Science Explorer Series

Teaching Science To
Young Children

how2 FIVE SENSES

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Introduction

The how2SCIENCE approach to developing enriched science content is designed to improve the quality of science education for young children through teacher professional development. how2SCIENCE recognizes that educators face many constraints…limitations in resources, funding and, of course, time. As such, how2SCIENCE takes a utilitarian approach to facilitate the application of skills that can be directly applied in the classroom. Rather than presenting a defined curriculum, how2SCIENCE shows educators how-to develop meaningful science content that can be applied to any science topic and how-to connect science content to your lessons.

> *There is no learning curve with how2SCIENCE.* Rather, you are applying the skill sets you already possess in your teaching repertoire to developing science content. This approach allows you to customize and build sustainable science programs by providing you with the greatest flexibility in choosing how best to integrate science into your classroom based on individual program constraints, teaching styles and student learning methods.
>
> *Science-centric.* Throughout this book, content is developed using the science topic as the starting point, but it is not the only starting point. The potential inclusion of science content can be identified in every general-themed topic traditionally taught in most pre-school settings. Content can be fully integrated or layered into your lesson, but it is up to you to identify those connections and structure your science content accordingly. By performing a simple word association exercise you can identify relevant science topic that can be linked to your seasonally or holiday-driven lesson plans.
>
>> For example, the Thanksgiving holiday is generally associated with certain foods, including corn, cranberries and assorted gourds. A natural science link is to examine plants, fruits and seeds. The plant, fruit and seed topics can be elaborated into a multi-week exploration that includes observations of various seed types, seed dispersion, germination, roots, planting and growth, and comparisons between monocot versus dicot-type plants.

> You can expand your exploration to include content and experiments using corn-based products such as cornstarch, corn syrup, or corn meal. Another approach is to continue your seed exploration with an examination of the sink/float, i.e. density, properties of cranberries and other fruits, and elaborate this exploration into a more general lesson on the densities of solids, liquids and gases or the different states of matter. Here, too, the inclusion of corn-based products can be used to enrich your explorations. In addition, explorations of any and all subject areas can always be viewed from a five senses perspective, looking at the materials associated with and experiences of the theme or holiday.
>
> While there are more than a dozen different potential science-related activities and experiments in the Thanksgiving example, there are only a few subject areas, namely, plants, density and the five senses.

Science is everywhere. As you read this book, examine the activities you currently employ in your classroom and identify the "science" in these. For example, creating a bubble painting is a familiar preschool activity. Is there any science in this? For many of you, the connection may be obvious. Bubbles are filled with air, i.e., a gas. The bubble painting activity can clearly be linked to an exploration of gases or air. This and other similar types of activities represent science opportunities that can be used to add value and enrich young children's experiences by connecting the activity with science.

The Explore Activities included in this book should be viewed as starting points, bare minimums, designed to complement your content by providing context to your explorations. You will not find an index to these activities, since this is not a how2 experiment book. Science-based activities and experiments should be considered as part of a broader science initiative that enhances your ability to effectively communicate science to young children and with the objective of making your science content count!

The Building Blocks: 3 Skills, 4 Questions, 5 Senses & 6 Themes.

While you are encouraged to read through this book in its entirety, how2SCEINCE is pleased to present the essential building blocks for developing meaningful science content for young children, and children of all ages.

Explore Six Fundamental Themes. From birds to butterflies, solids to liquids, from the frozen tundra to tropical rainforests, you can use five basic themes to guide your explorations.

✓Change ✓Cycles ✓Growth ✓Diversity
✓Patterns ✓Energy-mediated Transformations

Use The Five Senses As Your Tools For Learning. Create sensory-rich science experiences.

Ask Four Simple (and Essential) Questions. The inquiry-based content development process distills your topic/subject into essential information and provides you with ready-made questions (and answers) for in-class use. These questions define basic connections; continue with more questions (who, what, where, when, why, how).

- What is "X"…
- How can we describe "X"?
- Why is "X" important?
- What if there weren't any "X's"?

Develop Three Process & Analytical Skills. The application of the following helps you elaborate your content that can be applied to scientific inquiries.

- Same, But Different (SBD).
- Compare & Contrast (C/C)
- Sort & Match (S/M).

The five senses are the tools we use to learn…to gather information…to make observations…to build memories…and experience life.

Chapter 1

Encouraging The Young Explorer

Children are naturally curious...observing, exploring, making predictions, and testing out their predictions through the manipulation of the materials in their environment. A child does not have to be taught to explore the world around them. Rather, it is a natural process that is integral to a young child's development.

But Children Are Not Scientists...

Child-directed discovery activities encourage the young explorer, but if kept exclusively within the child's domain the opportunity to impart foundational knowledge or develop process and reasoning skills may be lost without teacher facilitation. Providing children with a contextual framework represents the best of both worlds, namely, opportunities for discovery and exploration; as well as meaningful science content that not only enriches the discovery process but also enhances the child's ability to understand the world around them.

Science by its very nature is about connections and relationships. Most of these relationships are not intuitive. One of our most important roles as educators involved in teaching science to young children is to illuminate those connections, define relationships and facilitate their explorations. At first glance, many of these connections appear too intense or complicated to be meaningful to young children. Most science concepts, however, can be distilled into simpler concepts and presented with relevant, child-world examples that make them accessible and understandable to young children.

Some concepts and principles can be directly observed; others not. Some observations while seemingly correct can, nonetheless, lead to erroneous conclusions. In such cases, despite the best methodology and careful observation incorrect conclusions about how things work can occur without teacher-provided context or complementary content. While many view the process itself as beneficial, and sufficient to contribute to the science experience for the child. These, nonetheless, represent unfulfilled opportunities that can be used to advance a child's understanding of the world…their world. There are rules and fundamental truths in science. There are specific ways to apply scientific inquiry skills and methodology, or to use equipment such as a magnifying lens. A simple how-to lesson on how-to use a magnifying lens opens up a world filled with countless hours of self-directed discoveries, but only if the child knows how to use the magnifying lens properly.

Teacher-Facilitated, Child-Directed Activities

What is facilitation? According to the dictionary facilitate means to make easy, to make possible, to smooth the progress, to help or assist. According to the dictionary, the opposite of facilitate is to impede. Facilitate is a verb, an active process, an action, and in the classroom setting a reaction to the child-directed activities. Each form of facilitation has its place and time, and can be used to complement child-directed activities in order to enhance the value and maximize the benefit of early childhood science education.

Science Centers. Unfortunately, many science center activities and classroom science experiments fall short of fulfilling the purpose of teaching science to young children…knowledge. In many classrooms, educators rely primarily on "wow-me" type experiments, a cookbook of hands-on activities offered with little or any explanation. The search for bigger and better bangs often takes priority over the science and often includes the introduction of artificial, and even trick-based, elements. The science behind the experiment, its basis, is never explored or is offered with only a cursory look at the science. It should be remembered that science is not magic and packaging it as such diminishes its inherent value. While there is certainly a subset of science center activities that can be considered self-directed (i.e. self-contained and self-explanatory), the child's experience with these is greatly enhanced when the activity, process and outcomes is not only facilitated but also explained.

Review Science Center Activity Scenario A in terms of process and outcome.

A pre-K teacher places two plastic bottles in the classroom's Science Discovery Center. The two bottles are filled with glitter confetti, small buttons and beads suspended in different solutions. One contains red-colored water, and another with diluted corn syrup. Several children discover the bottle set and begin using them. Interest is high and more children join in the activity, tipping, tilting, swirling, watching and comparing how the small objects move in the two bottles. The teacher makes two more bottle sets, but decides to color the water differently in the new bottle sets.

During the week, the children explore the movement of the objects in the bottles. A few, believing there might be a difference between the different colored solutions, decide to tip-test the bottles. They find no difference between the colored water solutions, only that the materials in the clear (corn syrup) bottles all seem to move slower than in the colored bottles.

One child asks, "What's in the bottles?" The teacher tells her corn syrup is in some and water in the others. The teacher suggests that the child try to figure out which ones have corn syrup in them. The girl shrugs her shoulders and says, "okay." Another girl says, "I saw a magic wand in the store. It had glitter stuff in it and the glitter moved like these do."

By week's end interest in the bottles wanes and the following week the teacher replaces the bottle activity with a new science center activity.

- What is the purpose of a science center or self-directed activities?
- What did the children learn from the experience?
- Why or how was the science center activity chosen? What science, if any, was the teacher hoping to accomplish with the glitter bottles?
- How might the teacher have capitalized on the children's interest to develop content to complement the self-directed activity?
- What is the difference between the two solutions in the bottles that affected how the small objects moved through them?
- Did the use of different colored water solutions in the new bottle sets introduce a new, and unwanted, variable into the exercise?

- What do children know about corn syrup? Should the teacher have given the children an opportunity to work with the corn syrup outside of the bottle experience to expand the class' understanding of the properties and effects of the liquids in the bottles on the movement of the beads?

There are many ways and opportunities for a teacher to assist or facilitate a young child's investigation that does not diminish or intrude on the child-led component of the activity. In the previous scenario, the teacher presented the class with a science center activity, and while the activity was originally teacher-initiated it became child-directed. Was it really science? What was the science potential of the center-based activity? The activity certainly relied on scientific principles, but as described it cannot be construed as science. The children took the "experience" as far as they could, tipping, tilting, and occasionally swirling. There was indeed a difference between the bottles, but the "why" was never addressed. The bottles were a point of interest, a curiosity at best, but little more than a toy.

How might the experience be improved and the science evolved… emptying the bottles of their solutions and noting how slowly they pour would have been a simple follow-up as would including a third bottle filled with a mixture of both water and corn syrup, or a fourth bottle filled with oil and water. This might have launched an investigation of various types of liquids and their properties.

What science for young children isn't. A popular item in many classrooms is the use of glow-in-the-dark materials. The addition of fluorescent materials to the above solutions, or any experiment, for that matter, while interesting does not enhance the science, only the experience by potentially raising the children's interest level and thus increasing the longevity of the activity. The fluorescent "enhancement," in fact, detracts from the discovery process by introducing materials and phenomenon that: 1) are not natural to a child's environment; 2) are not easily amenable to explanation; and, 3) are packaged and presented as magic, and as such are inappropriate for young children.

Review Scenario B in terms of process and outcome.

A group of five (5) children make shadow figures on the ground. The next day it is cloudy and while they are able to still see shadows, they can't see them as well. The following day, the sun is shining again and through direct observation they examine their shadows at various times of the day. This time only four children participate in the activity.

The group's observations continue for several more days and become more sophisticated. They determine the sun causes shadows. They draw the parallel between the sun and a flashlight that can be used to make shadows on walls indoors. They observe how a tree's shadow also changes during the day. They observe how their shadows change during the day as well. They look to the source of light, the sun. They relate the changes in shadow length and movement to the sun's movement across the sky.

- Identify areas where the children might benefit from guidance from their teacher. Think about how you could help to clarify the children's observations.
- What types of classroom activities could you use to show how the Earth revolves around the sun and accounts for the apparent movement of the sun?
- Consider at what point during the children's investigation, you might assist/facilitate their study of the sun, shadows and shadow length.
- Think about how you might build on the small group's initial investigation to develop an exploration involving the entire class. How can you extend the opportunity to the entire class while still involving and also recognizing the original group's initiative?
- What type of lesson can you build off of the shadow exploration?

There are many opportunities for broad smiles in the child-directed exploration described above. The children involved in the experiment exhibited independence and initiative in conducting their investigation. They observed a phenomenon and sought an explanation. They "discovered" a relationship between the sun and shadows. They applied direct observation to themselves and the trees; ultimately building relationships and drawing conclusions.

There are, however, three red flags that need to be considered in determining the overall outcome and ultimately the value of the exercise, namely: 1) only a small group of children participated in the exploration, and as such only a few students benefited from the experience; 2) the children used direct observation, but they also looked directly at the sun; and, 3) after several days of careful observation they concluded the sun moves across the sky from left to right, from east to west-a valid observation, but nonetheless incorrect.

Review Scenario C in terms of process and outcome.
Approximately one month after the teacher and her class explored the property of density using both solid and liquid examples, a group of five students found an unusual item on the playground that they could not identify. After some discussion, the group decided to test whether the unknown object would sink or float. They proceeded into the classroom and asked their teacher for a bucket they could fill with water. They conducted their investigation and found that the object was a "sinker."

- Why did the students test the property of density?
- Does this reflect the "stickiness" of the lesson they previously had on density and thus represent a measurable outcome?
- What important lesson about solids did the class learn as a whole that was then independently applied by this smaller group of students?
- Did exploring the sink/float property of the unknown object yield information about what it is?
- How might you assist these students, and the rest of the class, in further exploring and determining the identity of the unknown? Of exploring other properties of solids?

Analysis. Some might argue that *Scenarios B and C* cannot, and should not, be compared. Except both explorations were not only child-directed, but child-initiated. Both groups demonstrated initiative; and, both applied their inquiry talents and skills in an attempt to explain/understand a phenomenon. Clearly, however, the foundational knowledge available to each group of children at the beginning of their explorations differed, but it is not that disparate. The distinguishing factor between the two groups is the role the teacher played in facilitating the learning process before, during and after the exploration.

