3-5: Realm of the Atom

Curriculum Connections

Physical Science

- Observe, investigate, describe, and classify materials based on their physical properties, including physical changes, such as the changes in water when heat is added or taken away.
- Observe, investigate, and describe light energy

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
- Position and motion of objects
- 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

Content Standard F: Science in personal and social perspectives

- Science and technology in local challenges

3-5 Exhibits List

Chemistry Demonstration
Shadow Wall (Very popular)
Street Light and Atoms
The Quantum Atom: Different from the "Everyday" World
The Idea of the Atom

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 what makes "frozen shadows", shadows that stay even when you leave.

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(Mystery is solved at Shadow Wall exhibit)

- Create a mystery about discovering why something that jumps and falls, makes light! (Mystery solved at Street Lights and Atoms exhibit and Quantum Atom exhibit)
- Create a mystery about how water can change into ice in matter of seconds and how a rubber ball can become so brittle is can be shattered with a hammer (Mysteries solved at Chemistry Demonstration)
- 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:

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- 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.

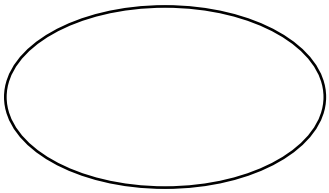
Time: (3)15-30 min. Sessions

Materials Needed:

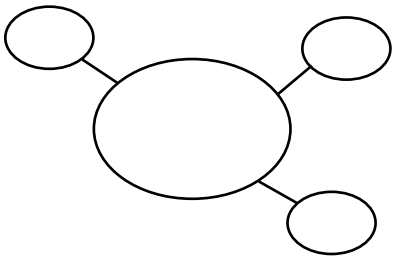
- Blank paper
- Pencils, colored markers

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

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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

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)

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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)

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 fol-

lowed

- 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?

Atoms, Lights, Action

Description:
Students will learn about how atoms make light and demonstrate of their understanding of the process through a variety of creative presentations. This is a cooperative learning activity.

Time: (3) 45 minute sessions

Materials Needed:

- Students will identify specific materials for their presentations, however we suggest you have balls or round colorful objects of varying sizes (atoms, electrons, protons) handy as well as a flashlight (protons making light).
- Performance Rubric (Optional-teacher created)

Procedure:

First Session-Introduction to Story

1. Tell students you are going to tell them a story about how atoms create light.
2. Tell students they must pay careful attention to the story because they will be working in groups to act out or present the story in a visual form.
3. Students who have experience taking notes can use this activity to practice their note taking skills.
4. When students are ready, tell the following story:

   First let's start with a riddle: What is right in front of you, but impossible to see?

   The answer is atoms.

   Atoms are the smallest components of elements that exist.

   Atoms are so small that if you lined 50 million of them up in a row, they would measure less than centimeter long. They are so small that light beams miss it.

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So it may seem odd to you that while light beams will miss an atom, atoms are what create the light!

Now you may be thinking that light bulbs create light, but if you were able to get inside a light bulb and become as small as an atom, you would see an amazing action taking place.

There are four players in this action; the atom, an electron, a proton and heat. Now pay close attention to what happens.

Orbiting around the atom is a tiny particle called an electron. (Think of a satellite orbiting the earth.) Now this electron has a regular orbit around the atom, nothing special, fairly routine... BUT when you energize the atom with something like heat...watch out. The electron jumps to a higher orbit! Yee-hah!

As this electron makes it's slow journey back into a regular orbit... out pops a photon! It is this photon that gives off light!

Now there are many forms of energy that can excite an atom. One form could be radiant energy like light or heat. Another form of energy could be when a moving photon strikes an atom. Mechanical energy such as electrical current can also excite an atom.

Energy is neither created nor destroyed but changes from one form to another. Atoms produce light by absorbing energy and later releasing that energy in the form of light radiation.

Okay, I'd like you to imagine for a moment the size of this photon. A photon is like a single paper clip compared to the size of the whole school. Pretty tiny huh? Well now imagine how many photons are needed to produce the light in a single light bulb....

O-o-h, it almost hurts your brain trying to imagine such a big number of photons. Let's just say it takes a lot of photons to produce light from a light bulb.

Now before we end this little story about how light is created, I just want to say one more thing about photons. If you think all light producing photons are alike...think again. They come in many different colors. The proof?

We'll find out at the New York Hall of Science. (Streetlights and Atoms exhibit)

END OF STORY

5. Divide class into groups of four.
6. If you have created a Performance Rubric for assessing the presentations, take time to explain the criteria to students.
7. Instruct groups to discuss ways they can present the story.
8.. Circulate around the room and summarize the story for groups as needed.
9. Instruct groups to make a list of materials they need to make their presentation.
10. Again circulate through the room to advise on materials you can supply and those that students will have to find. Some materials may not be available so encourage students to think of creative substitutions.

Second Session-Group Preparation
This entire session is dedicated to in-class, group preparation for the "electrons make light" presentation. Selected materials should be on hand for student use.

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Third Session-Presentations
This session will feature student presentations. If you created a Performance Rubric, use that to assess presentations.

Disappearing Water Experiment

Description:
Students conduct a simple experiment to discover under what conditions liquid water changes to water vapor the fastest. A teacher led discussion provokes analysis of results and further questions.

