3-5: Marvelous Molecules

Curriculum Connections

Life Science

- Observe, investigate, describe, and classify organic materials based on their physical arrangement of their atoms.

Scientific Connections And Applications

- Understand and describe examples of the importance of scientists, science, and technology and the impact they have on our lives, such as how research scientists discover new treatments for diseases

Scientific Communications

- Acquire information from observation, experimentation, print and non-print sources
- Use information gathered from experiments and other sources to explain observations and events, including actively listening for alternative interpretations and ideas

**Based on the New York State Elementary Science Core Curriculum and the New York City New Standards™*

National Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science

- Properties of objects and materials
- Light, heat, electricity, and magnetism

Content Standard E: Science and Technology

- Abilities of technological design
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

3-5 Exhibits List

Body Heat
Build a Molecule
Fluorescent Microscope Demonstration
How Many Molecules
How Many Molecules Are You
Make a Medicine
Marvelous Molecules Mini-Theater
Molecules to Cure You Not Kill You
Molecules for Sensing
Molecules for Sensing Computer Exhibit
Odor Molecules

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Guide Theme

The theme of these guides are based on popular crime and detective show investigations on TV; a mystery unfolds, questions are asked, evidence is gathered, conclusions are drawn. This process is similar to what scientists go through with the inquiry method. For more details see About the Guides.

Begin the Investigation At School

A mystery unfolds, questions are asked...

There are several ways you can introduce the topic and start the investigation. Here are some ideas that will help students start thinking about the topic and generate questions:

- Create a mystery around cracking a code (See Laboratory Activity- Code Breakers)
- Create a mystery about how the foxglove plant, tree bark, mold, and the poison dart frog are used to make medicines. (Answers at the exhibition)
- Demonstrate one of the Laboratory Activities with no explanation-let the questions begin
- Do one of the Laboratory Activities and facilitate a probing discussion

Prepare for Investigation at the New York Hall of Science

Once students have generated questions around the topic tell them they are going to continue the investigation at the New York Hall of Science.

At this point you may want to begin one of the Continuum Activities. These activities have the following features:

- Vary in length and depth
- Provide continuity and purpose for the visit
- Provide a way of assessing student understanding

Orientation and Planning: If you do nothing else, do this!

Here are five reasons to conduct student orientation and planning before going on a field trip:

1. Students focus on exploring and investigation versus the novelty of the location
2. Students don't have to worry about logistics like restrooms, schedule, eating etc.
3. Students who understand the plan and purpose of the visit are more likely to stay focused
4. Students who have clear goals for their visit are less likely to race from one exhibit to another with little understanding
5. Students who get involved in the planning of the visit, take ownership and are less likely to misbehave

Read more about the Orientation and Planning Process

Investigation at the New York Hall of Science

Evidence is gathered...

Okay. The class has arrived at the next phase of the investigation. The students have questions and seek answers. Everyone knows what exhibits they should visit and why. Everyone knows the schedule for the day. Students have materials to record findings or work on a Continuum Activity if required.

If all of the above is true, congratulations on a successful Orientation and Planning.

If you are curious about what teachers can do on site, we've put together a little piece called Teacher Role.

Finish the Investigation Back at School

Conclusions are drawn...
There are several ways you can complete the investigation. Some require less time than others. Here are some ideas:

- Student or group oral or written reports on investigation questions and answers
- Student or group illustrations of visit with answers to questions or mystery
- Do one of the Laboratory Activities
- Complete the Continuum Activity

Continuum Activities

Continuum Activities are designed to carry through the entire investigation. Some activities require less time than others.

Investigation Map

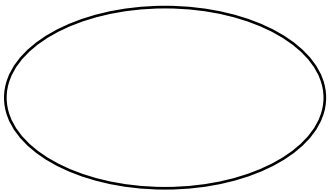
Description: Detectives will often map out related events, evidence and suspects during an investigation. This helps them get an overall picture. Students can map out their investigations with a concept map. The concept map will help you assess what students learn.

