CHAPTER 3: USING ROCK PACKS AS LEARNING TOOLS

This chapter provides guidance on using the Rock Pack Experiment to create authentic learning experiences focused on experimental design, experimental methods, and E-STEM skill-building, including advanced data collection and analysis, while connecting these experiences to state standards and curricular needs.

Importantly, the methods in the Rock Pack Experiment are very flexible and open to the type of design you would like to encourage in your students' experiments. The experiment is also a valuable extension of or alternative to the Leaf Pack Network, which can be used to establish baseline conditions and regular water-quality monitoring of a local waterway, as discussed in Chapter 1.

Rock Pack Goals and Learning Objectives

GOALS:

- To promote student inquiry by using scientific methods involving observational and explanatory activities
- To raise awareness of the importance of net-spinning caddisflies to stream ecosystems
- To use the Rock Pack Experiment and other educational resources to improve science education and teacher professional development

LEARNING OBJECTIVES:

At the conclusion of the Rock Pack Experiment, students will have:

- ✓ Conducted a research-oriented investigation of their local streams
- Engaged in inquiry-based, hands-on data gathering and monitoring
- Observed and described freshwater aquatic food webs
- Identified net-spinning caddisflies
- ✓ Measured physical characteristics of a stream
- ✓ Drawn conclusions about the relationship between habitat, land-use and macroinvertebrate diversity and density
- ✓ Formulated research questions related to rock packs
- ✓ Analyzed macroinvertebrate data by using indices to assess water quality (optional extension)





Alignment with the Next Generation Science Standards

Teachers could potentially meet the following NGSS standards for grades 6-12:

Standards for 5, MS, and HS

LS2: Ecosystems: Interactions, Energy, Dynamics LS4: Biological Evolution: Unity and Diversity ESS3: Earth and Human Activity ETS2: Engineering Design

Science and Engineering Practices Asking Questions and Defining Problems Planning and Carrying out Investigations Analyzing and Interpreting Data Developing and Using Models Constructing Explanations and Designing Solutions Engaging in Argument from Evidence Using Mathematics and Computational Thinking Obtaining, Evaluation, and Communicating Information	SECTORE DE ER CROSSCUTTING CROSSCUTTING
Disciplinary Core Ideas	Crosscutting Concepts
LS2.A: Interdependent Relationships in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS4.C: Adaptation ETS1.B: Developing Possible Solutions ETS1.A: Defining and Delimiting an Engineering Problem ETS1.C: Optimizing the Design Solution ESS3.C: Human Impacts on Earth Systems	Systems and Systems Models Cause and Effect Stability and Change Patterns

Getting Started with Students

Developing a plan of action can guide you in setting up and participating in the Rock Pack Experiment. It also helps you utilize the available resources to the fullest. You may choose to have students take part in all of the experiences or just participate in certain phases. Use some or all of the steps in the plan below as a guide to planning your project.

STEP 1: GENERAL INFORMATION

- 1. Which classes will participate in the Rock Pack Experiment?
- 2. How many students will participate? Which grades?
- 3. What stream will be used? What watershed or sub-watershed are we to study?

5. What logistical issues need to be addressed as you prepare to implement the Rock Pack experiment? (Include things like administrative, transportation, property access, schedules, collection permits, etc.)

6. How do you envision this project serving your curricular needs? Which topics will be of particular interest to you?

STEP 2: DESIGN THE EXPERIMENT

1. When do you plan to begin your project?

2. Describe the stream and location that the class will investigate. What conditions exist that will make this an interesting and effective location?



3. If experimental rock packs will be used, what will be investigated in the project? Your choice of variables might include:

ROCK SIZE! Either vary the average size (e.g., 10 millimeter b-axis diameter) or variation in sizes of rocks (e.g., some 10-mm rocks and 50-mm rocks together in one pack, or only 10-mm rocks in a pack) in the packs.

OR

WEIGHTS! Vary the weight of each rock pack (e.g., 200 grams vs. 1000 grams).

OR

LOCATION OF PACK! Place your packs in different areas of the stream (e.g. pool vs. riffle habitat, forest stream vs. meadow stream).

