Different?

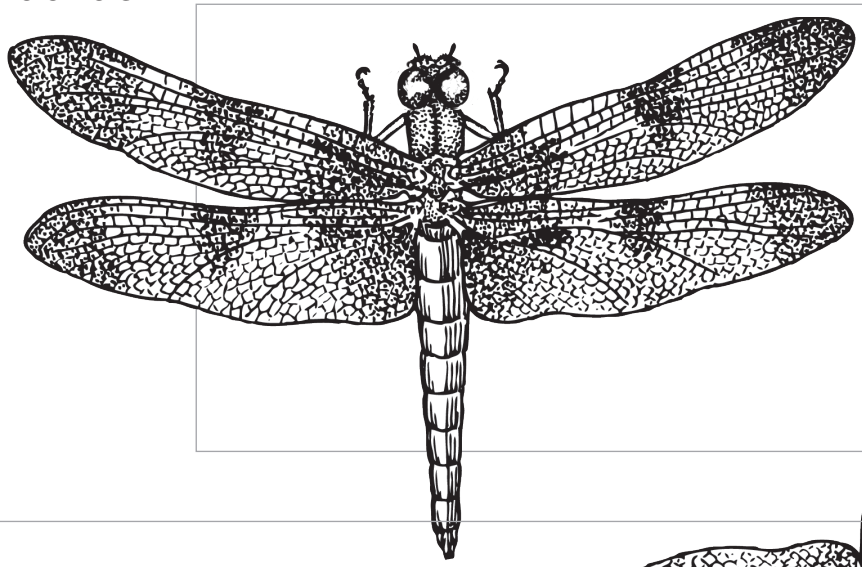
#8, What's Different?



Which Are the Same? ANSWER SHEET

Name _____ Date _____

Directions: Find which two dragonflies are the exact same and explain what's different about the others.



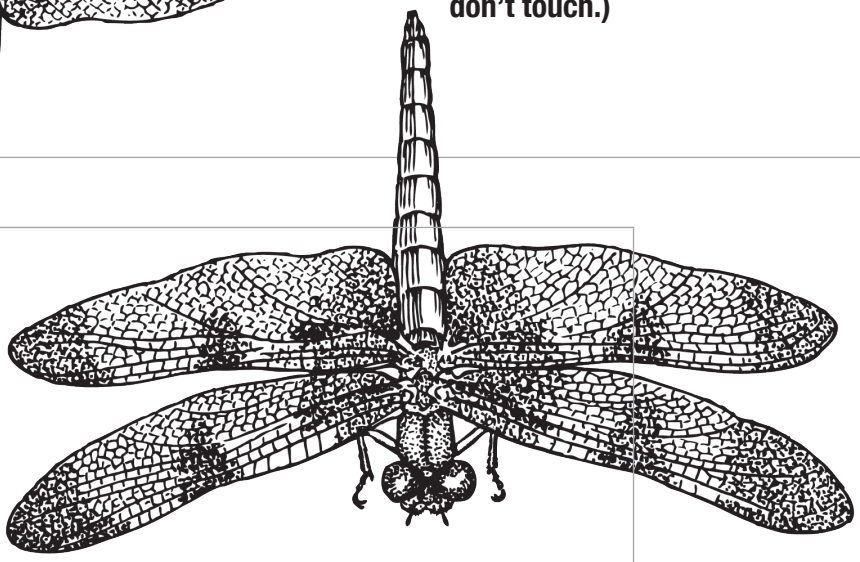
#1, What's Different?

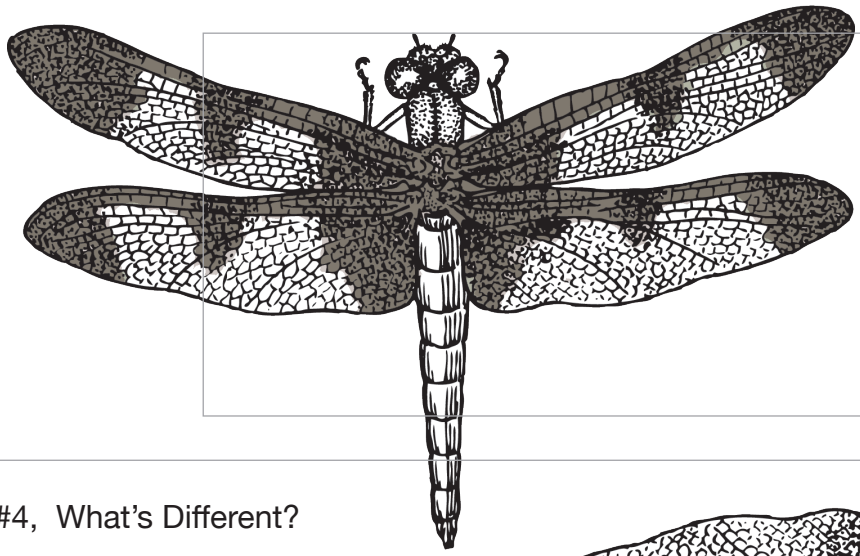
Eyes are smaller and touching.

(The clubtail family of dragonflies have eyes that don't touch.)

#2, What's Different?

This is one of the matching pair. It matches with #8.





#3, What's Different?

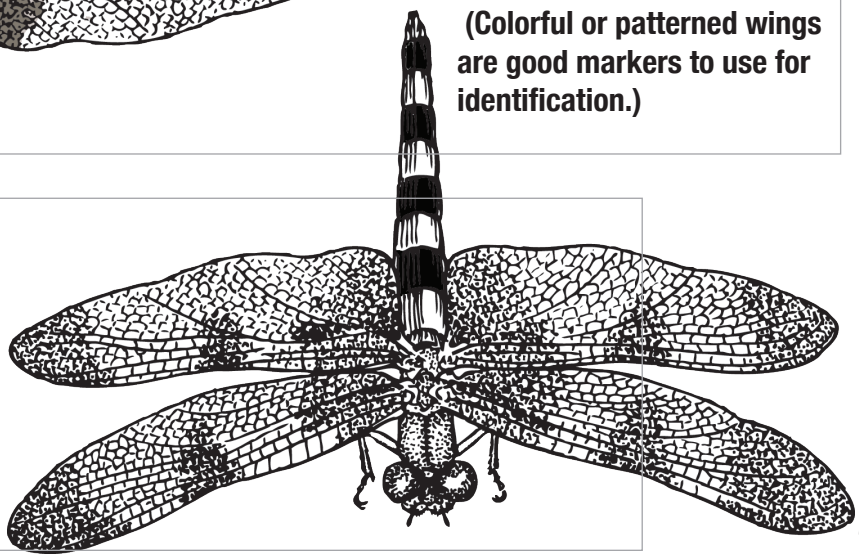
The wings have patches of grey.

(Colorful or patterned wings are good markers to use for identification.)

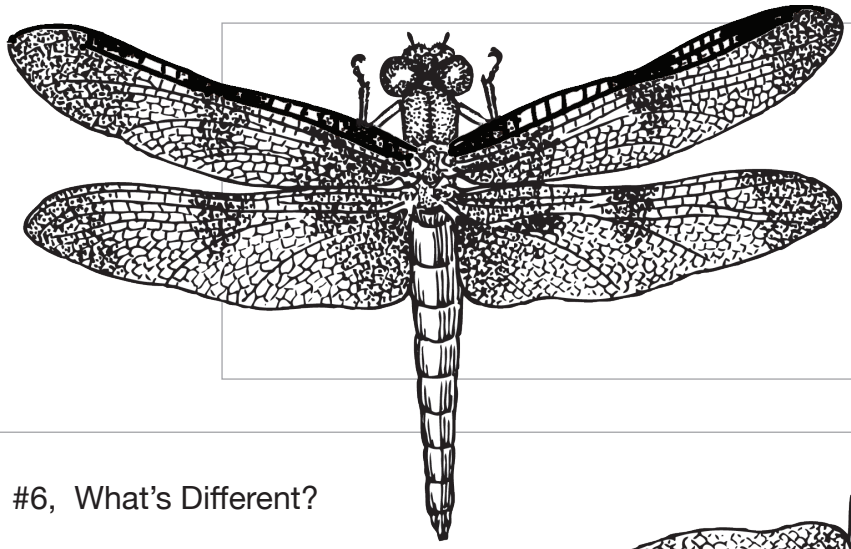
#4, What's Different?

The abdomen has black stripes.

(Patterns or colors on the thorax or abdomen are often an important key to identification.)



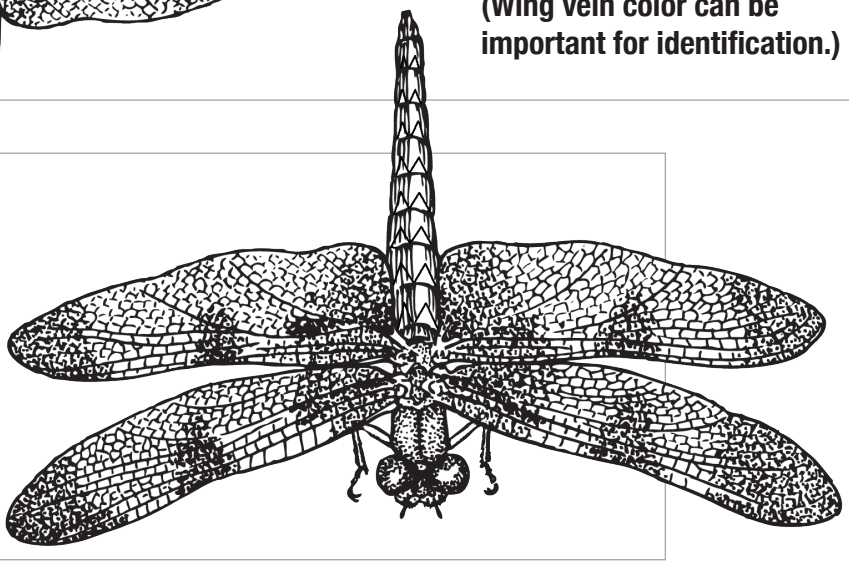
Name _____ Date _____



#5, What's Different?

The veins on the leading edge of the forewing are darker.

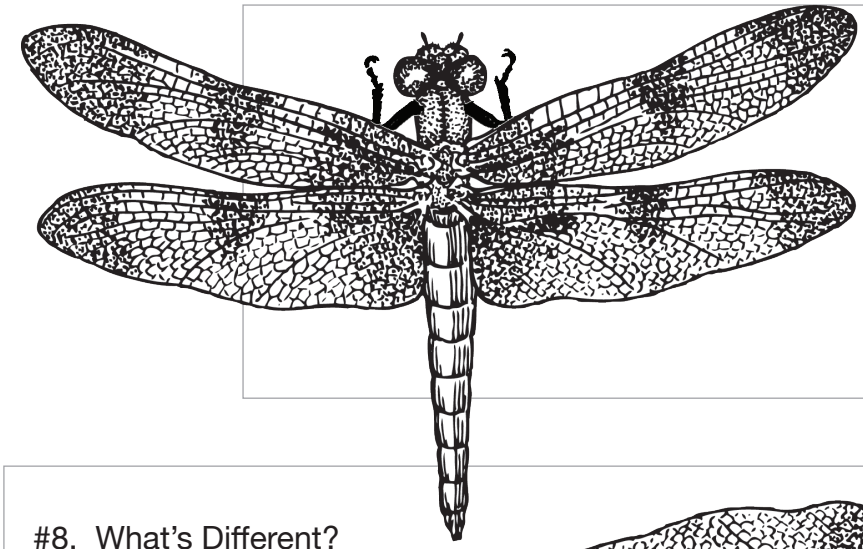
(Wing vein color can be important for identification.)



#6, What's Different?

The abdomen has small triangles.

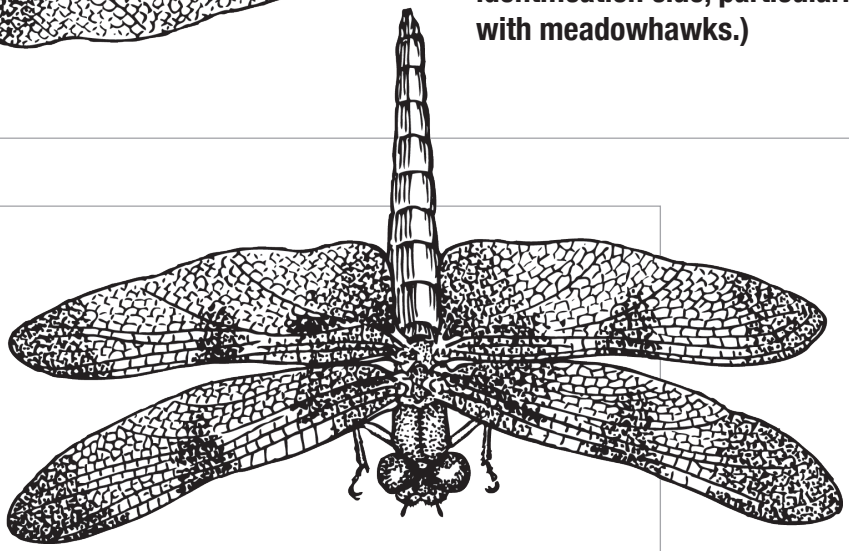
(Patterns or colors on the thorax or abdomen are often a key to identification.)



#7, What's Different?

The legs are black.

(Leg color can be an important identification clue, particularly with meadowhawks.)



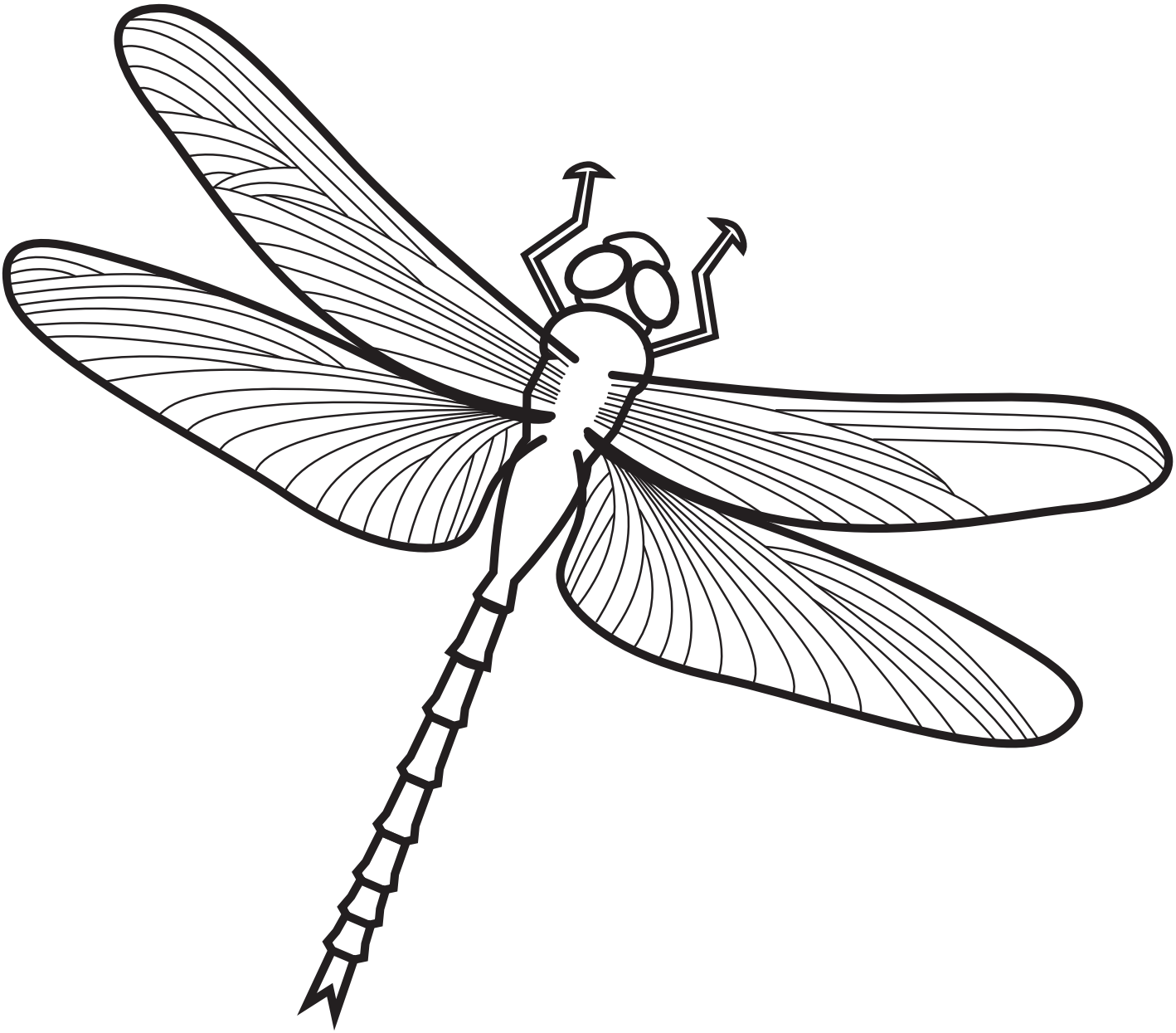
#8, What's Different?

This is one of the matching pair. It matches with #2.

What's Your Name?

Name _____ Date _____

Directions: Design and color this dragonfly with a unique palette and pattern. Draw its habitat in the background. Does it live near a tiny pond, a fast-moving stream, or somewhere else? How does its coloration help it adapt to its habitat? What is the name of your dragonfly?



Dragonfly Name:

Habitat:

Adaptations:

5. Ode to Family

Family groups of dragonflies and damselflies are easy to identify.

What You'll Need
Handouts
Nets
Hand Lenses
ID Guides
Access to a Wetland

Skills & Concepts
Asking Questions
Recording Observations
Structure and Function
Sorting and Grouping
Adaptation
Communicating
Investigating
Using Math
Patterns
Quantity

The six featured families of dragonflies from top left to bottom right: darners (Photo: Kurt Mead), clubtails (Photo: Arne Myrabo), spiketails (Photo: Kurt Mead), cruisers (Photo: Dan Irizzary), emeralds (Photo: Arne Myrabo), skimmers (Photo: Mark Wheeler).

Odonata common names are useful because they have been standardized (in North America) and the names readily describe the behavior, color, or habitat of a species. So they are, happily, easy to learn. I use common names in this guide, but feel free to teach the Latin names if you don't reside in North America or if you want to give your students an added challenge.

