Investigation 2
Wondering About Water

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Subject Area
Earth Science; Physical Science

Grade Level
Grades 5-6

Driving Question
Why is the grass wet in the morning and evening?

Abstract
Students keep a journal about a patch of grass. They discover that the grass is wet in the morning and evening. They hypothesize why this happens, and design and carry out investigations to test their hypotheses.

Michigan Curriculum Framework Science Benchmarks
http://www.miclimb.net/content/main.html

Constructing New Scientific Knowledge Benchmarks:
I.1.M.1 **Generate scientific questions about the world based on observation.**
Key concepts: Scientific questions can be answered by gathering and analyzing evidence about the world.
Real-world contexts: Any in the sections on Using Scientific Knowledge.

I.1.M.2 **Design and conduct scientific investigations.**
Key concepts: The process of scientific investigations—test, fair test, hypothesis, theory, evidence, observations, measurements, data, conclusion. Forms for recording and reporting data—tables, graphs, journals. See C-I.1 m-3 (tools).
Real-world contexts: Any in the sections on Using Scientific Knowledge; also, recognizing differences between observations and inferences; recording observations and measurements of everyday phenomena.

I.1.M.6 **Write and follow procedures in the form of step-by-step instructions, formulas, flow diagrams, and sketches.**
Key Concepts: Purpose, procedure, observation, conclusion, data.
Real-world contexts: Listing or creating the directions for completing a task, reporting on investigations.

Reflecting on Scientific Knowledge Benchmarks:
II.1.M.1 **Evaluate the strengths and weaknesses of claims, arguments, or data.**

Key concepts: Aspects of arguments, such as data, evidence, sampling, alternate explanation, conclusion; inference, observation.
Real-world contexts: Deciding between alternate explanations or plans for solving problems; evaluating advertising claims or cases made by interest groups; evaluating sources of references.

II.1.M.5 **Develop an awareness of and sensitivity to the natural world.**
Key concepts: Appreciation of the balance of nature and the effects organisms have on each other, including the effects humans have on the natural world.
Real-world contexts: Any in the section on Using Scientific Knowledge appropriate to middle school.

Using Physical Science Knowledge Benchmarks:
Changes in Matter
IV.2.M.1 **Describe common physical changes in matter: evaporation. condensation, sublimation, thermal expansion and contraction.** (Condensation)
Key concepts: States of matter—solid, liquid, gas. Processes that cause changes of state or thermal effects: heating, cooling. Boiling. Mass/weight remains constant during physical changes in closed systems.
Real-world contexts: States of matter—solid, liquid, gas. Changes in state, such as water evaporating as clothes dry, condensation on cold window panes, disappearance of snow or dry ice without melting; expansion of bridges in hot weather, expansion and contraction of balloons with heating and cooling; solid air fresheners.

Using Earth Science Knowledge Benchmarks:
Atmosphere and Weather
V.3.M.3 **Explain the behavior of water in the atmosphere.** (Dew point, condensation)
Key concepts: Water cycle—evaporation, water vapor, warm air rises, cooling, condensation, clouds. Precipitation—rain, snow, hail, sleet, freezing rain. Relative humidity, dew point, fog. See IV.2.m.1 (changes of state), V.2.m.2 (water on the earth's surface).
Real-world contexts: Aspects of the water cycle in weather, including clouds, fog, precipitation, evaporating puddles, flooding, droughts.

Big Idea
Water is present in the atmosphere as water vapor (an invisible gas) and becomes liquid when it condenses on cool objects. The dew point is the temperature at which water in the atmosphere condenses on the ground and other objects.

Prerequisites For Students
None

Estimated Time Needed
Several days for student observations and investigations at home.
Also 1 class period of approximately 30 minutes, and 3 class periods of approximately 55 minutes each.
This investigation needs to be done when there is no snow cover.

Background Information

The air around us is filled with invisible, gaseous water – water vapor. Water in the gas state is invisible because it is composed of individual water molecules separated at relatively great distances from each other, moving rapidly. Water in puddles, lakes, rivers, etc. is constantly evaporating into the air, creating water vapor. The water cycle describes the movement of water from liquid on the Earth's surface, to gas in the atmosphere, to liquid again as droplets that make up clouds and eventually rain or snow.

