6-8: Marvelous Molecules

Curriculum Connections

Life Science
- Understand the process by which cells divide
- Understand the role of genes in heredity

Scientific Connections And Applications
- Understand the relationship between form and function, order and organization, change and constancy
- Understand and describe examples of the importance of science and technology (DNA and genetic engineering) and the impact that they have on our lives

Scientific Thinking
- Use appropriate methods to apply information and ideas to build molecular models and explain their structure

Scientific Tools And Technologies
- Use tools to observe and measure objects (atoms & molecules)

Physical Science
- Understand the structure of matter at the atomic level

** 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
- Understandings about scientific inquiry

Content Standard B: Physical Science
- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Content Standard C: Life Science
- Structure and function in living systems
- Reproduction and heredity

Content Standard E: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Content Standard G: History and Nature of Science
- Science as a human endeavor
- Nature of science
- History of science

6-8 Exhibits List

Body Heat
Bonding the Same Molecules Together
Build a Molecule
Computer Graphic of Models of Molecules
DNA Determines Traits of Living Things
DNA Molecule Model

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Engineering a Tomato
Fluorescent Microscope Demonstration
Food Energy from Molecules
How Many Molecules
How Many Molecules Are You
Make a Medicine
Marvelous Molecules Mini-Theater
Mechanical Model of Muscle Movement
Molecules for Defending
Molecules for Movement
Molecules for Reproduction
Molecules for Cell Division
Molecules for Sensing
Molecules for Sensing Computer Exhibit
Molecules in Plants Kill Beetles
Molecules Make Strong Biological Structures
Molecules That Form Structures
Molecules to Cure You Not Kill You
More Strength, More Molecules Moving
Odor Molecules
Stacks of Glucose Molecules Make Cellulose Molecules
World of Recycling Molecules
Your DNA and Your Traits

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 about how a fish protected a tomato. (fish anti-freeze gene is transferred to tomato to protect it in freezing conditions-see exhibition)
- 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)
- Do one of the Laboratory Activities and facilitate questioning
- Demonstrate one of the Laboratory Activities with no explanation-let the questions begin

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:

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- 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

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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

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.

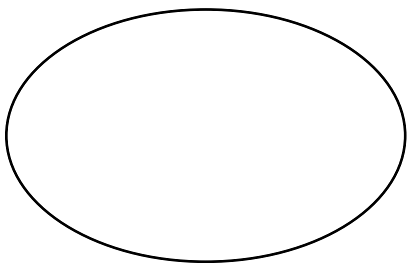
Time: (3)15-30 min. Sessions

Materials Needed:

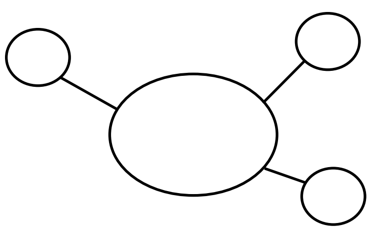
- Blank paper
- Pencils, colored markers

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.

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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

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

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- 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)

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.

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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 practice observation skills and 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: (3) 45 min. Sessions

Materials Needed:
(per student pair)

- Interesting objects for student observation that will fit in a lunch bag
- Lunch bag
- Print outs of On-Site Investigation Handout

(optional suggestions)

- 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

Preparation:
Place interesting objects for observation in lunch bags to keep hidden from student view.

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. Tell students they are going to do an activity to practice their observation and describing skills.
3. Distribute materials to student pairs.
4. Tell students that the person who is holding lunch bag will now describe the object inside to the other person without naming the object or describing what it is used for. Only descriptions of what the object looks like are allowed. The other student must guess what the object is.
5. Allow student pairs to complete activity and then switch lunch bags with another student pair. Each student pair should have a new object.
6. Repeat activity.
7. Conclude activity by telling students they will need these same skills of careful observation and detailed describing to explain exhibits they investigate.
8. Conclude the session by leading a discussion about 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

9. Distribute The On-Site Investigation Handout for use at the New York Hall of Science.

10. 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-good for ESL students)
   - 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.

