Invasive Crayfish Collaborative
Great Lakes

Lesson 3

Crayfish Adaptations

Subjects Science, Language Arts, Art

Grade Levels Ideal for grades 6–12, adaptable for 2–5

Time 50–75 minutes or more

Red swamp crayfish *(Procambarus clarkii)*: one of the most invasive crayfish species shows off its chelipeds.
Photo: National Park Service

Lesson Overview

In this lesson, students explore crayfish adaptations that help them to survive in freshwater ecosystems. Like the other lessons in the crayfish curriculum, it is designed to be highly adaptable. Options include having students brainstorm crayfish adaptations that help them to survive in their freshwater ecosystems, a short interactive multimedia presentation about crayfish anatomy and adaptations, and student-designed and engineered models of crayfish or a new type of scavenger/predator that is well-adapted to survive in an aquatic environment.

Goals

- Students will increase their understanding of crayfish adaptations that help them to survive and reproduce.
- Students will be provided the opportunity to apply the concept of adaptations to the process of engineering design.
- Students will demonstrate critical thinking about the particular roles of crayfish in freshwater ecosystems, and how they can help keep ecosystems healthy.

Objectives

- Students will demonstrate understanding of crayfish adaptations, including ways they are able to find food, reproduce, and escape predators.
- Students will create models of crayfish or new student-designed and engineered organisms adapted to be successful scavengers/predators in freshwater ecosystems and share them with their peers, gaining feedback that could be incorporated into new design iterations.
- Students will write about how crayfish or their own engineered organisms are adapted to survive, then share their ideas and models in class presentations and/or discussion.
- Students will verbalize the importance of food, water, shelter, and space in the survival of crayfish and other organisms, and how they are adapted to best use them.

Next Generation Science Standards

Performance Expectations

Building toward

- MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
- MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
- HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Crosscutting Concepts

- Structure and Function
- Stability and Change

Science & Engineering Practices

- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models
- Obtaining, Evaluating, and Communicating Information

Core and Component Ideas in the Life Sciences

LS1: From Molecules to Organisms: Structures and processes

- LS1.A: Structure and Function
- LS1.B: Growth and Development of Organisms

LS2: Ecosystems: Interactions, Energy, and Dynamics

- LS2.C: Ecosystem Dynamics, Functioning, and Resilience

LS4: Biological Evolution: Unity and Diversity

- LS4.C: Adaptation

Core and Component Ideas in Earth and Space Sciences

ESS2: Earth's Systems

- ESS2.C: The Roles of Water in Earth's Surface Processes

Common Core State Standards

Speaking and Listening Standards for Grade 6

(similar standards for grades 4–5; 7–12)

Standard 1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clarity.

Standard 4. Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

Standard 6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

College and Career Readiness Anchor Standards for Writing

Standard 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Standard 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Center for Great Lakes Literacy Principles

Principle 5. The Great Lakes support a broad diversity of life and ecosystems.

Teacher Background

Crayfish Life Cycle and Behaviors

Crayfish have adaptations that help them survive at each stage of their life cycle. They start out as one of 50–500 or more eggs that their mothers typically carry in their swimmerets, small appendages on the ventral side (underside) of their abdomen.

Photo: Rick Reynolds

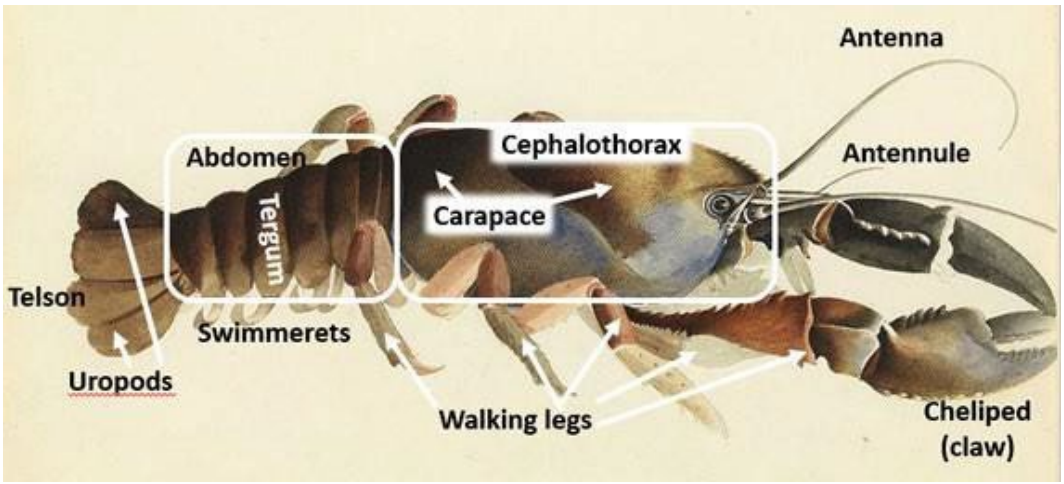
Crayfish go through incomplete metamorphosis during their life cycle. Unlike many other invertebrates, such as butterflies, which go through complete metamorphosis with distinct larval and pupal stages, they hatch from eggs directly into tiny crayfish and go through roughly 11 molts, in which they shed their exoskeleton and then replace it with a new one, growing into adults.