This lesson describes the six different families of dragonflies that reside in the upper Midwest of the United States of America: darners, clubtails, spiketails, cruisers, emeralds, and skimmers. However, you may encounter additional families of dragonflies if you live somewhere else in the world. For example, if you live in Southeast or the Western United States you may also encounter the family of petaltails. Like the clubtail family of dragonflies, petaltails also have eyes that don't touch.

Search out a dragonfly field guide for your area to discover what families your students may encounter. At the beginning of most dragonfly field guides is a specialized key for determining the family of dragonfly for the geographic area of focus. You can use that key to adapt this lesson to your needs.

The dragonfly families in this lesson are described in detail in Dragonflies of the North Woods but here is a simple summary:
1. Darners are all fairly large and have eyes that connect, making a line down the middle of the face.
2. Clubtails are the only dragonflies with eyes that don't touch (in the upper Midwest of the United States, your area may be different).
3. Spiketails have eyes that touch only at one very small point.
4. Cruisers have a single yellow stripe on their thorax.
5. Emeralds have a narrow, sometimes incomplete, yellow or white ring on their abdomens behind their wings.
6. The skimmer family catches all those that don't fit with the others. Skimmers often have patterned wings and brightly colored bodies.

And there are three different families of damselflies (in the upper Midwest of the USA, your area may be different): broad-winged, spreadwings, and pond damsels. The families are described in detail in Damselflies of the North Woods, but here is a simple summary:

1. Broad-winged: Wings very large and are often black, brown, or red.
2. Spreadwings: At rest, their wings are held at about a 45-degree angle from the body, not held together as in the other damselfly families.
3. Pond damsels: Wings are small, mostly clear, and held together above the body (this is the largest family).

Don't be overly concerned about the accuracy of your student's identifications in this lesson. The skills they are building in this exercise are detailed observation, data collection, and data analysis. They will still meet the learning objectives even if they misidentify the families. Encourage them to do their best but don't let fear of their identification being wrong prohibit them from getting the full lesson experience.

The three featured families of damselflies from top to bottom: broad-winged (Photo: Arne Myrabo), spreadwings (Photo: Mark Wheeler), pond damsels (Photo: Mark Wheeler).

Activity: Identify Dragonfly and Damselfly Families

1. Introduce the activity of identifying Odonata to the family level with photos (see "Ode Families PDF" available online at www.amidragonfly.com). Explain the key differences between the family groups and hand out and review the Family Dichotomous Key. You may need to get additional photos and/or edit the key to represent the dragonfly and damselfly families in your geographic area. Local identification guides are an excellent resource for this.

2. Break students into groups based on how many nets you have. Hand out the data sheets, nets, and identification guides if available.

3. Before you start catching insects, instruct students to record the current environmental information on their data sheets: the date and time, the weather, and a description of the location. Once they get started collecting, they should record how many individuals within which families they catch.

4. As they are catching, walk around and help students as needed. Remind them they are only identifying individual Odonata to the family level—not genus and species. Encourage them to record questions or challenges in their journals or data sheets.

5. In the classroom, tally and graph how many of each family the entire class collected. You will likely only find members of two or three families. Facilitate a discussion about why this is (habitat, time of year, commonness of family, etc.).

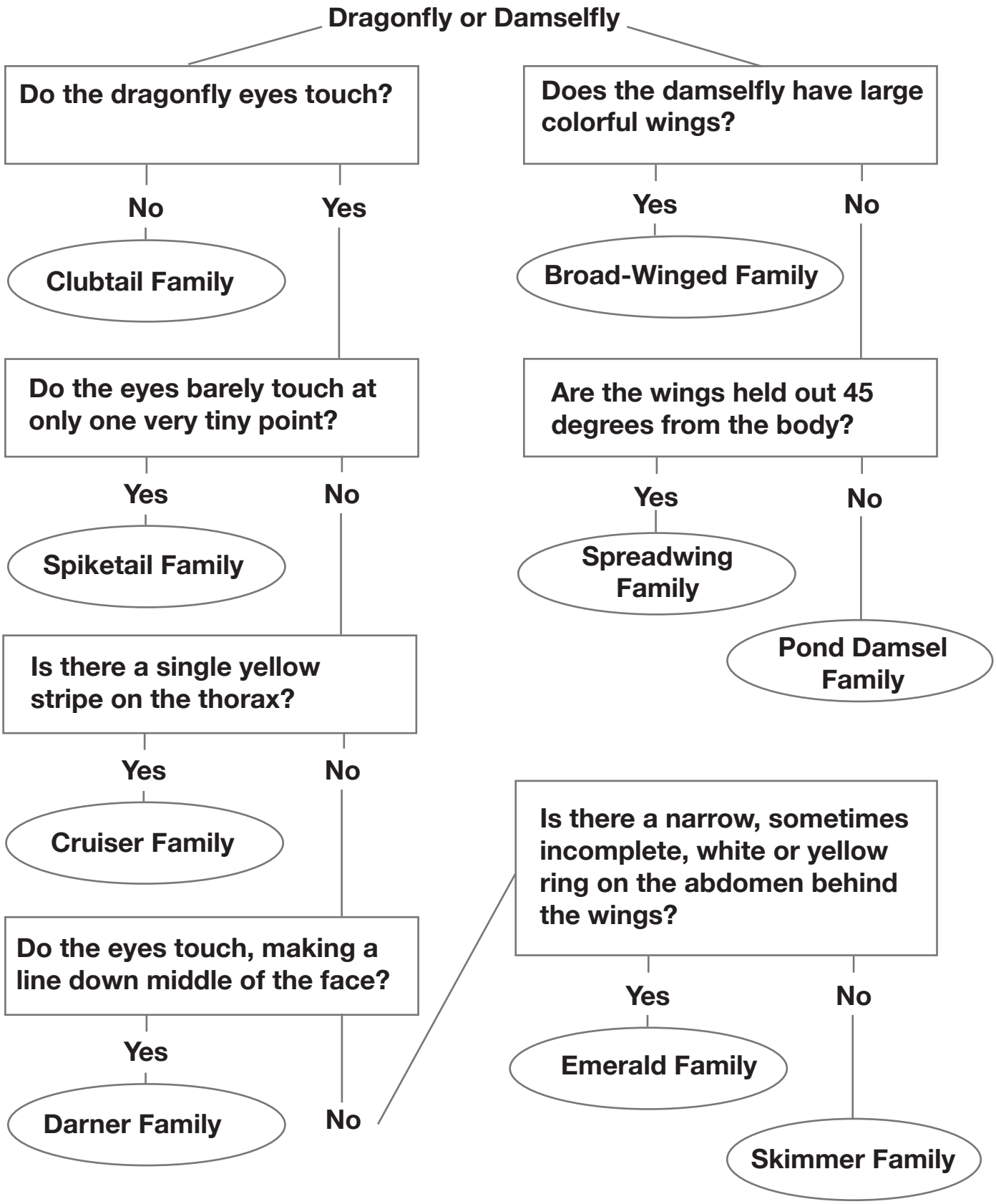
6. Discuss any challenges or questions students bring up. Potentially assign researching answers to these questions as homework.

Extension: Do this during fall and spring, and then compare the different types of families and volumes of individuals found.

Odonata Family Dichotomous Key

(for the USA Upper Midwest)

Name _____ Date _____



Odonata Family Data Sheet

Name _____ Date _____

Environmental Observations	
Date and Time:	
Weather Notes:	**Location Description:**

Odonata Family	Frequency of Capture
Write Family Name Here	~~||||~~ ||
Dragonfly Families	
Damselfly Families	

6. Diversity

Odonata diversity measured mathematically using data collected by students.

What You'll Need
Handouts
Nets
Hand Lenses
ID Guides
Calculators
Access to a Wetland

Skills & Concepts
Asking Questions
Recording Observations
Explanations
Human Impacts
Structure and Function
Sorting and Grouping
Adaptation
Communicating
Investigating
Using Math
Analysing Data
Patterns
Scale and Quantity

Odonata are fantastic indicator species. This means that the type and variety of dragonflies and damselflies found in an area can tell scientists about the ecological health of that habitat. Higher dragonfly diversity is associated with healthier habitats.

The presence of a single dragonfly species can indicate good water quality. Some species can only live in high-quality water conditions. More often, however, a healthy habitat is demonstrated by being home to a wide variety of Odonata.

Dragonflies are excellent at reflecting habitat quality because their life cycles require that they live both underwater as nymphs and in the air as adults. Pollutants and sediments that wash into water bodies can negatively affect aquatic dragonfly nymph development. After they metamorphose into aerial adults, Odonata need a healthy terrestrial ecosystem to support them. As predators, dragonflies need all of the trophic levels below them to be healthy, including the soil, plants, and smaller insects. Therefore, the presence of a variety of species of dragonflies can indicate a healthy functioning ecosystem.

For this activity, the health of your school habitat will be measured by observing the Odonata diversity: the more diverse, the healthier the habitat. This activity is based on one developed by the University of Minnesota's Monarch Lab, with permission.

To quantitatively measure diversity, students will record the total number of Odonata species they catch and the number of individual caught of each species. Diversity can then be calculated using the Simpson index:

$$D = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

Don't be intimidated by this equation. The Simpson index is quite simple, and ecologists really use it to quantify diversity. The higher the Simpson index number (D), the greater the diversity.

Breakdown of the equation:
D = **diversity**
S = total number of **species**
i = number of **individuals** of a species
P = **proportion** of individuals of a species; for each species, i is divided by the total number of individuals
Σ = a Greek **epsilon**, which means "to sum"

Snaketail dragonflies (within the family of clubtails) are the "trout" of the Odonata world, requiring pristine water conditions to survive. (Photo: Arne Myrabo)

While clubtails like this one indicate good water quality, a high diversity of Odonata at a site can also indicate a healthy aquatic ecosystem.
(Photo: Scott King)

Steps for solving the equation:

1. Gather data outside: catch Odonata, keeping track of the number of individuals and species (see handout #1).

2. Calculate the denominator using the chart and instructions (see handout #2). This number represents the likelihood that any two Odonates randomly sampled will be of the same species. We want to quantify the opposite of this "sameness" because we actually want to measure diversity.

3. So we calculate the inverse to get D (see handout #2). A higher value for D indicates higher diversity. The highest value D can be is equal to S (the number of species). So if your class finds five species of Odonata, then D cannot be larger than five. In other words, five would be the maximum possible diversity value in that scenario.

If you sample multiple areas or sample at different times of year, you can compare and contrast your results.

Note that this equation calculates species diversity, which is often confused with species richness. Species richness is the number of species found in an area (which is the same as S in the equation). Imagine that two groups of students survey two different ponds and each group collects four different species. These ponds have the same species richness (4). However, group A collected 25 Hagen's bluets, 25 common green darners, 25 twelve-spotted skimmers, and 25 eastern forktails. Group B collected 87 Hagen's bluets, 2 common green darners, 6 twelve-spotted skimmers, and 5 eastern forktails. Which pond is more diverse? You could figure it out using the Simpson equation. (Answer: group A's pond!)

Activity: Calculating Diversity

1. Ask your students if they think that the natural area your class visits is "healthy." They should explain why or why not. Make a chart on the board recording their stated evidence of what makes it "healthy" or "unhealthy." Ask how those factors could be measured. Introduce a few of the many ways that scientists measure habitat quality or health (dissolved oxygen in water, sedimentation, chemical pollution, temperature, plants and animals present or missing, etc.).

2. Introduce the activity of catching and identifying dragonflies and damselflies in order to measure Odonata diversity as a proxy for habitat quality. Review why and how Odonata diversity reflects habitat health, as explained above.

3. Introduce the identification guides to your students. They should be familiar with identifying to family level (activity 5, "Ode to Family"). Today they will be attempting to determine the genus and species of the dragonflies they catch. Introduce important tools that the identification guidebooks provide: time-of-year charts, habitat descriptions, commonness notes, and special field marks. If they haven't already observed that male and female Odonata can look very different, introduce this fact in class using pages from an identification guide as examples.

4. Instruct students to make their best educated guesses for the species identification. If they have any doubt, disagreement, or confusion, it should be noted on their data collection sheets. Emphasize that they should be consistent with their guesses; if they are presented with the same confusing species repeatedly they should always record the same guess of species.

5. Break students into groups based on how many nets you have. Distribute nets, hand lenses, data sheets, and guidebooks to each group.

6. Define the geographic area the students will be working in and head outside. You may want to create two or three different geographic areas and compare their diversity.

7. Let students catch, identify, and record as many dragonflies as possible. If they get stuck with identification challenges, help them with open-ended questions, encourage them to record their questions, and to make their best guess. For example, some of the meadowhawk dragonflies and bluet damselflies can be very difficult to identify to species, but for the purpose of learning how to calculate diversity, a best guess for species will be just fine.

8. When students get back into the classroom, compile all the student data in a chart that captures species name and number of individuals on the board for all to see. Separate the data per geographic area if you are measuring more than one.

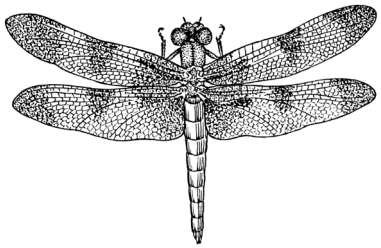
9. Introduce the concept of measuring diversity and shift into a discussion of what diversity means in ecology. Is a habitat with 10 common green darners, 10 slender spreadwings, 30 autumn meadowhawks, and 50 racket-tailed emeralds as diverse as one with 25 of each? (Nope!)

10. Introduce the Simpson index as a tool created by ecologists to place a quantitative value on diversity.

11. Have the students calculate diversity (D) using the data from entire class or from their geographic area (see handout #2).

12. Discuss your results. What do they suggest about the health of your class natural area?

Extension: sample your natural area multiple times throughout the year, and over many years, comparing the numbers. Brainstorm possible explanations for any fluctuations in diversity.



1. Odonata Diversity Data Sheet

Name _____ Date _____

Environmental Observations	
Date and Time:	
Weather Notes:	**Location Description:**

Odonata Species Name	Frequency of Capture	Total Frequency
Sample Species	~~IIII~~ II	7

2. Simpson Diversity Index Worksheet

Name _____ Date _____

Simpson Diversity Index Equation

Breakdown of the equation:
D = **diversity**
S = total number of **species**
i = number of **individuals** of a species
P = **proportion** of individuals of a species; for each species, i is divided by the total # of individuals
Σ = a Greek **epsilon** symbol, which means "to sum"

$$D = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

Step 1: Calculate and Sum P_i^2

Species Name	i = Total Frequency (number of individuals)	P_i = i /Total i	P_i^2
Total		1	$\square = \sum_{i=1}^{S} P_i^2$

Step 2: Divide $\sum_{i=1}^{S} P_i^2$ **by 1:**

$$\frac{1}{\square} = \bigcirc = D$$

2. Simpson Diversity Index Worksheet EXAMPLE ANSWER SHEET

Name _____ Date _____

Simpson Diversity Index Equation

Breakdown of the equation:
D = **diversity**
S = total number of **species**
i = number of **individuals** of a species
P = **proportion** of individuals of a species; for each species, i is divided by the total # of individuals
Σ = a Greek **epsilon** symbol, which means "to sum"

$$D = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

Step 1: Calculate and Sum P_i^2

Species Name	i = Total Frequency (number of individuals)	P_i = i /Total i	P_i^2
Hagen's Bluet	11	0.52	0.27
Eastern Forktail	4	0.19	0.04
Common Green Darner	2	0.10	0.01
Twelve-Spotted Skimmer	4	0.19	0.04
Total	21	1	0.36 $= \sum_{i=1}^{S} P_i^2$

Step 2: Divide $\sum_{i=1}^{S} P_i^2$ by 1:

$$\frac{1}{\boxed{0.36}} = 2.78 = D$$

7. Life of Defense

Odonata have special adaptations for each stage of life.

What You'll Need
Odonata Videos or Photos
Handouts
Scissors
Crayons or Markers (optional)

Skills & Concepts
Recording Observations
Explanations
Communicating
Sorting and Grouping
Life Cycle
Systems and Models
Asking Questions
Scientific Argument
Patterns
Structure and Function
Cause and Effect
Scale and Proportion
Energy Flow

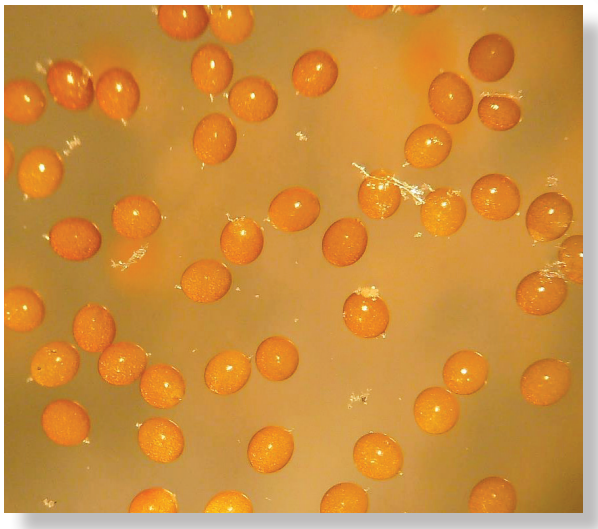
Odonata have three life stages: egg, nymph, and adult. They also have one major life event, called emergence, when they leave the water and transform from a nymph to an adult.

During all of these stages, dragonflies have adaptations that protect them from predation and other dangers.

Egg Stage:
Odonata eggs are very small, about the size of a period on this page. They are round or oval with a small hole. The sperm enters this hole to fertilize the egg, and the hole is also where the nymphs break open the egg when they hatch.

Most damselflies and some dragonflies lay their eggs inside reeds or other water plants. The females have a sharp tool on the end of their abdomens that slice open a place to insert the eggs. Inside the plant, the eggs are sheltered from predators and weather.

Dragonfly nymph. (Photo: Scott King)



Dragonfly eggs. (Photo: Scott King)

Some dragonflies wrap their eggs in a sticky substance to glob them together and attach them to sticks or other flotsam so they don't wash away.

Yet others lay their eggs on land in areas they think will flood in spring.

Some dragonflies dip their abdomens down through the water and deposit their eggs in the sediment below to hide the eggs from hungry fish.

Lastly, many dragonflies simply lay their eggs in open water. Sometimes fish can be seen following the depositing female, gobbling up the eggs. These species lay many eggs betting that at least a few will escape and survive.

Nymph Stage:
Odonata spend the vast majority of their lives underwater as nymphs. Nymphs are voracious predators and will eat anything that they can catch. In ponds without fish, large nymphs can live a top-of-the-food-chain life. Nymphs shed their skin as they grow, much like a snake. A larger body emerges from the shed exoskeleton and continues growing until it needs to molt again. Nymphs will molt roughly 6 to 12 times (sometimes more)

depending on species, water temperature, and food availability.