In Scenario B, the students began an exploration on their own and came up with a conclusion based on their observations-a tremendous achievement in its own right which is to be applauded. But what exactly has the group of four students examining shadows learned? How to inquire should be your immediate response. While we can acknowledge and cheer that *Scenario B* has inherent value in fostering a young child's inquiry skills, the outcome (conclusion) needs a little work. A modicum of structure and complementary content could have yielded a much more meaningful experience that could be used to impart foundational knowledge about how the world works for the small group of sun-chasers. In addition, the exploration could have been extended from the independent small group activity to include the entire class.

In Scenario C, the students had been provided with general background information concerning the properties of solids, in this case density. They then applied what they had learned to a new situation, finding an unknown and attempting to identify and characterize it based on its properties. The lesson on density had been constructed in such a way as to include transferable skills that could be applied in this alternative playground scenario.

The Flipside. Is a lesson about the sun meaningful to young children? Will a child fully comprehend that it is not the sun that is actually moving, but rather we on Earth who are moving around the Sun? Complicating the explanation is the notion that the Earth also spins on its own axis. Is it important for young children to understand how this aspect of our Universe works? Is it important for them to learn this now? How can the children's fantastic effort be recognized while gently re-tooling their observations toward a correct conclusion? Is there a simple experiment that could demonstrate shadow length change using a flashlight in a fixed position?

Taking our cue from the children's interest in shadows, *Scenario B* can be easily followed up with additional investigations that can be conducted with the entire class. The extension activity might include using: 1) a wristband-styled sundial; 2) a flashlight in a fixed location; 3) indoor shadow play; or, 4) a simple playground experiment using a tall plastic bottle and a piece of paper to chart the bottle's changing shadow position and length.

Similarly, *Scenario C* provides an excellent opportunity for a follow-up, classroom-based exploration as well. The small group of children could actually talk about their experiment, a presentation of sorts, which serves to acknowledge their initiative and, perhaps, even encourage other children to follow their example. The teacher can utilize the opportunity to elaborate the investigation to include other properties of solids using the same unknown or other solids.

While no experience is ever wasted, in each of the scenarios the teacher was presented with a science opportunity that could have been used as a springboard for further exploration. By facilitating these types of inquiries, self-directed or otherwise, we enhance the value and maximize the benefits of the learning experience for young children.

Chapter 2

Making Content Count

Re-introduce yourself to science. Often when we think of science, we think of all the information that's out there--an amoeboid-type blob that is in a constant state of uncontrolled growth. As such we disassociate from science, making it this foreign thing, far removed from our lives. Except science, math and technology are a part of our everyday lives and essential to every child's future. In fact, science is at the root of our everyday activities, we just don't always recognize and appreciate it as science.

> *Science is everywhere and in everything.* Examine everyday activities with a science eye. Is there any science in washing our hands with soap, cooking food, being hungry, making Jell-O, peddling a bicycle, playing on a seesaw, spinning around in circles and becoming dizzy, or drawing with a crayon? In fact, there is science in all of it.

Set realistic goals. For young children, the information is not the end all and be all. Realistically, some of the information will stick; some of it won't. Realistically, we're not going to stuff a lifetime of learning into a child's head and we shouldn't even try. The goal of teaching science to young children should never be rote memorization or regurgitation of the facts. Rather, in the process of telling a science story we impart foundational knowledge, nuggets of information, that expand a child's understanding of the world around them. Most importantly, through the inquiry process we assist young children in developing the skills and tools necessary for future learning.

> *What science for young children isn't.* Science is not just about the "wow me" type of visual experiments and demonstrations. A teacher-led experiment/demonstration offered without explanation or a cursory "let's see what happens" comment lacks context. Stand-alone type experiments offered without explanation appear magical, mysterious to a young child.

Experiments need to be complemented with context-based content that is framed by real-world, child-world, examples that can be easily understood and assimilated.

How? We act as facilitators, developing science stories and content replete with appropriate visuals, and companion experiments and activities.

Making Science Meaningful For Young Children

In choosing and developing science content for young children evaluate the subject matter in terms of: 1) complexity; 2) demonstration/experiments opportunities; 3) entertainment/engagement level; and, 4) desired learning or skill set outcome.

In determining the suitability of the material with respect to age-appropriateness, ask yourself the following questions:

- Is the subject matter relevant to young children? Is it appropriate and meaningful?
- Can the subject or aspects of the subject be explained clearly and concisely?
- How many classroom hours should be allocated to the initial exploration?
- What visuals, experiments, resources are available?
- Does the subject matter enhance a young child's understanding of their world?
- Is there a practical context to the subject matter that can be used to enhance the value of the topic?
- What is the desired learning outcome for including the subject matter in the curriculum?
- Are there opportunities for reinforcement, whether self-directed, activity-related or teacher-reinforced, that can be used to clearly demonstrate a principle or concept?
- What skill sets or tools for further learning are embedded in the subject matter that can be applied to other subjects?

Promoting Inquiry & Process Skills

Teaching science to young children is not rocket science, though it may seem that way at times. The volume and scope of material can be intimidating to many educators, and unfortunately, there are few resource and reference materials that explain the science behind the experiments. But exploring science topics with young children is no different than applying the same fundamentals that you normally would in developing any topic or class lesson.

The how2SCIENCE approach to developing science content for young children incorporates convergent levels of thinking and thought processes with such familiar explore activities, as: 1) same, but different; 2) sort and match; and, 3) compare and contrast.

In addition, content that promotes both critical and creative thinking as well as problem solving skills can be incorporated by positing evaluative and divergent-type questions within your exploration, including: what if; suppose; what do you think; what might happen if; and, what if we tried this…

There are four fundamental questions that you can apply to developing content for any science topic.

What is X? • How can we describe X? • Why is X important? • What if we didn't have X?

By applying the above elements you will, by default, develop enriched science content that provides your students with a deeper understanding of the world around them.

Telling Your Story

Think about the setting you use to read with your class. The circle time, large group activity is conducive to an interactive discussion. Your class also has an opportunity to not only listen to you, but to hear from their fellow classmates. Certain elements of your science explorations are best suited to such a setting or a large group setting around tables, while other activities or experiments are best conducted with smaller groups.

how2 Begin…

Define the story, the information you wish to share. Most science topics are huge, even when hyphenated into thematic units. Simplify your content. Convey big ideas simply. Organize your thoughts and define your take-home message. In other words, what would you like your class to learn? Emphasize the development and application of inquiry, process and critical-thinking skills. When appropriate, ask the same question in different ways.

Tell A Story-A Science Story

- Use a "less is more" approach. Spend more time on key concepts. Your beginning, middle and end of the story may take a single class period, an entire week or dynamically evolve as you go along.
- Be aware of cues from your class about interest areas, relevant tangents, and future topics. Be flexible and seize the opportunity to expand your explorations.
- Set the scene by defining **basic connections**. Include an overview, an introduction, before getting into topic specifics. Basic connections provide the contextual basis for your topic or theme, and provide young children with reference points for the future.
- Ask questions to find out what your class knows. Use this opportunity to assess student's knowledge and to understand their experience base.
- Ask questions and let them ask questions. Actively engage in an interactive exchange of information, experiences and ideas. Encourage them to participate. Your questions will show them how to ask questions, how to inquire.
- Whet their appetites, figuratively and sometimes literally. Engage your class in the exploration with an introductory activity.
- Repeat key concepts, showing and telling in different ways.

Use Experiments, Demonstrations, Activities, and Show, Tell and Do.

- Complement key concepts with illustrations in the form of fun, interactive activities, experiments and demonstrations.
- Choose experiments that complement and provide context to your content.
- Try to eliminate stand-alone experiments. Use experiments to provide context; and, conversely provide content (context) to your experiments. Avoid the use of the term magic, no tricks, no Wala!
- Use familiar objects and examples, i.e. child-world references.
- Some experiments are hands-on; some are not, but your class can still be involved. Let them help you prepare solutions, mix ingredients, or let them see you do it.
- Prime the experiment with questions. What do you think will happen when…
- Test out variables. What if we tried this instead? If a child asks would this work too or what if we used this, take it to the next step…let's try it and find out!

Reinforce Content With Contextual Activities.

- Contextual activities can take many forms, including: easy-to-repeat, in-class exercises (see: *Can You Hear Me Now?*) or, in-class science projects that children can take home.
- The activity serves to reinforce content discussed in class, and provides a cue, a reminder, when children talk about their day or what they did in science.
- The take-home project may be constructed as part of an experiment rather than as a separate activity (see: *It's A Mystery!*).
- You may elect to prepare a "handout" or activity sheet that has a simple explanation on it.
- Contextual activities provide embedded opportunities for further learning beyond the classroom.

Integrate Science Explorations With Classroom Centers & Non-Science Activities.

- Math, books, movement, sensory table, manipulatives, dress-up, art, writing, and music. Some, all, or just one!

Your subject matter will determine, in part, the nature and types of activities you will make available for your class during the exploration. Some lessons are inherently science centric; other content areas may have science elements that you can integrate into the subject matter and layer/integrate into classroom activities and centers. Regardless of your science content, your classroom centers can include relevant child-directed activities.

Classroom Centers

Below is a sample listing of possible classroom center-based activities using butterflies and/or insects.

- Through movement and music act out the various stages of butterfly development or metamorphosis;
- Create a symmetrical ladybug or butterfly using a ladybug or butterfly template and pre-cut geometric shapes;
- Design sort and match games using pairs of butterfly pictures;
- Sequence butterfly or ladybug lifecycle stages of development;
- Build-a-bug using various materials or a Cootie game;
- Design a series of habitats and camouflage (hide) plastic insects in these;
- Use insect pictures for counting progressions; and,
- Use bug bingo playing cards for sort and match exercises.

Chapter 3

Developing Content Using The Science Story

The science story approach provides you with a structural framework for developing science content. This approach can assist you in defining key concepts and developing companion "illustrations" that provide context to your content.

What is a science story? Think about how you choose a storybook to read with your class. You look at the plot, the characters, the moral and the illustrations. In terms of science storytelling, the plotline and the characters form the elements of your story that you will use to convey key concepts. The take-home message(s) can be equated to the moral of the story. While the illustrations for your science story take the form of fun, interactive (sometimes hands-on) experiments, demonstrations, and easy-to-repeat exercises that serve to illustrate key concepts.

There is a beginning, middle and end. While all science topics can be connected to numerous other science topics or themes, it is helpful to clearly define the content of a given lesson relative to the content development process. This is not to say that you will not find yourself going off on relevant as well as irrelevant tangents or expanding your science lesson into a multi-part lesson that includes a related topic. However, by defining the content of your story you will be able to cover key concepts and ensure that you convey those key concepts to your students.

Tangents & Child-Directed Cues…

Science explorations can and will evolve on their own, in unexpected ways or in new directions. Children will ask questions or perhaps draw a connection you had not previously considered while developing your content. Use these opportunities to not only elaborate your science explorations, but to also encourage children's interests by validating their inquiries.

Developing the science story. In approaching any science topic begin by asking yourself questions about the subject matter. This can take the familiar form of who, what, where, when and why, plus how, are/is, can and what if… scenarios. Where possible ask the same question in a different way. Develop secondary or derivative questions. Always include process skills in developing your questions: how are these the same, how are they different; how can we compare them; how can we sort them, etc. Some questions will be more appropriate to certain topics and more amenable to investigation.

In the process of developing your questions, you will:

- Refine your content into smaller, simpler informational units;
- Define basic connections, the big picture topic, which provides context to your content. The basic connection usually reveals itself in the question, why is/are X important and what if there weren't any X's.
- Identify areas where you may need to obtain additional information and materials you will need for the lesson;
- Develop a series of questions you will be able to ask your class;
- Determine what other science information is relevant to your topic;
- Identify where experiments or exercises can be used to illustrate key concepts, and,
- Identify non-science type activities that complement your science content.

Connect the Dots. The inquiry based content development process allows you to identify BASIC CONNECTIONS. These connections are directly related content areas and provide context to your topic. For example, in exploring butterflies the obvious connection is to define butterflies as insects.

To arrive at this, ask yourself, what is a butterfly? The simple answer is, an insect. By making this connection, part of your exploration of butterflies as insects can then be applied universally to other insects. By framing butterflies within the big picture context, as an insect-one of many different kinds-you provide children with a "license" to apply their acquired knowledge to new experiences.

Applying the Process. In the following example, the teacher has decided to explore the subject of clouds with her class. How had the teacher arrived at the topic of clouds? Was she/he interested in a unit on the weather; maybe one on the water cycle; or perhaps, the seasons are changing and the first snow has fallen or it has rained for a solid week? Think about why you might choose to study clouds.

While the subject of clouds is used in this example, the model can be applied to develop content for any science topic traditionally taught in preschool settings. Try the following exercise to practice developing content.

Exercise #1: Developing A Science Story.

Step 1: Choose a topic. Determine if the topic is age-appropriate and if it fits the criteria described in the "Making Science Meaningful for Young Children…" section. You can "justify" the selection of clouds as an appropriate topic because:

1) Children have seen clouds;
2) Children can see clouds any time;
3) Clouds are important to the water cycle; and,
4) Clouds provide embedded opportunities for further learning and reinforcement beyond the classroom.

Step 2: Ask yourself questions about the topic. Include: who, what, where-type questions about clouds. When possible, ask the same question in different ways to refine the question. Incorporate process-type skills such as: compare/contrast, same but different, and sort/match in developing your questions, as well as what if… scenarios.