Crayfish are generally nocturnal. Being most active at night helps them to stay hidden from predators and stay sheltered from the hot sun. When they do venture out from shelter beneath rocks or burrows during the day, it is in well-shaded areas.

Crayfish Anatomy/Structures

The body of a crayfish is divided into three segments: head, thorax, and abdomen. The head and thorax are fused together to form the cephalothorax.

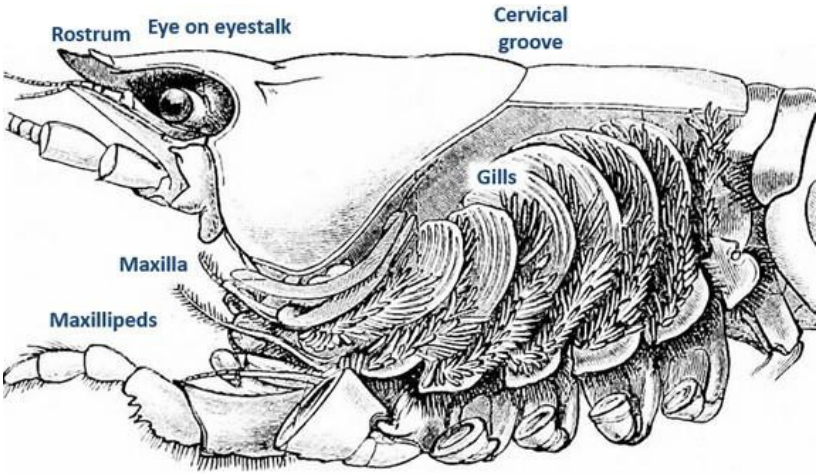
- **Thorax**: the crustacean equivalent to a chest; fused with the crayfish head to form the cephalothorax
- **Cephalothorax**: joined thorax and head of crayfish and other arthropods



Graphic: Rick Reynolds from public domain illustration

- **Abdomen**: section behind the thorax covered in six plates

- **Tergum**: name for the thickened plates on each segment of the body of crayfish and other arthropods; helps to protect soft interior
- **Carapace**: hard upper shell of crayfish and other arthropods that extends from the tip of the rostrum to the start of the abdomen; protects the crayfish
- **Rostrum**: beak-like projection; ask students what function might be; protects eyes, antennae, and antennules
- **Antenna** (plural antennae): long organs used for touch, taste, and smell; helps to sense prey and predators in murky water
- **Antennules**: shorter organs also used for touch and taste, as well as balance
- Five pairs of legs to move along river or pond bottom (locomotion)
- **Chelipeds**: Pair of legs nearest to the head, enlarged with claws (chelae) to hold food, provide protection, and use in combat
- **Chela**: claw located at the end of each cheliped (plural chelae)
- **Uropods**: Last pair of abdominal appendages of crayfish and related crustaceans; found on sides of the telson, completing the tail fan used for swimming
- **Telson**: An extension of the last abdominal segment; triangular-shaped structure found in between the uropods, completing the tail fan used for swimming
- Eyes on **eyestalks**: can be rotated for very large field of vision



Graphic: Rick Reynolds from public domain illustration

- **Cervical groove**: indentation that separates head and thorax, which are connected in crayfish
- **Gills**: extract oxygen from water; used to breathe
- **Maxilla**: help draw water over gills
- **Maxillipeds**: hold food; can touch and taste
- **Mandible**: crushes food to be swallowed by mouth

- **Green glands**: help to filter waste products and balance salt levels in blood; similar to kidneys in humans
- **Genital pores**: used in reproduction
- **Swimmerets:** small appendages on the ventral side (underside) of their abdomen; in males, they are used in mating; in females, they are used to hold eggs and baby crayfish

Crayfish body structures and other adaptations are presented with larger images and labels in the slides and notes of the Crayfish Adaptations PowerPoint presentation.