For example, student groups may form *a* hypotheses on the size of rocks/gravel net-spinning caddisflies will prefer during colonization. To measure this, student groups may prepare rock packs of varying sizes and later evaluate the density/number of net-spinning caddisflies per rock pack.

STEP 3: WORK PLAN & TIMELINE

Consider the following tasks while outlining a work plan or timeline. If time is a concern, it is not necessary to choose all of the components below.

- I. Class Introduction to the Rock Pack Experiment, including stream ecology, aquatic macroinvertebrates, and net-spinning caddisfly larvae. TIP:use any of the videos found on the Rock Pack Experiment website!
- II. Site Investigation
- III. Preparing the Rock Packs for the Stream
- IV. Placing the Rock Packs in the Stream
- V. Collecting the Rock Packs From the Stream
- VI. Processing the Rock Packs
- VII. Sorting and Identification, with an emphasis on net-spinning caddisflies
- VIII. Water Quality Calculations
 - IX. Sharing Data on the Leaf Pack Network Online Portal

CONSIDER THE FOLLOWING QUESTIONS:

1. How and when will you contribute your project data to the data portal?

2. How can your class use the web-based rock pack resources available at https://leafpacknetwork.org/?

3. How will you engage students in communication of Rock Pack Experiment data through group discussion, presentations, and/or written assignments? NOTE: This may have important interdisciplinary connections to literacy, language arts, technology, engineering, physics, and more.

4. How else is information-sharing possible for the data your students generate? (e.g., conferences, school board meetings, township meeting, local conservation groups)

Optional Activities

The following pages include optional activities that serve as helpful extensions of E-STEM lessons as well as new opportunities to integrate other state standards or learning objectives, including physics and art.



Crafty as a Caddisfly: Build a Net!



The aquatic larvae of the net-spinning caddisfly (Order Trichoptera, Family Hydropsychidae) use silk threads woven into a mesh web to catch their dinner. As a **collector-gatherer** and **omnivore-detritivore** during at least part of its larval stage, these nets help the crafty critters use a feeding strategy called **filter-feeding** to capture small particles, such as broken-down leaves and other **detritus**, on their net's sticky threads.

There are many different caddisfly species, and individual species vary in the nets they create, including the number of silk threads in the net, the strength of the silk threads, and the size of the silk structure. The nets are created with great detail and precision, with each silk thread placed into just the right spot to create mesh webbing that will stretch and balloon with food. Now it's time to model net-building with your students to creatively introduce them to the world of the net-spinning caddisfly!

MATERIALS:

- Yarn or string (precut in 24-inch lengths by teacher)
- Visual aids on Pgs. 24-25 of net-spinning caddisfly larvae and silk webs/retreats (optional)
- WiFi and computer access to play *Caddisflies, Engineering an Ecosystem,* on vineo (4 min, 33 seconds): https://vineo.com/273597362

PREPARATION:

Cut yarn or string of different colors and strength into 24-inch lengths. Plan to conduct the activity with access to the outdoors so students can collect twigs. If outdoor access is not possible, pre-collect a bag of twigs of varying lengths, thickness, and species distributions. Twig identification is NOT necessary.



INSTRUCTIONS:

- 1. Each student collects twigs to serve as the frame for their net.
- 2. Using different colors and strengths of yarn, each student builds a net that they think resembles a caddisfly net.
- 3. Have the students present their nets and share why they chose their net's silk structure and design.

Continue to next three pages for activity extensions and visual aids!



CRAFTY AS A CADDISFLY EXTENSIONS:

- Simulate Energy Flow in a Stream! If you have access to a stream or fan (or leaf blower!), consider having students make a much larger net, and then stand in the water or an open grassy area. Release handfuls of leaves upstream or in the wind, and see which student's net catches the most leaves.
 - Explain to students that leaves are the dominant source of carbon and energy for many streams, and provide habitat and food for aquatic macroinvertebrates like cranefly larvae, stonefly nymphs, and even crayfish. This "eating" process yields smaller particles (feces and leaf fragments), similar to "crumbs" created after eating crackers, for example), providing food for other highly specialized macroinvertebrates downstream. These small particles float downstream and catch on the sticky silk threads of net-spinning caddisfly webs. Bon appétit!
 - Throughout and following the activity, ask students: What might make their webs better at catching leaves (e.g., more threads, stronger threads, bigger webs, etc.)?
- Graph It! If you have older students, you can use graph paper to have them draw a structurally sound net. If you have access to AutoCad drawing software they can trace nets from pictures of caddisflies.

