Model Inquiries into Nature for Teaching Science

The MINTS Book

An Inquiry Field Guide to the Natural History of Schoolyards, Backyards, and Parks

By Frank Taylor, Alan Raflo, and Llyn Sharp

Illustrated by Jasper Burns

Developed by the MINTS project team of Susan Eriksson, Suzie Leslie, Alan Raflo, Llyn Sharp, and Frank Taylor with funding provided by the Howard Hughes Medical Institute

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F.T., A.R., and L.S.
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Introduction

"There is not a weed or an insect or a tree so common that the child, by observing carefully, may not see things never yet recorded in scientific books...." Anna Botsford Comstock, *Handbook of Nature Study* , 1911 (page 11).

"Students seem to learn better when it relates directly to their everyday lives and the things around them." A 6th-grade teacher and MINTS-workshop participant, 1994.

Origin of *The MINTS Book*

Model Inquiries into Nature for Teaching Science—The MINTS Book is a product of the MINTS project, developed by the Virginia Tech Museum of Natural History with support from the Howard Hughes Medical Institute. Along with this book, the MINTS project includes workshops and other activities to help teachers use inquiry methods and their schoolyards to lead effective science lessons. This book helps meet that goal in two ways: by showing that a schoolyard can be a rich source of material for teaching and learning science; and by modeling ways that inquiry techniques can be used in science lessons based on schoolyard **natural history**. (Please see the box on "What is 'Natural History'?" at the end of this section.)

The MINTS project began with teachers. In 1992, teachers on the Virginia Tech Museum of Natural History's educational advisory committee were asked how Museum resources could best be used to facilitate effective science teaching in local schools. The committee responded that the Museum could best help by providing teachers with teaching specimens, scientific information concerning local natural history, and training in inquiry or discovery teaching methods.

Based on teachers' recommendations, a grant proposal was submitted to the Howard Hughes Medical Institute's Precollege Science Education Initiative for Science Museums. The Museum proposed to develop an inquiry-based guide to schoolyard natural history, and to provide workshops on using the guide and inquiry methods generally. The Museum subsequently received a five-year, $175,000 grant for the project, and a biology educator was hired to develop the guide and related workshops. *The MINTS Book* is a primary result of that five-year effort.

The MINTS Book is based on the idea that children can both learn and actually do science in common outdoor surroundings, specifically in their own schoolyards. This idea can be applied nearly anywhere there are schools; *The MINTS Book* applies the idea specifically to southwestern Virginia schoolyards.

The MINTS Book provides much information about the plants, animals, and other interesting features one can find right outside a school building, and about how students can be guided in learning about these things. But, as you delve into this written material, keep in mind that, more than any book, actually *looking at nature* is often the best teacher. To paraphrase a famous saying attributed to Yogi Berra, former catcher for the New York Yankees baseball team: You can observe a lot just by looking!

What is "natural history"?

The meaning of the term "natural history" has its own long history, tracing back at least to 1567, according to *Webster's Ninth New Collegiate Dictionary* (1990). The earliest sense of the term was simply "a treatise on some aspect of nature," as in *A Natural History of Fishes*, written in 1795. The term also has two somewhat broader meanings. One meaning refers to the *study of natural things*, often focusing on their characteristics and life cycle (for living, or once-living, things). That is the meaning in the name, The Virginia Tech Museum of Natural History, a place dedicated to the study of natural things. The other meaning refers to the *object of such study*: When one talks about the "natural history of the Robin," this refers generally to the life story of Robins—where, when, how, and how long they live.

More so than in the past, natural history today also encompasses aspects of ecology, which is the study of living things in relationship to their environment and to one another. In this book, we have taken a very broad view of the natural history of schoolyards, and we include information not only on organisms' characteristics and life cycle, but also on their interactions with other organisms and with their environment, including the human aspects of their environment.

Using This Book

Who Can Use This Book

Anyone interested in learning about the natural history of familiar plants and animals may find much of interest here. While the primary target audience is teachers of science in grades K-12, the approach of the book can be applied to teaching and learning science at any level. The book is based on the natural history of schoolyards in southwestern Virginia, but many of the plants and animals described in this book are also common in other parts of the United States, especially in the east.

When to Use This Book

Use this book when you want to enhance your science teaching or curriculum with inquiry-based lessons on living things or other natural objects, their environments, and their relationships to humans. Specifically, this book will help you do these things:

- identify many organisms commonly found in southwestern Virginia schoolyards and also in many other regions and states, which can serve either as starting points or focal points of science and natural history lessons;
- learn basic, interesting information about the natural history of these easily found plants and animals;
- incorporate elements of inquiry and hands-on science into your existing science lessons;
- design new inquiry-oriented lessons to lead students in hands-on scientific investigations using the schoolyard as a laboratory; and
- find sources for more information on various natural history topics.