When sharing a wetland with fish, nymphs need to use their adaptations to avoid being consumed. Unlike most adult dragonflies, nymphs are bland in color and blend in with the brown lake or river silt. Sometimes they burrow down into the mud or sand—to both hide from predators and ambush prey. If they need a sudden burst of speed, dragonfly nymphs can shoot a jet of water out of their anus for propulsion. Nymphs can regenerate lost limbs and gills and some can grow defensive body spikes if needed.

Adult Stage:
The mission of an adult dragonfly is to live long enough to mate and lay eggs. Birds and other creatures love to eat dragonflies and damselflies if they can catch them. A dragonfly's best defence is its fantastic vision and amazing flying skills. Students will learn about these talents first hand when they try to catch dragonflies with nets.

Emergence:
While not a stage of the life cycle, this major life event has some adaptations of its own. Odonata who have just emerged and can't yet fly are called tenerals (think "tender"). Tenerals are as soft as warm butter and are extremely vulnerable to predation. To compensate for this, some nymphs emerge in large numbers and confuse predators. Nymphs can also emerge under the cover of darkness before sunrise in order to be hidden from daytime hunters. Lastly, dragonflies don't develop their eye-catching adult coloration until they are strong flyers.

Activity #1: Adaptation Brainstorm

1. Introduce Odonata life stages to your students. Show them videos and pictures and refer to any nymphs you may be keeping in the classroom (see the "Life Stages PDF" from www.amidragonfly.com).

2. Break your class into small groups and assign each group a life stage (egg, nymph, or adult) or the life event emergence. Repeat groups as necessary.

3. Each group should brainstorm and record what dangers that life stage or event faces and create

Mass emergence of dragonflies.
(Photo: Arne Myrabo)

educated guesses about what adaptations might exist to overcome these dangers. Have some photos and maybe some reference materials available for each group.

4. Ask each group to report to the entire class its lists of dangers and adaptations. Create a cumulative list on the board.

5. Ask probing questions if the groups missed some adaptation or if some listed are not viable.

6. Keep another list to capture any questions that pop up.

7. An additional assignment could be to have students research the lists or questions for accuracy or answers to questions.

Activity #2: Ode Snapper

1. Distribute the handout to students. Let them color it (optional), cut it out, and fold it. Think of this game as a fancy flashcard.

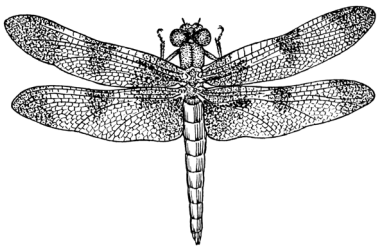
2. There are two options for the game sheet. The first sheet (the handout) has all the adaptations listed, and the other (the worksheet) has blank space for the students to write in the adaptations themselves.

3. Break students into groups of two.

4. Taking turns, student A chooses a class vocabulary word (your choice for options), then student B spells the word, moving the paper snapper once for each letter and leaving the snapper open for the last letter.

5. Student A chooses one of the two life cycle events displayed in the mouth of the snapper, then lists that life cycle/event's adaptations. Student B can give hints or reminders if needed. Repeat with students A and B trading roles.

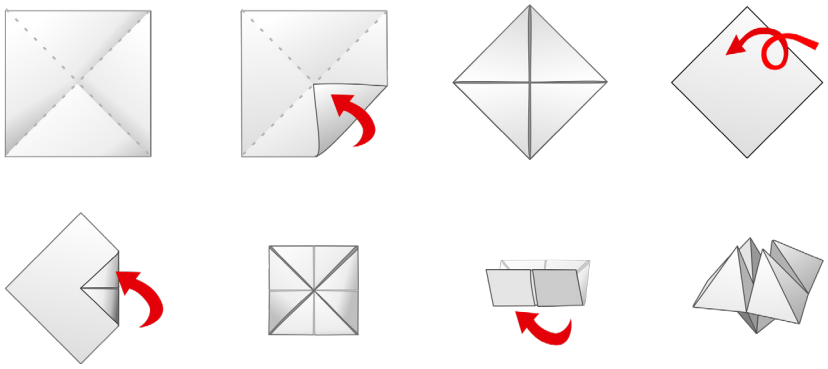
6. This can be a points-earning game you desire: one point for every word spelled correctly and one point for every adaptation list fully recited.

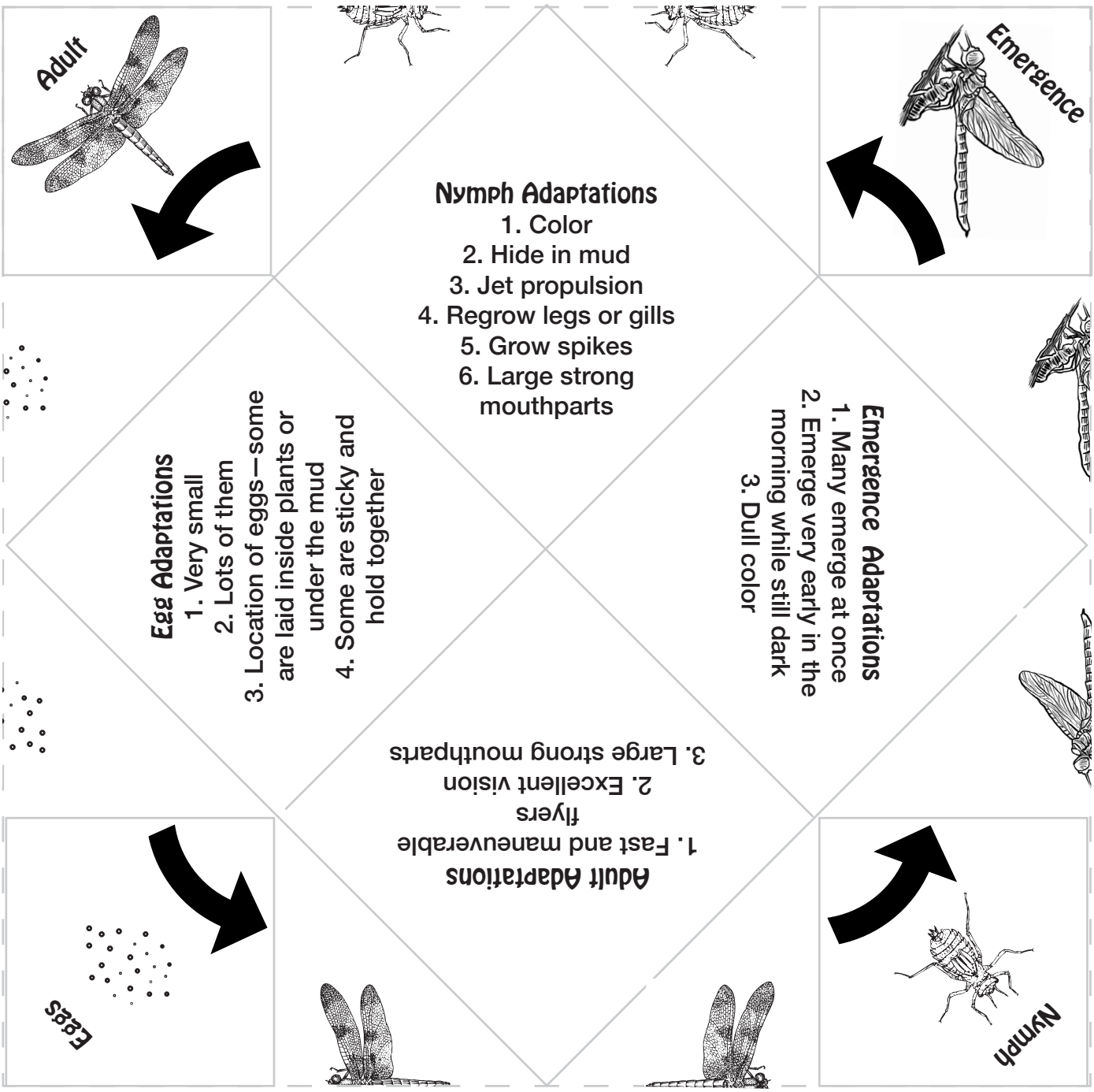


Dragonfly Life Cycle Handout

Nymph illustration by Rick Kollath from Dragonflies of the North Woods *by Kollath+Stensaas Publishing*

Folding Directions: *(begin with the printed side facing down)*

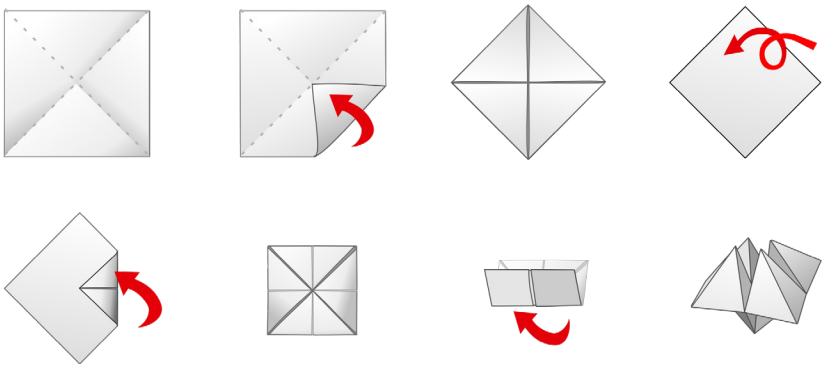


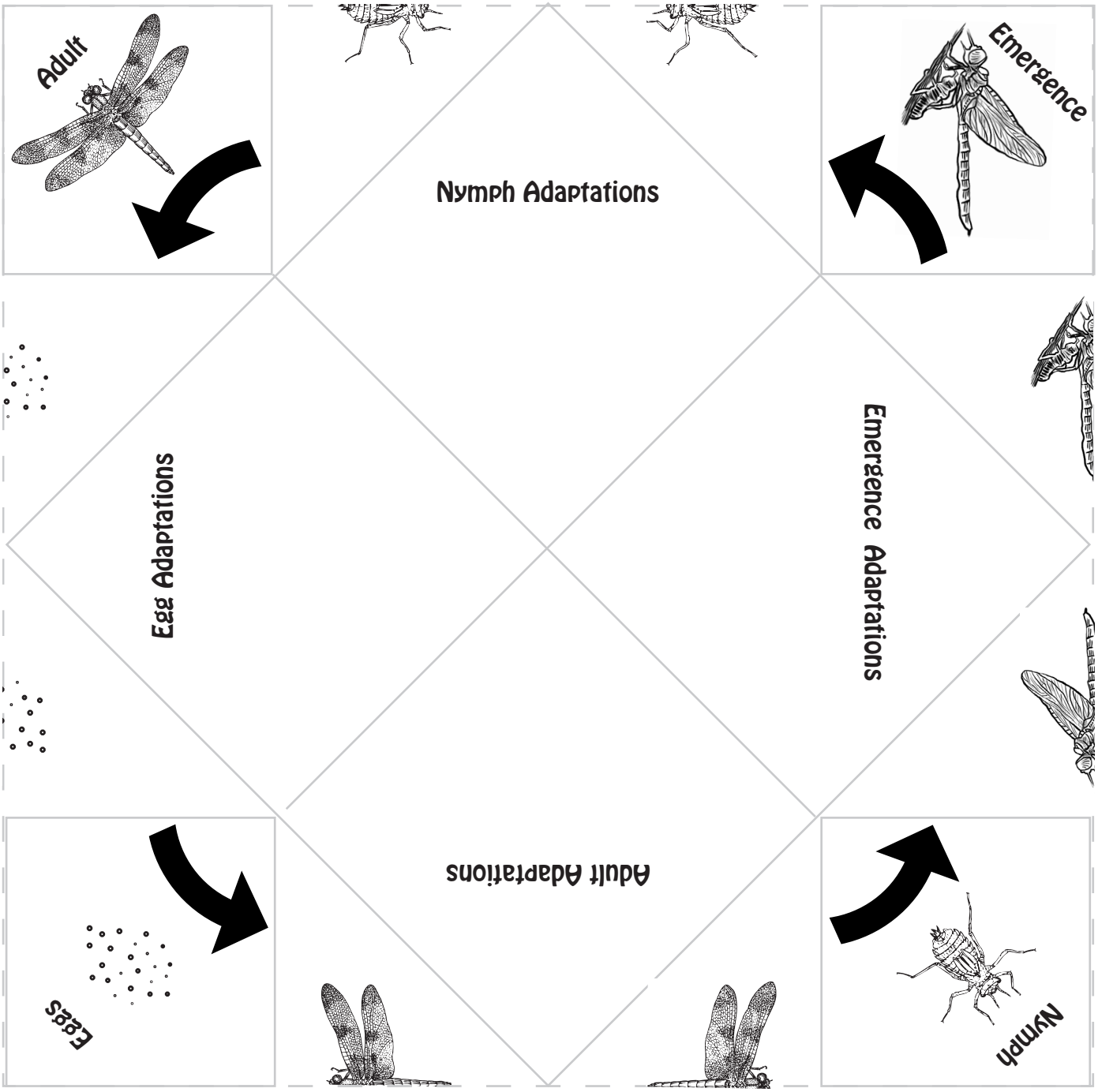


Dragonfly Life Cycle Worksheet

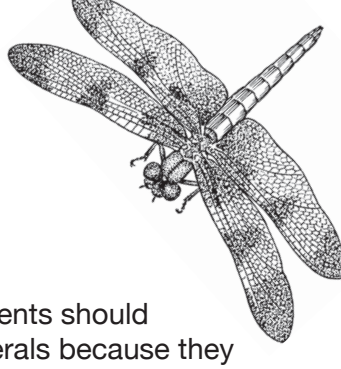
Nymph illustration by Rick Kollath from Dragonflies of the North Woods *by Kollath+Stensaas Publishing*

Folding Directions: *(begin with the printed side facing down)*





8. Metamorphosis



Odonata undergo incomplete metamorphosis when they emerge from the water and become adults.

What You'll Need
Access to a Wetland
Journals

Skills & Concepts
Recording Observations
Life Cycle
Patterns
Structure and Function

Dragonflies and damselflies spend most of their lives underwater as nymphs. It can take a few weeks to a few years for the nymphs to mature. In colder parts of the world they need more time to reach maturity. After they metamorphose into flying adults they only live for a few weeks during which they mate and lay eggs.

In order to transition from a water insect into a flying insect, Odonata go through a process called incomplete metamorphosis. Incomplete metamorphosis doesn't include a cocoon or chrysalis stage. Complete metamorphosis does. Dragonfly nymphs transition directly into adults. Larva that undergo complete metamorphosis look completely different from the adult—for example a caterpillar looks very different from a butterfly. Nymphs that undergo incomplete metamorphosis look similar to adults. Dragonfly nymphs have six legs, two large eyes, a head, a thorax, and an abdomen—just like adults. Older dragonfly nymphs even have little wing buds.

When ready to emerge, a dragonfly nymph crawls up out of the water onto a stick, reed, or rock. Then the nymph skin splits open right behind the head. The new adult dragonfly performs a few dramatic yoga-like moves to crawl out of the old skin.

At first the adult dragonfly's wings and abdomen are tightly crumpled and need time, perhaps about an hour, to be inflated with air and blood. A dragonfly is extremely vulnerable while in this stage. To counter this, Odonata often emerge in large groups very early in the morning to overwhelm or avoid potential predators. A newly emerged dragonfly or damselfly is called a teneral. They are very pale in color and cling to plants, not yet able to fly. You and your students should avoid catching and handling tenerals because they are very delicate.

Your students may not come across Odonata in the process of emerging. However, the insects leave wonderful evidence of their transition called exuviae—the leftover nymph skins clinging to sticks, reeds, or rocks. This is a great thing for students to look for while on walking along ponds and rivers.

Activity: Emergence Patterns

1. Introduce the Odonata life cycle (see activity 7, "Life of Defense").

2. Show students a variety of videos of dragonflies and damselflies emerging. (Many videos are available by searching for "dragonfly emergence" or "damselfly emergence" in YouTube.) Students will see the same series of events in each video. Ask them to observe, identify, and record the stages of emergence as they observe them. There

Emerging adult dragonfly. (Photo: Kurt Mead)

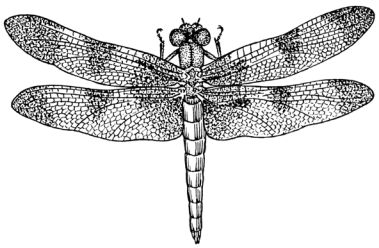
is no right or wrong answer; however they break down and describe the stages meets the learning objective of identifying patterns. Ask students what evidence of emergence Odonates leave behind.

3. Go on an outdoor exuviae hike. Walk around a pond or river looking for evidence of recent metamorphosis: exuviae or teneral adults.

4. Exuviae can be collected during the hike and brought into the classroom for closer study. It's a great way to learn about nymph anatomy (see activity 9 "Classroom Nymph"). The exuviae are brittle and should be handled with care. If you don't find any evidence of emergence, brainstorm with your students about why not. Did a recent rain and wash the exuviae away? Is it the wrong time of year for dragonflies to be emerging? Did another class earlier in the day already find and collect all the evidence?

5. If you are raising nymphs in the classroom (see activity 9) your students are more likely to be able to see a portion of the emergence process. The "action" of the dragonfly crawling out of its nymph skin only takes about an hour but it does takes a day or two for the adult to gain its mature coloration.

Note: You can collect exuviae on your own from anywhere convenient for you before your hike if you're worried you won't find any with your students. In fact, you can even "plant" exuviae along your hiking path for students to find. The exuviae legs are kind of prickly and stick like Velcro to plants, rocks, or on the soil.



9. Classroom Nymph

Observe the daily behaviors of dragonfly nymphs as classroom pets.

What You'll Need
Aquatic Net
Jars or Tanks
Sticks or Water Plants
Nymph Food
Journals
Handouts
Access to a Wetland
Water Conditioner
Tap Water

Skills & Concepts
Asking Questions
Recording Observations
Explanations
Using Tools
Life Cycle
Systems and Models
Investigations
Interpreting Data
Scientific Argument
Energy Flow
Stability and Change
Communicating
Asking Questions
Patterns
Structure and Function
Engineering

Dragonfly nymphs are remarkably easy to care for in the classroom. Raising nymphs is a great way to connect students to nature, particularly during the winter months.

Nymphs can be collected from any wetland with a fish net (be sure to get the land owner's permission). Dip your aquatic net a little bit into the sediment or scrape it along submerged sticks or vegetation for the best chance of finding one. Catching a nymph from the wild is the best way to get one for classroom observation because it's free and when you are done you can let it go outside.

