Water Filtration Game

Focus Questions:

- What makes drinking water safe?
- How does water become polluted and cleaned?
- How do Earth's cycles and structures interact with water?

Big Ideas:

- Water interacts with the earth in many different ways.
- Humans, animals, and plants need clean water to survive.

Vocabulary

- Filtration
- Nitrates
- Potassium
- Infiltration
- Carbon
- Phosphate
- Sediment

Materials:

- Game board
- Pogs (4)
- Character card (4)
- Dice (4)
- Whiteboard markers or overhead markers (4)
- *Riperia's River* (optional)

Estimated Class time:

- 20 minutes - 45 minutes (depending on depth)

Recommended Grade Level and Subject Area:

- 6th - 12th grade
- Science
- Social Studies

TEACHER NOTES

Preparation

- Obtain all materials and ready the game.
    - Readying board games:
        - Print board games out and glue them into folders (or print on 11x17 paper) and laminate.
        - Cut out character cards and laminate
        - Obtain dice
        - Obtain small rocks or other trinkets to act as pogs
        - Place all materials into a plastic ziplock bag for easy storage
        - Scratch paper for scoring

Engagement

- Read pages 1-3 of *Riparia's River*, by Michael J. Caduto. Ask students if they have ever been in a river, pond or lake that was like the one in the story.
- Ask students "how does water become green and slimy?" Discuss with the class and keep a list on the board of what they say.
- Ask students "do we drink water that is all slimy and green?" Discuss with students where their water comes from.
- Ask students if they know how water interacts with the earth, then explain that they are going to explore this further today in the game they will be playing
    - Go over the Water Filtration Game rules and split students into groups of 4

Explore

- Students play through the filtration board game making their own choices in order to create clean drinking water. As they play they will keep track of their nutrients on their character card.

Explain

- Have students mix groups and share their water molecule character with a different partner than what was in their original group. Have students compare their end water molecule. What is similar, different? Did their choices matter? Would they change which paths they took if they played again?

Elaborate

- Finish reading *Riparia's River*
    - Discuss with students what was similar about the book and their filtration game map. Was there anything that helped them gain or lose nutrients? Were all nutrients created equal? How did the choice in the book and during the game affect them?
- Have students choose 3 of the following claims to either agree or disagree with. They should then support their claim with evidence:
    - Farmers are working hard to feed the people and if that means water quality must go then that's what must happen.
    - All nutrients in water are healthy nutrients.
    - Drinking water for humans is the same for plants and animals.

- The Earth's cycles of water and soil interact.
- Iowa is made up of not only farmland, but also prairie, forest, and wetlands.
- The use of sustainable farming practices do not benefit humans directly and are costly to the farmer.

Evaluate

- Throughout this activity the use of verbal discussion can be used to assess student learning. You may also collect the students claims and evidence to evaluate their learning as well.

Extension and Modifications

- You may omit the *Riparia's River* section of this lesson and focus on the ways in which water is filtered and the effects of water pollutants.
- Have students investigate the different regions of Iowa.
  - Use this helpful resource: 1800's and 2002 vegetation landscape. Extend this by having students compare and contrast predicted water qualities of then and now supported by evidence.
  - Another investigation that students can look into is the amounts of urban, corn, beef, dairy, and pork in Iowa. Why are they located where they are? Why are certain types of agriculture more prevalent? What are the reason for the different pathways? Does the location of the types of food Iowa produces differ than other countries?
- Increase the number of rounds played
- After playing the game have students research about the dead zone. Does Iowa play a role in this phenomena? What are the cost benefit ratios to sustainable midwest farming practices and the influences on the fishing industry?
- Students can survey their neighborhood/surrounding area for farming practices that are helpful or harmful to water quality and look for areas that may have an increased amount of nutrients.
- Encourage students to explore what goes into their water or where their water comes from (this is a good place to also include the water cycle/nitrogen cycle).
- Use engineering to tie all of the water filtration back together and challenge students to make a water filter in a water bottle.
- Have students use their gaming experience to create a model of their water molecules interactions.
- Expand student understanding by having them design a buffer strip, or other sustainable farming practice, that will also increase biodiversity.