Time: (3)15-30 min. Sessions

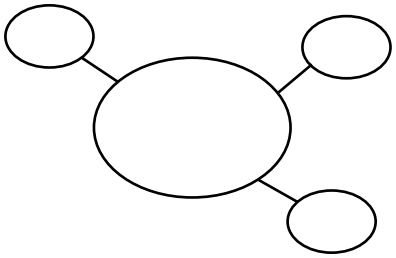
Materials Needed:
- Blank paper
- Pencils, colored markers

Procedure:

1. Begin with a center circle and write in the name of the main topic. (Students who do not write can have an adult assist or draw a representation of the main topic)



2. As students generate questions about the topic, they can add offshoot circles. They can also add circles for facts they know about prior to the visit to the New York Hall of Science.



3. When students return from their investigation at the New York Hall of Science they add additional circles of information. Their final map should reflect everything they know about the topic. Teachers can easily assess what is learned based on how the map develops.

Investigation Journals

Description: Investigation journals provide a way for students to record their questions and findings throughout the investigation.

Time: (3)15-30 min. Sessions

Materials Needed:

- Blank or lined paper
- Pencils, pens or colored markers
- On-Site Investigation Handout (print out from this web site and make copies)
- Zip-lock bags (for on-site handout only)
- Soft yarn or thick soft string (for on-site handout only)

Procedure:

1. Ask students if they have ever seen a detective take notes when trying to solve a mystery. Tell students that as "science detectives" they too will make a record of the mystery.
2. Have students begin their journal or report with questions that are generated when they Start the Investigation at School.
3. Students who do not have writing skills can make a large question mark and draw representations of their questions. If an experiment or demonstration is done, non-writing students can sketch what they observe.
4. Older students with writing skills can list their own and other students questions in their journal.
5. We strongly advise students not bring journals to the New York Hall of Science where they can get lost. We have provided an On-Site Investigation Handout that can be copied if students want to record observations or make sketches.
6. When students return from their investigation at the New York Hall of Science have them write answers to questions or draw what they observed.

Science TV- Investigative Reporters

Description:
In this activity, students plan and produce a TV show featuring investigative reports on the topic. This is a cooperative learning activity that integrates language arts, science and technology. There is a significant amount of writing involved, however students who are not prolific writers can also contribute as camera people, script supervisors, directors and on-camera reporters. Students will video tape at school and at the New York Hall of Science so pre-planning is essential for this activity.

Time: (3) 45 minute sessions (writing)
(1) video shoot at school
(1) video shoot at the New York Hall of Science
(1) 45 minute session (writing)
(1) video shoot back at school
(1) 30 minute session for viewing final TV show

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Materials Needed:

- Video camera
- (1) video tape per student group
- External wired microphone for camera (optional but suggested for good audio)
- TV
- Cables to run camera to TV for viewing
- Student internet access (optional for research)
- Lined paper and pencils
- Large plain paper and markers (cue cards)

Procedure:

First Session-Planning

1. Tell students they are going to plan and produce a TV show with investigative science news stories that are 4-5 minutes in length.
2. Divide the class into groups of four or five students.
3. Have students or the teacher chose a writer/script supervisor, camera person, director and on-camera reporter for each group.
4. Tell students about the various roles in the production team:
    - Writer-writes groups ideas for script, makes revisions
    - Cameraperson-operates camera
    - Director-supervises camera person and on-camera reporter, calls for action and cuts
    - Script Supervisor-makes cue cards for on-camera reporter, makes sure script is followed
    - On-Camera Reporter-person who reports and appears in video
5. Tell students that everyone the group will work together to create the script.
6. Remind students of the topic of study and the trip to the New York Hall of Science.
7. Instruct students to begin to create questions around the topic for the news show. They may want to create questions for interviews with New York Hall of Science "Explainers" too.
8. Tell students to watch the local news on TV so they can observe how news reporters do their job.

