



3-5: Connections *The Nature of Networks*

Curriculum Connections

Life Sciences

- Describe how organisms and the environment are dependent on one another.
- Observe and explain how plants and animals depend upon each other, and how their characteristics help them survive in their differing environments (adaptations and interdependence)

Scientific Connections and Applications

- Begin to understand big ideas and unifying concepts including the relationship between form and function; order and organization; change and constancy; cause and effect.

Scientific Communication

- 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 C: Life Science

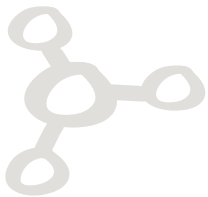
- The characteristics of organisms
- Organisms and environments

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

- "Float"
- Network Finger Maze
- Overhead
- Ropes and Pulleys
- Spider Webs
- Internet Arm Wrestling
- Near
- Ant Colony
- Shell Display
- Braided Streams
- Flocking behavior
- Pachinko Routers
- Train Tracks
- Network Building





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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.

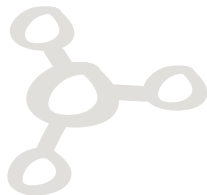


Begin the Investigation At School

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:

- How is it possible to arm-wrestle an opponent in Alaska, Pennsylvania or Iowa without leaving New York? (answer at Internet Arm Wrestling exhibit)
- How are a spider's web and a river network like the World Wide Web? (answer at Spider Webs and Braided Streams exhibits)
- How is an ant farm like our school?
- 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





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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.

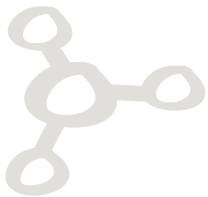
If you are curious about what teachers can do on site, we've put together a little piece called Teacher Role.

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





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Continuum Activities

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

Investigation Map

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.

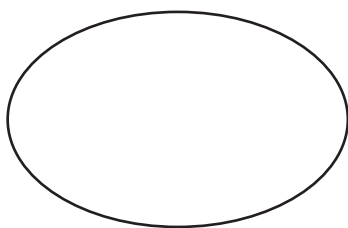
Time: (3)15-30 min. Sessions

Materials

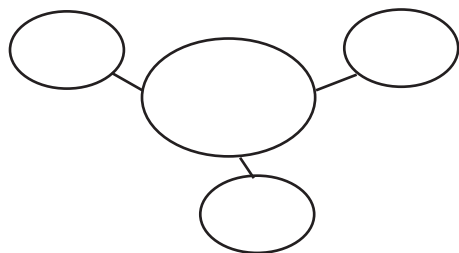
- Blank paper
- Pencils, colored markers

Procedure

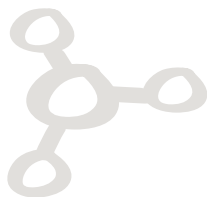
1. Begin with a center circle and write in the name of the main topic. (Students who do not write can have an adult assist or draw a representation of the main topic)



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.





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Investigation Journals

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

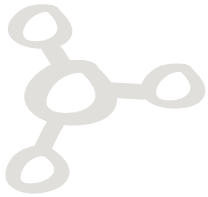
Time: (3) 15-30 min. Sessions

Materials

- 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.



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Science TV- Investigative Reporters

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)

- video shoot at school
- video shoot at the New York Hall of Science
- 45 minute session (writing)
- video shoot back at school
- 30 minute session for viewing final TV show

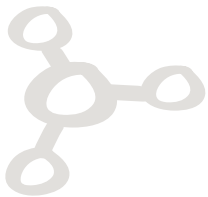
Materials

- 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.





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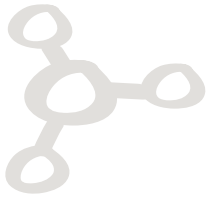
Second Session-Location Scout and Scriptwriting

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 followed
 - On-Camera Reporter-person who reports and appears in video
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.





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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

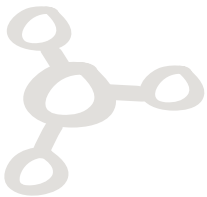
1. Production groups will need to write the conclusion to their video script after their New York Hall of Science video shoot.
2. The conclusion should include a summary or opinion of the overall story as well as the reporter sign off.
3. Allow production groups to review their video footage (if necessary) 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.





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Become an Explainer

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

- 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.





