Chapter 15

Science

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Before We Begin

One question...

(illustration 15-0-1)
(Show one each of the Power Blocks used below with the letter reference printed beneath each one.)

The teacher's one question was not complex. She asked her class:

Teacher: Which of your Power Blocks can you make from two other Power Blocks?

The purpose of the question was to give her students a basis for understanding fractions.

Amanda: Can we use three Power Blocks to make another Power Block shape?
Kristina: Or four?
Teacher: I guess so. Yes.

After all, the purpose of the lesson was to let the students see what shapes they could make into other shapes to provide a background for fraction questions later on.

Jason: Or more?
Teacher: Sure.

As the teacher strolled around the room watching her students work, she added the broader range of questions from her students to her own.

Teacher: Kendrick and Kirk, I see you have made the larger P-4 parallelogram with two P-3s. Can you make the P-4 parallelogram with three smaller parallelograms?
Kirk: (After a little while) Yes. See.
Teacher: Try four.
Kendrick: Do we have to use parallelograms?
Teacher: See if you can find a way with parallelograms, then see if you can find a way without.

The teacher did not anticipate that her broader range of questions would include what Brett and Jessi thought to do. They had taken four P-4 parallelograms and made a parallelogram four times larger than P-4. This was their interpretation of Amanda and Kristina's question asked. They had made a larger shape from four smaller ones.

Teacher: Can you make a parallelogram that same size from parallelograms smaller than P-4?

Gennaro and Hayley made a square with four pieces, then made a square next to it with five, then a square next to it with six.

Teacher: Is the next square you are going to make a square that uses seven pieces?
Gennaro: Yes.
Teacher: Then eight, then nine, then ten?
Hayley: Then eleven, then twelve, then thirteen.
Teacher: How far up do you think you can go?
Hayley: Infinity.

The teacher's view was that infinity was not the likely number to be reached in this class period, but Gennaro and Hayley could find that out for themselves.

Teacher: Let me know how far you have managed to go when our lesson time is over for today.

Aaron and Hanny made a square larger than the S-5 square in their set.

Teacher: Can you make a larger square than that?
Hanny: Yes.
Teacher: Come and get me when you have.

A little later on.

Aaron: This is the largest square that we can make.
Teacher: That's a pretty large square. But you made it using only smaller squares. Do any of your other pieces make into squares?
Hanny: Yes.
Teacher: Show me.

Hanny and Aaron made a square using triangles.

Teacher: Any other way?

Hanny and Aaron made a square using rectangles.

Teacher: How about parallelograms and triangles together? Come and get me if you find a way.

After considerable experimentation, Hanny and Aaron showed their teacher a way they had found to make a square using parallelograms and triangles.

Teacher: Can you use any of the different ways you have found to put triangles or rectangles or parallelograms together to add to your large square?

Hanny and Aaron commenced adding to their large square.

Kyle and Ky-nam made a T-2 triangle from two T-1s, a T-3 triangle from two T-2s, a T-4 from two T-3s and a T-5 from two T-4s.

Teacher: Could you make a triangle twice as big from two T-5s?
Ky-nam: Yes. You just put them side by side like this.
Teacher: How large a triangle could you make if you kept putting each new triangle you make side by side like that?

Kyle and Ky-nam doubled and doubled and doubled some more. When they eventually ran out of triangles from which to make triangles twice as large as the triangle before, they used other shapes to make more triangles so they could keep on doubling.

Krystal and Angela also made successively larger triangles. They started by adding parallelograms to the edge of the large triangle they made. Then they found ways to add other pieces, too. They were determined to turn all the pieces from their set into the largest triangle that they could build. The teacher stopped by to admire their work and could think of nothing new to ask.

Theron and Julie made a long rectangle from fourteen triangles and then occupied themselves with seeing how many other shapes they could make with just fourteen triangles. The teacher did not ask Theron and Julie any question that might change the direction of their explorations. She just noted in her head a question she might ask the whole class to explore on a different day.

Ryan, Monica, Brittany and Danielle, working in teams of two on a problem they posed for themselves, made the S-5 square using 32 pieces.

Teacher: How many different ways can you make the S-5 square? I know you can make it with one piece and I know you can make it with two. Can you make it with three and four and five all the way up to the thirty-two piece way that you have found?
All four: Yes.
Teacher: Come and get me when you have found all the ways between one and thirty-two.