> What is a cloud? What is a cloud made of? Where do we see clouds? Where do clouds come from? How are clouds formed? Why are there clouds? Why are clouds important? Are there always clouds? What if there weren't any clouds? Are all clouds the same? How do clouds differ from one another? How can we describe clouds? What color are clouds?

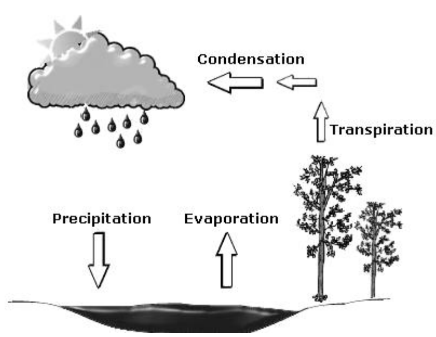
Step 3: Determine what you know. Review the questions you have asked. You probably already know the answers to many of these questions, while you may need to source out additional information for other questions.

> Your key questions to answer are: 1) how clouds are formed; 2) are there different types of clouds and if so, what are the different types of clouds; and, 3) do the different cloud types have a consistent shape or appearance that we can recognize and use to describe them?

Step 4: Gather your technical and classroom resources. Find a good introductory book or website on clouds that also has good cloud photos. While you plan on using the clouds in the sky, you have no control over what clouds will be in the sky on any given day, so a book with good photos will help you tell your story.

Step 5. Develop key concepts. Answer outstanding key questions about the topic.

- How are clouds formed? Clouds form when water vapor (water in its gaseous form) condenses. Cloud formation is part of the **Water Cycle**.



- How are clouds classified? There are three main types of clouds, namely: cirrus, cumulus, and stratus.

Step 6. Re-define your content. You now have new information about clouds, key information that forms the basis of your science story. This new information, however, leads you to ask new questions about clouds, and also what kind of big picture connection(s) you need to "draw" for your class.

- How do stratus, cirrus and cumulus clouds differ from one another in appearance, in composition? Should I use the technical names?
- How can I describe these differences? What does each type of cloud look like? Is there more than one type of cirrus cloud? Do I have pictures to show of each type of cloud?
- How and when should I incorporate direct observation into this exploration? What if there aren't any clouds in the sky on the day I want to explore clouds or if there aren't examples of all three main types of clouds?
- What other kinds of "illustrations" can I use? Are there any experiments or cloud activities I can do in the classroom?
- What about the water cycle? How and when do I introduce the concept of condensation? What about the other parts of the water cycle?

In using the science story approach, you have refined your content, distilled it into key concepts by asking fundamental questions about clouds. You have determined that not all clouds are the same, so you can develop process skills, i.e., same, but different; sort & match; and, compare & contrast with this exploration. Because of these differences, you can hyphenate the complexities of clouds by describing the three main types of clouds.

Step 7. Complement key science story concepts with illustrations, i.e. demonstrations, activities and experiments. For the cloud exploration you already have the clouds in the sky (whatever they may be), and the various cloud pictures from a book, depicting the different types of each kind of cloud. What else can you do and use to enhance your class' understanding of clouds? In other words, how can you help your class develop an appreciation for clouds?

Re-tooling Activities Into Science Projects. Have you ever made a picture with clouds in it? Did you use cotton puffballs or shaving cream? How could you re-tool this activity to incorporate the three different cloud types? What materials could your class use to make the three types of clouds using what you have learned about clouds? Stratus clouds are stacked, thick like a blanket; Cumulus clouds are fluffy and puffy; and, Cirrus clouds are thin and wispy.

One type of in-class activity is to create representations of each of the three cloud types. This might take the form of a take-home project on paper; a hanging mobile or an in-class weather chart with movable magnetic or felt pieces. What kind of materials could you use? Scrunched tissue wrapping paper or a couple of pieces of Kleenex for Stratus clouds; cotton puffballs or shaving cream for Cumulus clouds; and pieces of pulled fiberfill, gauze, or some other sheer material to depict Cirrus clouds. You might have your class observe a small portion of the sky for a short time and create their artistic view of the sky on paper. You might choose to include a simple water cycle diagram on the take-home sheet and/or questions for further learning.

Experiments. There is a simple "cloud in a bottle" experiment that requires a plastic bottle, a small amount of hot water and that you "seed" your "cloud" formation reaction with a match. Is this particular experiment necessary? You certainly don't detract from your exploration by including it. Will it illuminate clouds further for your class? Not really. What comes out of and is contained in the bottle looks like smoke, a cloud of sorts. Perhaps, more meaningful to your exploration of clouds would be a series of simple experiments involving evaporation and condensation to reinforce the connection to the **Water Cycle** and which complements your exploration of clouds.

Direct observation. The last element to consider in developing your clouds exploration is when and how to incorporate direct observation of clouds. You can certainly launch or conclude your exploration with a look up at the sky. Just envision your class lying on the ground and looking up at the sky. Clearly, your class will have a new appreciation for the clouds in the sky after your in-class exploration.

One approach is to bookend your cloud exploration with direct observation, and to include relevant questions accordingly.

> What kind of clouds do you see? How many different kinds of clouds can you find? Are there thin and wispy clouds, stacked clouds or fluffy puffy clouds in the sky? Do you see just one type or all three? Do all wispy clouds look the same?

Embedded Opportunities for Further Learning. The direct observation component of your cloud exploration not only provides context and reinforces your in-class exploration, but also provides the necessary cues for child-directed further learning experiences. Later that day or on any given Sunday, some of your students may take notice of a specific cloud type, they can refer to their "make a cloud" activity and look for a "match" in the sky. The opportunities for continued observation are endless and ongoing…as long as there are clouds in the sky!

Science Is About Relationships

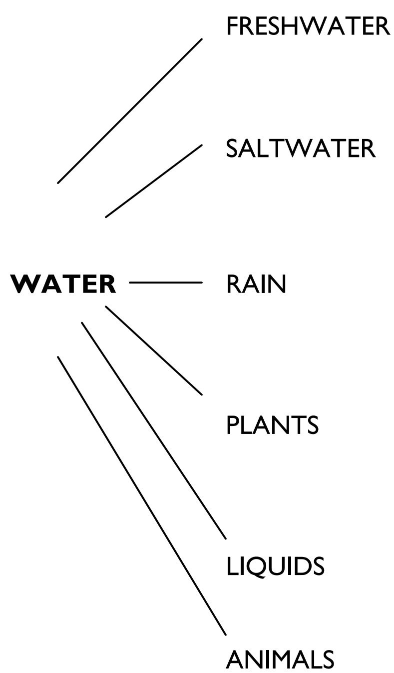
The urge to quit; the impetus to continue. At some point during this exercise, you probably questioned your sanity in selecting this topic and wondered whether you should continue your investigation of clouds (or for that matter any science topic). Clouds appear to be far more complicated than you intended your exploration to be.

Reality check. The reality is all science topics are potentially huge. All science topics can be connected or related to numerous other topics with very few degrees of separation. Should you view your exploration of clouds as a standalone unit? No. While clouds can be connected to many topics, it is most directly linked to a study of the Water Cycle and the processes of condensation, precipitation, and evaporation. Should you consider first teaching a unit on the Water Cycle or leading off with an exploration of the processes of evaporation and condensation before proceeding with clouds? Only you can decide, but consider the following with respect to clouds. Condensation defines the process by which clouds form. The Water Cycle provides context, relevance to the subject of clouds by giving meaning to the statement, "Clouds are important because…" It's important to remember that science, by its very nature, is about connections and relationships. Most of these relationships are not intuitive. A child cannot be expected to approach a phenomenon through a self-directed activity if they are not even aware that the phenomenon exists.

Exercise #1. Science Relationships.

Connect as many topics as you can to water by using word associations and topic relationships to create your branches. Hyphenate topics into separate, but potentially overlapping branches.

(See Connections Diagram: Appendix A).



Chapter 4

Give Me Five! Senses

How do we use our five senses? Our senses tell us about our environment and the world around us. We experience life with our five senses, building memories, knowledge and information that we use to interpret future experiences. Our five senses, together with our brain, are the tools we use to learn. What we learn and the associated memories we have are sensory based, inextricably linked to the smells, tastes, sights, sounds, and feel (touch) of the experience.

Our senses provide sensory cues to our brains about the things we like, and about the things that are potentially dangerous to us. Everyday is rich in sensory input-some unique to a day, a holiday, birthday or special event; while, others are ubiquitous to everyday life. Sometimes all five of our senses work together; and, sometimes we use just one or two of our senses.

Our brain remembers the experiences of our past, triggered by visual, auditory, olfactory, gustatory, and tactile cues, and applies that knowledge to future experiences. Often, the process is passive and we are not even aware that we are using our five senses. Think about your immediate surroundings…is the chair or floor you're sitting on hard or soft? Is the room hot or cold? Is the sun shining now or is it cloudy? Is someone cooking in the kitchen? Is it a food we like? Is there a skunk nearby?

Hopefully, long before you ever see a skunk you'll recognize its distinctive smell. In smelling it, you become aware of its presence. Your senses are now on high alert, on the lookout for the elusive skunk. But how do you know to stay clear of a skunk? When did you learn to associate that particular smell with a skunk, and that it is an animal to be avoided at all cost? At some point in your life you learned about skunks, what it looks like, and how it smells. You experienced the skunk through your senses, specifically its odor, and the scent memory stays with you forever.

While each of our five senses is important, much of the information we gather from our environment is visually based. For example, we don't need to touch a porcupine to know that its quills are likely sharp. Through experience, we have come to associate long pointy things that have a narrowed tip with objects that are sharp. Perhaps the initial encounter was with a sharp pencil, an accident with a pushpin, or we were told to never run with sharp objects like scissors. At some point in our lives we encountered long pointy things and have subsequently applied our knowledge to other objects and similar experiences.

The experiences of our lives and our knowledge is embedded in the information we gather, both actively and passively, through our five senses. The sensory input received through our senses is an ongoing process that expands our world and our understanding of it.

Experiences Differ

The smell of popcorn is unmistakable, the sight of steaming fluffy white popped kernels tempting, but where does the experience of popcorn for a group of children from diverse socioeconomic backgrounds and home environments begin? Many children have experienced popcorn through slim microwave packages. They can take one look at the package and recognize it as popcorn. Others have watched it popping in an air popper, at the movie theater or even heating in oil on the stovetop. Still other children may have never gotten close enough to a microwave oven to hear the pops, or seen corn kernels before they've been popped and many do not realize that the popping kernels come from the more familiar corn on the cob. As you explore the five senses realize that the sensory cues related to specific experiences will likely differ among the students in your class based on cultural, ethnic, religious and geographic influences.

KEY CONCEPTS: **Introducing The Five Senses**

Our five senses help us learn about our environment.

We have different sense organs for each of our five senses.

Our brains help make sense of all the information we receive from our five senses.

Animals have senses too. These tend to be far more specialized and acute than our own five senses, because animals must rely more heavily on their senses to survive.

Getting Started…

Many teachers choose to explore a unit on the five senses at the start of the school year since the timing correlates well with "Getting To Know You" and "About Me" themes. Others select a particular holiday, such as Thanksgiving, and explore the associated "flavors" and sensory experiences associated with the holiday. While there is no "best time" to explore the five senses, there is a rationale for including it toward the beginning of the school year.

As described at the beginning of this chapter, the five senses form the basis of how we learn and experience life. This applies to children as well as adults. Every science exploration is experiential in nature, and as such relies on sensory input from our senses. Objects and materials have a certain look and feel. Metals differ from plastics. We observe, analyze, compare, and describe the differences in terms of visual, auditory, gustatory, olfactory and tactile input, and develop a "library" of reference information we can call on in the future. As such, heightening a child's awareness of their senses through an exploration of the science behind the five senses provides young children with a basis and a vocabulary to describe, compare and analyze.

Regardless of when you choose to explore the five senses, try to teach it as a continuous unit as part of a multi-week lesson plan. Allocate at least one full week for each of the senses, with the exception of the senses of smell and taste, which can be combined. Where appropriate, include explorations and/or comments about specialized animal senses, such as, echolocation in bats, dolphins and whales for the sense of hearing; thermal (heat) sensing and infrared imaging by snakes; and, night vision in nocturnal animals.

Establishing Basic Connections-The Overview

Ask Questions. Begin with an overview of the five senses, how we use them, the organs associated with each sense and why we have them, then explore each sense one at a time. If you choose to overlay your five senses exploration with a specific season or holiday you can include themed take-home art/science projects accordingly.

A • E • I • O • U

Assessment. Find out what your class knows. Nearly every child knows they use their nose to smell, eyes to see and ears to hear, but things get a little dicey when you ask about taste (tongue) or touch (skin). In addition, children may not know that these organ systems collectively are known as sense (sensory) organs or that we have five senses. Choose your questions accordingly, introducing the five senses by using the proper terms, noting the organ and/or body part, and by defining the functions of sight, smell, taste, etc. as the five senses. By finding out what your class knows, you can structure your lesson to fill-in the associated blanks, gaps or correct common misconceptions.

? ? ?
Questions

- What are the five senses? Can you name the five senses?
- What organ (body part) do we use to see…hear… smell… taste…touch?
- How do we use our five senses?
- What part of our body puts all the information together?
- Why do we have five senses?
- What do we use our senses for?