Time: (1) 20 minute session
3 day waiting period
(1) 20 minute session

Materials Needed:
(per student group)

- 1 jars with a lid
- 1 jar without a lid
- large shallow bowl
- graduated cylinder or measuring cups
- water

Procedure:

First Session

1. Tell students they are going to do an experiment to discover under what conditions liquid water changes to water vapor the fastest.
2. Distribute materials to student groups.
3. Instruct students to measure and add 200 mL water to each jar and the shallow bowl.
4. Have students place a lid on one of the jars.
5. Have students place their jars and bowls in an area that won't be disturbed for 3 days.
6. Instruct students to create the recording chart below:

Container	Amount of water after 3 days (mL)
Jar-no lid	
Jar with lid	
Shallow bowl	

7. Have students record a prediction about what container will make water to turn to vapor fastest under the chart.

WAIT 3 DAYS

Session Two

1. Using the graduated cylinder, have students measure the amount of water left in each container.
2. Have students record results in their chart.
3. Ask students: Under what conditions does liquid water change to water vapor the fastest?

4. Ask students to raise hands if their prediction turned out correct.

5. Lead a discussion using these questions:

- Why did you make the prediction you did?
- Why do you think the _____ caused water to turn into a vapor the fastest? (a great teaching moment may arise where more questions are generated and you can encourage more research)
- Why would knowing what kind of container makes water disappear faster be valuable in every day life? (this question requires the imagination of students, there are no right answers)

Atoms and Light Sources

Description:
Students observe different light sources through diffraction gratings. The diffraction gratings separate light waves and reveal characteristics of atoms emitting the light.

Time: (1) 30 minute session
Homework or Field Trip to New York Hall of Science
(1) 30 minute session

Materials Needed:

- Variety of light sources; incandescent light bulb, fluorescent, mercury vapor (gym lights?), sodium light (streetlights), neon light

(per student)

- Diffraction Grating Film (inexpensive science supply –try Edmunds Scientifics)
- Colored pencils or markers (red,orange,yellow,green,blue,violet)
- Blank paper

Procedure:

First Session

1. Tell students they are going to learn how to identify different sources of light by exploring atoms.
2. Distribute materials to students.
3. Have students look at the classroom light source through the Diffraction Grating.
4. Tell students that the Diffraction Grating separates light into colors and that it will be the tool they use to identify light.
5. Have students create the following chart or print it out:

Colors in Light Sources Chart

Light Source	What color(s) of light is given off by the source? (Draw what you see)
Incandescent light (Regular bulb)	
Fluorescent light (Found in your classroom)	

Mercury Vapor lamp

(light source found in a gym)

Sodium light

(street light)

Neon light

(Signs found in stores)

6. Tell students their task is to observe different light sources using the Diffraction Grating and record what they see. (Task can be assigned as homework or completed at New York Hall of Science)

Second Session

1. After students have completed their observations, lead a discussion to share results. Here are some questions to frame the discussion:

   A. What colors were atoms emitting from the ...

   - Incandescent light?
   - Fluorescent light?
   - Mercury Vapor lamp?
   - Sodium light?
   - Neon light?

   B. If you were to present these results as evidence to other people, what would you say to them? (Students are asked to make conclusions about their results. Conclusions could be that different kinds of light are made up of different kinds of atoms or that atoms are a kind of fingerprint that identifies types of light).

2. Conclude by telling this short story about Annie Jump Cannon:

   Identifying types of light by separating the colors was also a method used by early Astrophysicists when they were studying the stars. Special photographs taken through prisms would show the spectrum of colors in stars. Scientists would examine these photographs and be able to identify the star type.

   Now as you know there are many, many stars and no one had come up with a way to organize the star types into categories. That was until Annie Jump Cannon got involved. Annie Jump Cannon created a system to classify stars. Looking at the spectrum fingerprint of star colors, Annie Jump Cannon could tell the age of the star. This was based on the temperature of the star surface. For example, electric blue stars, which were hottest were new stars. Red stars actually had a cool surface temperature and were thought to be very old.

   Annie Jump Cannon lost her hearing when she was in college, but that didn't stop her. During her career she identified close to a quarter of a million stars!

Book List

Atoms

Ardley, Neil. *The World of the Atom*. Gloucester Press, 1989.
Rosenfeld, Sam. *Ask Me a Question about the Atom*. Harvey House, 1969.

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Motion

Ardley, Neil. *The Science Book of Motion*. Gulliver Books, 1992.
Watson, Philip. *Super Motion.* Lothrop, Lee & Shepard Books, 1982.

Heat

Jennings, Terry. *Heat.* Children's Press, 1988.
Wood, Robert W. *Physics for Kids 49 Experiments with Heat.* Tab Books, 1990.

Light

Anderson, L.W. *Light and Color.* Raintree Children's Book, 1978.
Ardley, Neil. *The Science Book of Light*. Harcourt Brace Jovanovich, 1991.
Aust, Siegfried. *Light! A Bright Idea*. Lerner Publication, 1985.
Baines, Rae. *Light*. Troll Associates, 1985.
Jennings, Terry. *Light and Color*. Children's Press, 1989.
Lafferty, Peter. *Energy and Light*. Gloucester Press, 1989.
Lyon, Sue. *Science in Action: Light and Sound*. Marshall Cavendish, 1989.
Murphy, Bryan. *Experiment with Light*. Lerner Publication, 1991.
Taylor, Kim. *Flying Start Science*: Light. John Wiley & Sons, 1992.
Ward, Alan. *Experimenting with Light and Illusions*. Dryad Press Limited, 1985.
Watson, Philip. *Light Fantastic*. Walker Books, Ltd., 1982.