If getting a "wild" nymph is not possible, they can be ordered from biological supply companies. However, this is usually expensive (about $50 with shipping) and requires a minimum order of about 12 nymphs. Furthermore, these nymphs cannot be released when you are done with them. They are not native to your local ecosystem and may harm it if released. Instead, they need to be humanely euthanized by freezing, preserved with acetone, or fed to another classroom pet.

When catching wild nymphs, choose to keep larger ones with big wing buds. These nymphs are older and are more likely to emerge in your classroom within a few weeks. Once you catch a nymph or two, place them individually in any container that's convenient: glass canning jars or any type of fish tank would work well. The nymphs need to be in separate containers because they are cannibalistic. Install twigs or plastic mesh that stick up out of the water for the nymphs to emerge on. Water plants (real or plastic) and rocks are also a nice addition. The water plants can either be scooped up from a pond (make sure they are not invasive plants which may be illegal to transport) or purchased at a fish store. You can use tap water, but be sure to let it sit out overnight or put a few drops of water conditioner in it (available from pet stores) to remove the chlorine and fluoride. Don't seal containers shut: nymphs need fresh air to exchange with the water. However, placing a breathable mesh over the container is a good idea.

Nymphs will need their water refreshed when soiled and to be fed every few days. An occasional week without food is okay. If you must leave the nymph without care for longer than a week place it in a refrigerator while you are gone.

Dragonflies will eat anything that moves that is small enough for them to catch and subdue. Most of the time you can simply catch little critters from a nearby pond. In winter, you'll need to purchase inexpensive living food from a fish or bait store. I've successfully fed nymphs both aquatic "black worms" and terrestrial red worms. The quantity you feed will depend on the size of your nymph. Just guess a starting point, and if there is a lot of

Damselfly nymph. Notice the very large extendable lower jaw. (Photo: Scott King)

food left over, feed less; if your nymph gobbles it all up quickly, feed a little more. For medium to large darner nymphs, 10 tiny aquatic black worms or one small red crawler per feeding seems to be about right.

Nymphs have a bunch of interesting behaviors to observe. The most common are hanging motionless from a stick or plant, walking around the container, burying themselves in sand, "swimming" around the container using their butt-jet propulsion, and eating. Sometimes they will cover themselves in their food or plant pieces (for camouflage). They also leave frass that is shot out of their anus in a little package. This action is rarely seen, but the poop will build up in the tank—one or two every day. Scientists sometimes use the poop packages to study what nymphs eat.

Nymphs will stop eating for few days before they are ready to metamorphose. At this time, their mouthparts are changing in preparation for their new aerial life. They will also crawl up a twig or plant and stick their heads out of the water as they transition from water to air breathing.

If something happens and your nymph dies or doesn't emerge, don't feel bad. This is an opportunity for you and your students to speculate as to why. Use your thoughts to engineer different care techniques and try again with a new nymph. Rearing multiple nymphs at once in the classroom will allow some "room for error." If one dies, you'll still have another to observe.

Special thanks to Ron Lawrenz of the Lee and Rose Warner Nature Center for nymph-raising guidance.

Activity #1: Nymph Observation

1. Introduce the Odonata life cycle (activity 7, "Life of Defense"). Explain that students will be catching and observing nymphs outside.

2. At a pond or wetland, distribute fish/aquatic nets (not the same nets as those used for catching flying Odes) to individual students or groups, depending on how many nets you have. A wetland with a dock in a vegetated area is perfect.

3. Place a few (four or five maybe, depending on number of students) white (or light-colored) plastic tubs in your outdoor work area and fill them with a couple inches of pond water.

Dragonfly exuvia. (Photo: Arne Myrabo)

4. Encourage the students to scoop macro-invertebrates out of the pond using the water nets, and place the creatures they catch in the tubs for observation. Nymphs are often found in the bottom muck, along vegetation, or in undercut banks. While dragonfly nymphs do not bite or sting, other aquatic insects can. Creatures like water boatmen, backswimmers, water scorpions, and giant water bugs have piercing-sucking mouthparts that can give a painful poke. If you are not sure how to instruct your students to safely hold these other insects, you can tell them to only use the nets (and not their hands) to collect and observe them.

5. When dragonfly or damselfly nymphs are caught, separate them for closer observation.

6. After a bit of pond time, direct students' observation to the Odonata nymphs. Return other creatures back to the pond. Give students time to record their observations in their journals. Ask them to draw or describe the physical appearance, the behavior, different ways they move, or any other observations they made while catching them (i.e., sandy areas had fewer, weedy and mucky areas had more). Compare and contrast damselfly and dragonfly nymphs.

7. Back in the classroom, distribute the nymph anatomy handout or worksheet as an at-home or in-class refresher. There are two versions—one harder and one easier.

8. This is the perfect time to keep a nymph or two (or three) for classroom observation if you like. Choose larger, more mature nymphs for the best chance of observing emergence within a few weeks.

Be aware of any outdoor hazards in your geographic area and prepare students as appropriate. For example, scout your sample site for poison ivy and instruct your students to wear long pants and closed-toed shoes.

Activity #2: Classroom Nymph

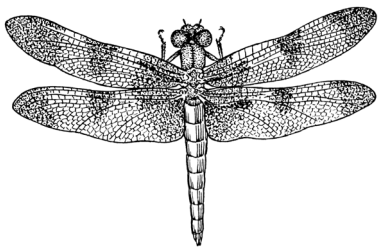
1. Keep a nymph (or two, or three, or more!) in the classroom.

2. Develop a care routine. You can take responsibility for this or delegate it to students. It will include food collection (from a wetland or a fish store), feeding (every few days), and water cleaning (once a week, if needed). Use the care record sheet to keep track of how much of what was fed when.

3. Establish a daily (or time period of your choosing) expectation of students that they will record observations of the nymph habitat, behavior, water quality, etc.

4. Encourage students to look for evidence of behaviors not frequently seen or noticed—eating, pooping, breathing. Show videos of these nymph behaviors (search Youtube).

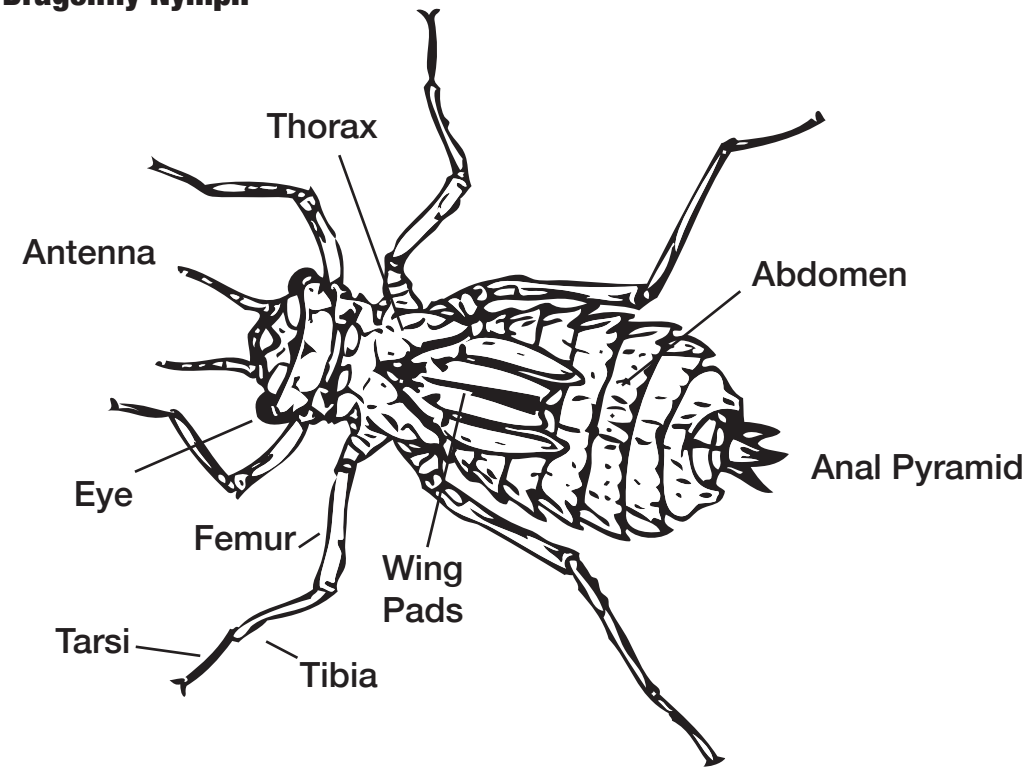
5. After a week or two of observations, ask the students if they can see any patterns or notable changes in behavior. Has the nymph molted, has it stopped eating, or is its head sticking out of the water?



Nymph Anatomy Handout

Name _____ Date _____

Dragonfly Nymph



Damselfly Nymph

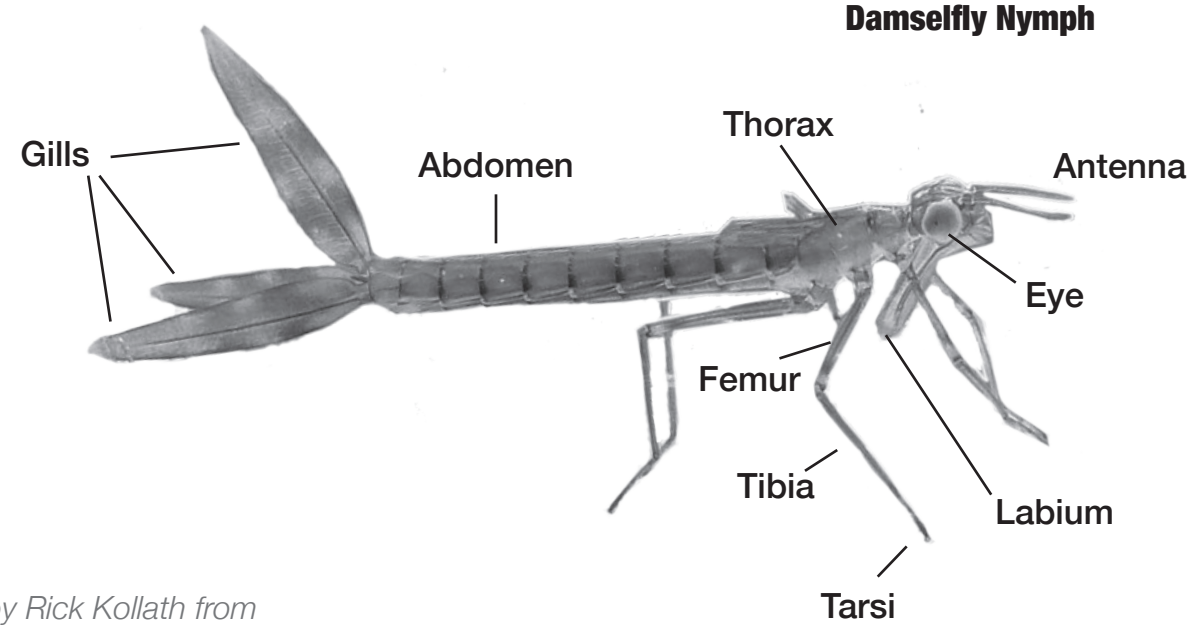
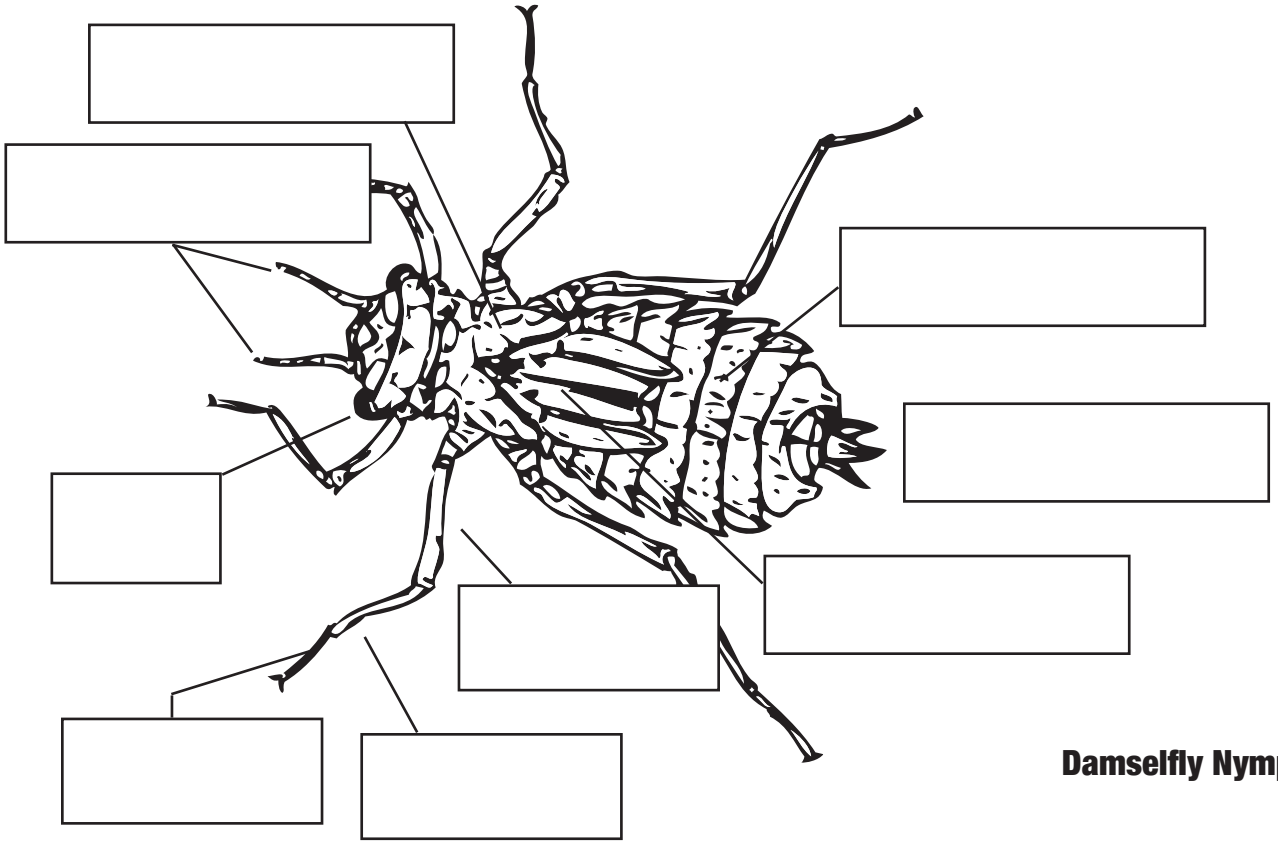


Illustration by Rick Kollath from Dragonflies of the North Woods *by kollath+Stensaas Publishing*
Photo: Scott King

Nymph Anatomy Worksheet

Name _____ Date _____

Dragonfly Nymph



Damselfly Nymph

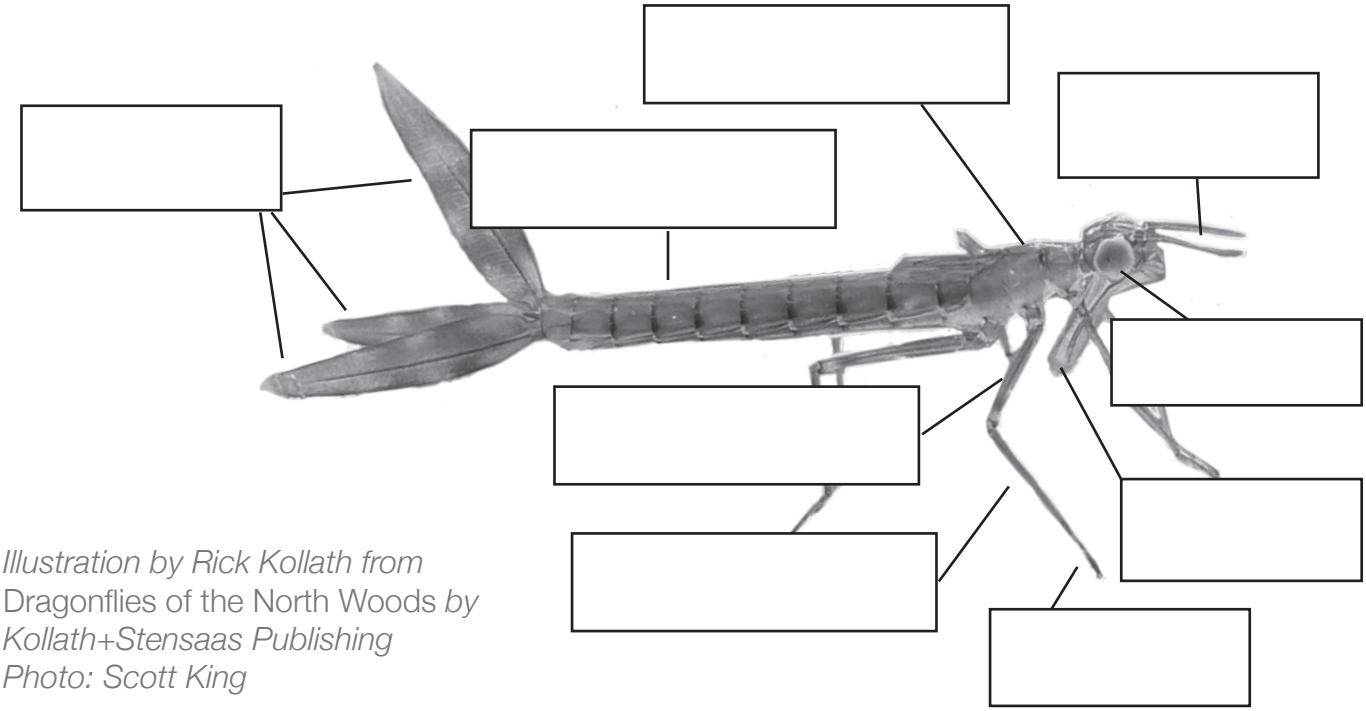
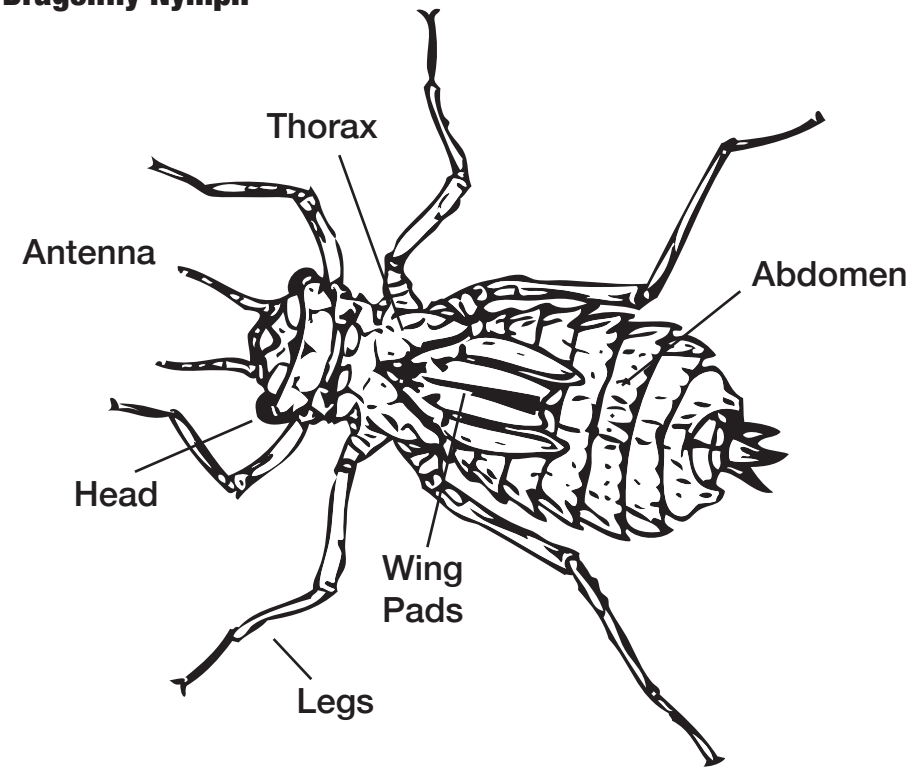