Engagement. Combine your initial questions with an *Engagement Activity.* The activity can be viewed as a type of hook that serves to actively engage your class. Engagement activities can take many forms, but are frequently packaged as a kind of guessing game, or a sort and match exercise. The activity can be prompted by questions such as, what is it, what do think is in it, where is it, or, how do you know. For example, "secretly" popping popcorn (best if done with an air popper) and asking your class to describe the experience is a good gateway into the Give Me Five! Senses lessons, or you can challenge them with a simple guessing type game that encourages them to use all five of their senses. (see: Explore Activity #1: What Is It?).

Interaction. Telling a story to young children is an dynamic interchange of information. Think about how you read a book with your class. The book is your tool. Rarely, if ever, do you sit in front of your class and simply read the book. You show them the illustrations and discuss the nuances of the story. The same applies to your science story. Make it an active and interactive process.

Organizational Framework. Organize your story into key concepts. These are the relevant points about the subject that you wish to convey. The content development process assists you in identifying and prioritizing content. Logic will, in part, determine the order in which you will present information, as will child-interest areas. While it is difficult to generalize what defines the beginning, middle and end of a topic, look at each day's lesson as having its own beginning, middle and end.

Understanding. While science subjects are chocked full of information, not all of it is appropriate, or more importantly relevant, to young children. While you have spent time gathering information about each of the five senses (or any other subject matter) that information should be doled out in small, meaningful doses. For example, the detailed, fine structure of each organ system associated with the five senses or the neuronal connections of these while relevant to the five senses, the content, in all its detail, is not necessarily relevant or meaningful to young children. The wealth of information may instead become a source of confusion. The ultimate goal in teaching science to young children should be to increase their foundational knowledge and understanding the world around them. The nuances of anatomy and neuroanatomy are best left to future study beyond preschool.

Introducing the Five Senses With An Engaging Activity

Sight. What can we tell just by looking at our unknown? Is it big or small? What shape is it? What color? Does it have a pattern or a part that you can recognize? Does it remind you of something familiar, something you know?

Touch. How does it feel? Is it safe to touch it? Is it sharp? Is it hot or cold? Touch it. Is it rough or smooth? Hard or soft?

Sound. Does it make a noise? How can we find out? Shake it. Squeeze it. Do you hear anything?

Smell. Does it smell? Bring it near your nose. Does it smell good or bad? Does it smell like anything familiar?

Taste. Is it something you can eat? Does it look like food? Is it safe to taste? Taste it. How does it taste? Does it remind you of anything familiar?

Explore Activity #1: What is it?

Using an unusual food item is an easy way to launch your exploration of the five senses. Referring to your "unknown" food, ask your class what it is or what they think it is. (Hopefully, no one will know.) *Possible unusual food items:* prickly pear, pomegranate, coconut, Asian pear, sushi seaweed wrap, vanilla bean, chestnuts, beets, red cabbage or a fresh herb.

Observe, experiment (experience) and ask questions. Working as a group, have your class describe the item using each of their senses in turn. Build out vocabulary skills with adjectives and other descriptive words. You can prompt the initial investigation of the unknown with leading questions, i.e. does it smell, how does it feel-rough or smooth, etc.

After introducing the five senses with an exploration the "unknown" item, move on to a more detailed exploration of each sense or repeat this exercise by asking your class to describe other objects using each of their five senses.

Chapter 5

Get In Touch With The Sense of Touch!

As you embark on your explorations of each of the five senses, you can apply the inquiry-based content development process described in previous chapters. In general, to improve the quality of your questions you may find it helpful to first do some reading about the topic to facilitate the process. The questions provided below are used as a basis for exploring the sense of touch and include derivative-type questions as well, in this case, questions related to skin. Note that not all of the information nuggets provided are designed for kid consumption, but are intended for your own edification.

Content Development Questions

What is the sense of touch? How do we use it? What part of our body do we use to experience the sense of touch? Where is the sense organ associated with touch? Where do we "feel" things? Do all things feel the same? Is there only one kind of touch sensation? How are these the same? How are these different? How can we describe the experience of touch relative to certain objects? Is our sense of touch the same all over our body?

What else does our skin do? What does our skin look like? Is everyone's skin the same? How is it different?

Is our sense of touch the same as an animal's ability? How is it the same? How is it different?

General Key Concepts

- Skin is the body's largest organ.
- The skin is not only a sensory organ, but it also protects our internal organs (what's inside our bodies).
- The skin has sweat glands, which helps us to regulate our body temperature.
- The skin has three types of touch receptors. There are touch receptors that are sensitive to: pressure, pain and temperature.
- The concentration and type of sensory receptors varies over the surface of the body and makes some areas more sensitive than others.
- The fingertips, tongue and lips are among the most sensitive areas of the body because these contain more nerve endings than other areas.
- Animals have specialized skin cells that make up claws, spines, hooves, feathers, scales, and fur.

Feel It All Over!

Generally when children are asked what they use "to touch with," most will respond by waving their hands in the air or will shout out, "hands." Reinforce the idea that every sense has an organ, a body part, associated with it. With our sense of touch it is actually our skin that is the primary touch organ. Unfortunately, many reputable texts are misleading in this regard as well. It is important to broaden a child's appreciation for the sense of touch as a whole body, all-over experience. Kids can easily relate to their assorted scrapes and bruises--head, shoulders, knees and toes.

Show, Do & Tell-demonstrate key concepts with follow-up activities.

Rather than just stating that our sense of touch is an all over-body experience because our skin covers our bodies, include activities that allow your class to explore/experience the sense of touch using not only their hands, but face and feet as well.

Explore Activity #2: Feet First!

Have your class take off their shoes and walk on various textured surfaces, including: "hot" (warm, no hot coals), cold, rough, bumpy, smooth, hard and soft surfaces). Ask them to describe and compare how each surface feels.

As a follow-up take home activity, make footprints with cool squishy paint! Turn this fun activity into an active learning opportunity with starter questions, like how does the paint feel? Is it smooth? Is it cold? Can you feel the paint squishing between your toes? Extend this activity to include handprints or add various textured materials, i.e. sand or oil, to the paint.

The 3 C's: Concept, Context and Content

Meeting the challenge of challenging concepts. A thousand words later, you look into the blank faces staring back at you and you realize the explanation of a key science concept has been lost somewhere around word ten. As a rule, "less is usually more." This applies both in terms of how much to teach in a given science lesson and what you choose to say about a topic. So then how do we develop content that counts?

Sample Concept: Our skin is the sense organ that lets us sense temperature, pressure and pain.

Right about now, a loud alarm bell should be ringing in your head! As stated, the above concept is neither simple nor easy to present. So how do we simplify it and translate it into information a child can relate to?

Begin with a simple idea or the simplest concept then move on to more complex concepts.

Who knows what skin is? Where is our skin? It covers our bodies.

What does our skin do? We use our skin to feel things.

Has anyone ever touched something hot, a stove, hot food? Our skin can tell us if something is hot or cold.

Should we touch a pot on the stove or go near fire? No. Why… because it's hot.

In the winter when you go outside and the wind is blowing, is it hot or cold? How do you know? You can feel it. Where? On your face, hands and feet. You feel it on, and with, your skin.

When you get into the bathtub or a swimming pool, how does the water feel? Bath water may feel warm, while a swimming pool's water or the ocean might feel be cooler against our skin.

Do we feel it with just on our hands? No, we can feel it all over.

This simple introductory "story" to the sense of touch is logical and builds progressively from one concept to the next. By using this approach you establish several foundational concepts, specifically that the sense of touch is a whole body experience because the organ responsible for our sense of touch, our skin, covers our entire body. Secondly, you have defined one of the ways we use our sense of touch, namely, for sensing temperature-hot and cold, and various points in between. Like each of our other senses, the ability to sense hot and cold is a protective mechanism. This is a fundamental principle associated with each of the five senses. Repeat it.

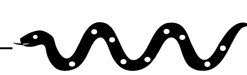
Concept: With our sense of touch, we are able to sense if an object is hot without actually touching it. We can come close to the object and tell if it's hot.

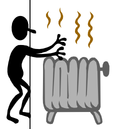
Provide context. Whenever possible, provide context to your content, complementing each key concept with a follow-up explore activity.

The contextual activity serves to:

1) Reinforce each key concept;
2) Demonstrate the concept in action; and,
3) Give your class time to assimilate the information before moving on to the next key concept.

Did you know that pit vipers and other snakes are able to sense a warm body (food) from several feet away? Snakes create a type of thermal image, a heat image, to determine where best to strike its prey. Areas such as the heart and arteries appear hotter to the snake and make the best striking targets.





Explore Activity #3: Sense It!

Examine how sensitive your hands are to temperature differences. For cold, use a can of soda. For hot, try using a piece of equipment that generates some heat, like a computer monitor or other piece of equipment.

- Set a cold bottle on a table. Don't tell your class if the bottle is hot or cold.
- Have them slowly bring their hands close to the bottle (or piece of equipment), without actually touching it.
- See how close they have to be to tell if the object is hot or cold.

You have now introduced one aspect of the sense of touch, giving it context with both a discussion (a story) and an explore activity (an illustration). Having established the sense of touch, you can refer to it as such and move on to the next related topic.

What types of child-world examples could you offer that would help define the ability to sense hot and cold? Think about a child's normal routine, eating food, going outside to play, swimming in a pool or taking a bath. Each contains tangible examples of how children relate to their ability to sense hot and cold using their sense of touch.

> *Choose examples and experiences from a child's world.* A child's relationship to their skin is generally taken for granted, except when they get hurt. Discussing how our skin protects everything inside our body would be meaningless without first discussing surface "owies." Children can easily relate to a cut, scrape, bruise, a shot at the doctor's office, putting hot food in their mouths or touching a hot stove.

Stay on topic with a related concept. What else does our sense of touch tell us? What happens if you fall down and scrape your knee, bump your head, or cut our finger? It hurts. Where have you gotten hurt? Head, knee, arm, toe? Our skin gets injured-hurt-and we feel it. It hurts.

Summarize your science story as you go. …So with our sense of touch we can tell hot from cold, or if we get hurt we can feel it because of our skin. What else does our sense of touch tell us?

Sample Concept: There are deep pressure receptors located in the dermis of the skin (lower portion of the skin), and "light" pressure receptors located in the epidermis (the upper layers of the skin).

There goes that alarm again! Simplify The Concept.

Is the floor (or chair) you're sitting on, hard or soft? How do you know? You can feel it. Our sense of touch also tells us when we're touching something, or if something is touching us. We are able to feel the pressure of something against our skin. Some things push hard; others lightly. So with our sense of touch, we can tell if something is hard, soft, rough, sharp or smooth, etc.

Explore Activity #4: Feel the Pressure!

We can feel pressure on our skin. We can feel the light touch of a feather against our skin and when someone is pushing against us. Both are components of our sense of touch.

- Gather your class on a carpeted area and distribute feathers to all. Compare how the light touch of a feather feels against your chin, lip or wrist.
- Compare the feel of a feather to what pressing your finger into your chin or wrist feels like. The two feel very different, but you can feel both kinds of pressure against your skin.
- Next, ask your class rub their hands over the surface of the carpet. How does it feel, rough or smooth?
- Ask them to rub their hands back and forth very quickly on the carpet. After about ten seconds, have them lift their hands away from the carpet. How do their hands feel now?

Applying Inquiry Skills To Your Explorations

Up until this point we have dealt with three aspects of the sense of touch: temperature, pain and pressure. Of the three, pressure is not only the most difficult concept to grasp, but also the subtlest form of touch. As such, an additional explore activity that investigates various textures is warranted.

In the "Have a Ball" exercise described below, you can apply three fundamental inquiry skills by exploring different textures using: 1) same, but different; 2) compare and contrast; and, 3) sort and match.

Explore Activity #5: Have a Ball-Ten of Them!

Gather as many different kinds of balls you can find. These should differ in size, color, texture and bounce. Have your class compare these using descriptive words.

Begin by defining your collection of balls as balls. It may seem absurd or too obvious to define the collection of balls as balls, but in looking at the great diversity in balls you are presenting your class with a fundamental principle in science that can be applied to nearly every animal or plant system you will explore in the future. Consider the following fill-in the blank. With some minor tweaking of the sentence, you can substitute everything from seeds to birds and all subjects in between.

> There are many different kinds of ________. How are ______ different from one another? How are ________ the same? Let's take a closer look.

By examining each ball, and the collection as a whole, you are defining what makes a ball a ball and what distinguishes one ball from another. How are all balls the same? How are they different? How does one ball compare to another? How can we group or sort our collection of balls…by size, shape, color, texture, or whether they bounce?

Our collection of balls is no longer just a random sampling of round (or oblong) things. We have applied order to them, an organizing principle. They are all balls, but balls can be very different from one another. Many balls bounce. Some bounce better than others. Some balls are round. But not all balls are round. Some balls have a smooth surface; others are rough. Do all the balls feel the same? How are they different? Some balls are heavy; while, some are light.

Perhaps, when it's time to store the balls away again, all the sports balls will go into one bin, the bouncy ones in another, or your class may choose to sort them by size or using some other ball feature.

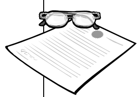
Challenging The Senses.

Clearly, our perception of the world would be very different were we unable to hear, see, smell, taste or touch. Our senses work together as we gather information from our environment. But what would happen if we could not use all of our senses? In the following exercise, your class can "test" their sense of touch, and also gain an appreciation for what it might be like if we had to rely more on our sense of touch in the absence of one or more of our other senses.