Iowa Science (NGSS) State Standards

6th Grade

Standard	DCIs	CCC	SEPs
MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	**ESS2.A:** Earth's Materials and Systems	Stability and Change	Developing and using models
MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A:** Earth's Materials and Systems **ESS2.C:** The Roles of Water in Earth's Surface Processes	Scale, proportion, and quantity	Constructing Explanations and Designing Solutions

8th Grade

Standard	DCI	CCC	SEP
MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	**ESS2.C:** The Roles of Water in Earth's Surface Processes	Energy and Matter	Developing and Using Models
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	**ESS3.C:** Human Impacts on Earth Systems	Cause and Effect	Constructing Explanations and Designing Solutions
MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	**ESS3.C:** Human Impacts on Earth Systems	Cause and Effect	Engaging in Argument from Evidence
MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*	**LS2.C:** Ecosystem Dynamics, Functioning, and Resilience Biodiversity **LS4.D:** Biodiversity and Humans **ETS1.B:** Developing Possible Solution	Stability and Change	

Middle School Engineering Standards

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.	**ETS1.A:** Defining and Delimiting Engineering Problems	Influence of Science, Engineering, and Technology on Society and the Natural World	Asking Questions and Defining Problems
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**ETS1.B**: Developing Possible Solutions	N/A	Engaging in Argument from Evidence
MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	**ETS1.B:** Developing Possible Solutions **ETS1.C:** Optimizing the Design solution	N/A	Analyzing and Interpreting Data
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	**ETS1.B:** Developing Possible Solutions **ETS1.C:** Optimizing the Design Solution	N/A	Developing and Using Models

High School Standards

Standard	DCI	CCC	SEP
HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	**ESS2.A:** Earth Materials and Systems **ESS2.D:** Weather and Climate	Stability and Change	Analyzing and Interpreting Data
HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on	**ESS2.C:** The Roles of Water in Earth's Surface Processes	Structure and Function	Planning and Carrying Out Investigations

Earth materials and surface processes.			
HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	**ESS3.A:** Natural Resources **ESS3.B:** Natural Hazards	Cause and Effect	Constructing Explanations and Designing Solutions
HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*	**ESS3.A:** Natural Resources **ETS1.B:** Developing Possible Solutions	N/A	Engaging in Argument from Evidence
HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	**ESS3.C**: Human Impacts on Earth Systems	Stability and Change	Using Mathematics and Computational Thinking
HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*	**ESS3.C:** Human Impacts on Earth Systems **ETS1.B:** Developing Possible Solutions	Stability and Change	Constructing Explanations and Designing Solutions
HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*	**LS4.D:** Biodiversity and Humans	Cause and Effect	Using Mathematics and Computational Thinking

High School Engineering Standards

Standard	DCI	CCC	SEP
HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	**ETS1.A:** Defining and Delimiting Engineering Problems	N/A	Asking Questions and Defining Problems
HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable	**ETS1.C:** Optimizing the Design Solution	N/A	Constructing Explanations and Designing Solutions

problems that can be solved through engineering.			

Lesson and Game Design by Cathryn Carney, 2018
Map Design by Dylan Jacobson, 2018

Iowa Social Studies Standards

6th Grade

- SS.6.16. Utilize and construct geographic representations to explain and analyze regional, environmental, and cultural characteristics.
- SS.6.17. Analyze and explain the cultural, physical, and environmental characteristics of places and regions and how this affects the life of the people who live there.
- SS.6.20. Analyze connections among historical events and developments in various geographic and cultural contexts.
- SS.6.23. Compare Iowa's geography, natural resources and climate to other regions of the world.

7th Grade

- SS.7.21. Evaluate the push and pull factors involved in human population movement and patterns.
- SS.7.22. Explain how the relationship between the environmental characteristics of places and production of goods influences the spatial patterns of world trade.
- SS.7.25. Explain how and why perspectives on various contemporary issues have changed over time.
- SS.7.27. Analyze the role that Iowa plays in contemporary global issues.

8th Grade

- SS.8.19. Explain how push and pull factors contributed to immigration and migration in early American history.
- SS.8.23. Explain multiple causes and effects of events and developments in early American history.

High School

- SS-Gov.9-12.28. Identify local and state issues in Iowa and evaluate formal or informal courses of action used to affect policy.
- SS-Geo.9-12.13. Employ maps to display and explain the spatial patterns of human and environmental characteristics.
- SS-Geo.9-12.17. Analyze how environmental and cultural characteristics of various places and regions influence political and economic decisions.
- SS-Geo.9-12.18. Evaluate the impact of human settlement activities on the environmental and cultural characteristics of specific places and regions.
- SS-Geo.9-12.21. Analyze how changes in the environmental and cultural characteristics of a place or region influence spatial patterns of trade and land use.
- SS-Geo.9-12.23. Analyze the consequences of human-made and natural catastrophes on global trade, politics, and human migration.
- SS-Geo.9-12.24. Identify and evaluate Iowans or groups of Iowans who have influenced Iowa's environmental or cultural geography.

