# Age Levels:

* Grades: 10-12
* Subjects: Environmental Science, Digital Electronics

# 

# Total Time Required:

### 18 classes (48 minutes/class)

# Prepared by:

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# Unit Objectives:

Students will be able to:

* Observe biological processes as a source of design inspiration
* Predict the outcome of changing inputs into a system
* Design and model a natural system
* Calculate a biodiversity index and correlate how that indicates the health of that ecosystem
* Interpret the River Continuum Concept text and translate to an educational model

# Science Standards and Standards for Technology Literacy:

**Science and Engineering Process Standards**

**SEPS.1** Posing questions (for science) and defining problems (for engineering)

**SEPS.2** Developing and using models and tools

**SEPS.5** Using mathematics and computational thinking

**SEPS.8** Obtaining, evaluating, and communicating information

**Biology I 2016**

**Standard 3: Interdependence**

**B.3.1** Use mathematical and/or computational representation to explain why the carrying capacity ecosystems can support is limited by the available energy, water, oxygen, and minerals and by the ability of ecosystems to recycle the remains of dead organisms.

**B.3.2** Design, evaluate, and refine a model which shows how human activities and natural phenomena can change the flow of matter and energy in an ecosystem and how those changes impact the environment and biodiversity of populations in ecosystems of different scales, as well as, how these human impacts can be reduced.

**B.3.3** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, and identify the imp

**Environmental Science 2016**

**Standard 1: Environmental Systems**

**Env.1.2** Understand and explain that human beings are part of Earth’s ecosystems and give examples of how human activities can, deliberately or inadvertently, alter ecosystems.

**Standard 5: Biodiversity**

**Env.5.5** Identify the indirect and direct threats to biodiversity (e.g. habitat loss and destruction, invasion by exotic species, commercial overfishing and hunting, pollution, climate change, and bioaccumulation and biomagnification of toxins).

**Env.5.6** Identify and explain the three levels of biodiversity: genetic, species, and ecosystem.

**Standard 7: Pollution**

**Env.7.3** Compare and contrast the effects of environmental stressors (i.e. herbicides, pesticides) on plants and animals. Give examples of secondary effects on other environmental components.

**Digital Electronics 2016**

**Standard 9: Microprocessors**

**DE.9.1** Formulate to flow chart to correctly apply basic programming concepts in the planning of a project

**DE.9.2** Design and create a program, using correct syntax, to evaluate data and make decisions based on information gathered from the environment using external digital and analog sensors

## **Standards for Technology Literacy**

**11-12.LST.1.1:** Read and comprehend science and technical texts within a range of complexity appropriate for grades 11-CCR independently and proficiently by the end of grade 12.

**11-12.LST.2.2:** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

**11-12.LST.4.3:** Synthesize information from a range of sources (e.g., *texts, experiments, simulations*) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

**11-12.LST.7.1:** Conduct short as well as more sustained research assignments and tasks to answer a question (including a self-generated question), test a hypothesis, or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

# Recommended Instructor Preparation

Flexibility is key for this project. Student designs can incorporate a wide variety of materials, 3D printed pieces, and information. This project can be done as a whole class project or by assigning smaller groups to complete individual portions of the model. It is best to test the running water portion of the model before placing final pieces.

Lesson Plan: How Do Systems Change?

# Lesson Focus:

Students should be able to describe how a change in one part of the system can affect other parts of the system. They should also be able to discuss how biodiversity responds to changes in the system and why biodiversity is important to an ecosystem.

# Total Time Required:

* **2 class periods (48 minutes/period)**

# Lesson Objectives:

Students will be able to:

* Calculate turbidity
* Compare different sources of turbid water
* Discuss trophic cascades

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Secchi Disc | 4 per class |
| Gradients of turbid water | 4 cans full |
| 32 gal trash cans | 4 per class |
| Meter sticks | 1 per can |
| String | 2 ft per group |

## Special Notes on Materials:

Secchi discs can be purchased pre-made, printed pre-made, or made by students. Discs can be laminated or packaging tape can be used. Turbid water can be collected from different sites or made within the trash cans depending on availability.

**Lesson Procedures:**

1. Trophic Cascade videos. (1 class)
   1. [How Wolves Change the Rivers](https://www.youtube.com/watch?v=ysa5OBhXz-Q), [How Whales Change Climate](https://www.youtube.com/watch?v=M18HxXve3CM)
   2. Ask students to document changes that they see as they watch the videos and write down questions they may have.
   3. Open discussion- what were the main points of the video? Attempt to tease out how changes in one part of an ecosystem can have unexpected changes to the overall biodiversity of the ecosystem

1. Turbidity Lab (1 class)
   1. [What is a Watershed?](https://www.youtube.com/watch?v=QOrVotzBNto&feature=youtu.be) Use this video to introduce the idea of a watershed and how changes affect all parts of the system.
   2. Using secchi disks, students will test the turbidity of different samples of water (mimicking the water that would be found in the three main parts of the river continuum) to begin looking at how sediment influx affects the light availability in the water. Students will begin to make the connection of how light availability is an important component of determining the biodiversity within a river ecosystem.