Additional sources for teachers and/or students are listed in the "Extend/Enrich" and "Expand Knowledge + Skills" sections at the end of the lesson.

Materials

- "Crayfish Adaptations" PowerPoint presentation available on the Invasive Crayfish Collaborative website: invasivecrayfish.org/products
- Computer access, data projector, display screen, and Microsoft PowerPoint (or other software capable of displaying a .ppt file)
- *Optional:*
  - "Crayfish Adaptations" reading and questions, "Crayfish External Anatomy" diagram activity, "Crayfish External Anatomy" descriptions, and "Comparing Adaptations" handout at the end of the lesson
  - Modeling clay or Play-Doh and natural materials like dried vegetation, twigs, pine needles, and pinecones for students to share
  - Human-made materials for students to share, such as used paper towel tubes and/or toilet paper tubes, popsicle sticks, elastic bands, paper, cardboard, tape, and non-toxic glue
  - Paper plates on which to construct creatures
  - Colored pencils, markers and/or crayons for students to share
  - Live native crayfish and/or preserved crayfish specimens
  - Microscope(s) and/or hand lens(es)
  - Enlarged photographs of crayfish
  - "Curious Crayfish + Freshwater Ecosystems" activity, which can be found before this lesson in the crayfish curriculum.

Preparation

1. If possible, identify an expert partner to work with your class about crayfish and their adaptations. Contact us here for possible recommendations: invasivecrayfish.org/contact-us.
2. Write the word "Adaptations" on the board to refer to during the lesson.
3. Ensure all materials above are ready for student use.

4. *Optional:*
    - Review more about crayfish and their anatomy/adaptations to prepare to answer student questions. Good sources include those listed at the end of the lesson in the Expand Knowledge + Skills section.

Teaching Suggestions in the 5E Model

Engage

1. Introduce the expert visitor, if one is present, and tell students they will be learning more about crayfish today to prepare them for a field trip to find crayfish in a nearby freshwater ecosystem (if you will be visiting one). But first, tell students you'd like them to think about what they already know about crayfish and their freshwater ecosystems.
    - Ask them to turn to a neighbor and quickly brainstorm on a piece of paper all of the **adaptations** they would need to survive in their underwater **environment**.
    - Write "adaptations" on the board and explain they are traits of crayfish and every other **organism** (living thing) that **evolved** over millions of years to help them survive—both physical structures of their bodies, as well as behaviors that help them find food, escape predators, reproduce more crayfish, etc.
    - They should record all their ideas from their brainstorm without worrying about if they are good ideas or not, and they can also draw pictures of the adaptations.
2. Circulate through the room, answering any questions. After a minute or two, tell students they have one more minute to brainstorm and that they should be prepared to share one or more of their best ideas with the class.
3. Ask the pairs to share their best ideas with the class and discuss them.
4. Open the "Crayfish Adaptations" PowerPoint presentation and you and/or the visitor can lead a brief interactive discussion about it, drawing on student ideas and information in the slide notes to talk about important crayfish body structures, behaviors, their life cycle, and the functions adaptations play in helping crayfish survive and reproduce. If available, you can also show the students live crayfish, which is especially engaging.

Explore

5. Next, tell students that they will have the opportunity to create a model of either a crayfish or a new organism that is adapted to be a successful scavenger and predator in freshwater ecosystems.
    - Explain that they will be able to use a variety of materials, their creativity, and what they have learned about adaptations to help with their engineering designs.
    - Show them the available materials, such as clay, Play-Doh, natural vegetation, toilet paper tubes, pipe cleaners, and scrap paper, with which they will be able to create their designs.

6. Ask students to choose a partner (if desired, or they can work individually) and collect materials with which to work. Rotate though the groups of students, answering questions and helping students get started, if necessary. Tell students that they should be prepared to present their work to the class, including about how the organisms' adaptations help them to survive. If they have time, they can create another life stage for their organism (such as a crayfish's egg stage or an insect's aquatic larval stage).