Andrew and Patrick traced their shapes on paper. They traced the S-5 piece. Inside of the S-5, they traced two T-5 pieces, one of which they labeled 1/2. Inside the second T-5, they traced two T-4s, one of which they labeled 1/4. Inside the second T-4, they traced two T-3s, one of which they labeled 1/8. They repeated this tracing and labeling process all the way to T-1s, one of which they labeled 1/32.

Andrew: Can we draw shapes that we don't have in our set?
Teacher: (Looking at the tracings done so far) What shape do you want to draw?
Andrew: Can we divide the T-1 in half, even if we don't have a piece smaller than T-1?
Teacher: Yes. What fraction would you get if you did?
Patrick: One over sixty four.
Teacher: One-sixty-fourth.
Andrew: And then one-one hundred twenty-eighth.
Teacher: I'll be interested to see how far you can go.

By the time the lesson was over, the teacher had difficulty remembering what she had originally asked her class to do. Were there any students who had spent the entire lesson time making one Power Block shape from two others? Not that she had seen. Once her students understood or misunderstood her first question, they had gone off in directions of their own. Each new direction one child took taught the teacher something new she could ask of every other child.

In mathematics, we must often narrow the focus of the questions that we ask to achieve specific learning goals. The original point of this teacher's Power Block question was to give her students a background for understand fractions. To insure that every student eventually acquired the background she desired, the teacher would phrase tomorrow's question more narrowly and guide her students' choices more specifically.

In science, no such narrowing is required. In science, we ask a question and encourage the diversity of thinking that the question may inspire. A Power Block question directed to some specific end is the kind of question that we ask in mathematics. A Power Block question left free to follow intellectual curiosities is an example of how the learning in a science lesson flows.

Science...

> Science (si' ans) N. Abbr. sci. l. The observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena.
>
> *The American Heritage Dictionary of the English Language*

When we were students in the elementary grades, science was often presented to us as a body of facts to be memorized. Any experimenting we were allowed to do in science labs was designed only to reinforce our knowledge of the facts. If we did not get the results the lab manual said we should, we repeated the experiment until our results matched the manual's.

Many of the facts I learned in school have turned out to be fiction. Matter can be destroyed. There are more than 100 elements. The atom is made up of more than protons, electrons, and neutrons. The list of facts that I was taught to accept without question that have been questioned and rejected goes on and on. The half-life of scientific knowledge is presently four years, and the body of general knowledge is doubling even more rapidly. The greatest advances in the sciences are made by men and women who accept "facts" not as absolutes, but as hypothesis.

In our own classrooms, we do not present science to our students as a body of knowledge to be memorized. There are some basic hypothesis that scientists have set forth to explain certain phenomena such as gravity, or the earth's path around the sun, that our students will someday need to know, but our role is not to teach facts, it is to teach thinking. We want our students to question, discuss, challenge, predict, form hypothesis, test, and share their findings with their classmates. We want our students to think. We want our students to be scientists.

Since our emphasis in science is on thinking and on problem solving, all of the activities we present to our students involve their active participation in forming their own experiments to answer their own questions. While at any given time the materials we provide are centered around the areas we wish our students to explore, our students themselves are free to conduct any experiment they wish—subject to a few safety rules—and pursue any question that interests them.

We do not need to be an expert in any area to permit our students to conduct experiments related to it. We do not have to know the answers to the questions we may ask in advance of asking them. Our responsibility is not to provide answers, it is to provide questions that serve as a catalyst for curiosity. Our students find the answers, and, eventually, they find the questions as well.

Our class science periods are conducted in very much the same manner as the Power Block lesson described above. We begin each science period by asking our students to find the answer to a question or two. Once the question has been posed, students may either work on our question or go off in any direction that their curiosity may lead. As our students work, we walk around talking to them about their explorations and posing new questions to individuals when appropriate. We also share the findings of individuals and small groups with our whole class. We are the information spreaders, the catalyst. Our students are the thinkers, the experimenters, the scientists.

The day's work may leave more questions unanswered than answered. The unanswered questions from one day's lesson are the questions with which we lead off the following day's activities.

Safety first...

While it is as important in science as it is in math to build up the educational value of a material in advance of its use, the materials we use in our science activities demand an extra care not always necessary in math. In science, we use candles and matches, oil, wet clay, alcohol, and extensive amounts of water. The potential for messy floors and desks, ruined clothes, and actual physical injury is present in our science activities to an extent not true in math. This potential is not mentioned as a deterrent to science activity. Any potential problems can be avoided if both the use of the material and its importance in the learning of the child are made clear in advance.