Illustration by Rick Kollath from Dragonflies of the North Woods *by Kollath+Stensaas Publishing*
Photo: Scott King

Basic Nymph Anatomy Handout

Name _____ Date _____

Dragonfly Nymph



Damselfly Nymph

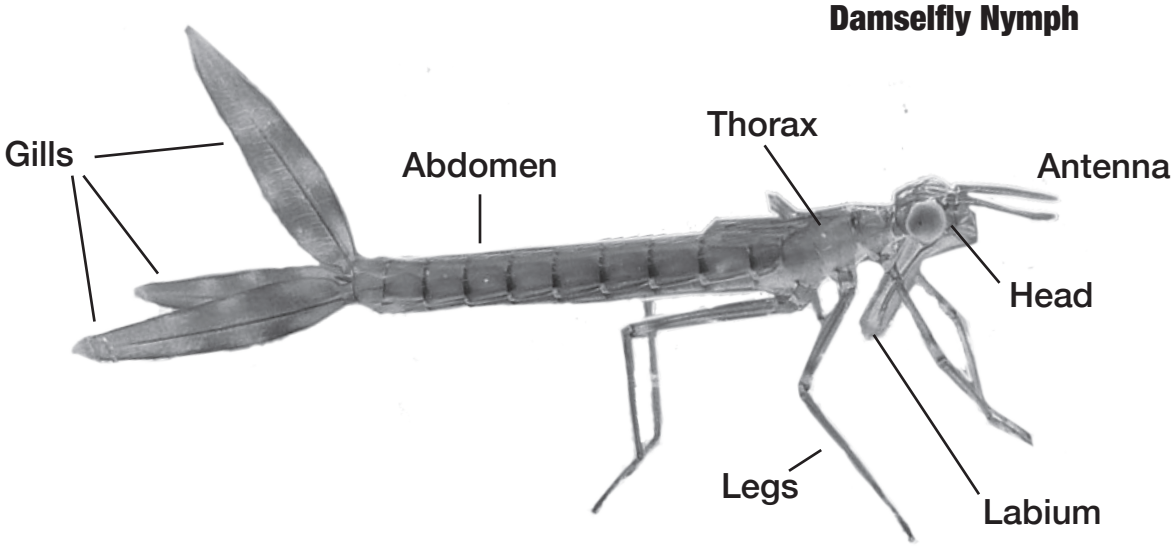
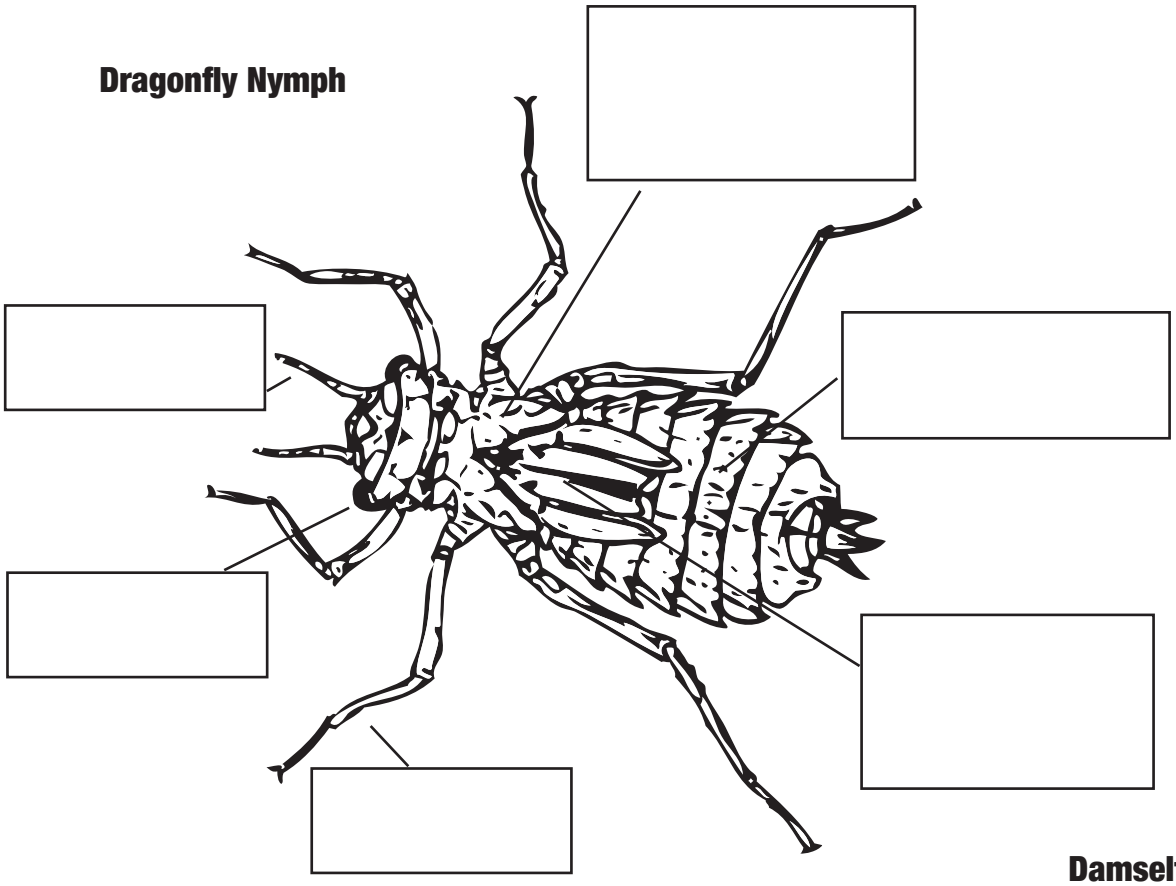


Illustration by Rick Kollath from Dragonflies of the North Woods *by Kollath+Stensaas Publishing*
Photo: Scott King

Basic Nymph Anatomy Worksheet

Name _____ Date _____

Dragonfly Nymph



Damselfly Nymph

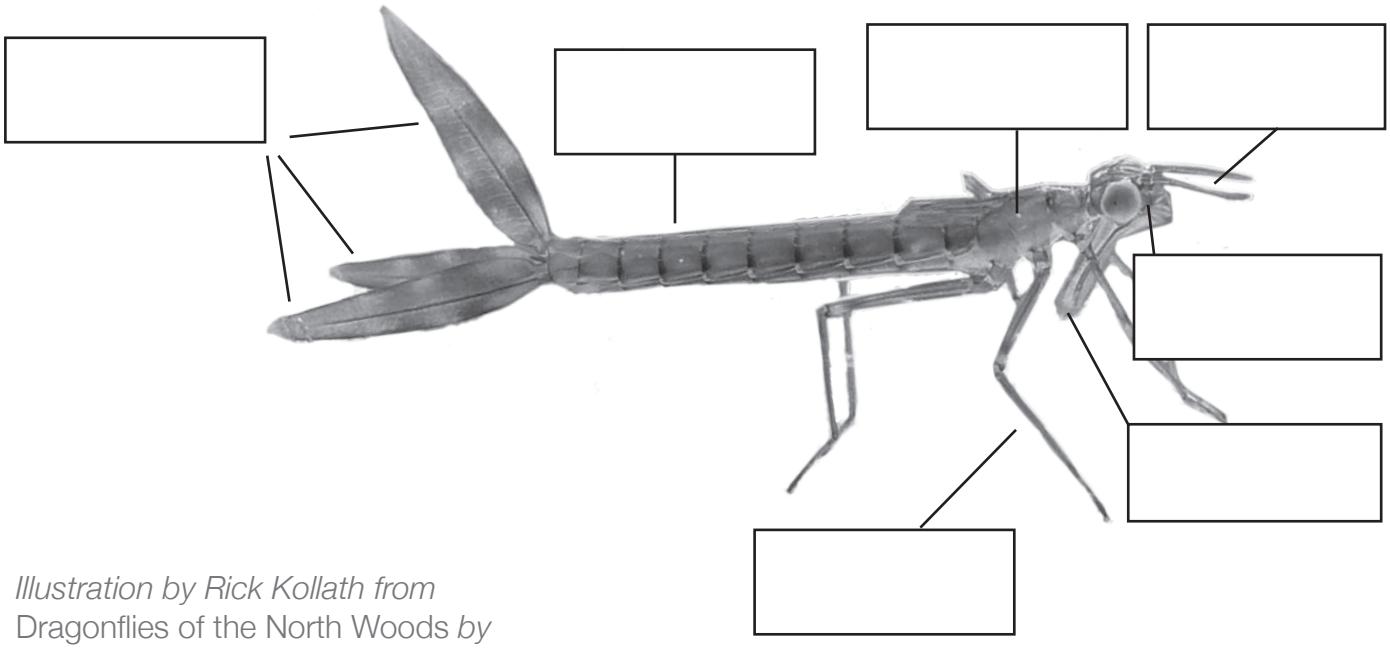


Illustration by Rick Kollath from Dragonflies of the North Woods *by Kollath+Stensaas Publishing*
Photo: Scott King

Nymph Care Record Sheet

Name of Nymph _____

Date:	Time:	Your Name:
Any Food Left?		If so, how much?
Any Scat?		If so, how many?
Behavior Observation Notes:		Other Notes:
Cleaned Water: ☐	Fed Nymph: ☐	What type of food, and how much did you feed?

Date:	Time:	Your Name:
Any Food Left?		If so, how much?
Any Scat?		If so, how many?
Behavior Observation Notes:		Other Notes:
Cleaned Water: ☐	Fed Nymph: ☐	What type of food, and how much did you feed?

10. Behavior

Odonata have many unique behaviors that can be observed in the field.

What You'll Need
Ode Videos
Ode Photos
Handouts
Journals
Net
Access to a Wetland

Skills & Concepts
Asking Questions
Recording Observations
Explanations
Adaptation
Energy Transfer
Maps
Cause and Effect
Life Cycle
Systems and Models
Investigations
Interpreting Data
Scientific Argument
Energy Flow
Stability and Change
Communicating
Asking Questions
Patterns
Structure and Function

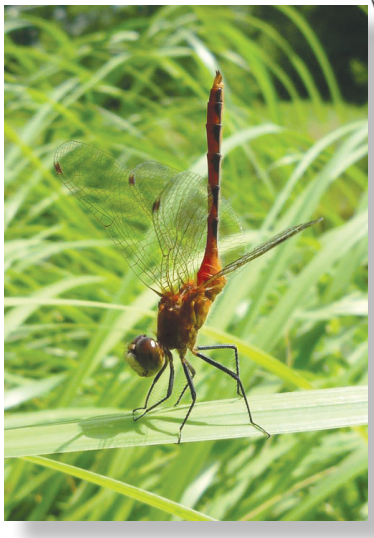
An adult dragonfly's repertoire of behaviors is relatively small and usually has to do with temperature regulation, hunting, or reproducing.

Temperature Regulation:
As ectotherms, dragonflies primarily rely on their environment for thermal energy.

Basking and Whirring:
Dragonflies need to cultivate a high internal body temperature to operate their massive flight muscles. They will bask anywhere they can find warmth, even on compost piles.

In the cool morning hours, a dragonfly may bask in the sun and "whir" its wings. This shiver-like movement attempts to warm up the muscles enough for flight. Newly emerged tenerals also whir to build muscle strength. If you have trouble catching big fast darners, an early outing on a cool morning will give you an advantage.

A dragonfly eating another dragonfly. (Photo: Arne Myrabo)


Dragonfly in obelisk posture. (Photo Scott King)

Obelisk Posture:
While they usually thrive in hot weather, occasionally Odonata in sun-beaten habitats need to cool off. One method, called obelisking, occurs when a dragonfly lifts its abdomen nearly straight up over its head. This posture casts a cooling shadow over the thorax and head of the dragonfly.

Hunting:
Dragonflies are voracious predators and will eat anything they can subdue and consume, including other dragonflies.

Hawking:
Dragonflies are hawking when they catch insects in mid-air, often using their front legs to funnel insects into their mouths.

Gleaning:
Odonata are gleaning when they pluck insects off of vegetation.

Patrolling:
Hunting dragonflies will often fly a predictable patrol along a brush line, bank, or natural feature. Some males patrol to claim breeding habitat and have spectacular aerial fights to defend it.

Damselflies in the copulation wheel.
(Photo: Mark Wheeler)

Reproducing:

Tandem:
In this position the male dragonfly is using his claspers at the tip of his abdomen to grasp the female by the back of her head. This position occurs before and after insemination (which takes place when they are in the copulation wheel).

Copulation Wheel:
While in tandem, the female dragonfly will curl her abdomen under and up to meet the male's secondary genitalia (located ventrally at the front of his abdomen). In this posture, the male fertilizes the female's eggs. Dragonflies can fly or perch while in the copulation wheel.

Egg Laying:
Females deposit their eggs in a variety of ways. Some dip their abdomens in the water, some fly over the water and drop eggs, and yet others deposit their eggs into plants or moss.

Guarding:
Male Odonata will sometimes guard egg-laying females to prevent other males from mating with her before she finishes laying the eggs inseminated by the guarding male. Guarding males either fly close above the female, chasing away other males, or remain in tandem position while the female lays her eggs.

Activity: Behavior Bingo

1. Introduce the common dragonfly behaviors to your class with photos and videos ("Behaviors PDF" at www.amidragonfly.com and search YouTube for videos). After each video, ask students to explain what they saw happening and ask them to guess at the reason for the behavior. Record their answers on the board. Provide a list of behavior options if students need some guidance.

2. Prepare students to go outside. No student nets will be needed for this activity, but you might want to bring one for yourself. If you can gently catch a pair in tandem or in wheel, you can allow students to have a closer look. Students will need their journals and perhaps binoculars if you have them.

3. Give each student a place to sit or a small area within which to walk around to observe Odonata behaviors. Ideally, this location would be far enough away from other students to discourage chitchatting.

4. Instruct students to make behavorial observations and take notes in their journals and make some sketches. Alternatively, you can send students out with the accompanying behavior bingo card. When they see a behavior, they can mark it on the card. Encourage students to note the weather, time of day, and date in their journals.

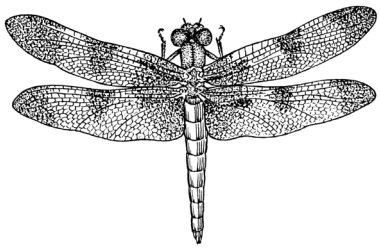
You can use the completed bingo card provided below, or use the blank one and have students create their own cards. Read off the bingo behavior words: Patrolling (3x), Obelisk (2x), Guarding (3x),

Female dragonfly laying eggs while being guarded by the male. (Photo: Mark Wheeler)

Whirring (2x), Tandem (3x), Hawking (2x), Egg Laying (2x), Basking (3x), Wheel (2x), and Gleaning (2x). As you read each word, students can add it to boxes on their bingo cards. Some words need to be added to two boxes and some to three (noted above). Encourage students to mix up the words, one word per box, however they like. You can also add or remove words to meet your classroom's needs.

5. Back in the classroom, discuss which behaviors were most common and which were rare or not observed. Discuss whether this had to do with weather, time of day, or time of year. Did they observe any behaviors not presented beforehand? If so, ask them to describe those and postulate why the dragonfly was behaving that way. Perhaps draw a map and note where certain behaviors were observed. Did anyone get BINGO? If you like, have small prizes to give out.

6. A potential activity extension would be to observe dragonflies at different times of day and in different weather conditions and record their observations. Then evaluate the observations and see if any patterns emerge.



Behavior Bingo!

Name _____ Date _____

Environmental Observations	
Date and Time:	
Weather Notes:	**Location Description:**

Behavior Bingo				
Patrolling	Obelisk	Guarding	Whirring	Tandem
Tandem	Hawking	Egg Laying	Basking	Guarding
Wheel	Basking	FREE	Gleaning	Patrolling
Whirring	Guarding	Hawking	Wheel	Egg Laying
Gleaning	Patrolling	Tandem	Obelisk	Basking

Behavior Bingo!

Name _____ Date _____

Environmental Observations	
Date and Time:	
Weather Notes:	**Location Description:**

Behavior Bingo				
		FREE		

11. Reproduction

The main goal of an adult dragonfly is to mate and lay eggs.

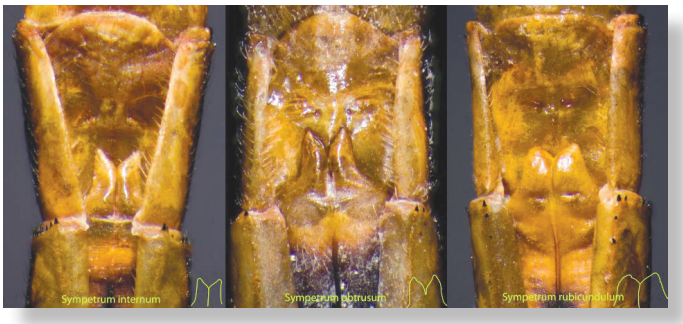
What You'll Need
Nets
Hand Lenses
Odonata Envelopes
Journals
Handouts
Access to a Wetland

Skills & Concepts
Recording Observations
Structure and Function
Life Cycle
Communicating
Patterns
Systems and Models
Energy Flow

The reproductive behaviors of Odonata are very conspicuous, and your students will definitely notice them. In fact, the main purpose of an adult dragonfly's life is to reproduce.