CRAFTY AS A CADDISFLY VISUAL AIDS, PART I OF II



Caddisfly Silk Nets



CRAFTY AS A CADDISFLY VISUAL AIDS, PART II OF II

Caddisfly Silk Retreats









ROCK PACK MANUAL

Determining Stream Discharge

The amount of water moving past a point on the stream can be determined if four sources of data are known. The amount of water (cubic meters per second) is calculated using this formula:

channel width x water depth x roughness coefficient x water velocity = discharge (m³/s)

MATERIALS:

tape measure	meter stick	clip board	pencil
boots	stop watch	floating device (walnut	, orange, tennis ball)

PROCEDURES:

Note: It is recommended that this exercise be completed before the rock packs are placed in the stream.

1) Stream channel width:

Step 1: In the proximity of the rock pack locations, stretch a tape measure tightly across the stream.

Step 2: Measure width from the water's edge, one bank to the other.



2) Stream depth:

Step 1: Measure and record three equidistant depth measurements along the width transect.

m

___m

_____m

Step 2: Add all three measurements and divide the total by three to calculate the average.

Average stream depth = _____ m

3) Velocity:

Step 1: Measure distance of 10 meters parallel to the stream, along or upstream of where you will place your rock packs.

ROCK PACK MANUAL

Step 2: Place observers at the start and end of the 10-meter course, along with a person who is a recorder and a timekeeper.

Step 3: Float an object and record the time it takes to travel the 10 meters. Drop the float approximately 30 cm above the starting point.

Step 4: Observers are to call "start" and "stop" for the timekeeper. Timekeeper is to give readings to the recorder.



_____ sec

Step 5: Repeat this procedure three times. Add all three measurements and divide the total by three to calculate the average.

_____ sec

_____ sec

Average time: _____ sec

Step 6: To determine velocity, calculate: <u>10 m (distance)</u> = average seconds

Velocity = _____ m/sec

4) Calculating Volume of Flow/Discharge: How much water per second?

- **NOTE: Roughness Coefficient** is a value given for the type of stream bottom. Check the box that best describes the stream where you are working:
 - **0.9** *if the stream bottom is smooth with silt, sand or bedrock*
 - **0.8** *if the stream bottom is rough with rubble, stones or gravel*

width x avg. depth x roughness coefficient x velocity = discharge (m³/s)

_____ (m) x _____ (m) x _____ x ____ (m/s) = _____ (m³/s)

Discharge = ____ m³/s

Conversion factor: Multiply cubic meters/sec (m³/s) by 35.31 to calculate cubic feet/sec (cfs).

Digital Detectives: Caddisfly ID

This macroinvertebrate identification activity is highly recommended for an indoor setting *before* rock pack processing to orient students, teachers, trainers, and citizen scientists alike to net-spinning caddisfly identification. It also puts the "T" in E-STEM learning as participants use Macroinvertebrates.org, a dynamic, digital learning tool, this activity, to explore the identifying characteristics of the:

- Order level of caddisflies (Trichoptera)
- Family level of net-spinning caddisflies (Hydropsychidae)

The Macroinvertebrates.org online resource can be used to build confidence in identification of common freshwater macroinvertebrates across eastern North America.