What This Book Contains

The features of this book are summarized and described below.

Chapter 1: Guide to Planning Schoolyard Inquiry Lessons. The opening chapter offers guidelines for using the schoolyard and inquiry methods to teach science.

In Chapters 2-6: Background Information on Habitats and Organisms. These chapters provide information on organisms found in most southwestern Virginia schoolyards, explaining what the organisms look like, how to find them, interesting life features, and their natural history.

The five chapters are based on five broad **habitats**: The Parking Lot; The Lawn; Fencerows and Other Overgrown Areas; Roofs, Walls, and Eaves; and Trees. (Please see the following box on "What's a habitat?"). The Table of Contents lists the main topic sections in each habitat chapter. Neither the chapters nor the sections within the chapters need to be followed in sequence; each section can stand alone and can be a starting point. We do recommend, however, that you read the Parking Lot chapter (Chapter 2) before the other habitat chapters. It discusses general features of a habitat and how they relate to natural history, themes to which we return frequently in the later habitat chapters.

What's a habitat?

The primary definition of **habitat**, according to *Webster's Ninth New Collegiate Dictionary* (Merriam-Webster, 1990), is "the place or type of site where a plant or animal naturally or normally lives and grows." In this book, we call parts of the school and schoolyard "habitats" because they are identifiable areas where certain kinds of organisms are *typically* found. A parking lot, of course, may not be a place where organisms occur "naturally" (no parking lots in nature!), but it does present certain conditions in which certain organisms typically will live.

In reality, all of the areas discussed in this book offer *many* different habitats. For example, a single tree may provide a habitat for a Robin on its branches, for leaf-mining insects within its leaves, and for wood-boring insects within its trunk.

The term **microhabitat** is used to mean a very small, well-defined area that meets the specific living requirements of some organism; each of the five schoolyard habitats offers many microhabitats.

In Chapters 2-6: Model Inquiries, organized into "Lines of Inquiry." Each topic section within the five habitat chapters contains model inquiries into that topic, placed in boxes at the end of the background information in the section. The model inquiry questions are grouped into what we have called "Lines of Inquiry." Separate Lines of Inquiry are identified by an bolded title. Instructions to teachers are printed in italics, while the suggested questions and any instructions or guidance that a teacher would give to students are printed in normal type.

The Lines of Inquiry are sequences of related questions that can be used to guide the investigation of a particular topic. Some of the questions have specific answers that may be found in the background material, but many do not, because they ask what a student sees, thinks, or predicts.

The Lines of Inquiry are *models* of how an inquiry lesson might develop. They are *not* meant as "the" way to approach a topic, or as a test of what someone ought to know about a topic. Far from that! Rather, a given Line of Inquiry represents a sequence of questions that *might* occur, either to a teacher or to students, while observing and learning about an organism or a habitat. It is quite likely during an inquiry-based lesson that other questions—perhaps very different ones—will arise, depending on the interests, observations, and insights of all involved in the lesson. Therefore, use the Lines of Inquiry as suggestions for inquiry-based lessons, and think of the individual questions as tools to encourage students' use of fundamental science skills: observing, making inferences, making predictions, collecting and graphing data, and interpreting and communicating results.

All the Lines of Inquiry titles within a habitat chapter are listed, by topic section, at the start of the habitat chapters.

Chapter 7: Sample Inquiry Lessons and Student Data Sheets. The first part of this chapter gives samples of plans for lessons that integrate the background information, the Lines of Inquiry, and tips on planning schoolyard field trips. The second part of the chapter gives samples of student data sheets that could be used in lessons on various topics. As with the Lines of Inquiry, these are presented as *models* of inquiry-based lessons and data sheets. Our hope is that these models will help teachers develop their own inquiry lessons.

Chapter 8: Additional Materials for Teachers. This chapter includes information on other references for science, natural history, and inquiry methods. Also included is information on inexpensive science tools and where to find them.

Chapter 9: *The MINTS Book* and the Virginia Science Standards of Learning. In this chapter, we suggest Lines of Inquiry that will support the teaching of the 1995 Virginia Science Standards of Learning, for grades K-12. No attempt has been made, however, to tailor specific Lines of Inquiry to grade levels. Many inquiries in the book, as well as the background information, are adaptable to different grade levels.