A student-created organism
Photo: Lucinda Watson

Explain

7. After about 15 minutes, or whenever groups start to complete their designs, explain that you will be looking for volunteers to make a brief presentation to the class about their organisms, and ask them to start cleaning up when they are finished.
8. Ask students to explain their organisms' adaptations in writing using one of the following methods or another way that they devise:
    - They can create labels with small pieces of card stock, attached to their organisms with toothpicks and tape or another method.
    - They can illustrate their engineering designs on paper, labeling the adaptations that help them to survive. Color can be added with pencils, markers, or crayons.
    - They can write a narrative in paragraph form that explains the organism's adaptations.
9. Ask students to share their work, giving other class members a chance to ask questions about the organisms' adaptations at the end of each short presentation.
10. Tell students that they will be able to finish their projects for homework or in class the next day (if necessary and as you deem appropriate). Collect the finished projects to review more carefully and display around the classroom and/or the school. You could also ask students to refine their creations based on constructive feedback you and/or the rest of the class has provided before the creations are displayed publicly.
11. Close with a quick review of concepts learned during the lesson and crayfish adaptations that help them survive in their aquatic habitats.

Enrich/Extend

- Ask students to complete the "Crayfish External Anatomy" diagram activity at the end of the lesson with the support of the "Crayfish External Anatomy" descriptions handout, which is also found at the end of the lesson. The "Crayfish Adaptations" reading can also be used to support the activity and the others below.
- Ask students to compare crayfish with their new organism—or one of their peers' new organisms. For example, a Venn diagram could be used. They should compare

their creature's physical and behavioral adaptations to those of crayfish, including their organism's different structures and functions that help them to survive.

- Ask students to first plan their organisms on paper before they start engineering them with physical materials, labeling the adaptations that will help the organisms to survive.
- If you have access to live or preserved crayfish, students can view them and/or their body structures under magnification with a microscope, hand lens, and/or macro lens to better see their unique adaptations. You can also use a microscope or macro lens connected to a computer and/or data projector to show specimens to the whole class. Obtain and dispose of your live crayfish responsibly– always use native or non-invasive species and NEVER release your classroom plants or animals into the wild.
- Ask students to dissect crayfish specimens with the guidance of one or more resources, such as:
    - "Crayfish Dissection" page from Biology Junction: biologyjunction.com/crayfish_dissection.htm
    - "Detailed Crayfish Dissection: Part I" video: youtu.be/AOZdmUKoViY
    - "Detailed Crayfish Dissection: Part II" video: youtu.be/0QgB9xNqtGU or
- Students can write fictional stories or poems about crayfish and/or the new organisms they created.
- Take students on a field trip to a stream or other area of freshwater to observe crayfish and their ecosystems firsthand.

A student prepares to dissect a preserved invasive crayfish
Photo: Deb Berg

- Set up classroom centers with other activities related to adaptations, the new organisms, and/or crayfish, such as those listed above. This would provide more opportunity for student choice and differentiated learning experiences.
- Show one or more short video clip(s) about crayfish:
    - Crayfish babies hatching: youtube.com/watch?v=_e1LV9MR9MQ
    - Crayfish molting: youtube.com/watch?v=mF6NgMBcNCM
- For younger grades, read a story or nonfiction book with your class about crayfish. Examples include:
    - "The Life Cycle of a Crayfish" by Bobbie Kalman, Crabtree Pub Co: amazon.com/Crayfish-Cycle- Paperback-Bobbie-Kalman/dp/0778707032
    - "Crayfish" by Meg Gaertner, North Star Editions: barnesandnoble.com/w/crayfish-meg- gaertner/1129536594
    - "Crayfish" by Phillis W. Grimm, Lerner Pub Group: amazon.com/Crayfish-Early-Bird-Nature- Books/dp/0822530309

Evaluate

- Review student descriptions of their model crayfish or new organism's adaptations, including ways they are able to find food, reproduce, and escape predators. Students should also be able to discuss crayfish adaptations orally.
- Students can be asked to reflect on the lesson in writing and/or orally, including about what they learned and what you, as the teacher, might do to improve the lesson next time.

Expand Knowledge + Skills

- Carpenter, M.E. (2017). "Adaptations of the Crawfish." Sciencing: sciencing.com/adaptations-crawfish-10006220.html
- "Crayfish Biology." Biological Surveys and Assessment Program. University of Illinois: publish.illinois.edu/biologicalsurveys/research/crayfish-biology/
- Helfrich, L.A., Parkhurst, J., and Neves, R. 2001. "The Control of Burrowing Crayfish in Ponds." Dept. of Fisheries and Wildlife Services, Virginia Tech. vtechworks.lib.vt.edu/server/api/core/bitstreams/163b1c0e-5ba8-465c-99f4-52072a1f5b7f/content
- "Marbled Crayfish Raises Eyebrows, and Concerns." Great Lakes Now: Detroit PBS: greatlakesnow.org/2024/04/marbled-crayfish-raises-eyebrows-and-concerns