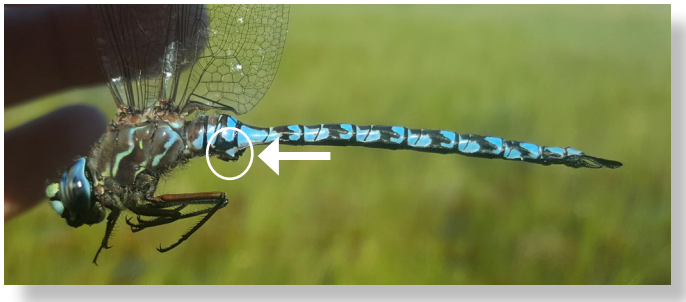
Male vs. Female Odes: Dragonfly reproductive parts are located on the underside of the abdomen. All Odonata have ten abdominal segments. Odonatologists have numbered each segment for easy reference. Segment ten is at the distal end of the abdomen and segment one is where the abdomen meets the thorax. It's easier to identify each segment by counting backwards from segment ten because the lower-numbered segments are often partially fused and hard to differentiate.

To identify the sex of a dragonfly, look for the secondary reproductive parts that only males have at the front of their abdomens, just behind their wings, on their belly (on the underside of segments two and three). It will look like a hole with some bumps in it. Females will be smooth on the bottom of those segments because they have only one set of reproductive parts at the end of their abdomen, under segment eight.



The subgenital plates from three different species of meadowhawks. Notice how they are all a little different. (Photo: Curt Oien)

Like birds, male dragonflies are often more brightly colored than females. The bright coloration of males can allow for easy species identification by students. Some female Odonata are difficult to identify without a hand lens or a microscope.



The location of male secondary genitalia. (Photo: Ami Thompson)

Both males and females have reproductive parts at the tips of their abdomens. Males have testes under segment nine and claspers—comprised of two cerci above and an epiproct below (dragonflies) or two paraprocts (damselflies) below. The claspers grab on to the back of the female's head (dragonflies) or thorax (damselflies) during copulation. Females have ovipositors or subgenital plates, under segment eight, used to lay eggs. Female Odonata also have cerci. The shapes of these parts are often important clues for identification.

Copulation
Male dragonflies usually hang out near the water and will often claim and defend territory, sometimes resulting in spectacular aerial fights.

Before they are ready to mate, females feed and mature in forests or prairies away from the males. When sexually mature, females will return to the water to find mates and lay eggs. In some species the males will court the females, displaying their vibrant coloration or showing off their great territories.

In order to mate, a male dragonfly must first transfer his sperm from his testes, at the tip of his abdomen, to his secondary reproductive

parts, just behind his legs, by curving the tip of his abdomen under his body. Dragonflies usually do this before grabbing onto of a female, and damselflies after.

When a male dragonfly uses his claspers to latch onto a female, they are then said to be in tandem. Students often mistake this step for copulation, but it is just a preparatory step. You will often see dragonflies and damselflies flying around or perched in tandem.

Copulation begins when the female curls her abdomen under and connects it to the male's secondary reproductive parts. This position is called the copulation wheel. Males have reproductive anatomy that can remove any previously deposited sperm, and then insert their own.

After the sperm has been transferred, the eggs are ready to be laid almost immediately. Depending on the species, females may lay eggs at the surface of the water, in shallow muddy bottoms, in plants, or along the shore.

Some males will guard the female while she lays eggs. They will either hover nearby or continue holding the female in tandem while she lays. In this way, other males are prevented from mating with the female and disrupting her egg laying.

As with all animals, it's very important not to anthropomorphize. This can be difficult for students, particularly when it comes to reproduction. Fortunately, Odonata have unusual

Common green darners in tandem. Note that the male is clasping onto the female's eyes. (Photo: Ami Thompson)

Female dragonflies either have a subgenital plate, as pictured on the previous page, or an ovipositor like this one. (Photo: Arne Myrabo)

and mechanical reproduction with lots of great terminology to learn. Correcting students with scientific Odonata reproductive terminology can discourage anthropomorphizing.

Activity: Copulation Vocabulary

1. Review the reproductive behaviors in activity "7. Life of Defence." Distribute the reproduction anatomy handout and introduce the topic of Odonata reproduction.

2. Prepare students for going outside, break them into groups, and distribute nets, hand lenses, and the anatomy handout. They should bring their journals to record observations.

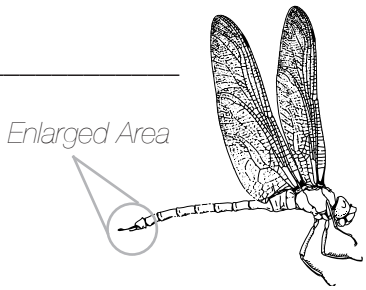
3. Students should catch Odonata and use a hand lens to determine if they are male or female. They should record their observations in their journals with sketches. Do they notice any other differences between male and female dragonflies and damselflies?

4. Then have students set their nets aside and observe Odonata flying around in tandem or wheel, if present. Students should record observations in words and drawing in their journals. Do they notice any anomalies, such as three dragonflies in tandem or fish eating damselflies in an area where many are laying eggs?

5. Back in the classroom, hand out the worksheet. It can be done as an in-class assignment or quiz, or brought home as homework.

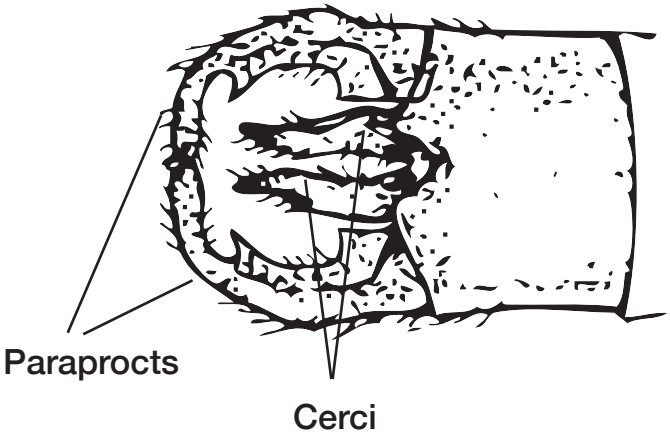
Odonata Reproduction Anatomy Handout

Name _____ Date _____

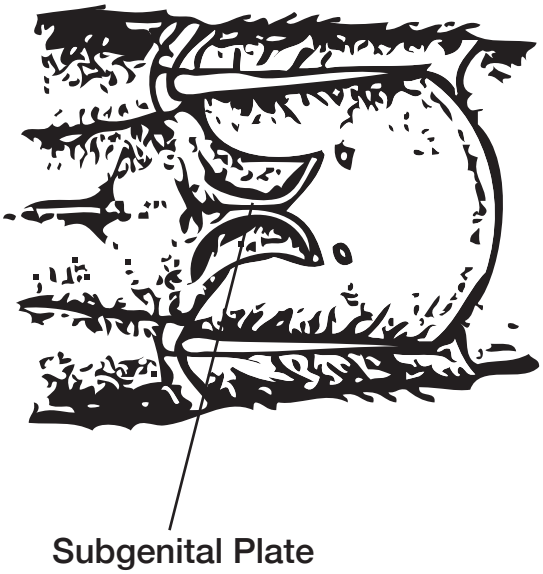


Damselfly, Female–Side View

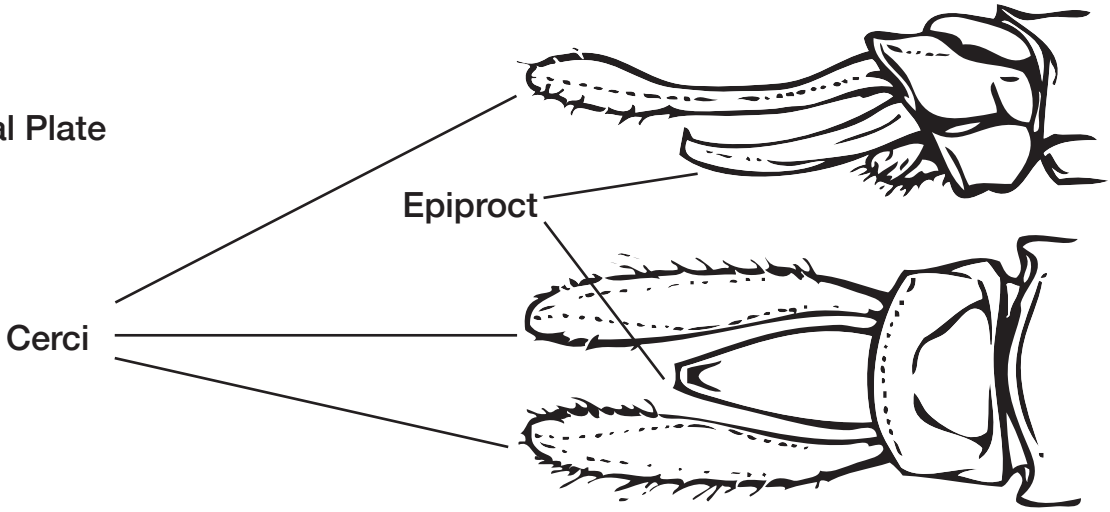
Damselfly, Male–Top View



Dragonfly, Female–Bottom View



Dragonfly, Male–Side and Top View



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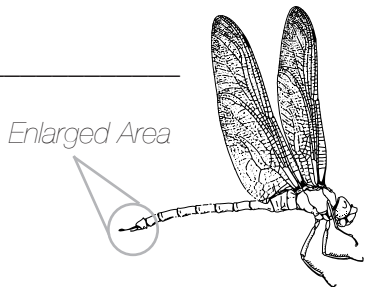
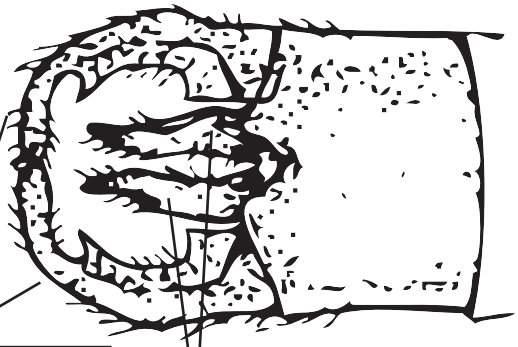
Odonata Reproduction Anatomy Worksheet

Name _____ Date _____

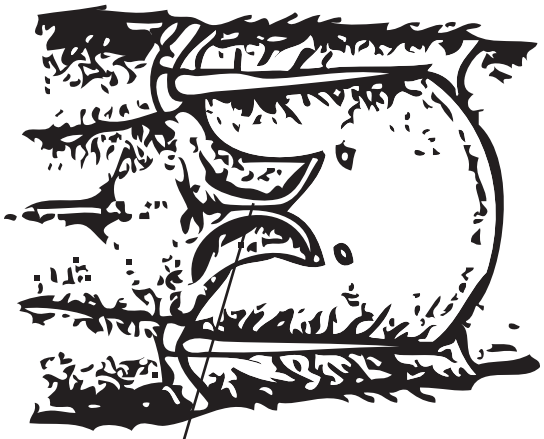


Damselfly, Female–Side View

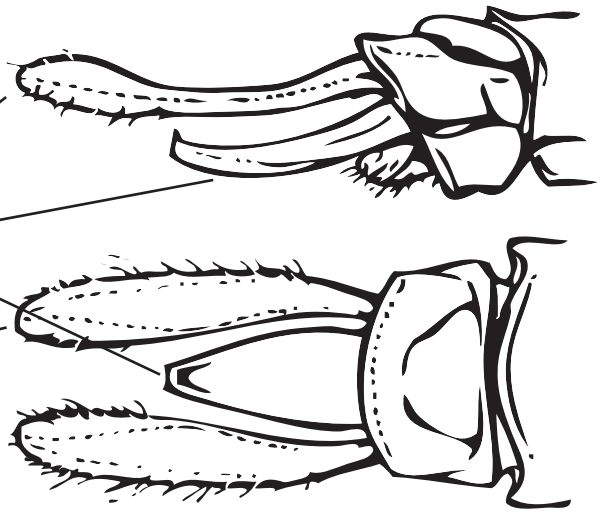
Damselfly, Male–Top View



Dragonfly, Female–Bottom View



Dragonfly, Male–Side and Top View



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12. Wing Beats

Dragonflies beat their wings in different patterns to fly in different ways.

What You'll Need
Video of Odonata

Skills & Concepts
Recording Observations
Structure and Function
Energy Flow
Systems and Models
Communicating
Patterns
Cause and Effect
Stability and Change

Dragonflies have truly amazing flying abilities. They are arguably are the most agile flying animal in the world.

All Odonata have four wings. Dragonflies, or suborder Anisoptera (meaning "uneven wings"), have front wings that are shaped differently than their hind wings. The back wings are wider front-to-back. This allows them to glide and migrate over long distances with ease. Many dragonflies migrate internationally. In fact, the wandering glider dragonfly undertakes the longest known insect migration. It has been observed migrating more than 11,000 miles (18,000 km) over multiple generations. Damselflies, or suborder Zygoptera (meaning "paired wings"), don't have this adaptation. All four damselfly wings are the same shape.

The physics of flight requires both thrust and lift. Thrust is the physical force that generates forward motion. Birds create thrust by flapping their wings.

Dragonfly in flight, forewings and hindwings flapping in opposition. (Photo: Mark Wheeler)

Dragonfly in flight with the forewings flapping slightly behind the hindwings. (Photo: Arne Myrabo)

Lift is the force that brings the flying object away from the ground. It is created when the air travels at different speeds above and below the wings.

Damselfly wings generate thrust, or directional movement, on both the down- and upswing. Their front and rear wings work in opposites; when the front are down the back are up, and vice versa. In this way, they are always generating thrust during flight.

However, dragonfly wings only create thrust on the downbeat, and they use their four wings independently. During normal forward flight, the four dragonfly wings do not move in sync; instead the front pair are moving just after the rear pair. If the dragonfly needs a sudden burst of speed all the wings will up and down beat in unison. If the dragonfly needs to hover, the front and back wings will beat up and down in opposition, just like damselfly "normal" flight (the front wings up while the back wings are down). To glide, all wings are held straight out. To make a sharp turn, a dragonfly may move just one wing up or down.

To better understand lift, hold a piece of paper up to your mouth and blow air forcefully over the top of it. The paper will pop up. Wings of all types (on birds, planes, and dragonflies) work the same way. Lift is generated when the surrounding air and an

object are moving at significantly different speeds. A dragonfly wing has a rigid leading edge with thick veins to strongly cut through the air. Tiny hairs on the back of the wing create turbulence and more lift. These tiny hairs on the wings also allow the dragonfly to feel every detail of their flight.

In addition to the wings and fancy moves, dragonflies have a lot of muscle. They have more body mass dedicated to flight than any other creature, up to 60 percent by weight.

Expansion experience: The study of flight dynamics is within the field of fluid dynamics. Paddling a canoe can be a great experience to help understand how wings interact with the air.

Activity: Flight Control

1. Show a video of dragonflies flying (find some on YouTube). Tell students to closely observe how they use their wings.

2. Ask for two student volunteers. One student will "be" the front wings of a dragonfly, and the other the back wings. They should stand one in front of the other.

3. Ask them to demonstrate how dragonflies fly by flapping their arms. They will probably flap randomly, in unison, or alternating.

4. Explain that damselflies and dragonflies have special ways of flying. Introduce all the different flight patterns of dragonfly and damselfly wings (as described below) and ask the students to demonstrate.

Damselflies:
- Normal flight: Opposite movement of front and back wings; back wings are up while front wings are down, and vice versa.

Dragonflies:
- Normal flight: Front wings flapping a little "after" the back wings.
- Sudden burst of speed: All wings flap together.
- Hover: Opposite movement (like a damselfly's normal).
- Glide: All wings straight out.

5. Ask the demonstrators to sit down. Show another video of Odonata in flight, or the same video again, so the students can try to see these patterns.

6. Break students into groups of two or four (depending on your class size).

7. Ask the groups to stand up and create enough space between groups that outstretched arms don't touch or hit anything. (This is a great activity to do outside.) Groups of two should stand one person in front and one person directly behind—one will act out the actions of the front wings with their arms, and the other the back wings. Groups of four should arrange two people in front immediately next to each other with one person directly behind each. Each person will use one arm to act out a wing.

8. Have all groups practice all the wing strokes as you call them out. The dragonfly normal stroke is the trickiest; allow the groups time to work out how to communicate the timing.

9. If you would like to add some competition, play a modified game of Simon Says, with you calling out the different wing beats.

13. Living Wings

Wings are a living part of a dragonfly with their own intricate anatomy.

What You'll Need
Nets
Hand Lenses
Odonata Envelopes
Journals
Handouts
Crayons or
Colored Pencils
Access to a Wetland

Skills & Concepts
Recording Observations
Patterns
Structure and Function
Communicating
Adaptations
Investigations
Scale and Proportion

A dragonfly's large wings are its lifeblood. Odonata legs are not capable of walking or running, only perching. They can't fold up their wings and hide like grasshoppers or beetles, but their incredible flying ability and eyesight make them difficult prey and formidable predators.

The long rigid wings of Odonata are an early evolutionary design. "Newer" wing versions include the ability to fold-up (like grasshoppers), hard covers over the wings (like ladybugs), and camouflage coloration (like katydids).

Nymphs develop wing buds after about their sixth shedding, or instar. At emergence, crumpled-up wings are blown up like balloons with insect blood, called hemolymph. Wings remain a living part of the body, circulating blood throughout the dragonfly's life. The general pattern of blood flow begins at the leading edge of the wing near the body, flows out to the tip of the wing, and the moves down to the bottom of the wing heading back to the body.

Close-up of a dragonfly wing. (Photo: Mark Wheeler)

This saffron-winged meadowhawk has orange wing veins. (Photo: Arne Myrabo)

Each wing contains five easily visible main veins and many smaller veins. The quantity of smaller veins varies per species. The spot where the front-most and second front-most large veins meet, on the forewing about halfway out, is called the nodus. The nodus allows for both strength and flexibility during flight.

Most species also have a stigma mark, also known as a pterostigma, near the far tip of the forewing. One suspected function of the pterostigma is as a flight-stabilizing counterweight. It also might be flashed around as inter-Odonata communication.