MATERIALS:

- ✓ WiFi Connection
- ✓ Computer(s), ideally one per individual or per small group
- ✓ Access to <u>Macroinvertebrates.org</u>
- Digital Detectives Activity: Instructional Slideshow (downloaded from <u>https://leafpacknetwork.org/rock-pack/</u>)
- Digital Detectives Activity: Net-Spinning Caddisfly ID Guide (downloaded from https://leafpacknetwork.org/rock-pack/)
- ✓ ID Focus Worksheet(s)
- ✓ Dichotomous Key (optional)
- ✓ ID Flashcards (optional)
- ✓ Live or preserved specimen with hand lenses (optional)
- STEM career highlight video of an entomologist from the Stroud Water Research Center: <u>https://www.youtube.com/watch?v=S7ayyXPgkjU&list=PLrmuh958ChibSVPi6W1n8nGtis4nDw3Cp&index=1</u>

PREPARATION:

Participants should have a basic understanding of insect anatomy and aquatic macroinvertebrate life histories. You may
want to first introduce what aquatic macroinvertebrates are as well as their general morphology. A next best step is
also to have students become familiar with a dichotomous key which can be found here on the macroinvertebrates.org
website: https://www.macroinvertebrates.org/key/





 The main activity is intended to be used in combination with the Instructional Slideshow and the Net-Spinning Caddisfly ID Guide to introduce the activity and basic insect anatomy, as well as the defining characters of the net-spinning caddisfly. These slideshows are available on the rock pack page of the Leaf Network website. The ID Guide may also be printed as a student worksheet, or completed as a large group

as a PowerPoint projected onto a large screen.

INSTRUCTIONS:

 In small groups or as individuals, navigate to Macroinvertebrates.org. Select the order "Trichoptera," or the caddisflies, on the homepage from "The Atlas of Common Freshwater Macroinvertebrates." Alternatively, click the dropdown menu on the top left (three black lines), select "Navigational Views" from the menu, and select "Insect Order View." The order "Trichoptera" can then be selected.



- 2. Use the Net-Spinning Caddisfly ID Guide and the Instructional Slideshow in combination with Macroinvertebrates.org to explore the site and complete the ID Focus Worksheet.
- 3. Discuss your findings as a group. How does the dynamic imagery on the digital platform allow you to study the macroinvertebrates similar to entomologists in the laboratory? How can it build your confidence in hands-on identification with live specimens in the field? What new discoveries did you make about the defining characters of the net-spinning caddisfly?



Who Am I? Macroinvertebrate ID

This activity introduces students to the use of a dichotomous key to identify **benthic freshwater macroinvertebrates**, or "stream bugs" that inhabit the bottom/substrates (benthic) of streams, rivers, lakes, or ponds (freshwater), are big enough to see with the naked eye (macro, 0.2 – 0.5 mm), and lack a backbone/vertebrae (invertebrate). Macroinvertebrates play important roles in freshwater food webs and can also be valuable indicators of water quality.

Although these macroinvertebrates include animals like crayfish and mussels, many macroinvertebrates are aquatic insects that spend the first part or all of their lives underwater. For students new to macroinvertebrates, it is recommended that this activity focuses only on the aquatic insects and their life cycles, while integrating students' existing understanding of insect anatomy (e.g., head,

thorax, abdomen) and life cycles (e.g., the larval stage of a butterfly). Teachers may opt to extend the activity to include non-insect (e.g., crayfish, mussels, annelids, planarians) as students increase their understanding of macroinvertebrates.

MATERIALS:

- ✓ Macroinvertebrate ID flashcards (from the Leaf Pack Network Resources website page)
- ✓ Macroinvertebrate dichotomous key (see Macroinvertebrates.org OR the Resources section in Chapter 4)
- ✓ Clothespins

PREPARATION:

- Brainstorm names of familiar insects.
- Draw a generic insect body with help of participants. If age-appropriate, identify the insect anatomy together.
- Show caterpillar photo, asking if it is an insect. Using information and resources available in the Rock Pack Manual, discuss the unique life cycles and common larval stages of aquatic macroinvertebrates.
- Introduce the macroinvertebrate dichotomous key and how to use it.
- Generate a list of words regarding insect anatomy that are unfamiliar to the participants. Explain words to the students, showing
 images of aquatic macroinvertebrate anatomy.