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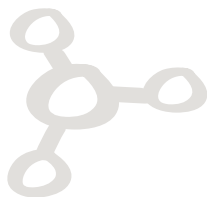
Second Session

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?

Make a Minotaur's Maze

Drawing from the Greek legend of Theseus defeating the Minotaur in the great maze on the island of Crete, students make mazes on grid paper for partners to solve.

Time: (1) 10 minute session; (1) 30 minute session

Materials

(per student pair)

- Graph paper (blank paper is okay too, but graph paper helps with maze creation)
- Pencil



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Procedure

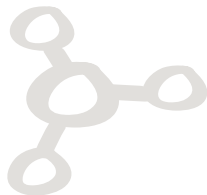
First Session

1. Begin by telling students this brief Greek legend of Theseus defeating the Minotaur on the island of Crete.



Long ago, according to Greek legend, there was a fearsome monster called the Minotaur. The Minotaur was half man and half bull with horns as sharp as swords. He lived on the island of Crete in a great maze of winding passages. Every year seven young men and seven maidens were sent to the island as a sacrifice. They would enter the maze, but never come out.

One year a young man named Theseus asked to go to Crete to slay the Minotaur. He was granted permission and set sail for the island. When he arrived a young maiden approached him and asked him why he had come. Theseus told her he intended to rid the land of the horrible monster and the young maiden decided to help him by giving him a large ball of golden thread. She told Theseus to unwind the thread as he made his way through the maze so he could find his way out.



Armed with his sword, Theseus made his way through the maze leaving a trail of golden thread. Along the way he saw the skeletons of the Minotaur's many victims. These horrible sights made him all the more determined to kill the monster. It wasn't until he reached the very center of the maze did he encounter the Minotaur. A great fight ensued as Theseus and the Minotaur clashed with sharp metal and horn. Theseus was an excellent swordsman and very nimble on his feet. The Minotaur was not as nimble and was caught off guard. In that one fateful moment, Theseus plunged his sword into the Minotaur's heart and the monster fell instantly dead. Theseus's victory would have meant nothing had he not been able to find his way out of the maze, but thanks to the golden thread he was able to find his way to freedom. The citizens of Crete gave him a hero's welcome and the young maiden who helped him became his wife.

2. Tell students they are going to create Minotaur mazes for their partners to solve.
3. Divide class into student pairs.
4. Distribute materials.
5. Instruct students to make mazes on the grid paper using the following criteria:
 - Mazes must be solvable
 - Mazes must include many false paths and dead ends
 - Mazes must have a clear start and finish
6. Assign maze making as homework.



Second Session

Use this time for students to exchange mazes with their partners.



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Make An Ant Farm!

Students make an ant farm for live ants using simple materials. Tunnel formations are observed.

Time: (1) 45 minute session

Observation and maintenance over time

Materials

(per student team)

- large jar (able to fit soda can inside)
- dirt
- unopened soda can
- piece of sponge
- cloth
- rubber band
- black construction paper (enough to wrap around jar)
- tape
- ants-These can be ordered from a science catalog or collected from outside. Ants from Carolina Biological Supply Company will cost between 6-9\$, and you receive 30 worker ants (they can't sell queen ants). If you decide to collect ants from outside, keep in mind that the ants need to come from the same colony or else they will kill each other.

Preparations

- Gather enough dirt to fill the jars half way.
- Provide a scoop and easy student access to dirt.
- If you bought ants from a science catalogue read instructions on how to distribute

Procedure

1. Divide class into student teams according to available materials.
2. Distribute materials. (except ants and dirt)
3. Have students put the soda can into the glass jar. (The soda can forces the ants to build tunnels near the outside of the jar where they can be seen.)
4. Have students fill the rest of the glass jar with dirt -do not pack the dirt too tightly but fill the entire jar.
5. Have students place a small piece of wet sponge on top of the soft drink can.
6. Now students are ready to add the ants. Do either of the following:
 - Go on an ant hunt outside the classroom- remember ants need to come from the same colony or else they will kill each other
 - Distribute ants bought from science catalogue
7. Once ants are in the jar, have students cover the lid with the cloth and a rubber band.
8. Have students tape the black paper over the outside of the jar. (ants will tunnel against the dark sides of the jar and it may take a week for the complex tunnels to really begin developing)

Ant Colony Maintenance

- Feed the ants by placing food scraps on top of the dirt (try sugar water, dry pet food, and pieces of fruit)
- Keep sponge moist
- Black paper can be removed for short periods to observe tunnels.