Explore Activity #6: Missing Pieces

Gather several simple wooden puzzles. Put the puzzles together, leaving out one of the pieces, i.e. the missing piece.

- Turn off the lights so that the room is very dark and have your class navigate their way around the puzzles, first locating the empty space, i.e. the missing piece section.
- Provide your class with the missing piece and have them try to fit the missing piece into the puzzle by touch alone.



Explore Activity #7: Feel The Signs

A follow-up activity to "Missing Pieces" is to take your class on a field trip to the elevator or any other location with Braille signs. Have them examine the Braille numbers next to the elevator buttons, using both their hands and eyes. Explain how people who are unable to see, must rely on their other senses. In this case, they use their sense of touch to read.

Bring Home The Message With Take-Me Home Projects!

Young children love to show off what they've done in class. Parents are naturally curious about what's in a child's cubby, the day's project or activity. By including a science-based activity you provide both child and parent with an opportunity to discuss an aspect of the day's activities, in this case, their science activities. Take-me home projects and easy, follow-up "home-based" experiments provide embedded opportunities to promote further learning beyond the classroom. You can also design your content for easy re-telling and repeatability by the child.

Explore Activity #8: It's A Mystery…

You can use this exploration as both an in-class activity and as a take-me home project. There are several variations on exploring the sense of touch using mystery items. For example, you can place mystery items inside of paper bags or socks. The sock-based version literally adds another layer to exploring the sense of touch by initially eliminating direct contact with the object. Should you decide to use the sock method, first have your class try to identify the items through the sock, i.e. without directly touching the objects, then as you would do by placing the mystery items inside a paper bag, have them then place their hands inside the socks to see if they can more easily identify the mystery objects.

Try one or more of the following categories of mystery items to explore different aspects of the sense of touch: 1) a random mix of objects with no relationship in terms of size, shape or texture; 2) similarly shaped objects that differ in texture and hardness only; and, 3) items that can be easily identified by touch alone mixed with items that are more difficult to identify by touch alone.

If you are linking your exploration of the five senses to a specific holiday or seasonal theme, include a special themed surprise in the mystery bag or sock.

It's in the Bag!

- Place a variety of items that differ in shape, texture, and hardness inside a brown paper bag. You can also include an item that has a distinctive smell, such as a crayon.
- Have your class place their hands in the bags and then describe what they're feeling based on their sense of touch alone.
- Without looking, have the kids use their sense of smell to see if they can identify anything in the bag.
- Provide your class with a picture of one or more of the items in the bag, such as a button and a feather and ask them to find it in the bag, without looking. Glue the picture to the outside of the bag; then glue the identified object to the picture and add a "Sense of Touch" label to the outside of the bag.

Taking An Integrated Approach To Science

Science content can be actively woven into companion activities and classroom centers. Below is quick summary of questions that can assist you in developing various companion center activities. The examples provided relate specifically to the sense of touch, but can be applied to other topics. The number and types of companion activities you choose to include will, of course, depend on the topic. As you review the list, you will likely note that you have already developed materials, projects and companion literary, movement, drama, art, music, math and sensory-based activities for use in an integrated program.

Literature. What books deal directly or tangentially with the science topic or related theme?	Group these into fiction (F) and non-fiction (NF) resources. Choose when it is appropriate to read a fiction book. For example, after learning about the sense of touch, put some time and space between your science content and a story of *Goldilocks and the Three Bears*.
Drama & Movement. Is there a popular story or imagination-based scenario associated with the topic you can act out using pantomime, dress-up or playacting?	For example, children can express what it might be like to hold a hot potato. As a follow-up, play *Hot Potato*. Use pantomime to express reactions to tasting/touching something hot, feeling cold, stubbing a toe, having a toothache, etc.
Art. Can the topic be thematically explored, directly or indirectly, using art or some form of artistic expression?	Use finger painting to explore textures. Mix paint with various textured substances (sand, crumbled natural items, salt, and corn meal). Create a collage using different textures or examine closely related "pairs" of materials. See if your class can describe the similarities and differences between: cotton balls and poly-fill; burlap, rope and twine; and, different papers (construction, cardboard and tissue).
Music. Is there a song directly or indirectly related to the five senses? Is there a musical instrument that relies on the sense of touch?	Strum a guitar, bang on a set of bongo drums, play a piano, or blow on a reed instrument. Each of these musical instruments incorporates one or more aspects of the sense of touch, i.e. vibrations against your lips, fingertips or hands. You can also use your musical excursion to segue way into your next topic, for example the sense of hearing and sound.
Math. Is there a connection to a math-oriented activity that can be applied to the sense of touch?	Use a variety of simple counting and sorting activities to separate similarly textured or shaped items. In addition, since we are dealing specifically with the five senses, you can focus on the number five with various math-oriented activities.

Science Center Activities

Choosing Science Activities. As described in previous chapters, most science center activities should be chosen and developed as a means to end, not as an end in itself. In general, science center activities should be used to extend and/or complement your in-class science explorations. Activities can, of course, be self-directed but there should always be a reason for its inclusion, and an opportunity to provide science content related to the activity.

One approach to developing science center activities is to scale-up one of the activities you have previously used in class and add a new twist. For example, using *Explore Activity #8: It's in the Bag* as your basis, you could scale up the activity using a large cardboard box filled with oversized foam ABC letters. For this activity, you might choose a word related to the five senses in general, or specific to the sense of touch or the next sense that you plan to explore, and have children locate, without looking, the specific letters to spell out the word.

Another approach is to include new and unusual materials. Up until this point, your class has worked mostly with textured solid materials. In your science center, you might drop a few pennies into containers filled with various types of liquids including: water, Oobleck (corn starch & water), hand lotion, bubble solution, oil and shaving cream.

When selecting materials and activities to include in your science center consider why you are including this explore/discovery activity in the first place. What is the purpose or value of the activity? Is it relevant and integral to the topic at hand? If so, is the activity truly self-explanatory? If not, what type(s) of facilitation could you provide to extend the learning opportunity and make it more meaningful?

Chapter 6

Keeping Up With Science

1 + 1 = 2. Beehive cells have a hexagonal shape. Mixing red and yellow paint together will give you orange. Some fundamentals that we teach do not change; others do. The very nature of scientific inquiry and ongoing scientific research provides us with new information about nature and how things work.

For many years, specific areas of the tongue were associated with the ability to detect particular types of foods, namely salty, sweet, sour and bitter. The famed tongue tasting diagram, a hallmark reference for learning about taste, is considered passé. In fact, new research has shown that we are able to sense the different categories of taste with many different parts of our tongue, though there are areas that have higher concentrations of certain types of receptors. Ironically, what was once considered a standard teaching method is now being abandoned.

Say NO! To tongue-tasting areas

Has anything else changed we should know about? You bet! Unfortunately, many printed books do not carry this new information and finding reliable information and sources on-line can be a bit daunting. So what's a teacher to do? Begin by recognizing that rarely is anything in science absolute, or that there is just one kind of truth. The only truth you can count on is that for every rule there is at least one exception and usually more than one exception. In updating your science content, use reliable resources and try not to speak in absolutes.

> **Speaking Of Change…**
>
> The taste receptors in our tongue are able to detect five, not four, classes of substances: bitter, sour, sweet, salty and *umami* (savory). *Umami* (ooh-mah-me) is a new/old taste sensation that was discovered in the early 1900's by a Japanese scientist. It was officially added to the list several years ago. Umami is our ability to detect amino acids found in protein-rich foods, specifically the amino acid glutamic acid (which is related to monosodium glutamate, MSG).

About Our Senses of Taste and Smell

Why Five Senses? As described previously our five senses provide us with information about our environment. Our sense of taste not only feeds our hunger for certain foods, but also serves as a warning mechanism so that we can avoid spoiled foods or poisonous plants (sour and bitter, respectively). Similarly, our sense of smell draws us toward all those wonderful aromas in the kitchen, but also warns of potential danger such as smoke or spoiled foods.

Because the sense of smell and taste are physically linked to one another, the senses of smell and taste have been combined into a single unit. It is important, however, to first establish each sense separately, identifying the corresponding organs and their functions. As you proceed through your explorations, you will be able to make the connection between the two and explain how these are related to one another.

How smell and taste work together. When we chew food, certain chemicals in foods are released. Our taste buds by themselves are able to tell our brain that something like ice cream is sweet or that a sour apple lollipop is sour. With our eyes closed and nose plugged, however, we aren't able to tell the particular flavor of ice cream (whether it's chocolate, strawberry, or pistachio) or if the lollipop is sour apple or lemon flavor until we let go of our nose and have another taste. *How?* The chemicals released from food travel up into the nose via the back of our throat. These chemicals then trigger the olfactory (smell) receptors inside the nose and are recognized as specific odors (smells) to create what we perceive as flavors!

It's not just about taste! Some things that we sense as taste are, in fact, not really a function of taste. With many types of foods that are physically cold or hot, your sense of touch also comes into play. With "hot" foods such as peppers, pain receptors are also triggered. As yet, a specific receptor for fats has not yet been identified though there is some scientific evidence to suggest there is a taste phenomenon involved with fats as well. Scientists believe that the sensations associated with fatty foods, such as creaminess or smoothness (textures) is related more to a touch phenomenon that is perceived by the tongue as well as other parts of our mouth.

Content Development Questions

What do we use to smell with? What do we use to taste with? How are taste and smell related? What is the purpose of our sense of smell or taste? Do all foods taste the same? Are foods the only things that smell? Do all things smell the same? How can we describe different tastes or smells? How do we use our sense of smell or taste? Why is the sense of smell important? Why is the sense of taste important? When can't we smell things?

Key Concepts

- The bumps on the tongue are called *papillae*. These contain the taste buds. Each taste bud is made up of approximately one hundred (100) receptors, or "taste" cells. The average person has about ten thousand (10,000) taste buds.
- People, and most animals, use their noses to filter out particulate matter; humidify and warm incoming gases; and, for breathing.
- The upper part of our nose normally receives the chemical signals from the foods we eat. When our nose is congested the chemicals in foods or in the environment cannot trigger the olfactory receptors that inform the brain and create the sensation of flavor.
- Smell receptors are able to sense certain categories of odors (chemical signals), including: mint; floral; ethereal (pears); musky; resinous (camphor); foul (rotten eggs); and, acrid (vinegar).

Salt. Salts, like potassium and sodium, are needed for proper water balance inside our cells, and for muscle and nerve activity.

Sweet. Sugars, such as carbohydrates, are high-energy foods.

Savory (Umami) is associated with our ability to detect protein-rich foods, specifically the amino acid glutamic acid.

Bitter tastes are generally associated with poisonous plants, though there are many bitter tasting foods we normally eat such as mustard and coffee.

Sour is associated with acidic tasting foods, including: citrus fruits, unripe fruits and spoiled foods (milk). Kids have a particularly acute sense of sour and tend to love it!

Developing Your Science Story

The key concepts described above provide you with the relevant facts for your discussion of the senses of smell and taste. But facts alone do not a science story make. Similarly, hands-on experiments or demonstrations alone cannot tell the whole story. A science story about any topic needs companion visuals (illustrations). These visuals can take many forms, including: experiments, interactive activities, and demonstrations as well as in-class projects that children can take home.

> *Building Out Your Story.* To develop enriched content and content-driven explore activities begin by identifying and stating in simple terms the concepts you wish to convey to your class. In other words, what is a statement you would like to make about the senses of taste and smell? Continue by stating more individual concepts. If you are familiar with the subject matter continue by asking yourself basic who, how, what why, where questions about each concept statement. Also include what if…and what do you think scenarios to build critical thinking and problem-solving skills. Apply fundamental inquiry skills to develop your content, including: same, but different; compare/contrast; and, sort/match.

Try the following exercise to build a science story about the sense of smell. Your story will develop as a combination of questions and statements. Keep it familiar. Keep it simple. Begin at the beginning.

What do you want your class to learn about the sense of smell?

We use our nose for smelling. How does our nose look? Take a look. All of our noses have two openings. If we hold our nose, or if it's stuffed up from a cold, it is very difficult for us to smell things.

What are some basic questions you could ask about the sense of smell?

What is a smell, an odor? Where do smells come from? Who can name something that smells? Do all things smell the same?

Smells/odors travel. Have you laid the groundwork for this concept? Try to approach the key concept that "smells travel" in another way.

You don't always have to be near the source of an odor to smell it. You can smell things from far away because smells travel. Smells are carried by the air or wind. Smells travel.

What new questions might this key concept raise that merit further explanation?

How can smells/odors travel? Smells/odors are actually chemicals, tiny molecules we can't see, but we can smell them. How? They travel into our noses. (see: Explore Activity #12)

You've now built out part of your story about the sense of smell, but you have also raised some new questions. Now ask yourself how you can convey your story concepts with simple illustrations, i.e. explore activities using familiar items or objects.

How To Use Explore Activities…

- Explore activities do not have to be complicated.

  Have your class stick out their tongues and examine their tongue papillae with a mirror.

- Explore activities can be used to launch a topic or to reinforce concepts.

- Use one or more explore activities to explore each key concept or to develop related concepts. Think about what the types of explore activities you could use to show/demonstrate the following key concepts.
  - Not all things smell. Not all things smell the same.
  - Smells (odors) travel.
  - We can taste the difference between salty, sweet, bitter, sour and umami.
  - Our sense of taste helps protect us from eating foods that aren't good for us. Our sense of smell can also let us know if food, such as milk, is spoiled. (Our sense of sight does too!)