Second Session-Location Scout and Scriptwriting

1. Tell students they are going to do a location scout of the location they will be shooting at the New York Hall of Science. Scouting the location will help them think of more questions and give them ideas for what to shoot on location.
2. Make prints outs of the exhibits the class will visit at the New York Hall of Science OR have students access the exhibits online themselves.
3. Once students have become familiar with the exhibits, allow time for more scriptwriting. Make sure scripts have the following components:
    - Introduction to the report (name of reporter, where they are, news headline)
    - Questions the investigative report will answer
    - Conclusion (to be done after video shoot at New York Hall of Science, comment, opinion about answers, reporter sign-off)

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Third Session- Rehearsals and Final Script

1. Remind students about the various roles in the production team:
    - Writer-writes groups ideas for script, makes revisions
    - Cameraperson-operates camera, responsible for video tape
    - Director-supervises camera person and on-camera reporter, calls for action and cuts
    - Script Supervisor-makes cue cards for on-camera reporter to read, makes sure script is followed
    - On-Camera Reporter-person who reports and appears in video
2. Have groups rehearse their roles using the scripts. (Camera people can use their hands to frame shots)
3. Advise groups to make script revisions if they notice problems during rehearsal.
4. Rehearsals can be done in front of whole class or in individual groups depending on your classroom space and noise level.
5. After rehearsal have groups meet and finalize the pre-New York Hall of Science script.

Homework
Have groups give script supervisor the pre-New York Hall of Science script so they can make cue cards. (Script supervisor can ask others to help make cue cards too)

Video Shoot at School
During this session each group will shoot the introduction to their news story. Each group will have their own video tape. Make sure each group tape is labeled. If possible you may want to have groups shoot in a quiet separate location from the others or schedule group shoots during breaks in the day. If the entire class is present during shoots, make sure the others are quiet and don't distract the shooting. After shooting make sure camera people return the group tape to the teacher for safe keeping.

Video Shoot at the New York Hall of Science

1. Make the shooting schedule for the day.
2. Allow 15-20 minutes for groups to shoot in their location.
3. Choose a central location for production groups to meet the adult who will have the video camera and group tapes.
4. Make sure production groups stay together at the New York Hall of Science and Chaperones know the schedule for the day.
5. If students plan to interview a staff "Explainer", locate the Explainer in the area before shooting and ask for their assistance and cooperation for the shoot.
6. After shooting make sure camera people return the group tape to the adult for safe keeping.

Conclusion Script Back at School

1. Production groups will need to write the conclusion to their video script after their New York Hall of Science video shoot.
2. The conclusion should include a summary or opinion of the overall story as well as the reporter sign off.

3. Allow production groups to review their video footage (if necessary) so they can form opinions or summaries.

4. Have script supervisors and others in the group make up the final cue cards and conduct short rehearsals.

Video Shoot at School
During this session each group will shoot the conclusion to their news story. If possible you may want to have groups shoot in a quiet separate location from the others or schedule group shoots during breaks in the day. If the entire class is present during shoots, make sure the others are quiet and don't distract the shooting. After shooting make sure camera people return the group tape to the teacher for safe keeping.

View the Show
Hook up the camera to the TV and run the group tapes from the beginning. Enjoy the show.

Become an Explainer

Description: Students investigate one exhibit with the goal of being able to explain it when they return to the classroom. Students can choose a variety of methods to explain and make presentations.

Time: (1) 30 min. Session
(2) 45 min. Sessions (for in-class presentations)

Materials Needed:
- Interesting objects (used for student observation)
- Print outs of On-Site Investigation Handout

(optional suggestions)
- Variety of craft materials Variety of craft materials (pipe cleaners, popsicle sticks, straws, string, paints)
- Variety of clean, household recyclables (meat trays, cardboard tubes, aluminum foil, plastic wrap)
- Any other odds and ends students can construct with
- Poster board or paper
- Markers, crayons, colored pencils

Procedure:

First Session

1. Tell students as they will be investigating exhibits at the New York Hall of Science and will choose one exhibit to explain to the class when they return. (students can work in groups or individually)

2. Help students prepare for careful observation of exhibits by distributing interesting objects.

3. Now ask students to verbally describe what they see. Encourage details.

4. After students have described the object in great detail, tell them they will need to use these same observation skills when they are investigating their chosen exhibit.