Humidity is a measure of the amount of water vapor in the air. The warmer air is, the more water vapor it can hold. Humid days in the summer are sometimes described by people as being sticky, where very dry days in the winter require a humidifier to keep the inside air at a comfortable humidity level. Bathrooms are very humid after hot showers – often the humidity in the air condenses into tiny droplets inside the bathroom, and a little cloud forms! (We think of it as mist.) Usually, when the bathroom is very humid, some of the water vapor condenses on the mirror, making a fine mist that kids like to write their names in – and the mist forms droplets of water that run down the mirror as they get larger and larger.

Condensation phenomena are all around us, not just in bathrooms. Glasses of icy lemonade in the summer or cold cans of pop are surfaces where water vapor from the air condenses. This happens when the air is humid and when the surface is cold – because the individual molecules of water vapor need to slow down enough to coalesce with other molecules, forming tiny little droplets of thousands or millions of molecules. The cold surface cools the air around the glass or can, making the molecules move more slowly – and then they are attracted to each other by a force that makes them cling in droplets that get ever bigger and bigger as more and more molecules coalesce together.

This is what happens in the air, too, when clouds form. However, droplets in the air need a surface on which to condense (like the surface of the glass or can), so they condense on tiny pieces of smoke or dust in the air. The temperature of the air at cloud-forming level is lower than the air temp below the clouds, allowing the molecules to slow down enough to form droplets.

The same phenomenon happens on cool mornings or evenings, on the ground. The air itself (and the ground) cools down enough for dew to form, and it forms on the surfaces available to it – grass, cars, etc. This is dew. Students don't always recognize at first where the water comes from that forms dew – they might think it comes out of the ground, or that it rained overnight, rather than recognizing that it comes out of the air.

The temperature at which air becomes cold enough for dew to form is called the dew point. As air gets cooler, it can hold less moisture, so eventually it gets to a point where the water vapor can no longer be contained in the air and it condenses as dew on the grass, on plants, on cars, etc. How much colder the air has to get before dew forms depends on how much moisture is in the air. Air with less moisture has to cool down farther than air with more moisture, in order for dew to form. In other words, dew point is a measure of how much water vapor is in the air. For example, if the temperature is 75 degrees and dew point is 70 degrees, the air is pretty humid – it only has to cool down to 70 degrees before it can no longer holds its water vapor. On the other

hand, if air at 75 degrees has a dew point of 50 degrees, it is not very humid – it can continue to cool down and still hold its moisture until it reaches 50 degrees.

It is possible that the dew point of air can be below freezing. When this happens – when the air cools down to the dew point (below 32 degrees F) – frost forms.

Weather reports often state the "relative humidity" as well as dew point. Relative humidity means the percent of moisture that is presently in the air, compared to what it can hold at that temperature. 70% relative humidity is not particularly uncomfortable when the air temp is 50 degrees, but it is very uncomfortable when the air is 85 degrees. "Heat Index" is a measure of how uncomfortable the air is on hot, humid days. Heat index and dew point are being used more and more by weather forecasters because they describe actual conditions better than relative humidity.

Some web sites on dewpoint and moisture in the air are:
It's Not the Heat, It's the Dewpoint. Center for Mathematics and Science Education. 30 Jun 1998. University of North Carolina, Chapel Hill, NC. 20 Aug 2003
http://www.unc.edu/depts/cmse/nature/dewpoint.html

Understanding Water in the Atmosphere. USA Today Weather. 3 July 2002. Gannett Co., Inc. 20 Aug 2003 http://www.usatoday.com/weather/wcloud0.htm

What Relative Humidity Means. USA Today Weather. 6 Jan 1999. Gannett Co., Inc. 20 Aug 2003 http://www.usatoday.com/weather/wrelhum.htm

This lesson gives each student group a chance to design and do an investigation. Student groups will try different ways to answer the question, "Why is the grass wet in the morning and evening?" They develop a method for testing their question, pose a hypotheses, conduct the investigation and gather data, and draw a conclusion to answer their question. The apply what they learn to develop a deep understanding of condensation. Students end the lesson by presenting their results and conclusions.