INSTRUCTIONS:

- 1. Participants find a partner.
- 2. In student pairs, one individual selects a macroinvertebrate card and fastens it to the back of their partner without the partner seeing the card.
- 3. The individual with the card on their back holds the macroinvertebrate identification key in front of them and tries to figure out what macroinvertebrate they have by going through the key, strictly asking questions that get a "Yes" or "No" response.
- 4. The individual answering the questions looks only at the macroinvertebrate photograph on the card for their response.
- 5. Once the individual with the key is *certain* of the macroinvertebrate fastened to their back, they can name the macroinvertebrate and discover whether they are correct by looking at the other side of the card.
- 6. Now, reverse roles and choose a new macroinvertebrate card!



Wentworth Pebble Count

Identify the average gravel size in your stream! The Wentworth pebble count provides a method for quantitatively characterizing the substrate particles in your streambed by determining the percentage of silt, sand, gravel, cobbles, and boulders. The method requires a minimum of two people, but can also be done in larger groups. This method outlined below requires you to be in the stream. The accompanying data sheet can be found in Chapter 5.

MATERIALS:

- ✓ Metric Ruler with a 2-mm mark Size Chart, calipers or
- ✓ Gravelometer (See below procedure for more info)
- ✓ Wentworth Pebble Grid
- ✓ Wentworth Pebble Count Data Sheet (Chapter 5)
- ✓ Pencil
- Clipboard

TIP! Before collecting rocks, weigh 100 grams of rocks of different sizes as a demonstration. This can help students understand how many rocks are required depending on the diameter of the rocks (e.g., more small rocks will be equal to fewer large rocks in total weight).

- INSTRUCTIONS:
- 1. In teams of at least two people, select one team member to record data on the **Wentworth Pebble Count Data Sheet**. The remaining members of the group will be counters. You may wish to rotate these positions periodically throughout the pebble count. You may also wish to work in pairs of a counter and a note-taker.
- 2. Select a cross-section of your stream to sample. Look for an area of the stream with a representative number of **pools**, **riffles**, and/or **runs**. Make sure the area you choose is safe and wadeable.
- 3. Begin by wading through the stream (walking from downstream to upstream). Make sure to cover all areas of the stream cross-section up to the bankfull mark, the highest point water reaches on the banks before it spills into the floodplain. If only one person is counting, walk upstream in a zigzag from bankfull to bankfull. If a whole group is counting, walk upstream in a line formed from bankfull to bankfull.
- 4. When the recorder says "stop," each counter picks up the pebble closest to his/her right big toe. To avoid the natural tendency to pick up larger pebbles, you should pick a point on your toe or boot to use as a reference point. You should also use a reference point on the finger that descends into the water. The first particle touched by this point should be measured.
- 5. Using a ruler and the Size Chart, each counter determines if s/he has silt/clay, sand, gravel, cobble, boulder or bedrock. The pebble is measured at its middle length. This is not the longest or the shortest cross-section of the pebble, but in between.
- 6. Call the size out to be recorded on the data sheet.
- 7. Repeat the process until you have counted approximately 100 times.
- 8. Calculate the percentage that are silt/clay, sand, gravel, cobble, boulder or bedrock
- 9. Graph the number of pebbles versus pebble size.

APPROACHES TO MEASURING GRAVEL SIZE:

- 1. Use the Metric ruler, calipers or Wentworth grid to measure the length of the b-axis in centimeters (cm).
- 2. The following table contains particle size classes. Use the descriptions if you are making visual estimation. If more accurate measurements are taken, it is possible to obtain a clearer picture of changes in substrate composition over time.



Axis of a pebble (a) Long axis (b) Intermediate axis (c) Short axis

ROCK PACK MANUAL



Wentworth Pebble Count Size Chart

Size Class	Size Range (mm)	Description
Silt/Clay	< 0.062	Smooth when rubbed between fingers
Sand	0.062 – 2.0	May have some clay in it but you will feel the gritty texture.
Gravel	2.0 - 64.0	This line is just over 2 mm $_$
Cobble	64.0 – 256.0	This line is about 64 mm. This page is just over 256 mm tall.
Boulder	256.0 – 4096.0	These are big.
Bedrock	N/A	Bare/exposed rock.