Note: Your class may want to make their presentations to another class or younger students as well.

Science Court- Genetically Modified Foods Vs. Nature

Description:
In this activity students will research and debate the controversial question:
Are genetically engineered foods safe?

Time: (4) 45 minute sessions
(1) trip to the New York Hall of Science (go in the middle of the continuum to see exhibits on DNA and Genetic Engineering)

Materials Needed:
- Print outs of Print Resources
- Index cards

Procedure:

First Session

1. Tell students they will be participating in a mock court session debating the question:

Are genetically engineered foods safe?

2. Tell students they will be divided into two groups to present both sides of the debate:

   - Yes, genetically engineered foods are safe
   - No, genetically engineered foods are not safe

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3. Tell students the case will be decided by the judge (teacher) or a jury (another class).
4. Divide the class into the Yes Group and No Group.
5. Hand out the How foods are Genetically Engineered article to all students.
6. Hand out the Dangers of Genetically Engineered Foods article to the students in the No Group.
7. Hand out the article Biotech Food Myths, Misconceptions and Misinformation to the students in the Yes Group.
8. Use the remaining time to let students read through the articles and discuss them in their groups.

Second Session

1. Divide class into the two groups; Yes and No.
2. Have students review the articles and highlight major points they want to use in their argument.
3. Conduct a preliminary hearing by having each group reveal one or two facts for their argument.
4. Tell students that they now have some idea about their opposition and are more likely to win their case if they have more facts than the other side.
5. Help students to see where they may need more research by asking the following questions:
    - Does your group have more facts or opinions? (opinions don't hold much weight in a debate)
    - Does your group know why genetically engineered food is considered safe or dangerous?
    - Does your group know why foods have been genetically engineered and the benefits?
    - Does your group know why people oppose genetically engineered foods?
6. Discuss research sources where students can further prepare for their case. (Library, internet)
7. Assign research for homework.
8. Tell students they will prepare their case in the next session.

Third Session

1. Have students divide into their groups and discuss their research findings.
2. Have student groups choose a 2-3 representatives to present their case in court.
3. Have student groups choose 2-3 writers who will make index cards for the representatives.
4. Tell students they will have 15 minutes to present their group's case.
5. Student groups spend the remainder of the time preparing their case for the court session.

Fourth Session

1. Court is in session.
2. Set up the room so that representatives from each student group can present their case.
3. Allow each group 15 minutes to present their case.
4. Allow 10 minutes for the other class jury to deliberate on who presented their case the best.
5. If another class jury is not available spend 10 minutes discussing who presented their case the best with the entire class. The teacher acts as judge and makes a final ruling.

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Print Resources

How Foods are Genetically Engineered
Scientists have learned how to modify food plants by changing the DNA in the cells. There are several methods scientists use to change DNA, but all involve introducing DNA genes from other sources. Here are some examples of DNA sources and how scientists have used them to modify plants:

Source	Plant Modification
Various legumes	Insect resistance
Rice, Alfalfa, Barley	Fungal resistance
Rat	Virus resistance
Various viruses	Virus resistance

Dangers of Genetically Engineered Foods

The scientific facts demonstrating the need for an immediate worldwide ban
Because living organisms are highly complex, genetic engineers cannot possibly predict all of the effects of introducing new genes into them. This is the case for even the simplest bacterium, not to mention more complex plants and animals.

This is because:

- The introduced gene may act differently when working within its new host
- The original genetic intelligence of the host will be disrupted
- The new combination of the host genes and the introduced gene will have unpredictable effects; and therefore
- There is no way of knowing the overall, long-term effect of genetically engineered foods on the health of those who eat them.