Once, in my first year of teaching, a student leaned over her lit candle and accidentally caught the hair on top of her head on fire. Fortunately, I saw the hair at the very point it ignited and I was able to put the fire out before anyone, including the girl whose hair had ignited, was aware of the situation. I do not relate this story to discourage the use of candles. I have used candles in my classroom every year since. I mention the incident now, and to my students each fall, to emphasize the importance of handling materials carefully.

Matches burn, but if a standardized procedure for their safe use is in effect, the matches burn only what they were meant to burn. When we use matches, each team of students has a baby food jar partially filled with water. Once used, each match is dropped flame first into the water. If our students need to use a flame several times in succession, then they place a small candle in a piece of clay, which in turn is placed on top of the detached baby food jar lid. Successive lightings are made from this lid candle-holder, and not from a new match each time.

In my room, no one may strike a match when the match box is open, no one may carry any burning object from one desk to another, and no one may lean over any flame. If any student demonstrates through his or her own actions, that he or she is not yet ready to accept the responsibility that is a part of using fire, that student is excluded from any lessons where fire is used until he or she is ready to demonstrate responsibility.

In addition to discussing the rules for match or candle use in advance, we also discuss and demonstrate what to do in case of fire. "Fire" does not mean the class or the school burning down. Fire means a piece of paper or some similar object is aflame. These discussions, though theoretically directed at what to do if something happens, have as their underlying goal insuring that the techniques imparted are not needed. The best lifeguard is one who never has to make a rescue, because he or she has not let the non-swimmers get in over their heads.

While fire is the most dangerous of the materials we use, careful use of each material, whether in terms of physical danger, or just in terms of mess to clean up, is discussed. The amount of time spent in advance of any lesson planning how best to make the lesson run smoothly is well worth the minutes when measured against everyone's safety and enjoyment once the lesson begins.

A way of thinking...

As our students mathematical skills increase, their ability to tabulate their findings and display the resulting information increases, too. Tabulating and recording are a part of science. As our students learn to measure in mathematics, we encourage them to measure in science. As they learn to graph, use of graphing skills in science is encouraged, too. Science activities provide our students opportunities to apply concepts that they learn in math.

In mathematics, we teach the skills of thinking, reasoning and problem solving as the most basic skills of all. We teach these skills not just to produce answers to problems about numbers, but to produce answers to problems in life. As we teach our students to think mathematically, we encourage them to bring their own creativity and inventiveness to posing and solving problems. Through mathematics, we give all of our students the learning power that comes from knowing they can know.

In science, we also teach the skills of thinking, reasoning and problem solving as the most basic skills of all. As we teach our students to think scientifically, we encourage them to bring their own creativity and inventiveness to posing and solving problems. Through science, we give all of our students the learning power that comes from knowing they can know.

Mathematics is the tool that scientists use for tabulating findings and displaying results. But mathematics connects to science more completely than providing basic tools. Mathematics is a way of thinking. Science is mathematical thinking applied.

Teacher questions...

Teacher questions are a starting point. As our students engage in scientific explorations we use the questions that we ask to encourage them to:

Use their powers of observation.
Think flexibly and be aware of the thinking taking place.
Ask their own questions.
Pose their own problems.
Create their own experiments.
Make predictions—theorize.
Explore the possibilities.
Solve the problems that they pose.
See patterns that connect past knowledge to present situations—generalize.
Work cooperatively.
As sophistication grows, strive for greater accuracy and precision in their work.
Record their findings in drawings and in writing so that findings can be shared.
Strive for originality and creativity—see things in a different way.
Be persistent.
Be inquisitive.
Be curious.
Be imaginative.
Speculate.
Participate.
Wonder.
Enjoy.

Areas of exploration...

While all of mathematics is connected and the mathematics used in any science activity crosses chapter boundary lines, the areas of exploration presented in this chapter and the main chapters in this book the explorations relate to are:

Free Exploration and Creative Learning
Liquids.
Magnifying.
Patterns and Connections
Seeds and Plants.
Worms and Other Animals.
Beginning Number
Boats.

Sorting, Classifying, Expanding Language
Changes.
Objects in Water.
Geometry, Shapes, Relationships and Constructions
Moonshine.
Building.
Paper Planes and Kites.
Graphing, Probability and Statistics
Pendulums.
Candles.
Measurement, Estimation and Time
Ice Cubes.
Fractions, Ratios and Decimals
Shadows.
Advanced Addition, Subtraction, Multiplication and Division
(Arithmetic is in everything.)
Algebra
Friction, Force and Motion.