The minor veins throughout the wing create a variety of shapes: circles, squares, rectangles, and triangles. The type and location of these shapes are used by scientists to identity different species. Sometimes the wing veins are different colors, like the saffron-winged meadowhawk's orange veins.

Newly emerged dragonfly wings have an oily sheen. As the dragonflies age their wings become less shiny and wing pieces break off the back edges creating a tattered appearance.

Activity: The Wings are Alive

1. Introduce the day's focus on wings. Explain that wings are a living part of a dragonfly, with veins that constantly pump them full of nutrient-rich blood. Encourage students to be gentle during their observations. Remind students how to hold Odonata by all the legs so they can clearly see the wings. Practice this hold with paper dragonflies (activity 2, "Paper Dragon Practice").

2. Prepare students for going outdoors. Break students into groups and distribute nets and hand lenses. They will need their journals. To see the wings clearly, students will need to hold the insects by their legs. Dragonflies will protest this by pinching any nearby fingers with their mouth parts. Students nervous about the pinching may be comforted by a Band-Aid on their pointer finger.

3. As students catch Odonata, they should record their observations in both detailed drawings and notes in their journals. Distribute the handout with directed observational questions.

4. In the classroom, compile all observations and allow time for sharing of drawings. Lead the discussion toward capturing any "missed" observations or correcting any false conclusions.

5. Hand out the wing anatomy sheets for in-class review and/or assign the worksheet as homework.

Note: This activity can be done in winter with frozen or preserved specimens, or even with detailed photos. Or, you can pre-catch insects and have students observe them in clear Odonata envelopes in the classroom, being very careful not to squish them.

Art Extension: Students can expand on their journal sketches and create a large detailed piece of art based on the pattern of a dragonfly or damselfly wing.

Wing Observation Drawing:

Name _____ Date _____

Catch a dragonfly or damselfly and look closely at its wings.

Draw a larger-than-life dragonfly or damselfly wing below, including:
1. The veins you can see in the wing.
2. Any unique points or marks you see on the wing.
3. Any color on the wings or the veins.

Make note of:
1. The differences, if any, between the shape of the forewing and hindwing.
2. The differences, if any, between a dragonfly and a damselfly wing.
3. Any other observations or questions.

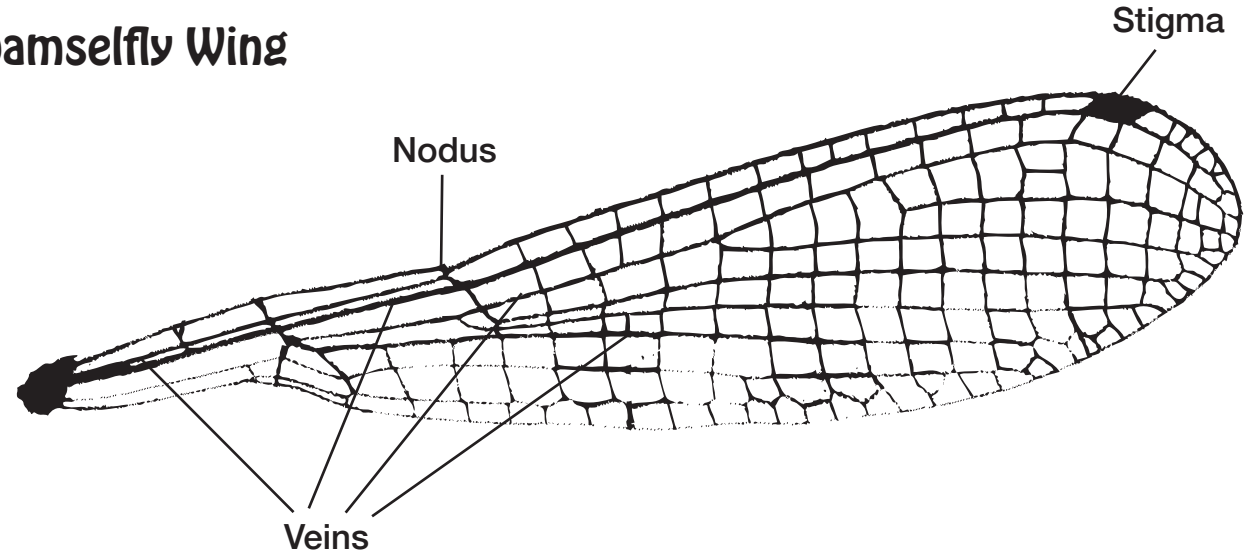
Drawing:

Notes:

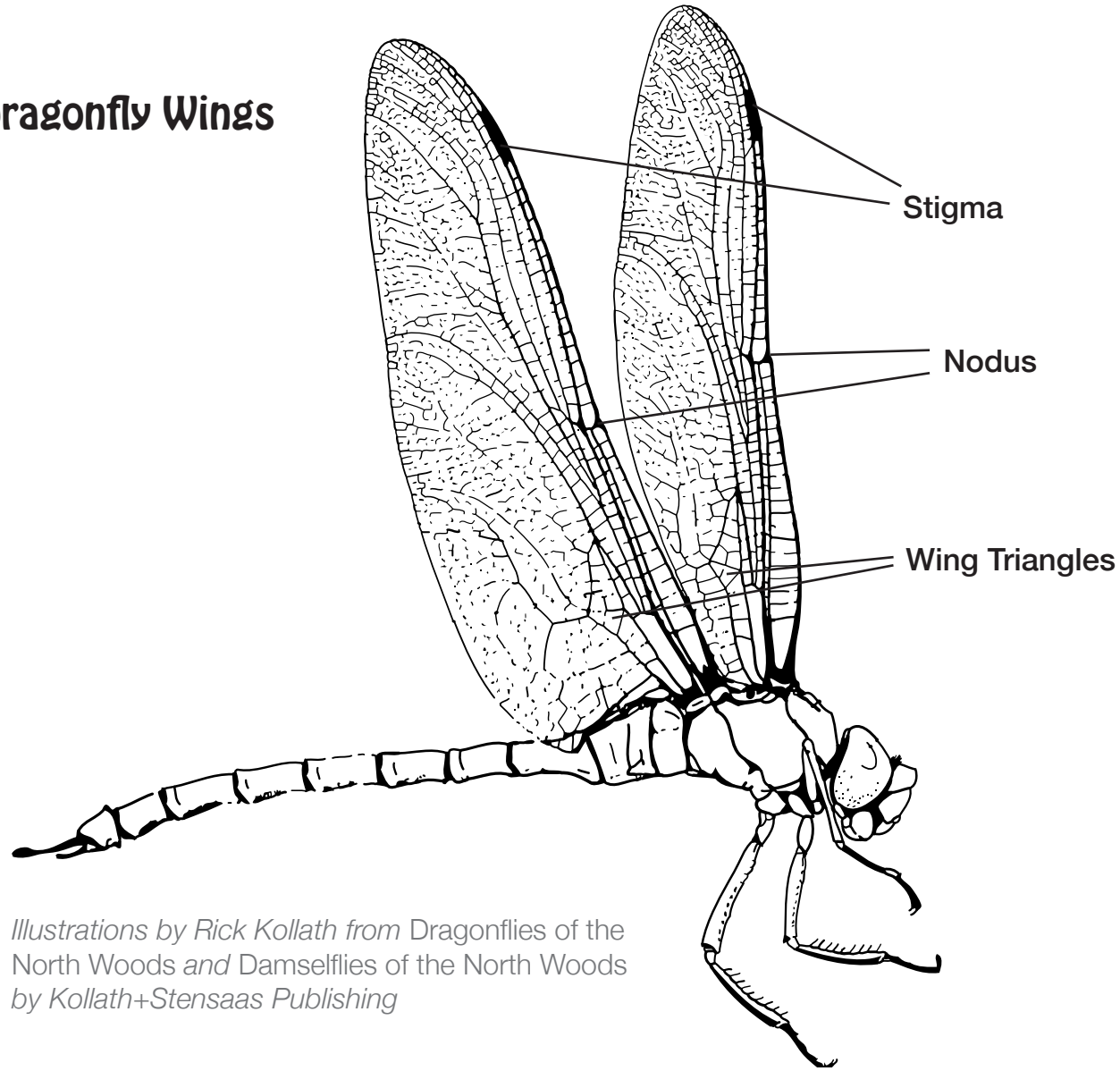
Odonata Wing Anatomy Handout

Name _____ Date _____

Damselfly Wing



Dragonfly Wings



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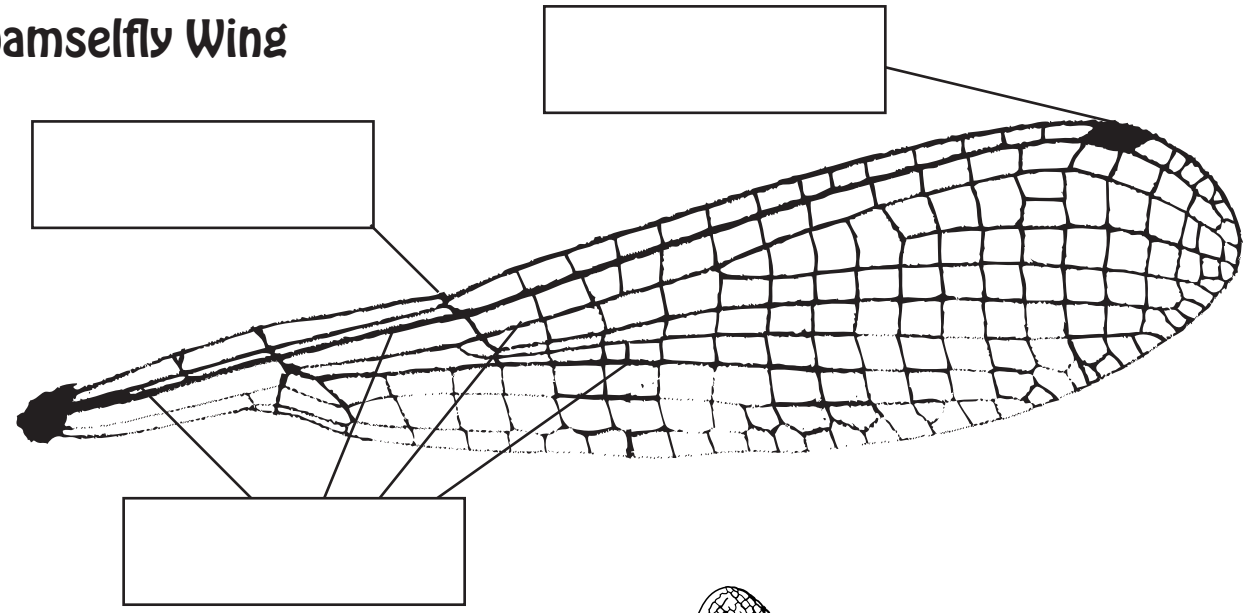
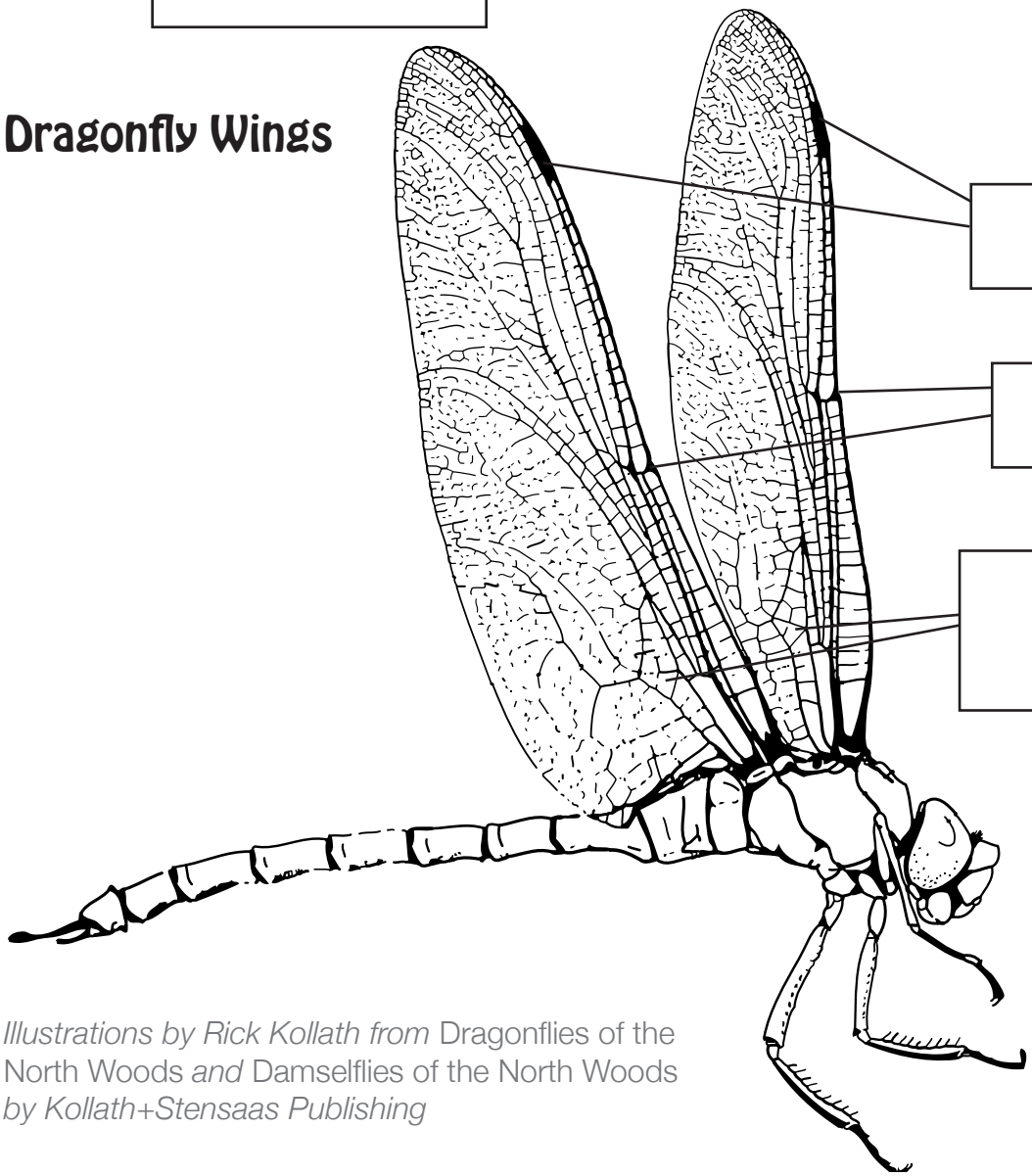
Odonata Wing Anatomy Worksheet

Name _____ Date _____

Damselfly Wing



Dragonfly Wings



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14. Self P-Ode-trait

Create a self-portrait using dragonfly facial components and proportions.

What You'll Need
Ode Photos
Handouts
Coloring Supplies
Rulers
Graph Paper

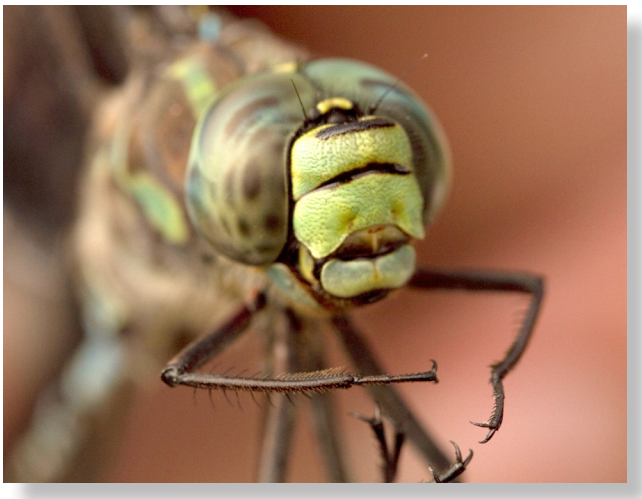
Skills & Concepts
Recording Observations
Structure and Function
Analysing Data
Using Math
Communicating
Scale and Proportion
Patterns

This exercise will ecourage students to imagine what it would be like to experience the world with a dragonfly's senses by drawing a portrait of themselves using the components of a dragonfly's face.

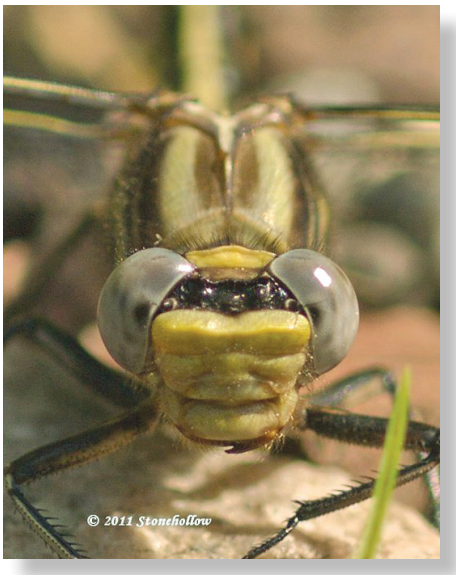
Dragonfly faces are mostly eyes. They have the largest compound eyes of all insects, with the most facets. The only place they can't see is directly behind their heads. They can see the visible spectrum colors, ultraviolet light, and polarized light. They also have simple eyes that detect light and dark.

A dragonfly's mouth is comprised of upper mandibles and lower maxillae. While the jaws chew, the "lips" (the upper labrum and the lower labium) hold the food in place. Dragonflies do not have a tongue, so they probably cannot taste.

Dragonflies have two small antennae that can feel wind direction and detect smells. They have no "ears" and may not be able to hear the way humans do.



Close-up of the face of a darner.
(Photo: Dudley Edmondson)



Close-up of the face of a clubtail.
(Photo: Arne Myrabo)

The rest of the dragon's face is made up of hard structural plates meeting at seams called sutures. The upper face is called the frons.

Refer back to the activity 1, "Catch, Observe, Release" for anatomy handouts of dragonfly and damselfly faces.

Activity: Picture Perfect

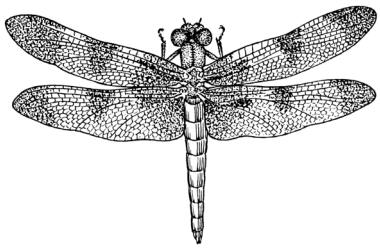
1. Students should research information about dragonfly senses in a variety of ways, including spending time observing Odonata behavior and morphology in the field and examining up-close photographs of dragonfly faces (see file 4, "Ode Families").

2. Compare and contrast a dragonfly face to a human face. Compare human senses to dragonfly senses. Brainstorm what it would be like to be a dragonfly. What would they sense? Then brainstorm what a human face would look like if it had the proportions and components of a dragonfly's.