5. Lead a discussion on what students can do at the New York Hall of Science to help explain and record what they see. Ideas include:

    - Sketching
    - Writing

- Using exhibit pictures on this web site
- Photography

6. Distribute The On-Site Investigation Handout (if needed) for use at the New York Hall of Science.
7. Go to the New York Hall of Science.

Second Session

1. Upon return to class from the trip, tell students they will spend time preparing to explain one of the exhibits they saw.
2. Here are some suggestions for student presentations:
   - Verbal explanation (with or without picture)
   - Labeled diagram
   - Group or individual poster showing how an exhibit worked
   - Group or individual model using materials to represent exhibit (materials can be used to substitute and represent real materials from exhibit— ex. Clear plastic wrap simulates glass, cardboard tube becomes a rocket etc.)

Third Session (optional)
Use this time for students to make their class presentations if they made posters, drawings or models.

Laboratory Activities

Laboratory Activities are designed for the classroom and generally require simple materials. These activities can be done before or after a visit to the New York Hall of Science. To help students use higher-level thinking and generate questions, facilitate discussion with these types of questions:

- What do you notice here?
- Tell me about this.
- What do you see?
- Why do you suppose this happens?
- What can you conclude from the evidence?

Moving Molecules

Description:
This is a short, teacher directed, physical movement exercise that helps students understand the impact of temperature on molecules.

Time: 10 minute session

Materials Needed:
- Students

Procedure:

1. Have the whole class stand up.
2. Explain that they are now going to "become" water molecules.
3. Explain that at different temperatures molecules act and move differently.

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Hot water molecules move fastest and have a lot of space between each other . Hot water molecules bump into each other a lot. Warm water molecules move around moderately and they like to spread out with some space between each other. Cold water molecules like to huddle close together (touching) and move slowly.

4. Tell students to move like hot water molecule by walking, bouncing, or dancing. The hotter the molecules are, the faster they move. Hot water molecules also bump into each other frequently. To simulate this action have the students closest to each other give each other high fives. Since the students are moving faster they should interact with many students. Tell students to act like hot molecules.

5. Allow time for students to demonstrate and interpret hot molecule movement. Substitute your own narration to the movement.

6. Now explain that they are going to become cold water molecules. Cold water molecules like to huddle together and bounce slowly. The colder the molecules are slower they bounce, and when they freeze they bounce really slowly, but they don't stop moving. Students' shoulders should be touching as they huddle together.

7. Tell students to act like cold water molecules.

8. As students move tell them they are beginning to freeze. (movement should really slow down)

9. Instruct the students to act like warm water molecules. Have the students pace moderately or sway back and forth. As the students are moving they will slowly high five the other students closest to them.

10. To conclude, tell students you are going to call out the temperature and they have to move according to how water molecules would move.

11. Yell out actual Fahrenheit temperatures or simply say hot, warm, cold, freezing. Vary the pace of your call outs.

12. Phew. Everybody relax and sit down.

Water Molecule Attraction-Demonstration

Description:
Demonstrate how water molecules are attracted to each other and can travel together leaving other substances behind. Students will present predictions and theories in writing or verbally.

Time: (2) 30 minute sessions

Materials Needed:

- Two glasses
- Water
- Dirt
- Paper towels
- A phone book or something similar

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Procedure:

First Session

1. Fill one of the glasses about 2/3 with water.
2. Add a handful of dirt and stir.
3. Place the glass of muddy water on the phone book, at the edge.
4. Place an empty glass beside it. The glass with the muddy water needs to be 2 or 3 inches higher than the empty one.
5. Roll the paper towel into a tube about an inch in diameter. Twist the tube until it looks like a rope.
6. Put one end of the paper rope into the muddy water and the other end into the empty glass.
7. Ask students to make a prediction about what will happen. (Students either write it down as homework or give verbal responses)
8. Let experiment sit undisturbed for a day. (changes will be noticed within an hour or so however)

Second Session

1. Return to the experiment and ask students two questions:

- What happened? (quite a bit of the muddy water has moved to the empty glass, but it is now clear)
- Why do you think this happened?