The following are some of the facts:

- Unnatural gene transfers from one species to another are dangerous. Biotechnology companies erroneously claim that their manipulations are similar to natural genetic changes or traditional breeding techniques. However, the cross-species transfers being made, such as between fish and tomatoes, or between other unrelated species, would not happen in nature and may create new toxins, diseases, and weaknesses. In this risky experiment, the general public is the guinea-pig.
- Biotechnology companies also claim their methods are precise and sophisticated. In fact, the process of inserting genes is quite random and can damage normal genes. Genetic research shows that many weaknesses in plants, animals, and humans have their origin in tiny imperfections in the genetic code. Therefore, the random damage resulting from gene insertion will inevitably result in side effects and accidents. Scientists have assessed these risks to be substantial. (Refs: Palmiter, R.D. et al (1986) ANNUAL REVIEW OF GENETICS 20: 465; Inose, T. et al (1995) INT. JOUR. FOOD SCIENCE TECH. 30:141.)
- Genetically engineered products carry more risks than traditional foods. The process of genetic engineering can thus introduce dangerous new allergens and toxins into foods that were previously naturally safe. Already, one genetically engineered soybean was found to cause serious allergic reactions, and bacteria genetically engineered to produce large amounts of the food supplement,

tryptophan, have produced toxic contaminants that killed 37 people and permanently disabled 1,500 more. (Refs: Nordlee, J.A. et al (1996) THE NEW ENGLAND JOURNAL OF MEDICINE 688; Mayeno, A.N. et al (1994) TIBTECH 12:364.)

- Increased pollution of food and water supply. More than 50% of the crops developed by biotechnology companies have been engineered to be resistant to herbicides. Use of herbicide-resistant crops will lead to a threefold increase in the use of herbicides, resulting in even greater pollution of our food and water with toxic agrochemicals. (Ref: Goldberg, R.J. (1994) WEED TECHNOLOGY 6:647.)
- Health-damaging effects caused by genetic engineering will continue forever. Unlike chemical or nuclear contamination, genetic pollution is self-perpetuating. It can never be reversed or cleaned up; genetic mistakes will be passed on to all future generations of a species.
- Inadequate government regulation. Biotech companies claim that government regulatory bodies will protect consumers. However DDT, Thalidomide, L-tryptophan, etc. were approved by U.S. regulators with tragic results. Recently it was found that 80% of supermarket milk contained traces of either medicines, illegal antibiotics used on farms, or hormones, including genetically engineered bovine growth hormone (rbGH). The facts show that regulators are not protecting the public adequately. (Ref: Epstein, S.S. (1996) INT. JOUR. HEALTH SERVICES, 26:173.)
- Ethical concerns. Transferring animal genes into plants raises important ethical issues for vegetarians and religious groups. It may also involve animal experiments which are unacceptable to many people.
- Gene transfer across species and competition from new species damaging the environment. When new genetic information is introduced into plants, bacteria, insects or other animals, it can easily be passed into related organisms, through processes such as cross pollination. This process has already created “super weeds”. Existing species can also be displaced from the ecosystem with disastrous effects, as happened with genetically modified Klebsiella soil bacteria. (Ref: Holms, M.T. and Ingam, E.R. (1994) Bulletin of the Ecological Society of America (Supplement), 75:97)
- Crops are now being engineered to produce their own pesticides. This will promote the more rapid appearance of resistant insects and lead to excessive destruction of useful insects and soil organisms, thus seriously perturbing the ecosystem. In addition, the pesticide produced by the plant may be harmful to the health of consumers. (Refs: Union of Concerned Scientists (1994) GENE EXCHANGE, 5:68; Mikkelsen, T.R. et al (1996) Nature 380:31; Skogsmyr, I. (1994) THEORETICAL AND APPLIED GENETICS 88:770; Hama, H. et al (1992) APPLIEDENTYMOLOGY AND ZOOLOGY 27:355.)

Global Threat to Humanity’s Food Supply

Giant transnational companies are carrying out a dangerous global experiment by attempting to introduce large numbers of genetically engineered foods widely into our food supply. Because genetic manipulations can generate unanticipated harmful side-effects, and because genetically engineered foods are not tested sufficiently to eliminate those that are dangerous, this experiment, not only jeopardizes the health of individuals, but could also lead to national or even global food shortages and large-scale health threats.