3. Introduce the project of drawing themselves, creating a self-portrait, as if they were a dragonfly. They should have two large compound eyes, a large sideways mouth, two small antennae, no nose, and no ears. Allow them to be creative with color choices and hair. You can incorporate math concepts by measuring and replicating proportions using rulers and graph paper. Or allow students to wing it, making their best guesses.

4. Display the portraits and ask students to share the reasoning behind their creative decisions with the rest of the class.

Creative Writing Extension: Students could write a first-person narrative about a day in the life of a dragonfly, noting some examples of how students speculate a dragonfly perceives the world.



Odonata Portrait

Name _____ Date _____

Create a self-portrait inspired by your face but using the proportions of a dragonfly's face.

Be sure to include:
1. Two large compound eyes
2. A large mouth with jaws that open side to side
3. Two short antennae
4. Hair and any special coloration

Note: Dragonflies do not have ears or a nose

15. Dragon Lore

Dragon and dragonfly mythology is abundant worldwide.

What You'll Need
Lore Stories
Pens or Markers
Thick Highlighters
Nature Photos

Skills & Concepts
Human Impacts
Cultural Traditions
Asking Questions
Explanations
Communicating
Patterns
Cause and Effect
Structure and Function
Stability and Change

Nature inspires art of all kinds. Your students can enjoy the work of artists who inspired by dragonflies and create their own artwork. Perhaps their interest will be piqued by the medieval world of knights, wizards, damsels, and dragons. Or maybe they will be inspired by the mythological stories about the constellations. The most joyful learning comes from following your nose.

Modern Myths:
There are two common myths around dragonflies that you may need to address with concerned students. In the first, lore warns that dragonflies will sew up the mouths or eyes (and sometimes the ears and toes) of naughty children while they sleep. Dragonflies obviously will not do this. The origin of this myth may be from the egg-laying habits of the darner family. These dragonflies look like large darning needles, and females have a sharp ovipositor at the tip of their abdomen. They slice small holes in plants and lay their eggs snugly inside. Flustered parents may have taken advantage of the dragonfly's intimidating appearance to scare children into behaving.

Illustration of an *Alice in Wonderland* Snap-Dragonfly from Oldbookart.com

In the other common myth, dragonflies are "snake doctors" and bring snakes back to life and/or speak with them. This myth may be based on the habits of some common snakes who "play dead" when threatened (i.e. the red-bellied snake or the hog-nosed snake). These snakes share the same habitat as dragonflies. Odonata will follow animals, including people, as they walk through tall grasses and scare up delicious insects. If a hiking human were to frighten a snake into playing dead then the human-trailing dragonflies could be close at hand when the snake deems it safe to "come back to life." Perhaps this series of events falsely created the perception that dragonflies are "snake doctors."

More Dragonfly Stories:
For a short period of time Japan was named after the dragonfly. It was know as "Akitsushima" (akitsu = dragonfly, shima = island). One story tells of the emperor standing on a mountaintop surveying the entire island country. A mosquito stings him, and immediately a dragonfly swoops in and eats the offending insect. The grateful emperor looks out again and observes that the shape of the island resembles the dragonfly, and so names it after the insect. Japanese culture includes a lot of wonderful dragonfly lore for further study.

A Zuni (a Pueblo American Indian tribe) story highlights a brother and sister who are accidentally left behind when their tribe moves to a new home in search of more plentiful food. The boy makes a toy dragonfly out of cornhusks and grasses to please his distraught little sister. To their surprise, the toy comes to life and flies up to the Gods to tell them of the children's suffering. The Gods give the dragonfly comforting words and survival tips to bring back to the children until they are reunited with their family.

Story telling can be a private and sacred part of a culture's community structure. While beautiful and enriching, they are often not ours to adapt or tell. As educators, we need to be respectful and cautious that we do not inadvertently contribute to stereotypes or appropriate the culture of others. Whenever possible, ask members of the originating communities to tell their own stories to your students. Local community groups, educational publications written by diverse authors, and YouTube can be great resources for authentic storytellers. You can also ask your students if they have any family stories they would like to share with your class.

Constellations

Constellation stories were created to help people remember the names and locations of stars for navigation. However, they also connect to the universal sense of mystery and awe that people feel when they observed the starry night sky. The constellation Draco is in the shape of a serpent-like dragon and has at least three potential origin stories.

Origin Stores for the name Dragonfly:
The word dragon connects to many ancient words meaning "to see clearly"—appropriate considering the amazing eyes of Odonata. The Greek word drakon later evolved to mean "water snake, huge serpent, or dragon." That word base has modern connections to things ancient, ferocious, dark, and powerful; think draconian and Dracula. The etymology of the word "dragon" is quite deep and diverse and worthy of deeper inquiry.

One theory about how the dragonfly earned its name is based on an old Romanian story about St. George and his equine steed. In the story, the Devil turns St. George's horse into a giant insect known as the "Devil's horse" or the "Devil's fly." The Romanian word for devil was the same word—or very close—to the word for dragon. And so the name dragonfly evolved. There are other stories about dragonflies harassing horses. Dragonflies follow mammals as they walk through grass and underbrush and eat the insects that are stirred up. The rider of a horse stung and spooked by a wasp is likely to notice a more conspicuous dragonfly and misplace the blame.

Hand-painted etching of Draco and Ursa Minor from Oldbookart.com.

There were also a group of Greek goddesses referred to as "nymphs." They were mostly goddesses of natural places like lakes, streams, meadows, mountains, beaches, and caves. They were responsible for caring for the resident plants and animals.

This is just the tip of a very large iceberg. Historical dragon lore abounds. Embrace the fantastical nature of these stories; being in nature is a magical experience that we can encourage through storytelling.

Activity #1: Damselflies in Distress

1. Read or tell your students a typical medieval knight and dragon story.
2. Identify the main characters and the plot—usually something along the lines of a knight kills a dragon to save a damsel in distress and collect treasure. Identify the protagonist, the antagonist, the challenge, and the solution. Also identify the supporting characters and their role in the story. With older students, have a discussion about any stereotypes in these stories.
3. Introduce students to writing their own dragon story. Pass out photos of their main characters: dragonfly, damselfly, nymph, kingfisher, Queen Ann's lace, snapdragon flowers, etc. Be creative in your "cast" of nature characters and encourage students to create their own.
4. Students can write their story based on imagination alone, on natural history research of their characters, or on outdoor observation and journal notes. The story's protagonist, antagonist, challenge, solution, and supporting actors should be identified on a separate sheet of paper.

Activity #2: Rain Dragon Doodles

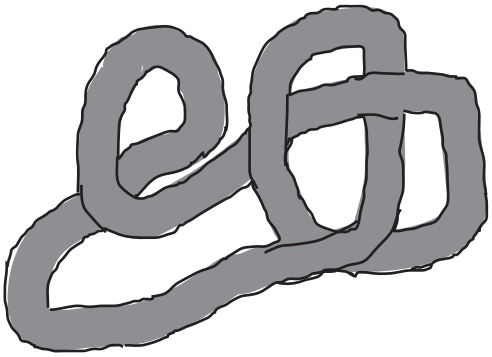
1. Introduce this activity by explaining that most European dragon myths involve fire, fighting, and dragons as the bad guy. However, Eastern dragon myths can be very different. Eastern dragons are often helpful water-bringing creatures. They support agriculture by bringing in clouds and rain. Dragons of the East also tend to be longer, skinnier, and more serpent-like than European dragons.

2. Students will draw rain dragons by using applied math theory.

3. Tell students to draw, using a thick highlighter, a squiggly line that ends where it begins; the line should connect to itself. All of the areas where the lines cross must be distinct and clear:

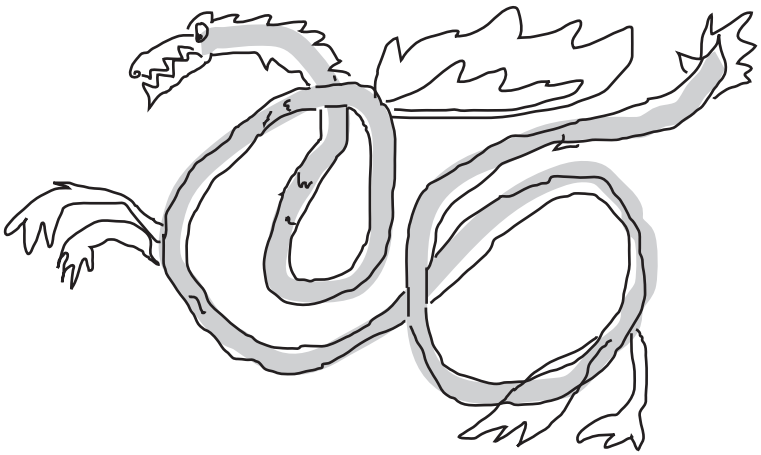
4. Next, draw in "over and under" lines using a pen or skinny marker. Start at one point and work your way around the line. Thanks to the beauty of math theory, the "over and under" lines will always work perfectly; you will not end with two "overs" or "unders" next to each other.

5. Trace all the sides of the squiggle with the pen. When you are done tracing, you will have created a really cool knot.



6. This knot doodling technique can be turned into a dragon doodling technique by simply not quite connecting the ends of the squiggle in the first step. However the ends must still be “outside” of the knot; it might help to imagine them connected with a section removed, or undrawn.

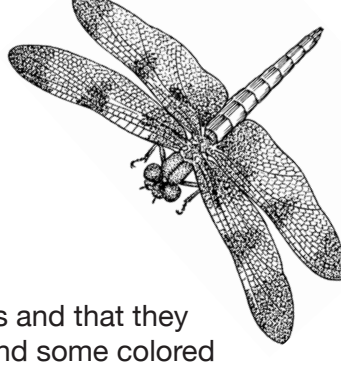
7. Draw the over and under lines as before. But this time add a dragon head, a dragon tail, some scales, wings, and legs, and voilà! Dragon!



8. Hang these illustrations around the classroom in hopes of bringing good weather and a productive agricultural season.

16. Color Palette

Odes come in a wide variety of beautiful colors.



What You'll Need
Nets
Hand Lenses
Odonata Envelopes
Journals
Art Supplies
Nymph in Tank
Colored Fish Gravel
Access to a Wetland

Skills & Concepts
Asking Questions
Recording Observations
Explanations
Communicating
Structure and Function
Patterns
Engineering
Investigations
Scientific Argument
Scale and Proportion

Dragon and damselflies exhibit a rainbow of colors. The males are generally more colorful than the females, likely because they use their flamboyant hues to attract a mate. However, bright colors also attract the attention of predators. When Odonata first emerge and when they are too cold to fly, their coloration is drab. As they mature or warm up, their body color becomes vibrant.

You may have noticed that museum displays of pinned dragonflies are rather dull-looking. This is because the bright coloration of dragonflies disappears after they die. The color can be preserved by immersing a dragonfly specimen in acetone that dissolves the body fat and inhibits decomposition. This is a valuable tool for scientists because color is an important aspect of Odonata identification. Therefore, modern museum collection standards call for immersing dragonfly specimens in acetone and then storing the dried samples in envelopes.

Nymphs are mostly mottled brown or black. However, some have a remarkable ability to change their color after a molt. Nymph colors such as transparent, black, green, brown, yellow, and pink have all been observed by the author.

Activity: Imitation as flattery

1. Prepare students for outdoor dragonfly catching. Inform your students that they will be closely observing the color of dragonflies and that they will need to bring their journals and some colored pencils. Perhaps start with a slide show of close-up cropped photos of dragonflies—so that they look like abstract art.

2. Outside, students should catch a dragonfly they find particularly beautiful then sketch it in their journal. Keeping the insects in clear plastic Odonata envelopes will allow for easier longer-term observation.

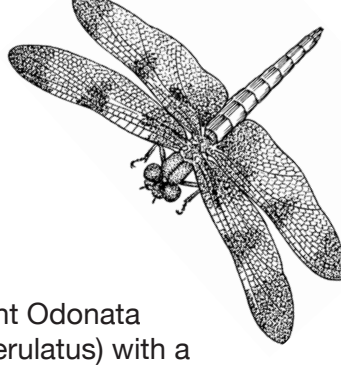
3. Encourage students to look closely and frame off certain areas for a sketch—perhaps just the colorful stripes on the thorax, or the pattern on a wing, or the iridescence of an eye.

4. Allow students to create multiple sketches, or take photos if possible, so that they will have enough source material to create a formal art project.

5. Assign an art composition assignment of your choice inspired by the dragonflies. You can put parameters around the assignment such as: it must involve symmetry, use a color scheme inspired by your dragonfly, or be a close-up of just a portion of a dragonfly, or include an accompanying poem or narrative.

This common green darner looks like it was painted with rainbow watercolors. (Photo: Ami Thompson)

17. Ancient Giants



Giant dragonfly-like creatures roamed the earth 300 million years ago.

What You'll Need
Photos of Griffenfly Fossils
Craft Supplies

Skills & Concepts
Recording Observations
Communicating
Patterns
Structure and Function
Systems and Models
Engineering
Using Math
Scale and Proportion
Stability and Change

Ancient dragonflies evolved adaptations that have been successful for hundreds of millions of years. Modern Odonata, while slightly different from their ancestors, are considered "living fossils" along with alligators, sturgeon, and horseshoe crabs.

Giant dragonfly-like creatures called Meganisoptera, or griffenflies, have been found in the fossil record as far back as the late Carboniferous period and continue through the late Permian. All griffenflies are now extinct.

Meganisoptera wings have proven very durable and are found preserved as fossils. Different species of Meganisoptera are identified by their specific wing venation. Griffenflies didn't have a pterostigma and modern dragonflies have evolved more complicated wing vein patterns.

Fossilized griffenfly adult bodies and nymphs are similar to modern Odonata because they all have large eyes, spiny legs, long slender bodies, and hooked mouth parts.

Griffenflies were the first to rule the ancient skies; they evolved about 100 million years before birds, bats, and flying dinosaurs (pterosaurs).

Most were only slightly larger than modern dragonflies, but a few species were very large. Meganeuropsis
permiana was the largest insect that ever lived with a wingspan of 28 inches (71 cm) and a head-to-tail body length of 17 inches (43 cm). (It's often falsely reported that Meganisoptera had a wingspan of over five feet.) The aquatic nymphs are estimated to have been a foot long (30.5 cm).

For comparison, the largest extant Odonata is a damselfly (Megaloprepus coerulatus) with a wingspan of 7.5 inches (19 cm).

Griffenflies were probably able to get so large because of the extra oxygen in the atmosphere during the late Paleozoic. At that time, extensive coal swamp forests generated lots of oxygen through photosynthesis. During the late Paleozoic, the atmosphere was about 35 percent oxygen compared to today's 21 percent. Recent research hints that more factors may have been at play in allowing insects to get so large, but the atmospheric oxygen level is at least part of the story.

Insects, including griffenflies, breathe through holes in their bodies called spiracles connected to internal tubular trachea. Odonata pump these tubes like a bellows for whole-body oxygen distribution; close observation will show a dragonfly abdomen expanding and contracting as it "breathes." The oxygen seeps into the insect's body through diffusion. This method of breathing is thought to limit the size of an insect based on the amount of oxygen in the atmosphere. More atmospheric oxygen means smaller trachea holes and larger insects.

While most of the other insects living with griffenflies were small, some were also gigantic, such as ancient mayflies. A few amphibians evolved to be equally large, so griffenflies were not completely free of predators. Like today's Odonata, griffenflies were diverse and lived all around the earth.

Activity: Build a Life-Size Griffenfly

1. Introduce griffenflies as ancient dragonflies that lived well before dinosaurs. If you are studying geologic time, be specific about when they evolved.

2. Explain that most griffenflies were small, just a little bigger than today's dragonflies. However a couple of the ancient species were gigantic: 28-

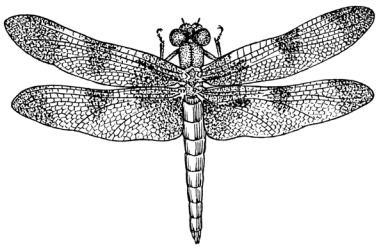
inch (71 cm) wingspan and 17 inches (43 cm) from head to tail. While not exactly the same as modern dragonflies, they were very similar in body shape: large eyes, long spiny legs, long skinny body, big strong wings, and chewing mouth parts.

3. Break the students into small groups and provide them with craft supplies to build their own giant griffenflies. They should measure to make their griffenflies the correct size but can be creative with their color and construction schemes. Each group should give its griffenfly an appropriate name and make up a bit of life history for it.

4. Let each group present its griffenfly to the entire class and explain its name and life history.

5. Lead a class discussion about why we don't have giant insects today. Help the students discover the connection to oxygen levels and plants.

6. Next time your students catch living dragonflies watch their abdomens expand and contract as they breathes.



Activity Alignment Chart

Curriculum Skills	Activity Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Asking scientific questions					x	x			x	x						x	
Recording observations, being careful to distinguish between actual observations and ideas about what was observed	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x
Explanations based on evidence						x	x		x	x						x	
Using and choosing the best tools	x		x						x								
Structure and function of dragonfly anatomy (for growth, survival, reproduction)	x				x	x		x	x	x	x	x	x	x		x	x
Sorting, grouping, and identifying Odonata				x	x	x	x										
Individual differentiation and adaptation					x	x				x			x				
Human impacts on Odonata ecosystems		x				x									x		
Test and evaluate engineering Solutions									x							x	x
Transfer of energy										x		x					
Water and dragonfly life cycle							x	x	x	x	x						
Communicating scientific results and process (clear, accurate, repeatable)	x	x	x	x	x	x	x		x	x			x			x	x
Cultural traditions															x		
Creating and using maps										x							
Practices (From *A Framework for K-12 Science Education*)																	
Asking questions and defining problems	x	x	x		x	x	x		x	x					x	x	
Developing and using models							x		x	x		x					x
Planning and carrying out investigations					x	x			x	x			x			x	
Analyzing and interpreting data						x			x	x				x			
Using mathematics and computational thinking					x	x								x			x
Constructing explanations and designing solutions									x						x		
Engaging in argument from evidence							x		x	x						x	
Obtaining, evaluating, and communicating information	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Crossingcutting Concepts (From *A Framework for K-12 Science Education*)																	
Patterns	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Cause and effect						x	x			x		x			x		
Scale, proportion, and quantity							x						x	x		x	x
Systems and system models							x		x	x	x	x					x
Energy and matter: flows, cycles, and conservation							x		x	x	x	x					
Structure and function	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stability and change									x	x		x			x		x