Teacher Page 2-1 gives a sample of how a student group might fill out Student Page 2-1, involving investigation design. Teacher Page 2-2 is an example of a Research Methods page. These are meant to be used as examples, not as instructions for any group's investigation.

Materials List
Have available one for each student
Plastic sheets (unopened garbage bags work well)
Ziploc bags
Pie pans or bowls
Ruler
Thermometer
Journals (notebooks or 15 pages of paper stapled together)

For each student group
1 sheet of newsprint and tape to adhere newsprint to the wall
1 marker
1 copy of Student Page 2-1 (have extras on hand)

Procedure

Part 1: Student Exploration
(30 minutes class time; then a few minutes at home every day over a period of several days)

1. Ask students what changes outdoors every day. They may have answers like the amount of sunlight, the temperature, wind conditions, etc. Ask which of these changes would affect the grass that grows on the ground.

2. Explain that they will be observing the grass near their home each day at different times. They are to check it in the early morning, the afternoon (after school) and the evening. Observations are to be collected in a science journal. Hand out journals. Turn to the first page, and ask students to write a title for the observations they will be making. Ask them to write down the date, and then SAMPLE on the first page.

3. Ask what types of observations they will be making as they observe the grass and how it is affected by conditions outdoors. They can write these categories on their sample page. Every student should have the same set of observations. Make sure they include: date; time (a.m. or p.m. is important); description of the grass; cloud cover; precipitation; and temperature. Go outdoors and have students write down their observations of these conditions today on their sample page. Have them measure the temperature using thermometers, if possible.

4. Tell students they will be collecting their data for several days. Three to seven days works well. Choose a time frame that fits into your schedule. You will need time to do the rest of the investigation after these observations are complete. Make sure they observe dew in the morning and evening on one of the days before you end the student observations.

5. After several days of data are collected, students discuss and share their observations. What did they observe, and when? With a little luck students will have discovered that the grass is wet sometimes.

(An alternative approach to this exploration, for students who do not have lawns or areas of grass to observe, is to use the following scenario:

Ellen is walking to school early one morning, and decides to cut through the park next to the school. When she walks off the path and onto the grass, her shoes start to get very wet. She looks down to notice that the grass is wet everywhere. Later, at lunch, she is outside again on the grass with her friends, and observes that the grass is completely dry. She is puzzled by this, because she remembers that there was not any rain last night – nothing but the grass was wet, not the sidewalk or the streets.

She decides to explore this a little, so she walks through the park every day for the next week. Each morning the grass is wet, even though there was never any rain. Twice during the week she went to the park after dinner to play with friends, and noticed that the grass was wet again, close to the time the sun was going down, even though the grass was totally dry at lunch time.

Most students will have observed dew or moisture on grass or cars. The purpose of the exploration is to observe the time of day when dew forms – and when it doesn't – to determine if there are weather factors that influence the formation of dew. To help students listen with understanding to this scenario, you can write a chart on the board with 7 days down the side, morning, noon and evening across the top, and write the word "dew" in the morning and evening cells on the chart.)

Part 2: Question to Investigate

(Parts 2 through 5 require about one class period of 55 minutes and a small amount of time at home over one or more days.)

1. Have students look through their observations (or think about the scenario) to see if they can find a pattern regarding when the grass is wet. Students can review just their own observations, or you can make a class chart of all students' observations. Students will find that the grass is wet in mornings and evenings, even when it hasn't rained.

2. Ask students to generate questions from their observations about the water on the grass. If they are having trouble, tell them to form "why" questions or "how does this happen" questions. Write their questions across the top of the board, leaving room for any possibly answers that they might provide. You can write their suggested answers (predictions) under the appropriate question, but at this point do not provide a definitive answer to any of the questions – the investigations will provide evidence to support one or more of the students' predictions.