Lessons/Activities

- "Crayfish Dissection." Biology Junction: biologyjunction.com/crayfish_dissection.htm
- *Crawfish Educational Materials for Grades K-8 & High School Biology*. Louisiana Crawfish Promotion and Research Board: lsuagcenter.com/~/media/system/4/4/6/b/446b98e3a69c8f3bdedd57feb2802c7b/crawfishlessonplank8hslab.pdf
- "COSIA Outreach Activities- Crayfish Investigations." Lawrence Hall of Science: marestage.lawrencehallofscience.org/college-courses/COSIA/outreach-activities
- *Crayfish Student Activity Book.* Elementary Science Program: currikicdn.s3-us-west-2.amazonaws.com/resourcefiles/54d26e5197a40.PDF
- "Introduction to Scientific Sketching" lesson plan. California Academy of Sciences: calacademy.org/educators/lesson-plans/introduction-to-scientific-sketching

Education Standards

- More information about the Next Generation Science Standards, to which this lesson was aligned: nextgenscience.org
- More information about the Common Core State Standards and links to the complete documents: thecorestandards.org

Crayfish Adaptations

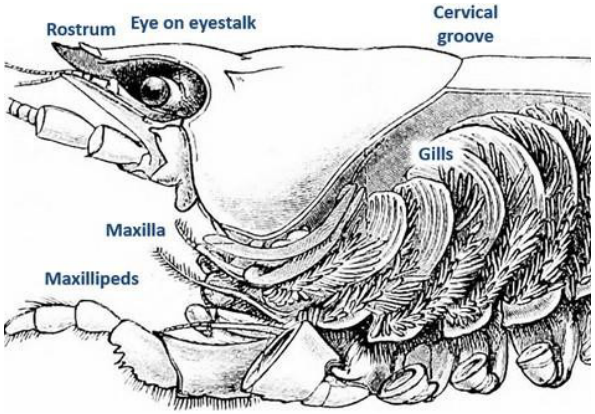
Crayfish have many adaptations that help them to survive: physical structures, like their hard exoskeleton, as well as behaviors (things they do). As you read, think about similarities and differences between crayfish adaptations and those of other species (including humans).

A red swamp crayfish defends itself with its chelipeds.
Photo: National Park Service

Finding Food + Staying Safe

Crayfish are not picky eaters. They will eat almost any dead or living animal or plant that they can get their **chelae** (claws) on. They can use their **chelipeds** (the pair of legs with chelae) for defense against predators and other crayfish, too.

Crayfish also use their chelipeds for digging and to get food to their mouths. Three **maxillipeds** and a pair of **maxillae** are used in feeding, too. Strong **mandibles** crush food before it enters their mouths. Crayfish grind up their food even more with teeth inside their stomachs! This is called the "**gastric mill**."

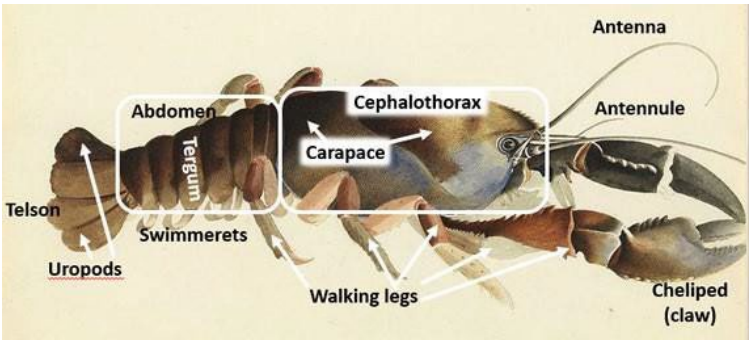


Graphic: Rick Reynolds from public domain illustration

Crayfish have **compound eyes** made up of many small eyes. Their eyes are on **stalks**, which gives them a larger field of view to spot food and predators. They are protected by the **rostrum**, also called the **supraorbital spine**, which sticks out in front of and above their eyes.

Crayfish have two pairs of **antennae** used for sensing food and danger in their murky habitat. The smaller pair are known as **antennules**.

If crayfish sense danger, they usually swish their **tail fan** down to escape backwards. The tail fan is made up of the **telson** with two pairs of **uropods** on either side that can spread out to move more water. Powerful muscles in their **abdomen** provide the downward force to make their quick escape. Protective plates cover their abdomen; each plate is known as a **tergum** on the **dorsal** (top) side and a **sternum** on the ventral side.