How to Win

Become clean drinking water.

At the end of ten rounds (or alloted game time) the player with highest positive score wins.

- If there is a tie those players filter one more time at their current location and take the result. This process repeats until one of them is the winner.

How to Play the Game

Set Up

1. Choose a character and a pog to match your character
2. Each player rolls a die. Place your pog on the corresponding map location. This is your starting spot.

1- Rainier Beef	2- Pittman Farm	3- Des Moines
4- Monteith Swine	5- Dylan's Perfect Cheese	6- Driftless Area

3. The person to go first is the person who most recently drank water. Game play will continue clockwise from that position.

Play

4. **There are two actions that occur during game play:**
    a. **Move**
        i. Your character should change one spot along the path.
        ii. Some paths may be one way and must be traveled that way.
        iii. Other paths may have actions based on their environment which should be completed while moving.
            1. For example: the buffer strip removes one nutrient.
    b. **Filter**
        i. At your location roll the die.
        ii. Perform the action located on the location's corresponding table.
        iii. Note any new traits gained or lost on your character or draw a card if indicated. If you are to lose any nutrients and do not have that nutrient nothing happens.

Playing a Card

Some locations can result in a player drawing a card. A player may only have two cards at any given time. If a player has more than two cards she must discard one of them.

- There are three types of cards:
    1. **Play immediately**: these must be played as soon as they have been drawn and their effects take place immediately.
    2. **During your opponent's turn:** this card may be played at the beginning or during an opponent's turn.
    3. **Play whenever**: these cards may be played at the card holder's leisure

How to Score

Each nutrient gained has specific points based on it's effects on the Earth's environments (including people).

Nitrates: -3

Why is nitrogen bad for humans?	**Why is nitrogen good for the earth?**
This nutrient can cause blue baby syndrome which is when an infant cannot obtain oxygen through their bloodstream causing suffocation.	Nitrogen is fixed within the environment to nitrates and nitrites. These two nutrients are key factors in the growth and development of plants.

Lead: -2

Why is lead bad for humans?	**Why is lead good for the earth?**
Along with a rise in infant mortality (death) repetitive exposure to lead causes brain and neurological damage.	This nutrient makes up part of earth's crust. Lead's resistance to radiation may be beneficial to the earth itself, however, on the surface, lead often causes more harm than good.

Sediment: -1

Why is sediment bad for humans?	**Why is sediment good for the earth?**
Drinking sediment mudshakes and sand slushies is untasteful, and they can carry harmful bacteria, protozoa, and some nutrients (like phosphate).	The breaking down of rocks and decomposition of organic material overtime creates soil which can lead to sediment. Soil is a key component of agriculture.

Phosphate: +2

Why is phosphate better for humans?	**Why is phosphate good for the earth?**
This nutrient is needed for most living organisms to create energy, grow, and repair as it is the backbone of DNA and RNA.	This is a nutrient that is necessary for plants and animals, but is also a main contributor to the dead zone.