2. Inform students you are going to reveal why the water is clear in the second glass, but you want them to create their own theories first.
3. Instruct students to write or verbally present their theories.
4. Instruct the students analyze their theories and decide how close their own theories match the following explanation:

   First, the water soaked into the paper towel. It did this by something called capillary action. Water molecules are attracted to each other and are attracted to the fibers in the paper. Water molecules move into the tiny spaces between the paper fibers, and they pull other water molecules with them. The water slowly soaks its way through the paper to the other glass. Once the water crosses the top of the muddy water glass, gravity helps to move it downwards, pulling more water up to take its place.

   Because the spaces between the paper fibers are very small, the particles of dirt get left behind. They won't fit in between the fibers, so they can't move with the water. That does not mean the clear water is safe to drink! Although the filter will screen out the dirt, it does not remove germs or dissolved chemicals, which bond to the water molecules.

Activity Extension

If time allows or you want to extend the experience, have students sketch the experiment in a labeled diagram and write about the results of the experiment.

Adapted from Experiment of the Week #351, Robert Krampf's Science Education Company www.krampf.com

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Code Breakers

Description:
Students break the codes of chemical formulas to build various molecules and learn about the basic building blocks for many common substances. Students will learn that molecules are made up of atoms and depending on the number of atoms and how they are arranged, molecules form different matter. This is a cognitive learning activity that builds on the student experience.

Time: (1) 45 minute session

Materials Needed:

- Gum drops, jelly beans or play dough in the following colors: black, red, white and blue (10 of each color per student or group)
- Small containers or plastic bags
- Toothpicks (20 per student or group)
- Molecule Recipe Sheet (print out for each student or group)

Preparation:

1. Count out 10 black, red, white and blue candies or make play dough balls
2. Put each color in a container or plastic bag for student distribution
3. Count out 20 toothpicks per student or group
4. Put toothpicks in plastic bag or container for student distribution

Procedure:

1. Display the following codes so students can see them:

   H_2O

   CO_2

   $C_9H_8O_4$

   $C_8H_9O_2N$

2. Tell students they are going to break the codes and discover what they represent
3. Distribute colored candy to each student or group
4. Tell students that you are going to give the colored candies or playdough a name called “atoms”. Explain to the students that atoms are the basic particles of matter and makes up everything in the universe.
5. Invite students to try to represent the first code (H_2O) using the colored atoms (this is a higher level problem solving skill-you can skip this and give them the hint below)
6. Hint: Each letter can be represented by a color
7. Students should have two atoms of the same color and one of another color (2 Hydrogen, 1 Oxygen).
8. Since students may assign different colors to different letters in the code ask students how they would share their code breaking with others? (The class the class needs to agree on what colors represent what letters).
9. Inform the students that scientists agree on how to classify and name things so they can communicate with each other.

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10. Suggest the following code key:

    Black =C

    Blue=N

    White=H

    Red=O

11. Have students work through the other codes in the same manner by organizing colored atoms into groups that represent the chemical formula.

12. Tell students they have broken the first half of the codes. The second half involves using the toothpicks. The toothpicks represent the bond between two atoms.

13. Hand out toothpicks.

14. Now ask students if they know some of the ingredients for making cookies (students respond).

15. Ask students to name different kinds of cookies (students respond).

16. Ask students if all cookie recipes are the same? (no)

17. Ask students if most cookie recipes have some of the same ingredients? (yes)

18. Tell students that they have been working with four ingredients of atoms—when you put them together in certain ways they make certain things.

19. Hand out Molecule Recipe Sheet (shows colored circles and toothpick location).

20. Show students how to connect two atoms using toothpicks.

21. Tell students to choose a recipe to copy with their atoms and toothpicks.

22. Allow time for students to compete one recipe.

23. Tell students their atom ingredients when put together have a new name-molecule.

24. Tell students they have just made a model of a molecule of something in real life, however you would only be able to see this molecule using a very powerful microscope.

25. Conclude the session by having students discover what their molecule represents by posting the following final code key:

    H_2O=water

    CO_2= carbon dioxide

    $C_9H_8O_4$= aspirin

    $C_8H_9O_2N$= Tylenol™

Ta da! They have broken the code.