There is no logical scientific justification for exposing society to this risk, nor is it necessary to take this risk for the purpose of feeding humanity. It is only of benefit to the biotech industry, which will obtain short-term commercial gains at the expense of the health and safety of the whole population. Tampering with the genetic code of food is reckless and poses a serious threat to life. It could easily upset the delicate balance between our physiology and the foods that we eat. There is already ample scientific justification for an immediate ban on genetically modified foods in order to safeguard our health.

Source: http://www.users.madasafish.com/~fabket/env/modified.html

Biotech Food Myths, Misconceptions and Misinformation: A Response to False Activist Claims

AgBioWorld Foundation

Myth: "GM crops failed to deliver promised benefits."

FACTS: Crops improved through biotechnology enjoy farmer satisfaction levels in the high 90% ranges, and these new varieties have penetrated the market at rates never before seen in agriculture. The reasons are very simple: Despite the desperate denials of activists, these crops deliver value to farmers, including lower overall costs and more efficient methods for controlling insect pests, weeds and diseases with reduced environmental impacts. This is why the overwhelming majority of farmers have freely chosen to plant biotech improved crops year after year once they try them.

As a direct result of the introduction of biotech improved crops, pesticide use has been dramatically reduced, and herbicide use has shifted from older, narrow spectrum and higher toxicity compounds to the newer generation of broader spectrum lower impact formulas (see Gianessi et al. studies at www.ncfap.org). There have been no confirmed crop failures with biotech-improved crops.

Myth: "Extensive transgenic contamination is unavoidable." Transgenic means genes from one plant travel to another)

FACTS: It is odd that some activists find the natural process of pollen flow to be alarming when it comes from precisely improved biotech crops that require fewer pesticide sprays, but are unremarkable from conventional crops or wild plants. To use this natural biological phenomenon as a tool to foment fear represents a significant departure from anything supportable by science. IF pollen from biotech crops has carried DNA from biotech improved varieties into Mexican landraces, it is because the landrace stewards have continued their age-old practice of importing foreign genetic material as a source of new variation to use in improving the ever dynamic and evolving man made corn varieties. The biotech traits involved, if transferred, would not present any kind of threat; instead, they would add value to these varieties by enabling the landraces to resist insect pests or herbicides. If the landrace stewards do not find these traits desirable they can easily eliminate them through selection. A pure or static crop landrace has never existed and could not exist.

Myth: "GM crops are not safe."

FACTS: Crops improved through biotechnology have undergone more safety and environmental testing than any crop varieties in history, and have been produced and consumed by humans and animals in millions of tons around the world for years. They have been proven as safe as the scientific method permits, by every valid method known to science and medicine. There is, to date, not a single solitary confirmed case of human or animal illness or disease associated with a biotech crop. Nor has a single negative environmental impact been credibly attributed to biotech-improved varieties. The entire body of this vast experience has shown these crops to be at least as safe as, and in many ways safer than, conventional crops and foods. Beyond the safety approval of three U.S. government agencies, both the American Medical Association and British Medical Association, as well as dozens of other scientific bodies, have said that there are no food safety concerns with currently commercialized biotech crops.

Myth "Dangerous gene products are incorporated into crops."

FACTS: Bt proteins are used because of their excellent and well-documented specificity for narrow groups of insect pests, as well as their long history of safe use by organic and non-organic farmers. Activists inconsistently claim there are safety issues when used in biotech crops, but they make no such representations when they are used indiscriminately and without regulatory oversight by organic farmers. This appears to demonstrate that the activists do not believe their own arguments about safety.

Myth: "Food crops are increasingly used to produce pharmaceuticals and drugs."

FACTS: Food crops used to produce pharmaceutical compounds provide a highly promising way to increase the safe and effective production of vital medicines to treat crippling diseases at lower costs to producers and patients. Furthermore, scientists have vast experience deriving medicinal and industrial compounds from plant sources. Indeed, canola (oilseed rape), which is one of the most important food crops in North America, is a conventionally modified variety of the same plant species used to produce industrial lubricants that are toxic to human beings. It is disingenuous to oppose the use of biotech improved food crops for producing medical or industrial substances, while condoning the use of canola. Perhaps activists do not oppose canola consumption precisely because growers and processors have an outstanding record of safe production and segregation.