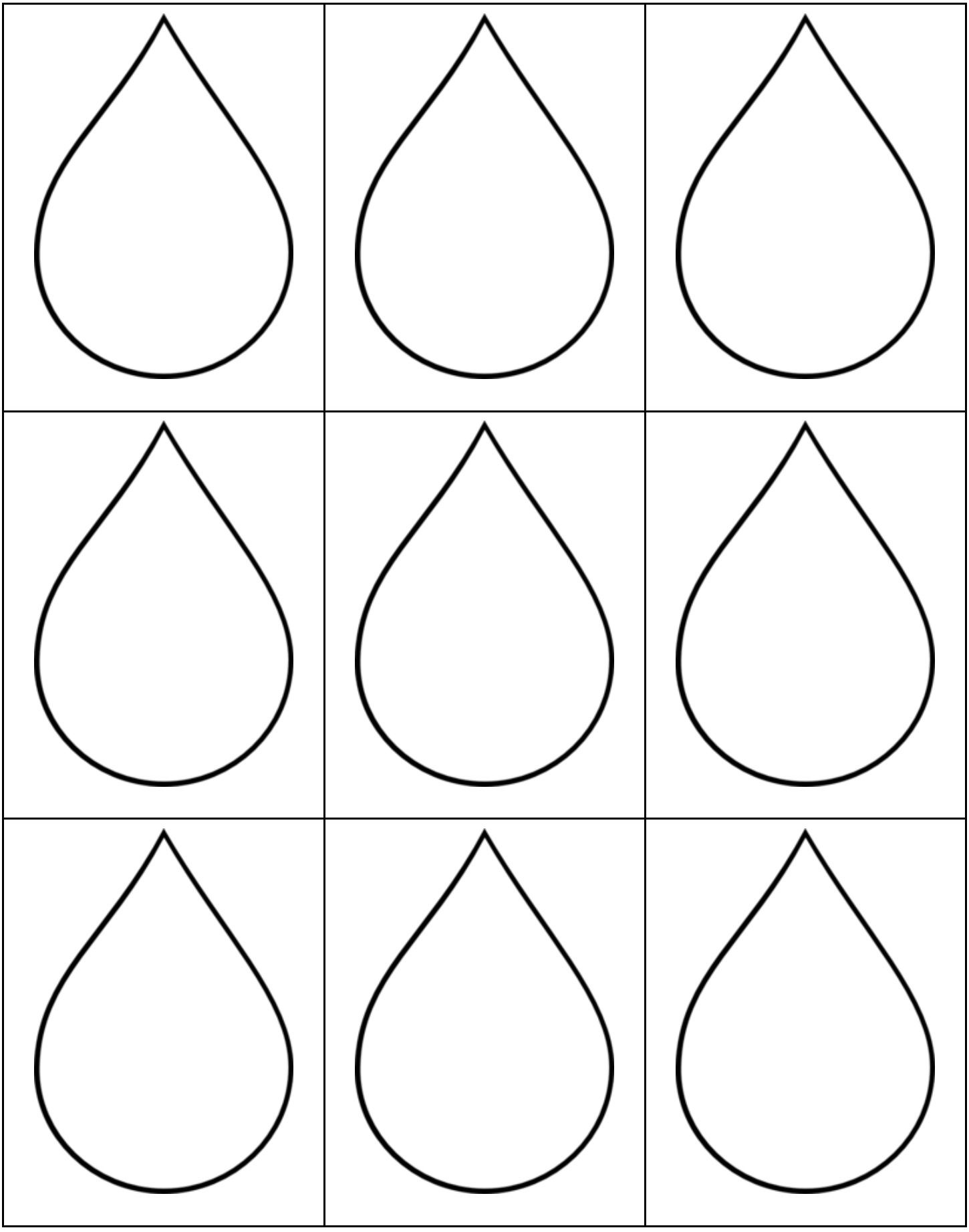
Fluoride: +2

Why is fluoride better for humans?	**Why is fluoride good for the earth?**
Cavities are a large concern for oral health. The introduction of water fluoridation projects has benefited over 200 million people by preventing cavities.	This nutrient is helpful for animals as it strengthens bones and teeth. However, if given to plants their leaves and photosynthetic processes will not work.