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Adapted from “Entomological Society of America’s seasonal lessons and activities”



Ant Farm Lab

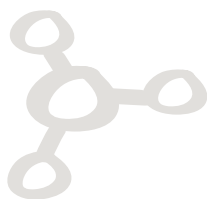
Students make an ant farm for live ants using common construction materials. A structured investigation with lab reports is included.

Time: 45 minute sessions
Observation and maintenance over time

Materials

(per student team)

- 2 pieces of plexiglass/acrylic sheet (14”x12”)
- roll of 3/8” adhesive weatherstripping
- Tube of acrylic-based bathroom caulking
- modeling clay for ant farm base and sealed top
- damp sand (2 cups per farm)
- damp cotton ball
- dry dog food or fruit pieces
- scissors
- ruler
- ants-These can be ordered from a science catalog or collected outside. Ants from Carolina Biological Supply Company will cost between 6-9\$, and you receive 30 worker ants (they can’t sell queen ants). If you decide to collect ants from the outside, keep in mind that the ants need to come from the same colony or else they will kill each other.



Preparations

- Provide a 2 cup scoop and damp sand for easy student access
- If you bought ants from a science catalogue read instructions on how to distribute

Procedure:

First Session

1. Divide class into student teams according to available materials.
2. Distribute materials. (except ants and damp sand)
3. Have students take one piece of plexiglass and remove any plastic coverings.
4. Instruct students to stick adhesive weatherstripping 3/4” from the edge of the plexiglass on three sides.
5. Have students attach another strip of weatherstripping on top of the original so that it is now twice as thick.
6. Now have students remove the plastic coverings from the second piece of plexiglass.
7. Instruct students to attach the second piece of plexiglass to the first, so they have a weatherstripping sandwich that will contain the sand for the ants.
8. Now have students apply caulking around the three sides of the ant farm so that it is flush with the edges of the plexiglass.
9. Let it sit overnight.



Second Session

1. Have students carefully sift the sand between the two plexiglass sides until it is approximately 3/4 of the way filled. Do not pack the sand.





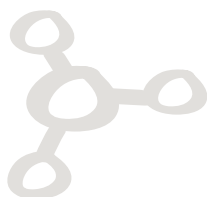
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2. Have students use clay to create a sturdy base.
3. Now students are ready to add the ants. Do either of the following:
 - Go on an ant hunt outside the classroom- remember ants need to come from the same colony or else they will kill each other
 - Distribute ants bought from science catalogue
4. Have students place one damp cotton ball and one piece of food in the ant farm. (The cotton ball needs to be changed every other day depending on your climate.)
5. Have students use clay to seal the top of the ant farm.



Third Session

1. Tell students they are going to conduct a scientific investigation of the ants in the farm.
2. The class begins the investigation by brainstorming questions. Examples include:
 - Do ants walk in long lines following each other or do they move randomly?
 - Do ants prefer one type of food material over another?
 - Do certain materials deter ants?
3. Split the class into project teams and ask them to choose one question to investigate from the list of questions the class has generated. (It should be a question that they think that they can answer by using a scientific experiment.)
4. Instruct students to write out a detailed experimental design in their project teams. Their lab report can include the following criteria:
 - Title
 - Introduction
 - Investigation Question-Hypothesis
 - Methods/Procedures
 - Observations/Data Collection
 - Conclusions/Interpretations
5. Circulate the class and assist as needed.



Observation Over Time

1. Guide students in creation of tables and graphs.
2. Allow students time to analyze data.

Shortest Distance Challenge

Students take up the challenge to find the shortest distance between nine locations.

Time: (1) hour session

Materials Needed:

- Nine heavy objects (that a string can be tied to)
- Large ball of string
- Measuring tape or stick (per student team)
- pencil
- blank paper



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Preparation:

- Place the nine heavy objects around the room

Procedure:

1. Begin by presenting the challenge scenario to students:

There are nine random spots in the room that have a piece of rotting food leftover from a recent class party. Now suppose a pregnant fly is in the room and wants to lay a few hundred eggs at each food site. This fly is on its last wings, and wants to visit each site, lay eggs once and then return to the starting point in the shortest distance possible. Our challenge is to find the most efficient flight plan for the fly.