For each area, the following information is included:

Materials we might make available to our students.
Safety considerations and other materials issues as appropriate.
Suggested questions with which to begin successive periods and a hint or two where appropriate.

The areas of exploration are not meant to limit the areas we encourage our students to explore. The areas described offer only a sampler of the kinds of activities we might employ to connect science explorations to the mathematics that our students learn. There is no sequence of events except the sequence we create. There is no timeline for how long we teach except the interest that our students show in the materials we provide. Our goal is the thinking involved, not whether a specific scientific fact is learned. Our own list of questions grows from what we observe happening in our class. Year two will find us wiser than year one. Year three wiser than year two.

Areas of Exploration

Liquids...

(illustration 15-0-2)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Various liquids: water, soapy water, salt water, vinegar, alcohol, salad oil, caster oil.
Liquids that the students think to try.
Baby food jars for liquid storage.
Small paper drinking cups. Dixie cups work well.
Eye droppers or cut pieces of straw for forming drops.
Waxed paper.
Aluminum foil.
Paper clips.
Tooth picks.
Newspapers.
Magazines.
Balances, if available in the room.
Coffee cans, for storage.
Sponges and paper towels for cleaning up.
A mop if necessary.

Materials considerations:

We prepare enough baby food jars of water and soapy water in advance so that each team of students may have these two liquids available continuously. Other liquids are examined and exchanged for a new liquid when the examination is complete. As long as not all students decide to examine a particular liquid at the same time, four or five jars of each liquid should meet our classes needs. We label the jars so that our students can easily identify the liquids they contain.

Materials for each team of students available at the start:

Baby food jar full of water.
Eye droppers or pieces of cut straw.
Cut straw becomes a drop maker by placing the straw part way into a liquid, then placing a finger over the end of the straw. The liquid remains in the straw until the finger is removed from the straw's tip. Students may experiment with pinching the straw, as well.
Sheets of wax paper.
Paper towels and sponges.

Questions:

What is a drop?
Can you make a drop of water?
What is the smallest drop you can make?
Putting the drops on your wax paper, can you make a two drop pile? A three drop pile? Four?
How is a pile of drops shaped?
When does a drop pile become a puddle?
Can you make a row of drops all the same size?
What happens when you touch a drop or a pile of drops with a pencil point?
Put a drop on your thumb. Touch it with your finger. Pull your finger away. What happens?
What is the closest you can put two drops on your wax paper without having them touch?
What happens when they touch?

Additional materials:

Whatever in the room we decide it is acceptable to experiment upon: children's clothing, writing paper, paper towels, desk tops, floor tile, bits of sponge, wood surfaces, and on and on.

Questions:

What kinds of things does water sink into?
When does the water stay on top? Why?

Additional materials:

An expanded selection of liquids with which to work.

Questions:

Select a new liquid with which to work.
Can you make a drop of (new liquid)?
What is the smallest drop you can make?

All the questions we ask for water, except the "sinking into-staying on top" questions we can ask again for each new liquid introduced. Additional questions we might ask:

How are the drops from the different liquids alike?
How are their drops different?
If you tilt your waxed paper so the drops may roll, which liquids move the fastest?
Do big drops slide down your wax paper faster than little ones? Why?

Additional materials:

A glossy magazine page.

Questions:

Put a drop of water on one of the words and observe what the water does to the letters.
Now try other liquids. Do they all make the letters look the same?
Which liquids magnify the letters more?

For the next series of questions, our students start with water. Once they have explored water, we reintroduce the other liquids and repeat the experiences.

Additional material:

Small paper drinking cups.

Questions:

When is a cup full?
Fill your cup to the brim. Once your cup is full, add water to it one drop at a time.
Can you pile water up higher than the brim of your cup?
Keep count of how many drops can you add before the water spills over the edge?
When does the water finally spill? Why?
If you only add one drop at a time, does only one drop at a time spill over the edge?
Will other liquids do the same thing?
Which liquid piles up highest over the brim?
Will any liquids not pile up at all?

For the next series of questions, our students start with water once again. After water has been explored, we reintroduce the other liquids and repeat the experiences.

Additional materials:

Small pieces of aluminum foil.
Tooth picks.
Paper clips.