*Note:* Water mimicking the parts of the stream will be made up beforehand. Appropriate sediment levels will be added and students will be instructed to stir the sediment before testing. If there is not time to discuss the videos in class, the videos can be watched as homework and the attached questions can be assigned.

# Student Resources:

[Secchi Disc](https://www.dropbox.com/s/8x0a1zxoi3wzb47/secchi%20disk.docx?dl=0)

# Student Worksheets:

[Turbidity Lab](https://www.dropbox.com/s/kbmmwlaum3ms2jy/Turbidity%20Lab.docx?dl=0)

[Introductory Video Questions](https://www.dropbox.com/s/c5wgy8kygxawaxa/Video%20questions-%20project%20intro.docx?dl=0)

Lesson Plan: What Differences Exist in Aquatic Insects?

# Lesson Focus:

**Students should be able to describe and discuss aquatic insects and what differences exist within the different families. Students should be able to describe how these differences determine where they exist and what types of insects live in different parts of a river ecosystem.**

# Total Time Required:

* **2 class periods (48 minutes/period)**

# Lesson Objectives:

Students will be able to:

* Collect and classify aquatic insects
* Understand evolutionary adaptations of aquatic insects
* Explain how insects can be used bioindicators

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| make-up cup/ice cube trays | 20 per class |
| aquatic insects | collected by class |
| Hand sanitizer | enough to fill cups |
| Seine nets | 3 per class |
| 5 gallon bucket | 1 per class |
| Hip waders | 1 pair (instructor) |

## Special Notes on Materials:

Necessary materials for insect collection are dependent upon the type of water body that is being surveyed. Boots may be able to be used instead of waders. Ice cube trays can be used to inspect insects for categorization. Hand sanitizer is used to preserve insects for later use.

**Lesson Procedures:**

1. Intro
   1. Have samples of insects scattered amongst groups. Samples can include pictures and preserved specimens. KWL about what they know about insects and observations of the insects at their tables.
2. Aquatic Insects
   1. Lecture on the main aquatic insect groups and how they live. Focus on adaptations that allow them to breathe underwater, move, feed, and hide.
   2. Aquatic Insect Presentation presented by TRAILS can be used
3. Bioindicator Lab:
   1. Using provided insects (collected from local water body), students will collect a few and begin to separate them into ice cube tray and identify them.
   2. Use [Hoosier Riverwatch Macroinvertebrate Manua](https://www.dropbox.com/s/xlq4d85or40hwqw/Hoosier%20Riverwatch%20MacroInvertebrates%20Manual.pdf?dl=0)l to help guide activity and allow students to identify insects to family level.
   3. Using data collected, use biological indicator information to determine water quality as indicated by insects.
   4. Pose inquiry using provided data: what type of habitat were these insects found in?

*Note:*

If insect collection as a class is not possible, insects can be collected ahead of time and preserved and then allow students to examine what they see. Students can move around the classroom and have the insects set up as stations and use adaptations to make hypotheses about the location of capture of the insects.

# Student Resources:

Aquatic insect identification cards are available from TRAILS

# Student Worksheets:

[Macroinvertebrate Worksheet](https://www.dropbox.com/s/vqf9xhz2uxvhv5n/Macroinvertebrate%20Worksheet.docx?dl=0)

Lesson Plan: How Can We Model a Natural Ecosystem?

# Lesson Focus:

Students should be able to describe and summarize the River Continuum Concept and then determine how we can model that concept.

# Total Time Required:

* **2 class periods (48 minutes/period)**

# Lesson Objectives:

Students will be able to:

* Read, review, and synthesize a response to the River Continuum Paper
* Formulate ideas of project-based model
* Immerse themselves in the brainstorming process

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Google | access per student |
| River Continuum Concept paper | 1 per student |

## Special Notes on Materials:

None needed

**Lesson Procedures:**

1. Paper Analysis
   1. Give students the [River Continuum Concept Theory](https://www.dropbox.com/s/x85vmgw15vzuxpz/River%20Continuum%20Article.pdf?dl=0) paper. Using reading strategies, have students read through paper while identifying vocabulary and concepts they are unfamiliar with. Students will then look those up and conduct independent research to construct meaning from the paper.
   2. Students will use notes to write a summary of the article.
   3. Students are assigned sections of the paper and then present their section to their classmates which further expands and explains the meaning of the paper.

*Note:*

# Student Resources:

[Example Analysis of Paper](https://www.dropbox.com/s/c10trn6m18e2jdj/River_Continuum_Concept_Analyzed.pptx?dl=0)

# Student Worksheets:

None needed

Lesson Plan: What is the Advantage of Having a Flow Chart Prior to Programming?