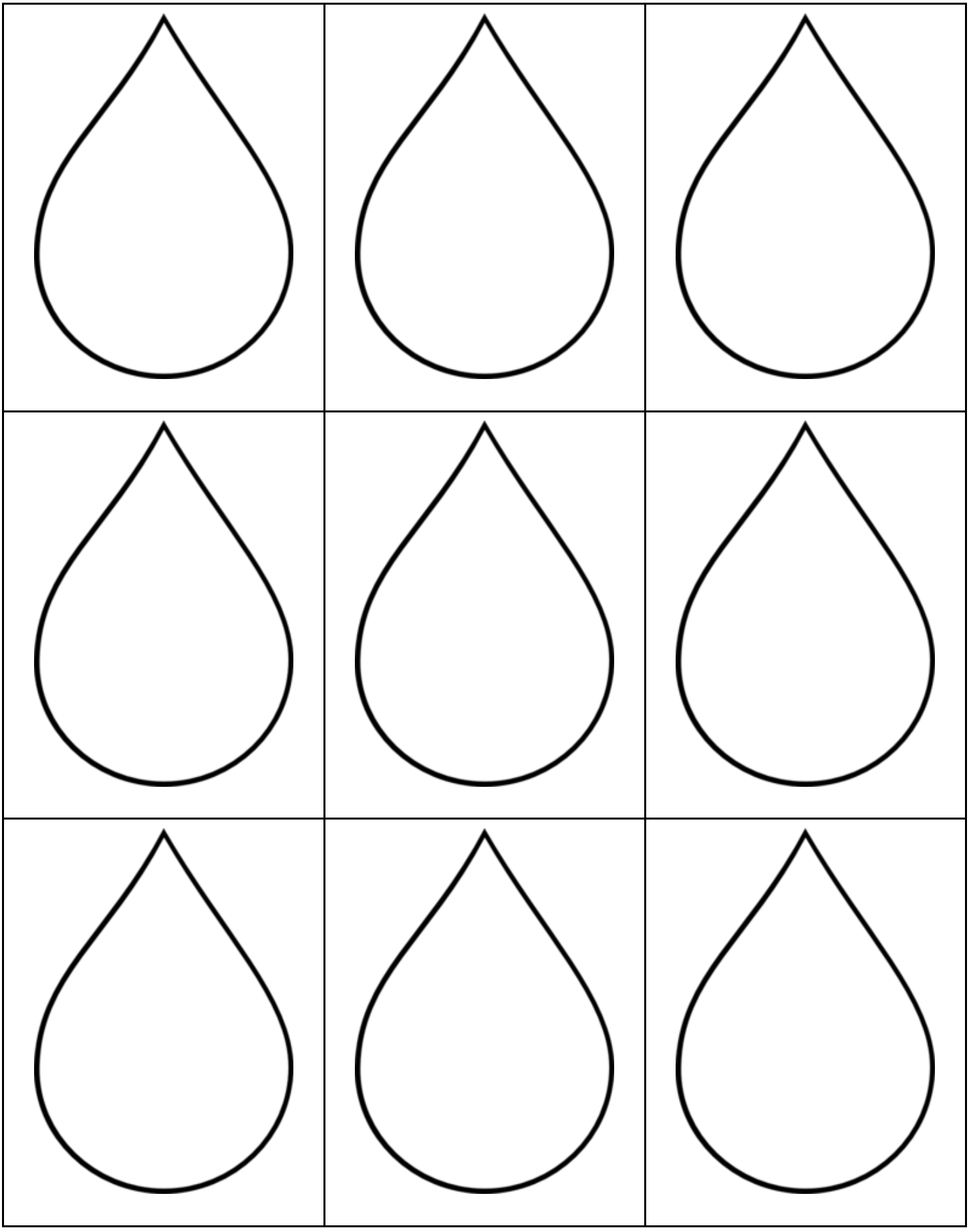
Carbon: +1

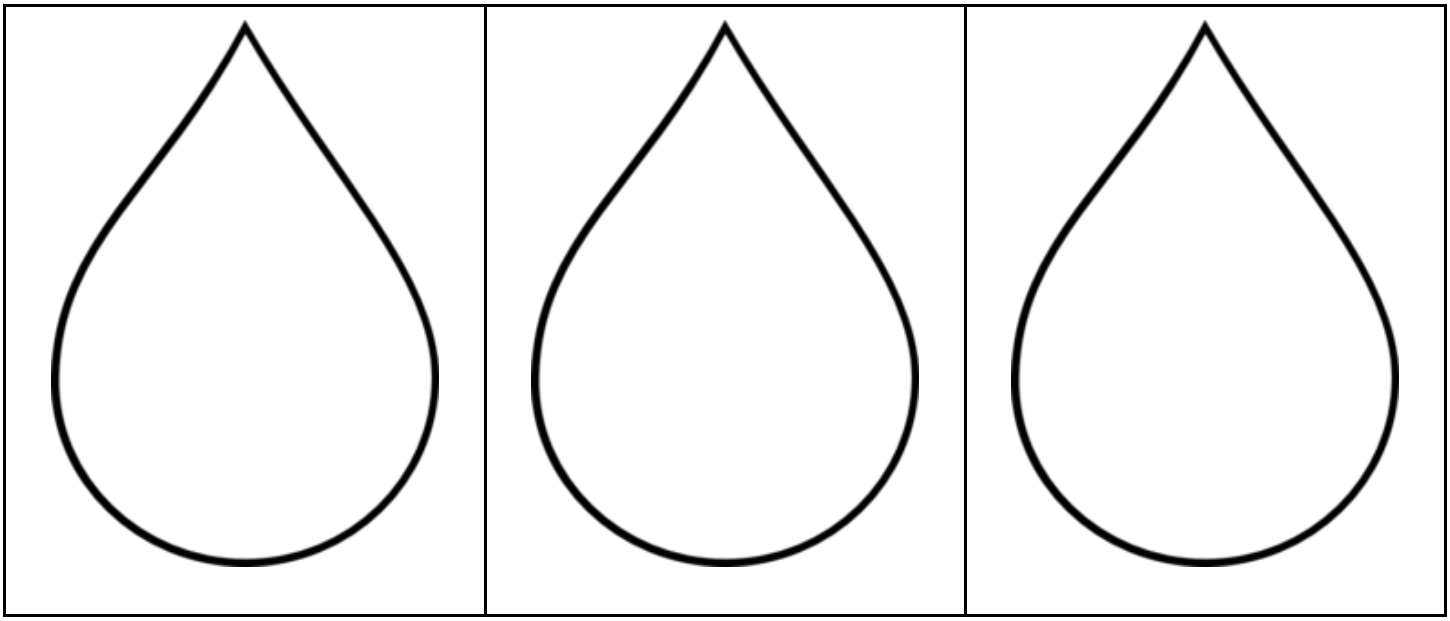
Why is carbon better for humans?	**Why is carbon good for the earth?**
As an organic element, carbon is one of the basic building blocks of life and can be found most places on earth.	An important nutrient in all living things, this nutrient is found in organic matter and in most places on Earth.