Graphic: Rick Reynolds from public domain illustration

Crayfish are generally **nocturnal**. Being most active at night helps them to hide from predators and stay

sheltered from the hot sun. When they do venture out from the shelter of rocks or burrows during the day, it is in well-shaded areas.

Burrowing in mud not only provides safety from predators; it can also help crayfish survive cold and/or dry periods. Burying themselves in the mud can help keep their gills moist and prevent them from freezing.

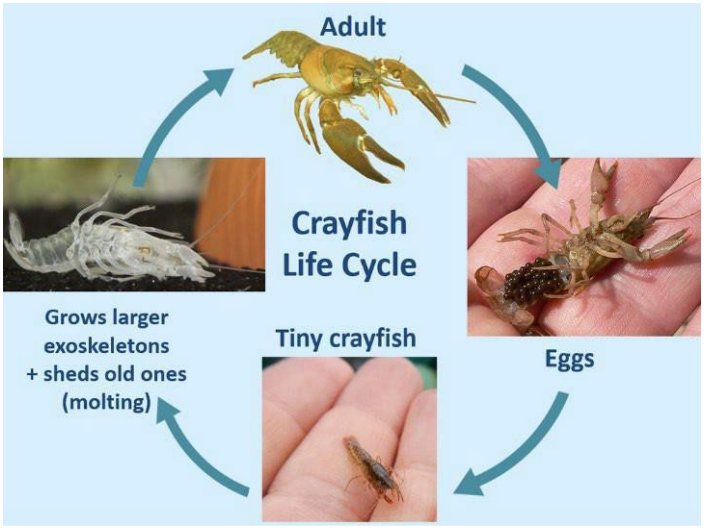
A female crayfish holding her eggs in her swimmerets

Life Cycle

Adult females lay 50 to 500 or more **eggs** at a time. The eggs are usually carried in their **swimmerets**, small **appendages** on the underside (**ventral** side) of their **abdomen**.

Crayfish go through **incomplete metamorphosis** during their **life cycle**. They hatch from eggs directly into tiny crayfish, which their mothers usually shelter until they grow larger.

Before they reach adulthood, they go through roughly 11 **molts**; each time they shed their **exoskeleton**—and they usually eat it! This recycles the calcium so they can quickly grow a hard, new one. Their life cycle differs from that of butterflies and many other **invertebrates** that go through **complete metamorphosis** with different **larval** and **pupal** stages—caterpillar and chrysalis, etc.



Graphic: Rick Reynolds

Male or Female?

Crayfish males have **gonopods** (modified swimmerets that are firmer than the feathery swimmerets). The gonopods are used to deposit sperm in the female when they mate. This fertilizes her eggs so they will develop into baby crayfish.

A male crayfish with gonopods circled
Photo: Deb Berg

Getting Oxygen

Crayfish get dissolved oxygen from freshwater using their **gills** (like fish). They use one of their two pairs of **maxillae** around their mouth to draw water over the gills. Their gills are attached to four pairs of **walking legs**, which also helps draw water over the gills as they walk.

Crayfish can survive out of water for short periods, as long as their gills stay wet. If they start to dry out, they need to return to water or bury themselves in wet mud so they can get the oxygen they need.

Name(s): _____ Period: ____ Date: _____

What Do You Know about Crayfish Adaptations?

1. Describe five interesting crayfish adaptations. Use complete sentences and include how they help the crayfish survive in their freshwater ecosystems. You might also add illustrations.

2. How could you divide a crayfish up into parts to explain what it is to someone who has never seen one? You might also add an illustration below or on the back of this sheet.

3. How do swimmerets compare to walking legs?

Crayfish
External Anatomy
(outside structures)

Your Name(s) _____

Period _____ Date _____

Dorsal View
(upper side)

Ventral View
(lower side)