# Lesson Focus:

Students will focus on answering what is flowcharting and how is it used in the design of an electrical system? Students should be able to describe how flowcharting is used in industry to share ideas in a simple manner.

# Total Time Required:

# 2 classes (48 minutes/period)

# Lesson Objectives:

Students will be able to:

* Use a flow chart
* Interpret other’s flow charts
* Program from flowchart

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Butcher paper | 1 sheet per group |
| Markers | 1 per student |

**Lesson Procedures:**

1. Flowcharting (1 class)
2. Present the concept of flow charting in electrical systems. Give the students a chance to view different types and styles of flow charting and explain the importance of having a plan prior to designing a final product.
3. Flowcharting and Digital Electronics (1/2 class)
4. Guided lecture about the history, importance, and methods of flow charting in the Digital Electronics world
   * 1. Explain best practices in flow charting
     2. Introduce if/then statements.
     3. Correlate the flow chart to the final programming language
     4. Practice using flowcharting for everyday tasks
     5. What does your daily routine look like in flow charting?

3. Flowcharting Practice (1/2 class)

1. How to make a peanut butter and jelly sandwich with a flow chart

# Student Resources:

None needed

# Student Worksheets:

None needed

Lesson Plan: What is Programming and How Are We Going to Use it in This Project?

# Lesson Focus:

Students should focus on the main idea of what is programming and what are the main the common themes in programming language? Students should be able to answer how it’s used in industry and to solve everyday tasks.

# Total Time Required:

* 4 class periods (48 minutes/period)

# Lesson Objectives:

Students will be able to:

* Explore programming language
* Write a basic program

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Arduino Uno | 1 per pair |

## Special Notes on Materials:

Programming language takes a while to learn. There was space between the beginning and end of this lesson for the students to explore syntax during subsequent class periods.

**Lesson Procedures:**

1. Programming Languages
   1. Introductory lecture on programming languages and the similarities and evolution of the different forms of programming languages.
   2. Introduce the design brief.
2. If/Then Logic
   1. Using if/then logic, learned in the flow charting lesson, define a problem and work through the pathways that the program will follow.
3. Programming Tutorial Project
   1. (PLTW DE 4.2.2 Introduction to Microcontrollers) and work through the different basic programs.
   2. Provide sample programs and the devices that will be used in the design of the capstone project and experiment with adjusting values in the program to solve the problem of “How do we detect different turbidities of water samples”

# Student Resources:

None needed

# Student Worksheets:

(Project Lead the Way) PLTW 4.2.1, 4.2.2

Lesson Plan: Which design is best?

# Lesson Focus:

Which design is the best model of the ecosystem? What is the audience for the model and how do we best reach them? What do we want our visitors to walk away knowing? How do we decide which product or aspects to use?

# Total Time Required:

* 6 classes (270 minutes)

# Lesson Objectives:

Students will be able to: (list 2-3 that apply directly to the lesson)

* Discuss ecosystem design
* Determine audience impact
* Design a model

# Equipment and Materials

|  |  |
| --- | --- |
| Tools and Materials | Quantity Needed |
| Dependent on design | Dependent on design |

## Special Notes on Materials:

Allow students to be flexible with materials that will suit their design.

**Lesson Procedures:**

1. Model Brainstorming
2. Introduce [design brief](https://www.dropbox.com/s/v3sujfd6rmoh09j/Go%20With%20the%20Flow%20Design%20Brief.docx?dl=0).
3. Begin brainstorming ideas for how to build a model of this concept. Brainstorming lesson can be found on TRAILS main page.
4. Different brainstorming techniques will be used to generate a wide variety of ideas. Students will present out their findings.
5. Model Design
   1. Students break into teams and generate designs for their vision of the model.
      1. Decision matrices can be used here if there are different designs generated. Decision matrix lesson from TRAILS can be used.
   2. Students will create a presentation and a prototype outlining their design for the model. Elements should include a title, a theme, and major points to address such as human impact, insect ecology, and how to translate the River Continuum Theory into a working model.
   3. At the end of presentations, students vote on the best design.

*Note:* Consider using smaller groups. For design, we split our classes in thirds and for the final model we utilized the class as a whole

# Student Resources:

None needed

# Student Worksheets:

* [Model Outline with Constraints and Criteria](https://www.dropbox.com/s/ja14txu8upk6wnf/Model%20Design%20Brief.docx?dl=0)
* [Model Design Project Details](https://www.dropbox.com/s/6kdb7o1obgjim9r/Go%20With%20the%20Flow%20Design%20Project.docx?dl=0)
* [Model Rubric](https://www.dropbox.com/s/wkzqzhv49jv4a18/Model%20Design%20Rubric.docx?dl=0)



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