Myth: " Herbicides used in genetically modified plants are highly toxic to humans and other species. Glufosinate ammonium and glyphosate are used with the herbicide-tolerant genetically modified crops that currently account for 75% of all genetically modified crops worldwide. Both are systemic metabolic poisons expected to have a wide range of harmful effects, and these have been confirmed."

FACTS: Allegations that herbicides like glyphosate pose realistic safety threats to humans and animals are simply false, as can be ascertained by anybody who takes the time to consult the review documents prepared by government safety regulatory agencies or the toxicological literature. These compounds target cellular receptors and metabolic pathways unique to plants that are absent from animals. They have received the strongest findings of safety from regulatory agencies and none of the negative consequences alleged by activists for human health are confirmed from their use.

Myth: " Genetically modified DNA in food is taken up by bacteria in the human gut. There is already experimental evidence that genetically modified DNA from plants has been taken up by bacteria in the soil and in the gut of human volunteers. Antibiotic resistance marker genes can spread from transgenic food to pathogenic bacteria, making infections very difficult to treat."

FACTS: There is ZERO EVIDENCE to support concerns that functional genes might be taken up from food, transgenic or otherwise, by bacteria in soil or the human digestive tract. Even if the antibiotic marker genes occasionally used in early biotech crops were so absorbed, they would not even be detectable against the pre-existing background of antibiotic resistance genes found widely in human intestinal flora. There is a strong consensus among medical experts in microbial antibiotic resistance that the clinical problems of antibiotic resistance stem from medical or patient mishandling of antibiotics, to which the mechanics of agricultural biotechnology are wholly irrelevant.

Myth: "There's a history of misrepresentation and suppression of scientific evidence."

FACTS: Activist claims have been thoroughly evaluated by the community of scientists and measured against replicable findings in published and peer-reviewed literature. Their speculative and sometimes bizarre claims routinely and repeatedly fail to survive this scrutiny. This is not because evidence is suppressed, but rather because activists are consistently frustrated in their search for credible evidence that might justify their claims.

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Myth: "In conclusion, GM crops have failed to deliver the promised benefits and are posing escalating problems on the farm. Transgenic contamination is now widely acknowledged to be unavoidable, and hence there can be no co-existence of GM and non-GM agriculture. Most important of all, GM crops have not been proven safe. On the contrary, sufficient evidence has emerged to raise serious safety concerns, that if ignored could result in irreversible damage to health and the environment. GM crops should be firmly rejected now."

FACTS: This "conclusion" has been shown to be false in each of its several components by the preceding refutations. The facts are that crops improved through biotechnology have, in advance of their use, been subjected to more rigorous scrutiny, in depth and detail, than any others in history. Wherever farmers have been allowed access to such crops they have adopted them at unprecedented rates and inspired the highest levels of farmer loyalty because they deliver value on multiple levels, to the farmer, to the environment, and to consumers. In the end, if genuine and systemic agricultural problems have arisen from, or ever do arise from, biotech enhanced crops, then farmers will abandon them.

The fact that farmers continue to embrace bioengineered crop varieties provides ample evidence that they HAVE been beneficial to the farm. And the fact that the overwhelming majority of scientists, as well as every major scientific organization that has evaluated the safety of biotech crops, find them to be as safe as or safer than conventional crops, provides ample evidence that health and environmental issues have been adequately addressed.
Source: http://www.agbioworld.org/biotech_info/articles/GMmyths.html