Other Features, in Separate Sections:

- a *seasonal guide* to the topics in the book;
- a short section explaining some key points of *how scientists classify organisms;*
- a list of the main *references* used in writing this book;
- a *glossary* to explain possibly unfamiliar terms; and
- an *index* of organisms and topics.

A Few Additional Points on Using This Book

A few points of clarification should help make your reading and comprehension easier, help you find information, and help you avoid being overwhelmed by too much information.

Safety. Chapter 1 includes a section on general safety precautions for taking students outside. *Please review this section before planning any schoolyard natural history lessons.* In the habitat chapters (Chapters 2-6), specific safety information is included on certain plants and animals (for example, Poison Ivy). In any section where safety information is found, the following caution symbol is placed at the beginning of the section: ⚠. Also, the most important safety information is printed in italics. Sections with safety information are also identified in the Index by the caution symbol.

More Safety: Don't Eat Plants or Plant Parts. Many sections in this book describe how certain plants can be used for food, teas, or home remedies or how these plants were used by early European settlers or Native Americans. This information is provided for anecdotal and historical background only. This book is *not* meant as a guide to allow you and your students to sample and eat schoolyard plants, and *the information in this book does not make you an expert on food or herbal uses of plants.*

Collecting Plants and Animals. Please see Chapter One for a section on the do's and don'ts of collecting plants and animals.

Use of Common and Scientific Names. For specific organisms that are a main focus of a section, the scientific (or Latin) name of the organism is identified when the organism is first mentioned in that section. In all other places, the common name only is used. Common names are used in the text for any other organisms mentioned. Scientific names of all specific organisms are listed in the index, beside the organism's common name. If a subject in the index is a group of organisms, the scientific name for the most specific group is identified. (For more on classification groups, see the section "What's a Family—What's a Genus?" near the end of this book.)

One or Many Organisms? In many cases, the common name of an organism really refers to several—sometimes several hundred or several thousand—species. For example, the common name "buttercup" refers to at least six different species that occur in the Blue Ridge Mountains region. On the other hand, "White Pine" is generally used to refer to only one species of tree. In this book, we have capitalized the common name of individual species, to distinguish them from groups of species. So, "Robin" (generally used to refer to one species) is capitalized throughout the text, while "spiders" is not capitalized.

Group Characteristics. Even if you don't know the name of a specific plant or animal, you will know a lot about it if you know the group in which the organism has been classified by scientists. For examle, all beetles share certain basic features, so they are classified as being in the same insect *order* (Coleoptera). In this book, we have identified the key groups to which organisms belong, such as plant families and insect orders. For those organisms that are the main topic of a section, that information is provided in the text. For other organisms, mentioned only briefly, the information is included in the Index. For an introduction to the scientific terms used to group organisms, see the special section near the end of this book entitled "What's a Family, What's a Genus...."

How New or Unfamiliar Words are Handled. Science words that we thought would be unfamiliar have been included in the glossary. When first used, those words are **bolded** and a short definition is included (if the word's meaning is not obvious from the context).

How Measurement Units are Handled. All measurements (for example, the size of a bird) have been given in both metric and English units, with the metric measurement first, and the English measurement following in parentheses.

Don't Worry About Doing It All! This book contains a lot of information and suggestions, some of which may be useful to you, and some of which may not. Choose what helps *you.*

Chapter 1. Planning a Schoolyard Inquiry Lesson

Nearly every school has an environment where students can investigate scientific processes, principles, and puzzles. Much can be found in that environment to engage children's' inherent curiosity about nature and their surroundings. The teaching and learning technique known generally as "inquiry" is a useful tool to take advantage both of children's curiosity and of the natural resources a schoolyard offers. Using inquiry and their schoolyard, teachers can design science lessons where students learn and practice key science skills as they attempt to solve puzzles presented by their everyday world.

Exploring the outdoors using inquiry teaching strategies can be a rewarding experience for both teachers and students, but a teacher needs to be prepared. The purpose of this chapter is to help you develop your own inquiry lessons based on the natural resources in your schoolyard and the natural history information that follows in subsequent chapters. Such lessons can be used to supplement and enhance your existing science curriculum.

The chapter has five main sections:

- characteristics of inquiry;
- safety considerations for schoolyard field trips;
- steps in planning the inquiry lesson;
- additional tips on questioning and class management; and
- a field trip planning sheet and two sample schoolyard inquiry lesson plans (additional sample lesson plans, along with sample student data sheets, can be found in the Sample Lessons chapter).

The Characteristics of an Inquiry Lesson

As we have used the term in this book, "inquiry" has several characteristics.