   Typical questions include "Where does the dew (water) come from?" "Does it have to be a certain temperature for dew to form?" "Does this happen every day of the year?" Some of these questions will be easier than others to investigate and collect data about. Try to help students find questions that can be answered with data they can collect, or by trying things out – rather than by going to the library to look up an answer.

Part 3: Method for Gathering Data

1. Place students into groups by the question they want to investigate.

2. Ask each small group to come up with one or two possible answers to their questions, by talking among themselves for a couple minutes. Some answers would have been suggested already and perhaps written on the board. Ask each group (in the whole group setting) to explain what they think the answer might be to their question. Allow more than one possible answer from any group.

Help each group clarify its answer by asking questions such as: "You think that the dew comes from the ground at night. Why doesn't it also come from the ground during the day? Or what happens to the dew during the day?" These kind of probing questions will help students think deeply about their question and get them ready for the next step.

3. Have students brainstorm possible ways that they might test their predictions in order to find answers to their questions. Let them use a piece of newsprint to record their brainstormed ideas. (You may need to explain brainstorming: A process where all students contribute their ideas without commenting or criticizing anyone else's ideas, in order to put forward the widest variety of possible ideas.)

   If any group needs help, ask them to think about what they expect the answer to their question will be, and ask how they would need to set things up to see if it is true. For example, if a group's question is "Where does the water come from?" and their suspected answer is "it comes from the ground," they might want to find a way to separate the grass from the ground with plastic so that no water could get through, and see if dew still formed. Of course, to do this, they would need to cut some grass and place it on top of a plastic sheet. For many of their questions about dew, they will probably need to set up a situation where they interfere with the dew-forming processes (as they think it happens) in order to do the investigation. The data they collect, in this example, is whether or not dew forms on top of plastic.

   Students with the following predictions may develop methods like these to see if their predictions are correct (these are meant as examples of what students may come up with, not instructions of what they should do). They are all related to the question "Where does the dew come from?"
   - "The water came from the ground (and the sun dried if off during the day)." Students may want to place a plastic sheet over the ground and put cut grass on top.
   - "It somehow rained during the night." Students may want to put a pie pan on the grass to see if it collects water.
   - "The grass sweats during the night time (or when it's cold)."* Students may want to cut the grass and set out dead, dried up grass to see if it gets wet.
   - "The water came from the air (and the sun dried if off during the day)." Students may want to put grass in a Ziploc bag, separated from the surrounding air.

4. After enough time for brainstorming, ask each group to decide what it considers to be the best method for collecting data. The method they choose has to be something they can do in the classroom (or outside the classroom) or at home, with reasonable equipment (things like plastic sheets, thermometers, zip lock bags, pans, etc.)

5. Have each group present its method to the class.

* Students who are really knowledgeable about photosynthesis and plant life may realize that plants, like animals, use oxygen and food and produce carbon dioxide and water (this is the process of cellular respiration, the way that plants get energy). They may suggest that the water comes from this process, and that during the day the plant uses the water for photosynthesis (which is does). If this were true, however, it would happen even on very dry days, but dew only occurs when it's relatively humid.

Part 4: Prediction/Hypothesis

1. Each group must now refine its prediction to closely match their method. For example, if their question is "Where does the dew come from?" and their method is to put a sheet of plastic over the grass and record what happens, they need to make a prediction (hypothesis) that says something like: "If we place a piece of clear plastic 1 meter by 1 meter over grass, then the grass under the plastic will not have dew on it when the grass outside the plastic does."

2. Hand out one copy of "Investigation Design" (Student Page 2-1) to each group. As groups fill it out, circulate and help them clarify their thinking regarding their final hypothesis and the things they will test. A sample is shown on Teacher Page 2-1.

Part 5: Research Details

1. Using a page titled "Research Methods," have students write a detailed plan for conducting their investigation. The plan should list every step they intend to take. They should also include a data collection chart. (A sample Research Methods page is attached, Teacher Page 2-2.)

2. Have groups hand in their Research Methods and Investigation Design pages (Student Page 2-1) for your review. Review them, looking for things like equipment availability, if there is time to do their research, if it is doable by students this age, and general workability. Check each group's design to make sure it will result in measurable data that may support or not support the hypothesis. Give guidance as you review the materials, but try not to dictate specific changes. This is best done by asking critical questions such as, "How will you measure that?," and "What things will you keep the same?" Then groups can come up with changes that answer your questions and critiques.