Questions:

Pile the water in your cup up over the edge, but not so high that it spills.
Put a small piece of aluminum foil on top of the water. What happens to it?
Now put a piece of tooth pick on the water. What happens to it?
Did the aluminum foil and the tooth pick act the same? Why or why not?
What happens if the cup is not full and you put the aluminum foil or tooth pick in?
Pile the water up over the brim again. Float a paper clip on your piled up water.

(illustration 15-0-3)
(Show how to lower a paper clip onto the surface of the water using another paper clip as the lowering device.)

Describe what you see.
Can you sink the paper clip?
Will it come up again?
Can you sink the tooth pick?
Will it come up again?
Can you float the paper clip if the water is not piled up higher than the brim?

Additional materials:

Other liquids.

Questions:

Can you float the aluminum foil in all the liquids?
How about the tooth pick?
What liquids will the paper clip float in?

Additional materials:

Balances, if available in the room.

Questions:

Which liquid is the heaviest?
Which is the lightest?
Can you put all the liquids in order from the lightest to the heaviest?
Do heavier liquids race faster on the waxed paper?
Do heavier liquids pile up higher in the little cups?
How can one liquid be heavier than another if both take up the same amount of space in their jars?

What additional questions will members of our class think to ask? What new questions will we learn to ask next time as we watch our students work?

Magnifying...

(illustration 15-0-4)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Magnifying glasses or jewelers' loupes—filling a clear plastic tube or cylinder with water and then sealing the tube produces an inexpensive magnifying devise.
Microscopes, if available.
The things around us everywhere—nature made and human made.

Our purpose in having our students examine nearly everything with devises that magnify is to cause them to look more closely at their world, both literally and figuratively. Learning to look more closely is a skill our students can use in all the science activities that follow. Learning to look more closely is a skill they can use in any area of life. Things are not always as they seem.

Materials for each team of students available at the start:

Magnifying glasses or jewelers' loupes or other magnifying devices.
Items to examine.

Things our students might examine as they learn to look more closely at their world:

Hands, back and front	Fingernails	Eyes
Dirt	Flowers	Seeds
Twigs	Leaves	Bark
Pebbles	Rocks	Sand
Shells	Insects	Feathers
Hair	Wool	Leather
Paper	Plastic	Styrofoam
Rubber	Metal	Cardboard
Cloth	Fruit	Vegetables
Meat	Bread	Candy bar
Anything at hand		

Things to be examined can be found in or by or on:

Classrooms	Playgrounds	A student's desk
Around the house	Backyards	On the way to school
Beaches	Forests	Vacant lots
Human bodies	Pets	Anywhere around

Questions:

Look.
What do you see?
Does it look like anything else you have seen before?
What patterns do you see now that you think you might have seen before?
As you view each new object, keep in mind the objects you have seen before, so that you can recollect when something you see now looks like something you have seen.
Why do you think what you see looks like that and not some other way?
Is there a purpose to its design?

The lists of things to examine is as limitless as the curiosity and imagination of the students in our class. When we wish the list to grow, we ask:

What new can you find to examine today?

Our questions are the starting point. Encouraging curiosity and wonder is our goal.

Seeds and plants...

(illustration 15-0-5)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Seeds.
Bleach (optional).
Vermiculite potting soil.
Pots for the seeds and soil.
Pizza trays or aluminum foil.
Plastic sandwich bags.
Magnifying glasses.
Water.
Watering cans.
Boxes or tin cans for creating darkness.

If our students wish to explore what happens if seeds are planted in different materials or if something other than water is added to the soil, we might provide the following:

Sand.
Dirt.
Gravel.
Sawdust.
Rocks.
Salt.
Vinegar.
Plant food.

Materials considerations:

The best kinds of seeds to use are those that grow quickly into plants. Seeds that grow relatively quickly and that can be purchased in quantity from grocery stores are kidney beans, whole green peas, navy beans, Yellow eyed beans, California pea beans, unroasted peanuts, and unpopped popping corn.

We may also try anything available in the grocery store that still looks like a seed in its natural state. The main difference between grocery store seeds and the same seeds purchased at a nursery is that the grocery store seeds have not been treated for mold. This treatment is not always necessary, but untreated seeds may be attacked by mold when placed in wet earth. The grocery store seeds can be protected from mold by rinsing them for a few seconds in a diluted solution of bleach. Two table spoons of bleach to a cup of water is a good dilution rate. The seeds should be dropped in the solution, stirred for a second or two, and then spooned or strained out. There is no need to rinse the seeds.