- Explore activities can be both observational and experiential.
  - Examine, smell and taste different types of fruits.
  - Compare a variety of different spices for smell (and taste).

- Give explore activities a real world context, a child-world context.

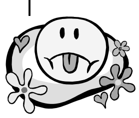
  Our sense of taste helps us tell if food is safe and good to eat. Ripeness is one example. Unripe fruits tend to be acidic. Acidic foods taste sour.

Explore Activity #9: Ripe Versus Unripe!

To explore this aspect of the sense of taste, have your class examine the differences between ripe and unripe fruits using their sense of sight, touch, smell, and taste. Relate this to going to the supermarket where people often touch, thump, smell and, sometimes, taste fruit to tell if it is ripe, i.e. good to eat. Good fruits to use, include: bananas, grapes, peaches or pears.

Weave together explorations. After your class has made their initial observations about unripe fruits, try aging a banana for several days. Do this in plain view. Look, feel, smell and taste the banana after a day or two. Compare the differences in appearance, smell and taste to a fresh banana.

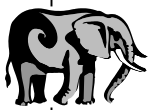
> **IMPORTANT NOTE:** When working with fruits, please be mindful of fungus, bacteria and chemicals that may be found, though not always seen, on fruits and vegetables!



Explore Activity #10: Tasty Treat Test!

Sample a variety of different foods corresponding to sweet, salty, sour, bitter and umami, including: lemon wedges and lemonade, candy, honey, jellybeans (sweet and sour), potato chips, pretzels, and unsweetened cocoa. Smell sour milk or taste some plain yogurt. For umami, you can try dissolving a beef bouillon cube in water. You'll get a combination taste of salty and savory, but definitely distinct from salty alone. Also try mixing sweet and salty tastes with chocolate-covered pretzels or yogurt-covered raisins.

Reinforce your sense of taste exploration. After exploring each of the different taste categories, have your class affix printed words for sweet, sour, bitter, salty, and umami to a *"Smiley" face handout* or make a collage of different food pictures cut out from a magazine.



Explore Activity #11: Same, But Different

Many animals have a highly developed sense of smell. Some animals, like snakes "taste" the air with their tongue, sampling their surroundings. Some insects have smell receptors located on their legs. Take a look at and discuss some familiar and unusual animal/insect mouthparts and noses.

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Questions

- What are nostrils used for? How do animals use their noses differently from people?
- Most animals have moist noses. Do you think this might help an animal smell better? Why?

Explore Activity #12: Where's That Smell?

Demonstrating that smells are chemically based is challenging because molecules themselves can neither be seen nor touched. Smells as physical entities, however, can be demonstrated using one or both of these simple transfer techniques.

Note: Since flavor extracts are usually made with alcohol tasting is not recommended with children.

- Smell an orange and the rind.
- Rub a section of the rind on a piece of paper or squeeze an orange peel so that some of the essence squirts out.
- Use a familiar flavor extract (like banana or vanilla) to show how the "smell" component can be separated from the original food.

???
Questions

- Referring to an orange, where is the smell strongest…on the orange peel (rind) or the orange itself?
- Where is the orange smell the strongest…on the inside portion or outer portion of the rind?
- When you bend the rind or rub it on the paper, does the smell of orange stay on the paper?

Explore Activity #13: Aromatherapy

Make spice sachets, smell cups, or smell sticks using whole cloves or other spices.

- Generously apply glue to the bottom of a 3 oz. paper cup or onto one side of a craft stick.
- Leave a small portion of the stick free of glue (and cloves) so kids can hold onto the stick.
- Sprinkle whole clove spices over glue and press gently.

Alternatively, you can use netting or tulle (available from any fabric or hobby craft store). Use raffia, ribbon or pipe cleaners to tie off the spice sachet.

Chapter 7

The Sense of Hearing-Good Vibrations!

In this chapter, you will be able to develop a science story using the principles described in previous chapters. The content development process uses both primary and secondary questions to build out the science story as a series of key concept statements. Some questions and key concepts described below are included for your own edification; while, others can be directly applied in the classroom. **Note:** some questions are asked in several different ways, retooling them, in part, for in-class use.

Content Development Questions

What is the sense of hearing? How do we use our sense of hearing? What organ is associated with the sense of hearing? How does the ear look? What are the parts of the ear? What parts of the ear can we see? Do all ears look the same? How are they different? How do we hear? What do you hear? How many different kinds of sounds do you hear? Can you still hear if you cover your ears? Can you describe how a rabbit's ears are different from your ears? What about a dog, an elephant, or a hippopotamus' ears, how are these different from our ears or from one another? What is sound? Where does sound come from? How does sound travel? How does sound move? Are all sounds the same? How do sounds differ? How can we describe sounds? What if we couldn't hear? Why is hearing important?

how2 Use Your Questions:

- Develop the key concepts for your science story;
- Identify what additional background information you need to obtain;
- Engage students in inquiry-based explorations; and,
- Identify areas where companion experiments, demonstrations and/or activities can be used to illustrate the key concepts.

*How we hear…*As sound waves "strike" the eardrum, the pressure is transmitted to the three tiniest bones in our body: the hammer (incus), the anvil (malleus), and the stirrup (stapes). These bones physically move in response to sound waves. The stirrup lies against the membrane separating the middle ear from the **inner ear**. The inner ear is also responsible for helping us maintain our equilibrium (balance). The part of the inner ear associated with hearing is the cochlea, while the three semi-circular canals are responsible for maintaining equilibrium. The inner ear is filled with fluid. As the sound is transmitted, the fluid is compressed. The fluid brushes against tiny hairs that line the membranes of the inner ear. This movement then triggers nearby nerve cells that send these sound messages to the brain. The brain then interprets the meaning of the sounds we hear.

R

Did you ever wonder why spinning makes you dizzy?
Blame your middle ear. The fluid in the inner ear spins with us. After we may stop moving, the fluid keeps going for a little while longer and so we feel unbalanced.

ting Your Questions To Key Concepts

- The ear has three main parts: outer, middle and inner ear. (What do we use to hear with? What organ is associated with the sense of hearing? What are the parts of the ear? How does the ear look?)
- The **outer ear** consists of the fleshy skin portion and the auditory canal. (What parts of the ear can we see? Do all ears look the same? How are they different? Can we still hear if we cover our ears? How do we hear?)
- Sound waves enter the ear and are amplified as they move through the auditory canal to the **tympanic membrane.** (How does sound move? What are the parts of the ear? How do we hear?)
- The tympanic membrane (eardrum) can be likened to a drum. It marks the beginning of the **middle ear**. (What are the parts of the ear? How do we hear?)

Relating Your Questions To Key Concepts (cont'd)

- Sound is caused by the vibration of an object. (Where does sound come from? What is sound?)
- Sound travels as a wave and ripples out in all directions. (How can we describe sound? How does sound travel?) Sound waves travel in three dimensions, meaning that the waves spread out in all directions, including up and down. (How does sound travel?)
- Sound waves exert a pressure force, moving air (or another medium) from the source of the sound to our ears. (How does sound travel?)
- Sound waves can move through solids, liquids and gases, but it travels at different rates through each medium. (How does sound travel?)
- Sound travels fastest through solids, followed by liquids, such as water, and then air (gases). (How does sound travel?) The ability to distinguish between high and low sounds in liquids is poor.
- Sound waves travel to our ears where they make the eardrum vibrate. (What is sound? How does sound travel?)
- Sound has three characteristics: pitch, quality, and loudness. (How can we describe sound? How are they same/different?)
  - The loudness of a sound is determined by: 1) the distance from the source; 2) the intensity of the vibration; and, 3) the surface area of the vibrating object.
  - The pitch of a note is determined by the speed of the vibration. A faster vibration creates a higher pitch. A slower vibration creates a lower pitch. Pitch can be influenced by the mass of the vibrating object-the greater the mass; the slower the vibration.
  - The quality of a sound includes those characteristics that make one sound distinct from others. Quality allows us to tell the difference between a car, a truck, or a wagon traveling down the street.

Complement Key Concepts with Related Explore Activities

Key Concept: How do we use our sense of hearing?

Explore Activity #14: Shake Things Up!

Make two homemade shaker toys. These can be made from small closed boxes, empty film canisters or metal Band-Aid boxes.

- Fill one box to the top with beans, and only partially fill the second container with beans or some other small noisy objects.
- Shake the containers, one at a time. Compare the sounds.

Questions

- Is there something inside the box? How do you know?
- Does Box#1 (full) sound the same as Box #2 (half-full)?
- Can you tell what's inside the box? How could we find out?

What type of Take-Home project(s) related to Activity #14 could you do with your class? Is there a musical instrument you could make in class? Is there a type of musical instrument that is reminiscent of a shaker toy? Are there other types of hand-held shaker type instruments you could "play" in class?

Key Concept: What do you use to hear with? How does the ear look?

Explore Activity #15: Lend Me Your Ears!

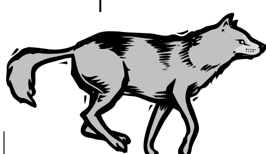
Have everyone show off an ear or two! Note how all "people" ears pretty much look the same. Identify the outer, middle and inner parts of the ear using a simple diagram or picture book.

Note: while it is not necessary or even recommended that you explore the internal structure of the ear in great detail, it is useful to show how the tympanic membrane (eardrum) can be likened to a drum.

Explore Activity #15 Lend Me Your Ears! (cont'd)

- Have your class cover their ears with their hands? Can they hear as well?
- Have your class cover just one of their ears. How do things sound?
- Have your class cup their hands, making rabbit ears. How do things sound, louder or softer?
- How are our ears shaped differently from elephant, rabbit, hippo, dog, or cat ears?

You can also use Explore Activity #15 to compare and describe different sounds, noting that some sounds are loud, others soft; and, that some sounds are high, and others are low.



Why do you think most animals have good hearing? Animals must rely on their senses to survive. The better these are, the greater advantage they have. Being able to hear well can be an advantage for both predator and prey animals.

Key Concept: What is sound? Where does sound come from?

Explore Activity #16: Feel the Vibrations, I

Like all sound, the sound of our voice comes from air rushing past our vocal cords, which causes the vocal cords to vibrate. That vibration makes the sound of our voice. Draw attention to the fact that our ears, nose and throat are all connected.

- Have your class gently rest hands against the side of their throats and sing a song. See if they can feel the vibrations in their throats.
- Continue singing, but ask your class to cover both of their ears. Then cover just one ear. How does the sound of their voice change when they cover just one of their ears and both of their ears?

Explore Activity #16: Feel the Vibrations (cont'd)

Questions

- How do we make sounds? Can you feel the vibrations of your voice?
- Have your ears ever gotten clogged, like when you have a cold? Does your voice sound different, kind of funny?
- How do things sound when you cover your ears? Can you hear as well when you cover your ears?
- Is it difficult to figure out where a sound is coming from when you cover one ear?

Explore Activity #17: Clink & Clunk!

- Fill a set of four glasses (or identical glass jars) with increasing amounts of water; the fourth glass should be nearly full.
- Tap each glass with a metal spoon. Compare the sounds. Do all the glasses sound the same?
- Tap out your best (or worst) rendition of "Twinkle, twinkle little star" on the glasses. Note the differences in tones.
- Cover the top of one of the glasses with your hand, or hold the glass in your hand and tap it again with the spoon. How does the sound change? Remove your hand and tap it again.
- Add enough water to each of the glasses so that they now all have the same amount of water in them. Tap again. Do the glasses all sound the same, or different?

You can perform a variation of this using other musical instruments. For example, see what the effect is on the sound produced if you stuff the bottoms of a set of bongo drums. If bongo drums are not available try this with a couple of large oatmeal boxes.

What's happening…

In the last part of Explore Activity #17, you are asked to cover the glass with your hand. Why does covering the glass change the nature of the sound produced? What change has occurred at the source of the sound by covering the glass with your hand? Can you hold the glass in another way and also affect the nature of the sound produced?

Think about the experiment and the nature of sound. By holding or covering the glass you affect the ability of the glass to vibrate freely.

Key Concept: What does sound do? How does sound move?

Explore Activity #18: Can You Hear Me Now?

This activity relates the key concept that sound waves travel (move) and how we are able to hear things from out in the hall, music playing in another room, or when a fire engine siren is blaring from far away!

- Have your class spread out across the room.
- As they remain in the same place, you move around the room, out into the hall, into the in-class bathroom (door closed).
- At each new location ask, "Can you hear me now?" When you are inside the bathroom, knock on the closed door, and ask if they can hear you knocking.

Your class should be able to hear you in each of the locations. Also each child is able to hear you, even though they are in different locations. Why? Because sound waves move!

Catch A Wave!

- Have your class wiggle their hands and bodies around like waves, keeping in mind that sound waves move in all directions…up, down and all around.

Key Concept: What is sound?

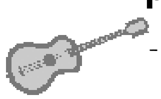
Explore Activity #19: Feel the Vibrations, II.

- Tie four to five 12-18" long pieces of string to a triangle. Make sure you use the triangle holder or if one is not available, tie a piece of yarn to it, so you can hold it.
- As you hold the triangle above your class' heads, have each child grab hold of one of the strings, pulling it tautly.
- Tap the triangle with a mallet or similar device. Each child will be able to feel the vibrations through the string.