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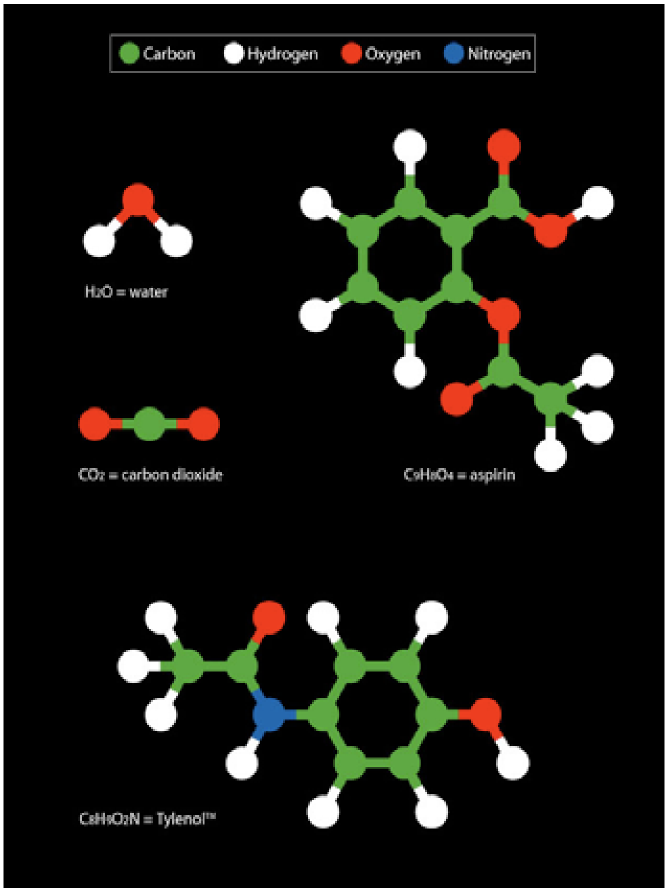
Molecule Recipe Sheet



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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?

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)

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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. Tell students that scientists agree on how to classify and name things so they can communicate with each other.
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 toothpicks).
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:

    H2o=water

    CO2= carbon dioxide

    C9H8O4= aspirin

    C8H9O2N= Tylenol™

Ta da! They have broken the code.

Water Molecule Attraction-Demonstration

Description:
Demonstrate how water molecules are attracted to each other and can travel together leaving others 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

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 home-work 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

Salt, Water Molecules

Description:
Students do a quick hands-on activity to learn how atoms form molecules and the definition of a compound.

Time: (1) 45 minute session

Materials Needed:
(per student or small group)

- 3 paper plates
- 3 labels
- 1 white index card
- scissors
- 3 colored index card halves
- glue

Procedure:

1. Label 3 plates for the three substances students will be making: "water", "salt" and "salt water".
2. Cut the white index card into 12 pieces. These will be hydrogen atoms.
3. Use the other three colors for the elements: oxygen, sodium and chlorine. Cut each half index card into six pieces.
4. Label all of the atoms and put each of the elements in a separate pile.
5. Combine hydrogen and oxygen. Glue the atoms together to make water molecules. The glue is like the chemical bond that really holds the atoms together. Put the water molecules in the plate labeled "water". This is a compound.
6. Combine sodium and chlorine. Glue the atoms together to make salt molecules. Put the salt molecules in the plate labeled "salt". This is a compound.
7. Now make salt water. Mix the water molecules and the salt molecules in the plate labeled "salt water". Note that you do not glue them together. They form a mixture, not a compound, and so there are no chemical bonds (and therefore no glue) between them.

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Make a DNA Model

Description:
The DNA molecule consists of two strands that form a double helix, a spiraling shape much like a twisted ladder. The DNA molecule has a sugar component, a phosphate component, and four different bases—adenine, thymine, cytosine, and guanine. To help students understand how these components fit together to form DNA, students make a model of DNA with fishing line, dried pasta, and different-colored pipe cleaners.

Time: (1) 45 minute session

Materials Needed:
(Per student pairs)

- (2) 24-inch pieces of fishing line
- (8) 2-inch pieces of blue pipe cleaners
- (8) 2-inch pieces of green pipe cleaners
- (8) 2-inch pieces of purple pipe cleaners
- (8) 2-inch pieces of orange pipe cleaners
- (18) pieces of dried pinwheel pasta
- (16) pieces of dried ziti cut pasta
- Large Ziploc™ bags

Preparation
Gather and sort the student materials and put them in a large Ziploc™ bag for each student pair. These will be your DNA model "kits" to distribute to students.