3. **(Day 2)** Return the Research Methods with your comments and let groups re-design or alter their research methods as needed. Each student should write down her or his own copy of the final investigation design. Make sure each group saves the original Student Page, and changes their answers on it to reflect any changes in investigation design. You may want to have extra copies of the Student Page available, for those groups whose design has changed a lot.

   Many times the observations and results of an open inquiry activity drive the next step in an investigation. Tell students that this is OK. If student groups add steps or change things as they perform their investigation, they should write these down, too.

Part 6: Data Collection

1. Explain to students that their research will be done at home. They should set up their experiment at night and collect the data in the morning (assuming that dew forms on that morning.) Ask them to involve their parent(s), at least by having each student explain what is going on while the parent listens.

They may do these investigations as a group, or as individuals. You should help them decide the best approach. If each member of a group does the investigation individually, they will be able to compare their findings and consider why it is important to replicate an investigation (conduct it several times to see if the results are the same).

2. Have each group organize their set of materials (such as a plastic sheet, pie pan, Ziploc bags, etc.), their copy of the Research Methods, and their copy of the data collection page, to take home after school.

3. Check to see that students have good data when they return to school. If no dew formed, or if it rained, give them additional days as needed to conduct their investigation.

Part 7: Data Analysis, Use and Communication of Results
(Parts 6-8: two 55-minute blocks of class time)

1. When all groups have finished collecting their data, let each individual compare their results with others in their group (if the investigations were conducted individually). Write these questions on the board for each group to discuss:
   - Are everyone's results the same? Why or why not?
   - Why is it good to do the same investigation more than once? (When an investigation is done more than once, or replicated, obvious mistakes can be thrown out and not considered in the data analysis. Also, more data is generated, making answers more accurate.)
   - How can we put together the data from each group member into one chart or graph?

2. Have each group discuss how they can display their data in a way that helps people understand it. They may want to use a graph, a chart, and/or labeled drawings. These visual aids should include all students' results.

3. Give students time to create this graphic representation of their data.

4. Have each group discuss its conclusion. Help them recognize invalid conclusions.

5. Write the following parts of a conclusion on the board, and as you write each one, ask one student from one of the various groups to answer it. This will help clarify what is being asked for:
   - What was the purpose of the investigation?
   - What did you find out?
   - Was the hypothesis supported by the data?
   - How does what you found out compare with what other researchers have found out?
   - How can you explain what you found out?
   - What else would you like to do with this investigation, and how would you make it better?

6. Have each group write a full conclusion based on its data and the preceding discussion. Use Student Page 2-2, which lists several questions to be addressed in writing their formal conclusion.

7. Discuss question 5 on the conclusion page: How can you explain what you found out? This is a crucial part of any investigation. Student groups have collected data that allows them to answer their question (or provide support for their hypothesis). They still need to go deeper, to *use* what they have found out to construct an explanation of the phenomenon of dew.

   To discuss this, ask students to state the explanations they have for what happened in their experiments. Ask questions to help them clarify where the water comes from, such as:
   - How can water appear when it doesn't rain?
   - Can water come out of nowhere?

   Some students will know that there is water in the air, and the dew comes from this invisible water vapor. If this comes up, you can ask questions to help every student understand this, such as:
   - How can water exist in the air and be invisible? (It is made from individual water molecules, which are too small to be seen.)
   - What state is water when it is in the air? (gas)
   - Do you think the temperature of the air or ground has anything to do with the formation of dew?

   For the last question, help students develop an understanding of the process of condensation. Dew forms just like the water or mist that forms on the outside of a cold can of pop. When the air cools down sufficiently (as it does on many evenings and mornings), the invisible water vapor in the air condenses on grass and other objects outside. This happens when individual water molecules slow down (lower temperature slows the molecules) and they attract each other and form droplets.