Explore Activity #20: Feel the Vibrations, III.

- Using a small toilet paper roll, secure a small piece of wax paper over one end with a rubber band.
- Distribute a roll to each child.
- Have each child hum, talk, or sing into the open end, while gently resting their open palm or just their fingertips against the wax-papered end. The vibrations should be easily felt.

Explore Activity #21: Showing Vibrations



- Using a small metal tin container or a shoebox, stretch three different weight rubber bands across the open top. Leave some space between each of the rubber bands so you can pluck them individually.
- Twang or strum across each rubber band. Compare the sounds.
- Have your class hold onto the container and let them feel the vibrations being transmitted through the metal as you twang the rubber bands.
- Place two different colored sands inside the tin (or shoebox) and once again twang separately on each of the rubber bands.

Questions

- How does the rubber band move when you pluck it?
- What happens to the sand as you pluck or strum on the rubber band?
- Does the sand move the same distance when the different rubber bands are plucked?

Explore Activity #22: Change-Up Pitches

- Using paper hot cups (not Styrofoam) cut two ¼" vertical slits into the rim, opposite one another.
- Wrap a rubber band around the cup, catching it in each of the slits.
- Twang or pluck the rubber band, then change the length of the rubber band by squeezing the sides of the cup. You should get a nice range of pitches!

Explore Activity #23: Cup Telephone

Just a whisper into a cup telephone is amplified and efficiently transmitted from one end to the other.

IMPORTANT NOTE: the sounds transmitted through a thin string or crocheting thread is intense for any age ear, please modify your cup telephone design as described below to make safer phones.

- ✓ Do not use a paperclip to affix yarn inside the cup, use tape instead.
- ✓ Use wax coated 5 oz. paper cups to minimize the chances that the bottoms will pop when the yarn is pulled taut. (Test the cup bottom by seeing if you can push it in).
- ✓ Use heavyweight yarn instead of string to prevent hearing injuries!

Explore Activity #23: Cup Telephone (cont'd)

To demonstrate how sound is amplified prepare a sample cup as follows:

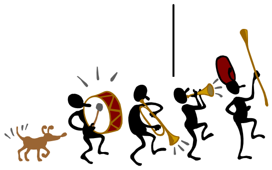
- Thread a 12-inch string (crochet or yarn) through the bottom of a paper cup.
- Hold the cup by string out in front of you, so that the cup dangles about waist high.
- With your free hand, rub the string between your thumb and forefinger. You will be able to hear a very loud scraping sound!

Cup Telephones

- Separate the class into two groups and distribute the cup telephones.
- Have them stand far enough apart so that the yarn on their cup telephones is pulled taut between each pair of students.
- Before you begin the communication phase of the experiment, have your class watch as you pluck or strum the yarn with your finger. They should be able to observe the yarn vibrating.
- Have them listen to what the "plucking" sounds like through the cup telephone.
- Have your class pass a secret word related to your exploration of the sense of hearing (such as sound and vibration).

Explore Activity #24: In Synch…

Art and music has always evoked emotions and moods in people. Crank up the radio or CD player and dance, or pick up a paintbrush and paint to beat of the music!



Explore Activity #25: Strike Up The Band!

Make one or musical instruments with your class, including: a simple rubber band guitar/banjo using a shoebox or a toilet paper roll shaker instrument filled with dried beans. In addition you can make wind chimes using a variety of metal objects, such as spoons, or by hanging a variety of different sized clay pots or PVC tubing cut to different lengths.

Specialized Animal Senses: Five Senses & Then Some!

Animal senses differ from humans and other primates in several ways: 1) animals may have specialized organs; 2) their sense organs may be located in different places from what might be considered traditional; 3) their sense organs may be more finely adapted such as for night vision; and, 4) their sense organs function beyond human norms.

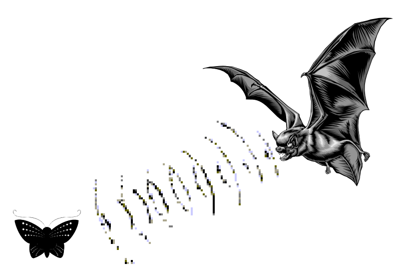
Discuss several different types of specialized animal senses, including how:

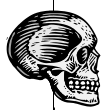
- Reptiles taste with their tongues.
- Butterflies have taste receptors on their legs.
- Earthworms have taste receptors all over their bodies.
- Many animals have a keen sense of smell, especially pigs and dogs.
- Dogs, and many other animals, can hear sounds we can't.

Echolocation.

Bats, dolphins and whales use sound in a unique way…to navigate as well locate food. Echolocation lets the animal know how close something is, where it is and, to some extent, how large it is. In a way, animals use sound to see.

How Echolocation Works. Animals send out a high frequency sound signal, which we can't hear. As the sound wave travels, it bounces off another object and back to the animal. This bounce-back wave is the echo. The echo returns to the animal in a certain amount of time. An echo from an object farther away takes a longer time to return to the animal. While the echo from an object that is closer returns faster.





Explore Activity #26: Feel The Vibrations, IV

WARNING! This activity must always be conducted under adult supervision. Children should never place the strings directly into their ears, or the part of their fingers that are wrapped with the string! This activity shows how sound is transmitted through solids materials, such as bone. Marine mammals, including dolphins and whales, use the bones in their heads to echolocate.

- Drop a metal spoon or a metal hanger on the floor. Listen to the sound.
- Using the same spoon (or hanger), tie a piece of 12"-15" long crochet string or yarn to it (1 per child).
- Hold the spoon by the string and let it swing against a hard surface (countertop, table, etc.). Listen to the sound.
- Next, have each child wrap the end of the string around one of their index fingers, and then have them rest the tip of their finger against the bone near the outside of their ear. For safety sake, they can also place their fingers near their temples. **Again, do not put the string or part of the finger wrapped in string directly into the ear!**
- Dangle the spoon and allow it to swing into the same hard surface you used before. Listen to the sound, hear and feel the vibrations!

Questions

- Can you feel the vibration through the string? What if you used a different type of string, like yarn?
- Compare the spoon sound to the hangar. How do the sounds compare? Why does the clanging spoon sound different when you use the string?

Take Me Home!

Explore Activity #27: Echolocation

- Provide each child with an *Echo Chamber* (toilet paper roll). Have them listen through the tube.
- Tell your class they are hungry dolphins in search of food. Have them speak into the tube, saying, "We are dolphins looking for food."
- Provide each child with a *Fish Stick* (a small fish picture glued to a Popsicle stick).
- Have them repeat the phrase, "We are dolphins looking for food," only this time they should place the Fish Stick at the end of the tube, covering the opening.
- Have them repeat the phrase several times moving the fish stick back and forth, and bringing it closer and farther away from the tube's opening.
- Listen to the difference in the quality of the sound.

Questions

- When you listen through the tube, are sounds louder or softer? How does your voice sound, the same or different?
- Can you feel the vibration on your hands, or lips?
- Is there a difference in the sound when the Fish Stick is near the end of the tube?
- How does the sound change as you move around the Fish Sticks?

Chapter 8

The Sense of Sight-"Eye" See You!

Developing a science story that is rich in both content and illustrations begins with a series of Content Development Questions. In this chapter you will examine the process of elaborating, categorizing and organizing your questions and resulting content. This approach allows you to hyphenate your questions into *Basic Connections, Essential Content* and *Challenge*-type questions. In so doing, you will be able to: 1) dynamically evaluate when and how to use Challenge-type questions during your exploration; 2) identify age-appropriate content and related explore activities; and, 3) hyphenate your content accordingly.

Defining Basic Connections. These questions generally take the following form: Why is "X" important?; What if we didn't have "X"? ; or, Why do we have "X"?

> *Why is the sense of sight important? What if we didn't have it? The sense of sight allows us to see. The sense of sight is one of the five senses. Our five senses tell us about the world around us. The sense of sight is CONNECTED to the five senses.*

Essential Content Questions. Essential Content Q's contain the substance of your science story. The answers (key concepts) are integral to the topic. In general, this category of questions contains fairly obvious activities and experiments that can be easily matched to key concepts and thus easily incorporated into your lesson.

> *What happens if we close our eyes? Activity: Have your class close their eyes. What happens if we turn out the lights, what can we see? What can't we see?*

Challenging Questions. Challenge Q's evolve your science story beyond traditional norms. These content areas require some finesse in terms of description and delivery. Depending on the subject matter, developing substantive answers to convey these in class might actually be counterproductive. In some instances, the identified key concepts may not be easily amenable to explanation or illustrations and are best excluded, in part or whole from your story.

In the previous chapter you were able to demonstrate sound in terms of vibrations using multiple experiments, activities and demonstrations. At first glance, this aspect of the sense of hearing might be considered too complicated, but you were able to provide context with tangible examples that served to clarify your explanation of the nature of sound.

The sense of sight, on the other hand, represents a content area that includes within its scope such sophisticated concepts as the visible light spectrum (electromagnetic radiation) and the complex inner workings of the eye. Neither of which can be easily described. For example, while you can demonstrate what image inversion looks like on the retina using a shadow image, a glass bowl and a flashlight, showing it does not necessarily make the inner workings of the eye more understandable or meaningful to young children. With this said, it is nonetheless possible to engage your class with a variety of activities and experiments that deal with different aspects of the sense of sight while purposefully providing a less detailed, scientifically oriented explanation of complex phenomena. As noted below [1, 2], before dismissing challenging content entirely realize that it may contain "easy" elements that you can use in your exploration.

Content Development Questions

Basic Connections: What is the sense of sight? How do we use it? Why is the sense of sight important? What if we couldn't see?

Essential Content: What organ (body part) do we use to see with? How does the eye look? What parts of the eye can we see? How can we describe the eye? How does the sense of sight work? Besides our eyes, what do we need to see? Why is light important? How is seeing in dim light different from seeing in bright light? How do our eyes adapt to dim light? How are our eyes different from animal eyes? What animals can see well in the dark? How do we see colors?

Challenge Questions: How does the sense of sight work? How do we see? How do we see colors? What is light? What is color?

How we see… Humans are only able to see wavelengths of light between 400-700nm, the visible light spectrum from red to violet. Many animals and insects have the ability to see outside of a human's visual range, specifically in the ultraviolet (UV) or infrared (IR) regions of the electromagnetic spectrum. The retina contains two types of photoreceptors: rods and cones. The rods are responsible for vision under dim light conditions; while the cones are responsible for color vision. Our eyes can adjust (adapt) to low light conditions, but there are limits. While it may seem intuitive, we need light in order to see colors. In dim light, we can see shadows and make out the shapes of objects, but the object appears in shades of gray-not in color.

General Key Concepts

- The **cornea** is a clear, dome-shaped tissue covering the front of the eye. *(The eye has many parts-some we can see; others we cannot.)*
- The **iris** is the colored portion of the eye. The iris is a muscle.
- The iris changes the size of a small opening known as the **pupil**, which allows light into the eye.
- The pupil changes sizes depending on how much light is available. In dim light it enlarges, and in bright light it contracts.
- The **lens**, located just behind the iris, helps to focus light on the retina. *(The lens functions like the lens in a camera.)*
- The **retina** is located at the back of the eye. It is the innermost layer comprised of sensory tissue. An image of what we see forms on the retina *(see: Persistence of Vision).*
- The retina contains millions of **photoreceptors,** light-sensitive nerve endings. There are two types of photoreceptors in the eye: **rods** and **cones** *(see: Let There Be Light & Color)*
- The photoreceptors convert light rays into electrical impulses and carry the visual impulse to the optic nerve.

Explore Activity #28: Look Into My Eyes!

What color are your eyes? Point out that this part of the eye is called the iris. See what else your class can see when they look into a classmate's eyes or in a mirror. The eye is very moist. We blink for many reasons, but one important reason is to keep our eyes moist. Point out the location of your eyes on your head. The eyes of birds and reptiles are located on the sides of their heads. Point out the part of the eye known as the pupil--the black circle in the center of the iris (continue your exploration with Explore Activity #30-Eyes Wide Open!).

Explore Activity #29: Two Eyes Are Better Than One!

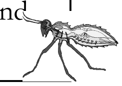
We use both our eyes to form a composite image. Each eye sees an object a little differently. The two images are then combined to provide us with a perception of depth about the object.

- Set an object on a table across the room by placing it next to a corner or edge of a bookcase or cabinet as a reference.
- Close one eye, hold up your thumb, and line it up with the object.
- Holding your thumb in the same location, close that eye and view the object with your other eye.
- With both eyes open, try lining up your thumb with the object. Check how well you did by opening and closing your eyes one at a time without moving your thumb.

Questions

- Did your thumb appear to move? Try it again. Move your thumb in line with the object, and then open your other eye. Did your thumb appear to move again?
- How many "thumbs" do you see when you try to focus on an object with your thumb?

Did you know…most insects have more than one type of eye? Simple eyes are used for detecting light changes resulting from movement (such as shadows); and compound eyes are used for detecting shapes.



Explore Activity #30: Eyes Wide Open!

Revisit the pupil portion of the eye. Explain how the size of the pupil changes depending on how much light is available. In dim light, the pupil is large. Under bright light conditions, the pupil contracts and is small. To help your students better understand how the size of their pupils react to light, you can draw the analogy to going out into the bright sunshine and how sometimes they have to squint when they first step outside. The light is sometimes too bright, but after a few minutes their eyes adjust to the brighter conditions. Their eyes adjust by changing the size of the pupil.