Procedure:

1. Students will make the DNA model first and then you will explain the components.
2. Distribute the DNA model kits to students.
3. Students should have 2 pieces of line, 18 pieces of pinwheel pasta, 16 pieces of ziti pasta, and different-colored pipe cleaners.
4. Tell students to start with the pinwheel pasta and alternate with the ziti pasta as they thread the pasta on the line.
5. On each line, they should string nine pieces of pinwheel pasta alternating with eight pieces of ziti.
6. Wrap the line around the final piece of pasta at the end of each line so that the pasta does not fall off.
7. After pasta has been strung on both lines, each line should have a total of 17 alternating pieces of pasta. Have students lay the two lines side by side.
8. Next, instruct students to twist the eight blue pipe cleaners and eight green pipe cleaners together, making a total of eight blue-green pipe cleaners, about 2 inches long.
9. Now, have them twist the eight purple and eight orange pipe cleaners together, making a total of eight purple-orange pipe cleaners, about 2 inches long.
10. Now, have students create a "ladder" using the pasta lines as the sides and the twisted pipe cleaners as steps.
11. Beginning at the top, students should connect the two ends of a twisted pipe cleaner to the top pasta pieces on the two lines.
12. Use a second pipe cleaner to connect the next two pasta pieces directly across from each other.

13. Students should continue building their ladder, one step at a time, until they have connected the bottom two pieces of pasta.

14. Remind them that they can place the twisted pipe cleaners in any order. (The blue-green pipe cleaners do not have to alternate with the orange-purple pipe cleaners.)

15. After all the pipe cleaners have been woven, the DNA model is complete.

16. Now facilitate the discussion:

- Ask students to brainstorm traits they have that are passed on from their parents, such as eye color, hair texture, and facial characteristics. Then ask them how these traits are passed on from one generation to the next. (The answer is DNA, or deoxyribonucleic acid.)
- Explain that all organisms carry an elaborate blueprint containing the information necessary to develop and maintain life. This "manual of instructions" is located in a chemical molecule called DNA.
- The DNA molecule has a sugar component, a phosphate component, and four different bases—adenine, thymine, cytosine, and guanine.
- Explain that the pinwheel pasta represents the sugar component, the ziti pasta the phosphate, and the pipe cleaners each of the bases.
- The blue pipe cleaners represents adenine; the green pipe cleaners, thymine; the purple pipe cleaners, cytosine; and the orange pipe cleaners, guanine. Explain that the bases in DNA are found in pairs and that adenine always pairs with thymine and cytosine always pairs with guanine.
- Tell students that DNA works something like the alphabet. While the alphabet has 26 letters, DNA's "alphabet" has only four letters. These letters are guanine (G), adenine (A), cytosine (C), and thymine (T). Just as the 26 letters of the alphabet can be used to form millions of words for communication, DNA's alphabet can be combined to form codes with more than five billion combinations of G's, A's, T's, and C's. The differences in these combinations result in differences among human beings. Just like letters spell out chapters in books, base pairs spell out genes. The body can read a chapter and learn how to make something, like a muscle protein or hair.

Extension- Integrate Art and Science
Instruct students to design and create a DNA model using materials of their own choice. Suggested materials include stained glass, clay, beads, buttons, wood pieces, recycled materials, and food items. They should include a key that explains what each item represents. After students have completed their models, have them display the models in the classroom.

Adapted from Wendy Goldfein activity, sixth-grade teacher, Fairfax County School District, Springfield, Virginia.

Source:http://school.discovery.com/lessonplans/programs/modeldna/

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New York Hall of Science • 47-01 111th Street • Queens, NY 11368-2950 • 718 699 0005 • Fax: 718 699 1341 • www.nysci.org

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