Play Immediately **Evaporation** It's sure been hot out these days and you have changed forms. Move anywhere on the board and remove 1 sediment. *Perform filtering at new location as the end of your turn*	**Play Immediately** **Evaporation** Windy days are among us. Move anywhere on the board and remove 1 sediment. *<u>**DO NOT**</u> perform filtering after movement*	**Play Immediately** **Evaporation** Plants are your transpiration my friend. Move anywhere on the board and remove 1 sediment. *Perform filtering at new location as the end of your turn*
During your Opponent's Turn **Interrupt the Cycle** Before or during your opponent's turn you may block a path.	**During your Opponent's Turn** **Interrupt the Cycle** Before or during your opponent's turn you may block a path.	**Play Whenever** **Monsoon** High amounts of evaporation have been occuring creating a lot of atmospheric water vapor. Gain an extra turn.
Play Whenever **Hail Time** Updrafts and a cold atmosphere have turned you into a power water molecule. Gain an extra turn.	**Play Immediately** **Rain Go Away!** Those hundred year floods seem to happen more often 'eh? Move along a path to an adjacent location. *Perform filtering after movement*	**Play Whenever** **Infiltration** Soil is a great way to take a bath and become clean. Remove a nutrient of your choice.



Play Immediately **Ingestion** Animals can be thirsty too. Lose 1 of each nutrient you have.	**Play Immediately** **Ingestion** Moo-moo says the cow, and you sure taste good. Lose 1 of each nutrient you have.	**Play Immediately** **Ingestion** Swimming and soaking is how a frog gets their water, and some of their nutrients. Lose 1 of any nutrient.
Play Immediately **Plant Absorption** No need to use any energy. Up through the roots you go. Remove 2 nitrates and 1 phosphate.	**Play Immediately** **Plant Absorption** No need to use any energy. Up through the roots you go. Remove 2 nitrates and 1 phosphate.	**Play Immediately** **Plant Absorption** No need to use any energy. Up through the roots you go. Remove 2 nitrates and 1 phosphate.
During your Opponent's Turn **Interrupt the Cycle** Before or during your opponent's turn you may block a path.	**Play Whenever** **Sandy Aquifer** Most water in Iowa comes from rivers and are cleaned by soil. Remove 1 nutrient	**Play Immediately** **Swimmer Dilemma** Oh, no! Up a nose and down a throat. You've been ingested by a summertime diver. Remove 1 fluoride and 2 nitrates.





Play Immediately **The Big Game** Football tailgating can be fun with all the food and soda. But what happens to the garbage after the party? Gain 2 sediment	**Play Immediately** **Use the Force** You've been hanging out in the soil a little too long. Time to run-off. Gain 2 nitrates	**During your Opponent's Turn** **Landslide** Move an opponent to an adjacent location. The opponent must perform filtration at the new location.