   To continue to develop this explanation of dew, you might ask students to think about how those days when there was no dew were different from those days when there was. Help them think about their original observations to see that there are two possible differences between days with dew and days without: It has to be cold enough for dew to form, and there has to be enough moisture in the air. If there is not much moisture, it has to get even colder for dew to form. The temperature where dew forms is called the dewpoint. If the difference between the outside temperature and the dewpoint is small, the air is very humid. If the difference is large, the air is dry. Ask students to make up examples to illustrate the concept of dewpoint, using their own data or observations.

8. You may have students complete Student Page 2-3, Thinking About the Data, if you want each individual student to think about the questions posed above and write about them. It is usually best to have students write answers to these questions after they participate in the class discussion, rather than to try to answer these questions without support.

9. Have each group present its question, hypothesis, research methods, data, and conclusion to the class. Every group member should have a part in the presentation. Presentations should include these parts (write them on the board):
   - The group's question
   - The full hypothesis
   - The research methods
   - The data, presented as graphs, charts, or drawings
   - The conclusion
   - Participation by each group member

10. Have students turn in their Investigation Design, the Research Methods, their data and the Conclusions page for assessment purposes. If you wish, you may have groups put these together on poster board as a display that can be set up where others in the school can see it.

Part 8: Guided Questions for Reflection

1. The following questions can be asked of each group:
   - What did you find out about why grass is wet in the morning and evening?
   - Did this support your hypothesis?
   - If your investigation did not support your hypothesis, do you have another explanation for why grass is wet in the morning and at night?
   - How might you investigate this other explanation?
   - Did your investigation work out the way you expected it to?
   - How would you change your investigation if you were to do it again?
   - Did everyone in your group get the same results?
   - Did you agree on one explanation of the results?

Part 9: Student questions for additional inquiry

1. Ask the class:
   - Do you have some questions the investigation didn't answer? What are they?
   - How could these questions be answered?

2. If you are able, do some of these subsequent investigations with students.

Assessment

Group assessment can be made by ranking proficiency in each of the parts of the final presentation: the hypothesis, the Investigation Design page, the step-by-step Research Methods, the Conclusion, and, finally, the participation of all members.

Individual assessments can be done by interviewing individual students about their group's project and assessing their understanding of what the group did and why it was done. If desired, you may require each student fill out their own copy of the Student Pages.

Student Page 2-1

Names

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Investigation Design

1. What is our question?

2. What do we know? – about when dew forms?

3. What will we do? – to figure out where dew comes from?

4. What data will we collect?

5. What is our hypothesis?

6. The things we keep the same on purpose are:

Names_____

Conclusion

Answer all of these questions in your conclusion:

1. What was the purpose of the investigation?
2. What did you find out?
3. Was the hypothesis supported by the data?
4. How does what you found out compare with what other researchers have found out?
5. How can you explain what you found out?
6. What else would you like to do with this investigation, and how would you make it better?

Name_____

Thinking About the Data

Answer all of these questions in your conclusion:

1. How can water exist in the air and be invisible?

2. What state is water when it is in the air?

3. Why does dew depend on the temperature of the air or ground?

4. Explain what dewpoint means and give an example.

Teacher Page 2-1

Names (Sample student responses)

Investigation Design

1. What is our question?
   Does dew come from the soil?

2. What do we know? – about when dew forms?
   Dew forms in the morning and evening. It is usually colder at those times than in the middle of the day.

3. What will we do? – to figure out where dew comes from?
   We will place a sheet of plastic over a patch of grass to separate it from the air. We will also place some cut grass on top of a piece of plastic to separate it from the ground.

4. What data will we collect?
   We will see whether dew forms on either sample of grass.

5. What is our hypothesis?
   If we separate the ground from the grass, then no dew will form on the grass.

6. The things we will keep the same on purpose are:
   We will try both of these experiments on the same day.

Research Methods

(Sample student responses)

1. Cut two pieces of plastic sheeting 1 meter by 1 meter.
2. Place both pieces on sections of grass that are close to each other.
3. Place grass cuttings on top of one of the pieces of plastic.
4. Allow the experiment to run overnight, and make observations in the morning.