Although students can experiment with a variety of planting mixtures, it is best to have them plant their first seeds in potting soil, which can be obtained at any nursery store.

Pots for the seeds can be anything that will hold soil and water. Students may use half-pint milk cartons from the school cafeteria or plastic cups. Each containers used for planting should have a hole in the bottom to allow for drainage. What happens when a drainage hole is not present can be a subject for student investigation.

Pots with drainage holes need something into which to drain to keep the draining water from spilling onto counters or window sills. Clusters of pots can be stored on pizza trays for watering. If necessary, small saucers can be made for each pot out of aluminum foil.

The plants our students grow from their seeds are to be used for learning what things make a difference in the growth of plants. As our students experiment and learn, a number of plants may die. Some students become so attached to their plants that they do not want to risk a plant's demise. In anticipation of this attachment we can provide two sets of plants, one for growing and one for experimenting. If a student still cannot bring himself or herself to experiment on his or her plants, we can change that student's assignment to seeing how well he or she can get her or his plants to grow.

Seeds and very young plants should be watered daily, unless a student is experimenting with the effects of no water. Each student has the responsibility of watering his or her own plants. To help the plants survive weekends without water, a plastic sandwich bag may be placed over the top of each plant to trap moisture for the plant's weekend use.

Materials for each team of students available at the start:

Seeds.
Potting soil.
Pots.
Trays in which to place the pots.
Water and watering cans.
Magnifying glasses.

Questions:

What is a seed?
What is not?
How can you tell if it is a seed or not?
Do all seeds grow into plants?
Is there a tiny plant already inside the seed?
How deep should you plant the seed?
How much water does the seed need before it begins to grow?
Will the seed grow if it receives no water at all?

Questions to be asked over time:

What happens to the seed as the plant grows?
How does the plant know which way is up?
What happens if you take a seed that has started to grow and replant it upside down?
Will half a seed grow?
Will a seed grow in all water?
Do plants grow toward the light?
Do you always have to start with a seed?
Can a plant live without its roots?
Can a plant live without its leaves?
Which is more important, leaves or roots?
How much does your plant grow each day?
Measure how tall your plant is each day and graph your measurements.
Can you use your graph to predict how tall your plant will be tomorrow?
How good was your prediction?
How does a seed know when to start growing?
How does a plant know when to stop growing?
Do all plants stop growing?
What part of the plant grows? Does the entire plant grow or does it just grow at the ends?

Additional materials:

For darkness experiments, students may cover a pot with a box or a tin can.

Questions:

Will a seed grow in the dark?
What makes plants green?

Additional materials:

Sand.
Dirt.
Gravel.
Sawdust.
Rocks.

Question:

What else will the seed grow in besides potting soil?

Additional materials:

Whatever our students wish to add to their experiments that can be added safely and inexpensively.

Question:

What else do you think you could find out about plants and how they grow?

Students can answer the questions that we ask, or they can plan, direct and carry out their own experiments. Subject to the limits of safety and the availability of materials, we encourage our students' curiosity to lead them where it will.

Worms and other animals...

(illustration 15-0-6)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Mice, hamsters, snakes, tadpoles turning into frogs, animals of all kinds are objects of study in our class. If we wish to develop our students observational and experimental skills before larger animals are introduced, studying mealworms is a place we may begin.

Materials:

Mealworms (which are not actually worms, but larvae).
Bran or dry breakfast cereal flakes.
Large jar with bran in it, in which to store the mealworms.
Flat boxes for student observation of the mealworms.
Sandwich bags for sending mealworms home.
Magnifying glasses.

Material considerations:

Mealworms can be obtained in farm food stores, pet shops or biological supply houses. Six or seven-hundred mealworms is a sufficient quantity for a class of thirty students. If interest in the mealworms continues for any length of time, mealworms should be replaced every two or three weeks.

Among the advantages of studying mealworms are that mealworms are clean, odorless, inexpensive, and practically care free. Mealworms eventually grow into adult grain butterflies, but they cannot fly.

For any animals we study in our class, the golden rule for animal treatment in our class is: No harm is to be done to any animal, large or small, in any of the experiments we devise.

Materials for each team of students available at the start:

Mealworms.
Dry breakfast cereal flakes.
Flat boxes for student observation of the mealworms.
Sandwich bags for sending mealworms home.
Magnifying glasses.