2. Point out the nine objects located around the room and tell students the objects represent the rotted food.
3. Instruct student teams to sketch the location of the objects on the room and try to figure out the most efficient flight plan for the fly.
4. After about 15-20 minutes, have students teams try out their flight plans by using the string to simulate the flight path.
5. Have students secure the string at each location.
6. When students have visited all nine locations and returned to the start, have students measure the length of the string that was used in the flight path.
7. The team that uses the least amount of string for the flight path wins the challenge.

Flocking

In this activity, students run around a large open area to try to create and maintain flying bird flocks of different shapes. Observations are made about which shapes are easiest to maintain.

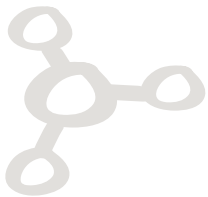
Time: (1) 35-45 minute session

Materials Needed:

- Large space for class to run around in

Procedure:

1. Ask students what shapes they have seen in flying flocks of birds? (Students may say they have seen lines, clumps, “V” shapes, etc.)
2. Tell students they are going to simulate flying in different shapes to see why flocking birds fly in certain shapes.
3. Take students to a large open area on the school grounds.
4. Choose 10-15 students to be the first flock of flying birds.
5. Tell the rest of the class they will be observers to see how well the flock stays together.
6. Instruct the flocking bird group to start “flying” (running around) in a clump.
7. After a minute or so, stop the action and gather the group.
8. Have the observer students comment on how well the flocking bird group stayed together.
9. Now choose another flock to try a different shape, this time a circle.
10. After this flocking attempt gather the group and share comments.
11. Repeat the flying flocks with these shapes:



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- The letter “V”
- The letter “Y”
- Other letters of the alphabet
- Student suggested ideas

12. To conclude, ask students why they think the letter “V” is a good choice for flying bird flocks?

Nerve Network

Students become the nerves that transmit messages to and from the brain. Linked together with yarn or string, students send messages about the five senses and various scenarios where the nerves and brain have to work together.

Time: (1) 45 minute session

Materials Needed:

- Large space
- ball of yarn or string
- objects that can be experienced with the 5 different senses (smell, sight, touch, hearing, taste)
- Brain name tag

Preparation:

- Make a brain name tag. You can draw a picture of a brain or use the word “brain”. Be creative.

Procedure:

1. Take students outdoors or to a large room.
2. Have students take a ball of yarn or string and pass it around until they are all linked together.
3. Designate one student in the web to be “the brain” and have them put on the Brain name tag.
4. Tell the other students they are nerves.
5. Tell students the brain is responsible for sending a message and the nerves are responsible for passing the message along.
6. Tell students the brain is going to send a message to someone they are linked to and that the nerve has to send the same message to another nerve they are connected to. The message keeps getting sent until every linked nerve has been used.
7. Hiding the object from the nerves, show the brain your object and have the brain send the following messages:

I smell_____

I am touching_____

8. Now let another student be the brain and send these messages:

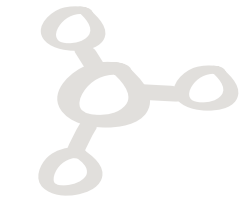
I hear_____

I see_____

I taste_____

9. Now do a variation on the activity by having nerves send messages through the web to the brain and have the brain respond. Here are some examples:

Nerve: I touched the stove burner with my finger.





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Brain: Move hand.

Nerve: I see a big growling dog foaming at the mouth.

Brain: _____

10. Another variation could have nerve students represent parts of the body such as arms, legs, hands, nose, eyes. Body parts send messages through the web to the brain and the brain responds.

11. Time how long it takes for a message to get from the nerves to the brain and back.

12. Conclude the session by telling students that the speed at which a nerve sends a message to the brain can *be as fast as 360 feet per second*.

Book List

The Spider's Web

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Ant Colonies

Chinery, Michael. *Life Story Series: Ant*, Troll Associates, 1991.

Fischer-Nagel, Heiderose. *An Ant Colony*, Carolrhoda Books, 1985.

Patent, Dorothy Hinshaw. *Looking at Ants*, Holiday House Books, 1989.

Retan, Walter. *Armies of Ants*, Scholastic, 1994.

Sabin, Francene. *Amazing World of Ants*, Troll Associates, 1982.

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