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Breaking the Bonds-Demonstration

Description:
Students are presented with a mystery about how police can catch a suspect in complete darkness because of molecules that produce body heat. A short demonstration illustrates how broken bonds create heat.

Time: 15 minutes

Materials Needed:

- 2 small wooden blocks
- Rubber band (large enough to wrap around wooden blocks)
- Scissors

Procedure:

1. Begin by posing this question:

   How did molecules help a police officer catch a suspect in pitch blackness?

2. Tell students that in order to answer the question you are going to do a little demonstration.
3. Bind the two wooden blocks with a rubber band.
4. Explain to students that the blocks represent two molecules in the body and the rubber band represents a chemical bond.
5. Show students the scissors and tell them the scissors represent a chemical that will break the bond.
6. Cut the rubber band and watch it fly.
7. Tell students that by cutting the bond you have just produced energy.
8. Explain to students that molecules interacting in our body not only make energy for food, build new cells, and enable you to move, but can also produce heat. As molecular bonds are made and broken in chemical reactions, some energy is lost as heat.
9. Ask students:

   Now that we know molecules produce body heat and the police suspect was producing body heat, how do you suppose the police officer could see the suspect in total darkness?

   (some students may know that night vision glasses can see objects that emit heat)

10. Tell students that police officers can use special night vision glasses that can see objects that emit heat and that is how an officer can see a suspect in total darkness.

Notes:

- Visit the Body Heat exhibit at the New York Hall of Science to experience this concept.
- Show students night vision or infrared visual images.

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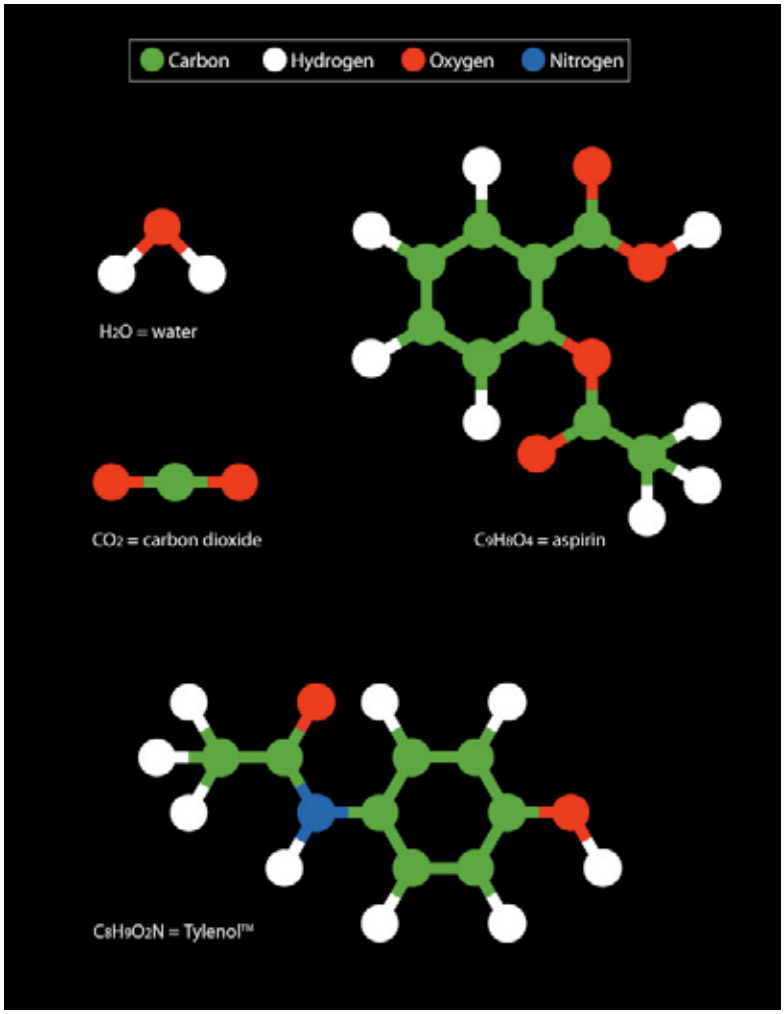
Print Resources
Molecule Recipe Sheet



Book List

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