Questions:

What can you find out about your mealworms by observing them?
Write or draw what you see.
Can you tell your mealworms apart?
If so, how can you describe them so that someone else could tell them apart as well?
How does a mealworm walk?
How fast?
How do mealworms eat?
How much in a day? A week? A month?
How does a mealworm find its food? By smell, or sight, or by bumping into it?
Can a mealworm see?
If you move your mealworm, can it find its way back?
Do mealworms ever seem to backup for no apparent reason?
Can a mealworm be made to back up?
What does a mealworm's path look like with and without food in its box?
Do all mealworms behave the same?

Keep track of what you do and what your mealworm does in response.
Does everyone always get the same results?
Is a mealworm smart?
What other questions can you think to ask?
What kinds of insects or worms or other living things can be studied in our class or at your home?
Find a bug at home. Study it. Report back to the class on what you learn.
Could you study your pet dog or cat?

The experiments in our class go in the direction that our students' observations take them. The answers to the questions we might ask reside within the mealworms and not ourselves. The factual knowledge gained by our students from studying the mealworms is not as important as the learning processes involved. As our students study their mealworms, they must be scientists. They must observe carefully, pose their own problems to be solved, create their own experiments, theorize, interpret and evaluate data, and generalize from what they see. They must explore the possibilities as they solve the problems that they pose.

We carry the learning from the mealworms to any other animals that join us in our class. Which of the questions we asked for mealworms might we ask again for hamsters or for Guinea pigs? What new questions might we add to our list for animals larger than a worm?

Boats...

(illustration 15-0-7)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Water.
Plastic buckets.
Empty half-gallon milk cartons.
Desktop containers for water. Plastic Tupperware containers work well.
Pizza trays or other equally wide trays to catch the water spilled from the desktop containers.
Blocks of wood.
Oil based clay.
Plastic sandwich bags in which to store the clay.
Unifix Cubes.
Plastic straws.
Aluminum foil.
Paper clips or other small weights.
Pint or quart size glass jars with mouths wide enough that a student hand can reach in.
Rubber bands.
Balances or scales (for advanced questioning if advanced questions are asked).
Paper towels and sponges for cleanup.

Materials considerations:

The water the students need for their experiments is placed in large plastic buckets stationed around the room so that students do not have to line up at a faucet to obtain water. The student assigned to get the water for his or her workmates takes an empty milk carton to a bucket, partially fills the carton with water, and transports the water back to the group

At cleanup time, selected students carry empty plastic buckets from desk to desk into which each work team empties its water container. These now filled plastic buckets become the water supply for the next day's work.

Materials for each team of students available at the start:

Water in containers.
Pizza trays.
Wood blocks, one per student team.
Oil based clay to stick onto the wood.

Questions:

Can you make your wood float flat?
Can you make it float side ways?

Can you make it float any way you want? It is okay to stick bits of clay onto your wood.
Can you make the wood sink and stay sunk?

Take the block of wood away.

Make your clay sink.
Make your clay float.
Why does it float?
Can you make it float a different way?
Is everybody's clay shape the same?
Make a clay shape and predict if it will float before you put it in the water. Then put the shape in the water and see if you predicted correctly.

Additional materials:

Small weights, like paper clips or tiny washers.

Questions:

How many paper clips will your clay boat carry?
Will a different shape carry more paper clips?
What's the most paper clips anyone's boat will carry?
Does it make any difference how the weights are placed in the boat? Is it possible to carry more weights if they are in the middle of the boat or along the sides?
What else can you find out about your clay boat?

Additional materials:

Aluminum foil.

Questions:

Make the foil sink.
Make the foil float.
Make the foil that floats, sink.
Can you make your aluminum foil boat still float while it also carries weights?
How many paper clips can your aluminum foil boat carry and still float?

Additional materials:

Plastic straws.

Questions:

Make the straw float.
Make the straw sink.
Make the straw float straight up and down in the water.
Make the straw float lying on its side.
Can you make it float crooked?

Additional materials:

Glass jars and rubber bands.
Two rubber bands go around the outside of the jar to indicate water level. One indicates the starting level of the water and one indicates any change that may occur.

Questions:

Place one rubber band around the outside of the jar to show where the water level is now.
What happens to the water level when objects are placed in the jar?
Do any objects make the water level rise?
Which objects make the water level fall?
Which objects placed in the water make the water level rise the most?
Would the same object push up more or less water if it was floating and you made it sink?
Would a bigger object mean more or less water up?

What happens to the water level as you add weights to a clay or aluminum foil boat?
Does the water level rise when the weights finally sink the clay or aluminum foil boat?
What else can you find out about why the water level goes up and down as you put objects in or take them out of the water or of the boat?