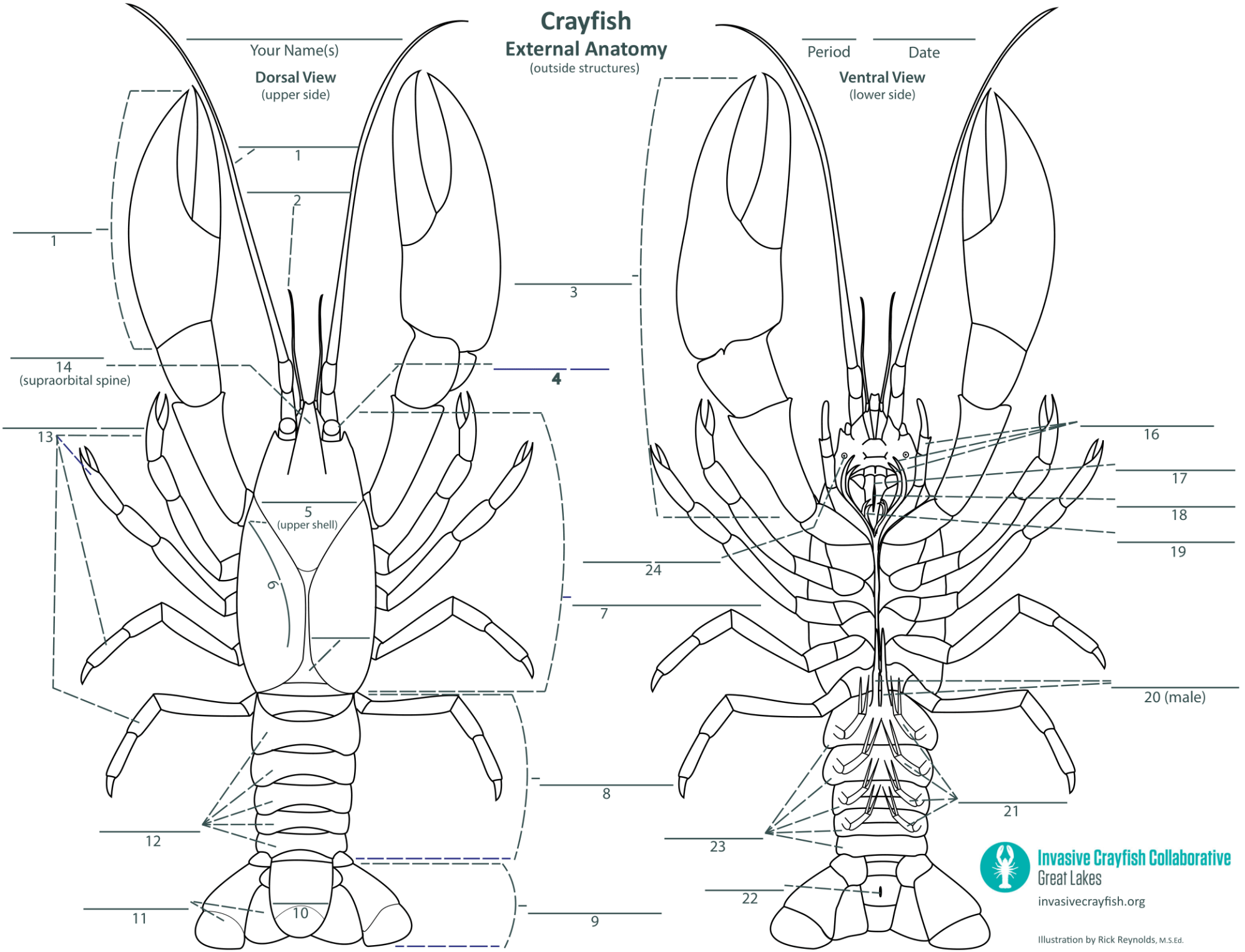


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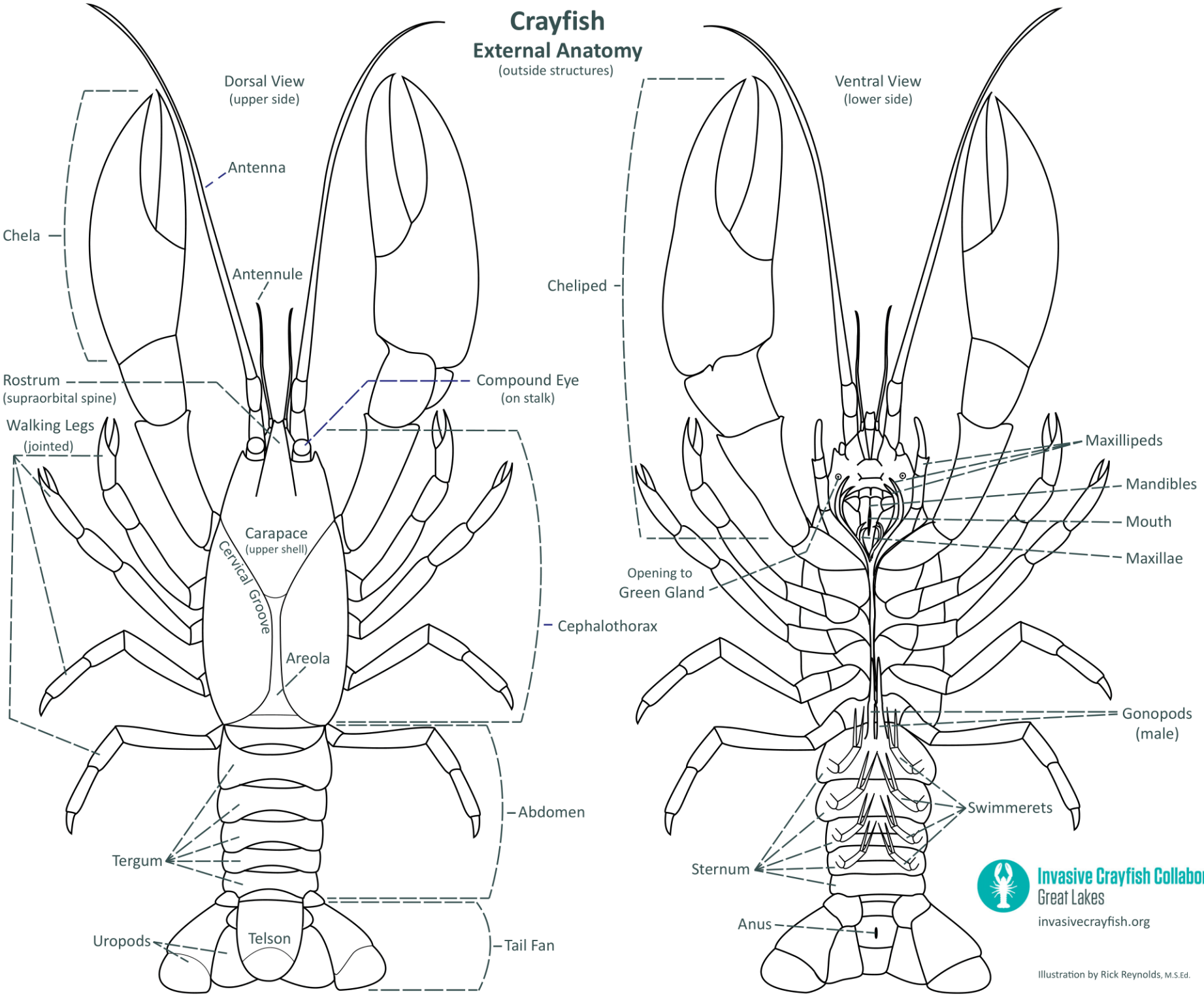
Illustration by Rick Reynolds, M.S.Ed.

Crayfish External Anatomy

(outside structures)

Abdomen	Tail area with segments; swimmerets, telson, and uropods are attached to it
Antenna	One of two long sensory organs at front of crayfish (**antennae**: two or more)
Antennule	One of two short antennae
Anus	End of digestive tract; located on lower part of telson
Carapace	Upper protective **exoskeleton** (shell) of cephalothorax
Cervical Groove	Indentation in carapace between head region and thorax region
Cephalothorax	Combined head and thorax; contains the heart, gills, stomach, and other organs
Chela	One of two big claws used for defense and food handling (**chelae**: two or more)
Cheliped	One of two long legs with chela
Compound Eye	Two eyes made up of many small eyes; located on **stalks**
Gonopods	Modified swimmerets of males; used to pass sperm to females
Green Gland	One of a pair of organs used to remove waste products and balance salt levels in blood; two openings to them are on the lower side of the head
Mandible	One of two strong **jaws** used to crush food
Maxillae	First pair of maxillae helps hold, tear, and pass food to mouth; second pair helps draw water over the **gills** (used to get oxygen from the water)
Maxillipeds	One of three pairs of feeding appendages; attached to jaws
Mouth	Opening at start of **digestive tract**
Rostrum	Beak-like structure above eyes; also called the **supraorbital spine**
Swimmerets	Five pairs of short appendages on bottom of abdomen used for swimming; females also use them to hold their eggs and young crayfish.
Tail Fan	The telson and four uropods; used for swimming backwards—fast!
Telson	Center section of tail fan
Tergum	Upper protective plates of abdomen
Sternum	Lower protective plates of abdomen
Uropods	Two pairs of appendages on tail fan that surround the telson
Walking Legs	Four pairs of jointed legs; the gills are attached to them

Crayfish
External Anatomy
(outside structures)



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Name(s): _____ Period: ____ Date: _____

Comparing Adaptations

Compare the structural and behavioral adaptations
of two species using words and illustrations.

Species 1: _____ Different Adaptions

Adaptations in Common

Species 2: _____ Different Adaptations