For this activity, you will need to make your room fairly dark, similar to dusk conditions. Your students should still be able to see one another and be able to see their classmates' pupils. It may be necessary to close the window blinds to decrease the light level in the room as well.

- Turn off the lights in the room and allow everyone's eyes to adjust to the dim light.
- Working in pairs, have your class look into one another's eyes. Their pupils should look fairly large in the dim light.
- Have your class continue to look into one another's eyes and then turn on the lights. The change in pupil size is nearly instantaneous.

If your class is having any difficulties, you can use your own eyes for demonstration purposes and simulate the lights on/lights off component by just closing your eyes and covering them to keep out any stray light, and then opening them again. The change in pupil size is less dramatic, but demonstrable.

Explore Activity #31: Seeing in the Dark

Gather a collection of objects that differ slightly in size or color from one another, such as 10 coke bottle caps, soda bottle caps, and water bottle caps. The items should feel about the same, but not look the same.

It is best to perform this experiment in a room that you can make very dark.

- With the lights on have your class separate the caps into "like" piles.
- After they are done, mix the caps together and turn off the lights so that the room is nearly dark.
- Ask your class to separate the caps again. Have them do this quickly so that their eyes do not have time to adjust to the darkened conditions.
- Turn on the lights and look at the results.
- Dim the lights again and allow your class' eyes to adapt to the room's darkened conditions. Use the downtime to talk about dark adaptation or about how nocturnal animals are able to see in the dark extremely well. Alternatively, you can use the dim light adjustment time to make a *Shades of Gray* art project.
- After a few minutes, see how well your class can now separate the bottle caps. Compare your results to when their eyes did not have time to adjust to the darkened conditions.

Explore Activity #32: Lights, Color, Action!

In order to see color, we need light. In general, under dark conditions it is extremely difficult to tell the difference between dark purple, navy blue, black. Similarly, light colors will appear mostly dull white or light gray.

Part I.

- With the lights off, examine the reflective surface of a CD-ROM.
- Turn on the lights and have your class examine the vivid colors on the surface of the CD-ROM.
- Turn off the lights again. When the lights are off, there is no light source and so the colors seen on the disk are muted. Do not perform this experiment outside or in an area with direct sunlight.

Part II. You will need a fairly dark area in order to perform this follow-up experiment. If you cannot get your classroom dark enough with the room lights off, try placing colored objects inside a large box that you can close and cut peepholes for easy viewing.

- Use pre-cut colored foam shapes or cut out colored squares, triangles and circles and place these in a darkened area or the box setup.
- Wait several minutes to allow everyone's eyes adjust to the dim light. Discuss how we need light to see colors. Then have your class try to identify the color of each object.
- Turn on the lights and see if their guesses were correct.

Questions

- What were able to tell about the objects with the lights off? Could you tell the objects' shape? Could you identify what it was?
- Were you able to tell what color it was? Can you see colors without light?

Explore Activity #33: I See You!

Point out the location of your eyes on your head. Show your class the range of motion of your eyes. Compare the location of human eyes to different animals whose eyes are located more on the sides of their heads, which gives them greater range (field of vision) as well as better peripheral vision. In addition, some animals are able to move one eye independently of the other.

You can demonstrate peripheral vision and field of vision with this simple two-part experiment.

Part I

- Have your class stand in a line.
- Have each child face forward, staring forward and without moving their heads see what they can see out to the sides by just moving their eyes.
- You can also set out a series of objects and see if they can see them or you can move up and down the line with the object of interest and see if and when then can see it.

Part II

- Have each child stand facing you, staring forward. They will need to be separated a little more than an arm's length from one another.
- Have them stretch out one arm to their side and slightly toward their back so it is out of their field of vision.
- Then ask them to slowly bring their arm forward while still keeping it outstretched. Ask them to continue looking forward at you, but to shout out when they are first able to see a part of their arm.

You can explain how it is advantageous for many animals to be able to see more of what's happening out to their sides.

Explore Activity #34: Seeing Is Believing…

Depending on when you choose to teach the five senses, you can substitute any number of science or holiday-themed images for this activity. The image, however, needs to be fairly solid and reasonably dark (or white) to see the afterimage effect.

- Distribute the *Themed Graphic* to your class.
- Stare at the white graphic in Figure A for about 15-20 seconds, then move your gaze over to the white square.

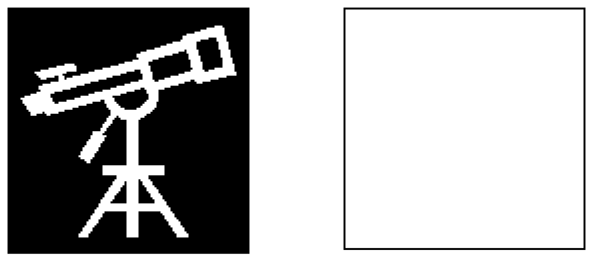


Figure A

Note: if you cannot obtain a negative image as shown in Figure A, begin with a positive-type image and use a black square to see a white afterimage (see: Figure B).

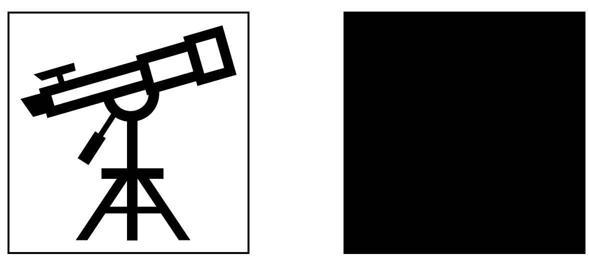


Figure B

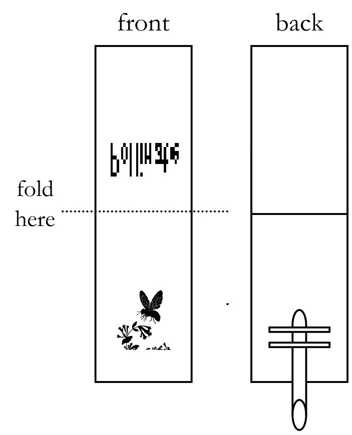
Explore Activity #35: Persistence of Vision

The flip stick relies on a phenomenon known as **persistence of vision** where an image is retained on the eye's retina for a short period of time. Traditionally, flip sticks are used to merge two objects into a single image.

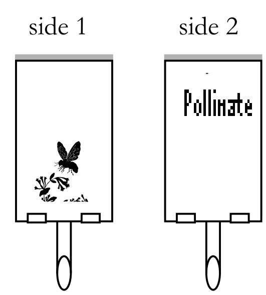
Depending on the science theme, holiday or time of year, you can create a variety of take-home flip sticks. You will need two images, one for each side of the flip stick. For example, when studying insects and pollination you can include the image of a bee with a honeycomb or a flower on one side; and, on the second side the word, pollination. Any number of combinations of "things that go together" can be used.

It is best to use two different color images, apply paint or crayon color to help you visually discriminate between the images on each side.

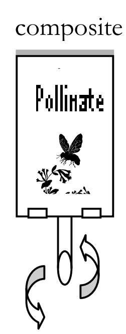
To make a flip stick:



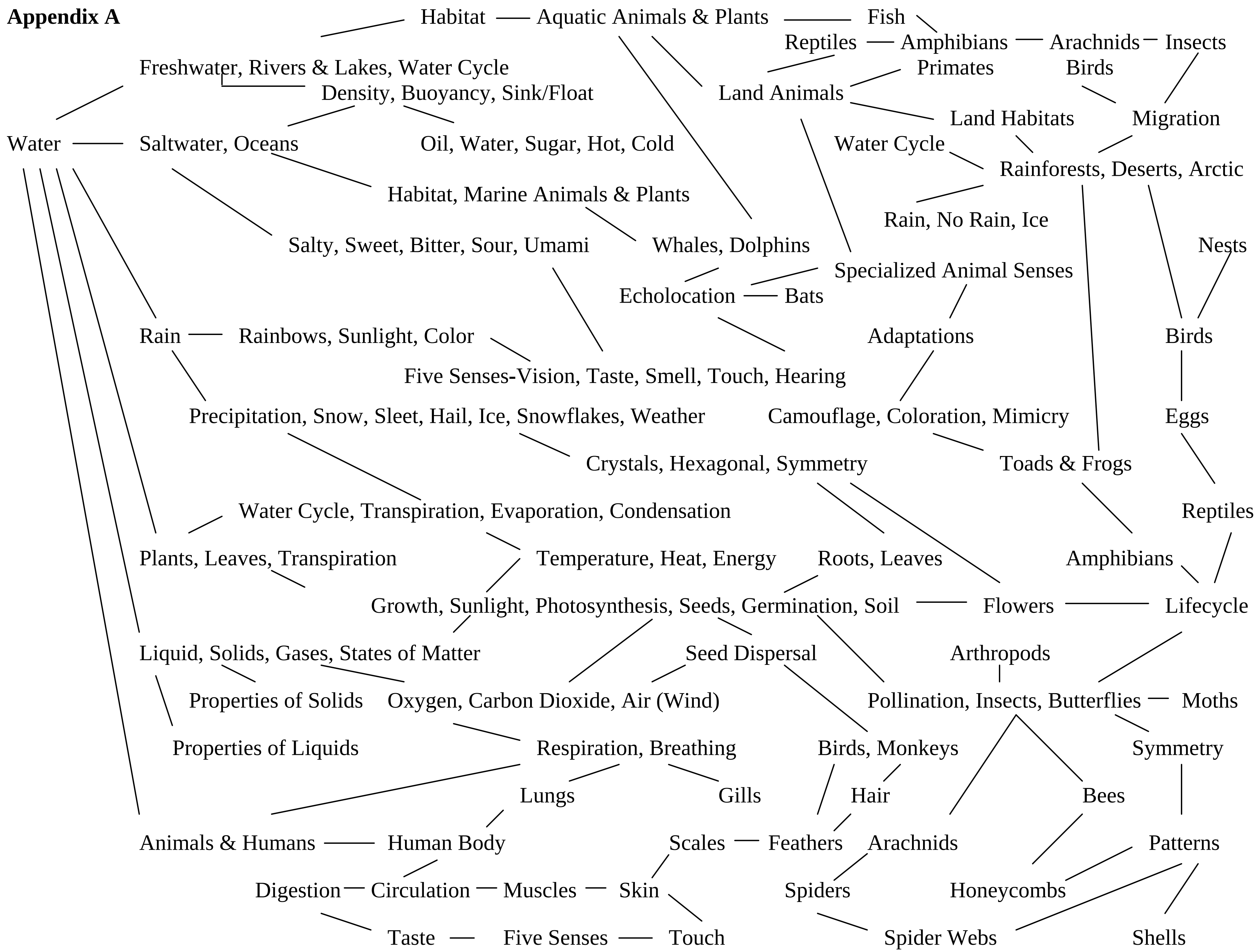
- Prepare a strip of paper that is approximately three (3) inches wide and approximately six (6) inches long.
- Have your class color or outline one of the images so that there is a difference in color between the two sides.
- Fold the strip of paper in half.
- Glue an image to each side of the paper. Be sure to avoid the fold. Be sure to have your images in the proper orientation to create the appropriate blended image effect. Once folded images



- Reopen the strip of paper and tape a straw to one side as shown.
- After securing the straw in place, refold the paper over the straw and seal at the bottom using tape.
- Extend arms out, hold straw in palm of hands or near fingertips and rotate quickly.



Appendix A


Habitat
Aquatic Animals & Plants
Fish
Reptiles
Amphibians
Arachnids
Insects
Freshwater, Rivers & Lakes, Water Cycle
Primates
Birds
Density, Buoyancy, Sink/Float
Land Animals
Land Habitats
Migration
Water
Saltwater, Oceans
Oil, Water, Sugar, Hot, Cold
Water Cycle
Rainforests, Deserts, Arctic
Habitat, Marine Animals & Plants
Rain, No Rain, Ice
Salty, Sweet, Bitter, Sour, Umami
Whales, Dolphins
Nests
Specialized Animal Senses
Echolocation
Bats
Rain
Rainbows, Sunlight, Color
Adaptations
Birds
Five Senses-Vision, Taste, Smell, Touch, Hearing
Precipitation, Snow, Sleet, Hail, Ice, Snowflakes, Weather
Camouflage, Coloration, Mimicry
Eggs
Crystals, Hexagonal, Symmetry
Toads & Frogs
Water Cycle, Transpiration, Evaporation, Condensation
Reptiles
Plants, Leaves, Transpiration
Temperature, Heat, Energy
Roots, Leaves
Amphibians
Growth, Sunlight, Photosynthesis, Seeds, Germination, Soil
Flowers
Lifecycle
Liquid, Solids, Gases, States of Matter
Seed Dispersal
Arthropods
Properties of Solids
Oxygen, Carbon Dioxide, Air (Wind)
Pollination, Insects, Butterflies
Moths
Properties of Liquids
Respiration, Breathing
Birds, Monkeys
Symmetry
Lungs
Gills
Hair
Bees
Animals & Humans
Human Body
Scales
Feathers
Arachnids
Patterns
Digestion
Circulation
Muscles
Skin
Spiders
Honeycombs
Taste
Five Senses
Touch
Spider Webs
Shells