Additional materials:

A balance or a scale.

More advanced questions:

Fill the water to the top before you put the object in.
Weigh the water that spills over the side.
Weigh the object.
Which weighs more, the water or the object?
Is the pattern the same for other objects that you place inside your jar?
Does it make a difference if the object sinks or floats?

Today's learning brings with it the questions that our students might explore tomorrow. Today's learning also brings our students a heightened sense of the learning opportunities available to them everywhere they are. Asking questions and posing problems is not confined to science class. Wondering is not confined to school.

Changes...

(illustration 15-0-8)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Transparent plastic or glass jars and boxes, all with lids.
Water.
Eye droppers or spoons for adding small amounts of water to the boxes and the jars later on.
Magnifying glasses.
Objects to observe for changes. A sample list of objects that might be used:

Cookies	Bread	Meat
Milk	Cheese	Butter
Fruits	Vegetables	Coffee grounds
Salt	Pepper	Sugar
Marshmallows	Assorted spices	Flower
Raw eggs	Boiled eggs	Jello
Apple juice	Soda water	Graham crackers
Assorted cereals	Assorted seeds	Aspirin
Aluminum	Copper	Brass
Nails	Steel wool	Wood
Leather	Cloth	Leaves
Soil	Plaster of Paris	And so on

Materials considerations:

In advance of the questions that we ask, we prepare boxes and jars in which we place the objects that our students will observe. Since each team of students will only be observing one object at a time, we prepare a minimum of at least one more box or jar than there are work teams in our room. The maximum number of items we might prepare is limited only by the space available in our rooms and the storage containers we can find.

The exploration of some questions requires that varying amounts of water be added to the jar or box. When water is added, it is useful to have two boxes or jars containing the same item to be observed—one with water added, one without.

It might occur to our students to smell the contents of the boxes or jars as the changes are taking place. However, some molds that form on foods can be more serious to inhale than to eat. We instruct our students never to stick their nose into a jar or box to smell its contents. If smelling is done, it is best accomplished by opening the box or jar, gently waiving a hand over the opening, and smelling the air above. Smelling the contents of jars with mold should not be done at all, not even with a gently waiving hand. For mold, the observations should be limited to what can be visually observed.

As our students look for changes, we allow the time for changes to take place. We leave the boxes and jars in our classrooms for weeks and weeks and weeks. How long will it take for mold to form on a piece of bread? How long for rust to appear upon a nail? Student observations take a few minutes every day or so. Observing change continues while other science activities come and go.

How our students record their observations is a function of their ages and their capabilities. For younger children, we might serve as the recorder as they describe to us what they see. Older children can use drawings and words to record the object at the start and what changes they observe.

Materials for each team of students available at the start:

Jars and boxes filled with objects to observe for change.
Magnifying glasses.

Questions:

Look at the contents in the boxes and the jars. Predict which objects you think will change over time and which objects you think will always stay the same.
What kinds of changes do you expect to see?
Why do you think some things might change and some might not?
How will you know when there has been a change? How can you remember what the object looked like at the start?

As time passes, more questions may be asked.

What kinds of changes do you see?
Which objects have made changes similar to the changes that other object have?
Which objects have not changed at all? Why?
Do the changes that you see match the predictions that you made?
Separate the jars and boxes into wet and dry and see if wetness gives a clue. Wet means any object from which liquid might be squeezed.
Have the objects we call dry changed as much as the objects we call wet?
Do dry foods change? Why?

Additional materials:

Add small amounts of water periodically to each of the boxes and the jars.

Questions:

If we make the dry things wet, will they change?
Do only wet things change?
Will all dry foods spoil when they becomes wet?
Do all wet foods spoil?
Canned foods are wet, but they do not spoil in the sealed can. Why?
What effect does water have on objects that are not food?
Does change always mean the object is spoiling or decaying or rusting?
What kind of change do seeds undergo when they are wet?

The science activities we present are meant to increase our students awareness of the world in which they live. Mathematics is patterns and connections. Life is patterns and connections, too. Science helps our students translate the search for patterns and connections in our class to a search for patterns and connections in their lives.

Changes are a natural part of life, whether we pay attention to the changes or let them happen without giving them a thought. Changes do not happen without reason—they do not happen randomly. We examine changes in our class to increase the likelihood that our students will learn to pay attention to the changes that are all around them all the time.

Questions:

What changes occur in objects in our daily lives?
What causes them?