- Inquiry is a systematic way of finding out by asking and investigating questions. It can actually become a way of thinking about what one observes in the world.
- Inquiry is an interactive process between teacher and students, so an inquiry lesson on a given topic can be different every time.
- Inquiry seeks and depends on correct science information or *content*, but it emphasizes the science *processes* used to collect, summarize, and evaluate information, rather than memorization of specific facts.
- A given inquiry lesson can include one or more of three general **types of inquiry**:

  Directed—The teacher asks a question for which there is a definite, known answer, such as "What is the function of a leaf?". The teacher may use additional questions to direct students to the right answer.

  Guided—The teacher asks a question for which the answer may or may not be known, such as "How many different types of leaves are growing in our schoolyard?" The teacher uses additional questions and other guidance to help students use science skills to answer the question.

  Open—Students develop and investigate their own questions, which may or may not have a known answer.
- Inquiry is a skill that teachers and students alike can learn, practice, and improve.

The following paragraphs identify some key features of a successful inquiry lesson.

The inquiry lesson starts in one of two ways: Students are confronted with a discrepant event or puzzling phenomenon; or they begin making observations of an object or phenomenon, in a search for patterns. Through questions about the object or phenomenon, and about students' observations and inferences, the teacher helps guide students to search for patterns and for possible explanations of observed patterns. *All* students are drawn into the activities, because *all* students can make observations or share their perceptions of phenomena under investigation.

As the teacher and students together consider the students' observations and possible explanations, the teacher asks questions that challenge students to evaluate the evidence for their possible explanations. One key step in evaluating the evidence is for students to begin to quantify their observations; the teacher introduces tools or asks students what science tools could help them quantify their observations. If necessary to help solve the puzzle, the teacher asks the students to think of how they might collect more information (by further observations or measurements, or by the use of other sources of information, such as references).

Students work in groups to analyze information that they gather, further promoting their active engagement in the learning process. Students are pressed to state clearly their observations and find ways to express their data and communicate their ideas. The teacher's role is to challenge students to summarize their findings, re-evaluate observations and inferences in light of known facts or theories, and search for answers. As students are guided to better understanding, invariably more questions arise, providing the teacher with the opportunity to invite students to come up with new ways to answer the original puzzle, or to tackle another.

Before You Start Planning, Think About Safety

Safety for People

Follow all safety guidelines for science and field trip activities that are outlined by your school or district policy. Please rely on your classroom and district policies for safety guidelines. Always adhere to these guidelines, and use common sense.

While we make no claim that this book presents information on all possible hazards that you may encounter, here are a few specific things you can do to help prevent mishaps on schoolyard field trips.

- Always carefully survey your outdoor study sites for potential hazards before you take a class outside.
- Plan your route to and from your study site ahead of time. Walk through it and evaluate the route with safety considerations in mind.
- Determine and define the boundaries of the study area. Make sure students know the boundaries. Consider using brightly colored flags or surveyor's tape to mark boundaries.
- Check for bee or wasp nests and for flowering plants that may attract large numbers of pollinating bees and wasps. Remind students to concentrate on observing insects, rather than grabbing or disturbing them.
- Learn how to identify Poison Ivy and check for it. (For information on Poison Ivy, please see the Vines section in the Fencerows chapter.)
- Warn students not to eat plants or plant parts. Many schoolyard plants are mildly to highly toxic. In some plants, the young leaves are edible while older leaves are toxic. Mis-identification of plants can have disastrous results. Harmless plants can easily be confused with look-alike toxic plants. Make it clear to your students before you go outside that they should *never* put any plants or plant parts in their mouths. Look for bright berries or other plant parts that might attract your children's' attention and warn your students not to touch them. If you can identify any local poisonous plants, check for them before the field trip and record where you find them. Several common poisonous plants are discussed in this book, and they are identified in the Index, but this is by no means a complete list of potentially poisonous plants you might encounter.
- Know how to contact your nearest poison center to find out what to do if a student does eat a poisonous plant. The poison center phone number is listed with the emergency numbers in your phone book. Write the number of the *nearest poison center* here: ______________________
- Be aware that some people can have unusual or allergic reactions to normally non-toxic plants or animals. Nature explorations may expose such people to organisms that they would not routinely encounter at school or at home. Be sure to ask students if they have had allergic reactions before, and become knowledgeable about how to respond if an unexpected reaction occurs.

- Never trap or keep wild birds or mammals in the classroom. These organisms can bite and carry disease, and many are protected by federal and state laws.
- Be aware of potential human-generated hazards such as trash (broken bottles, pieces of metal with sharp edges, etc.), holes in the ground, or power lines. Remove or avoid potential hazards when possible, change the study site, or be sure to caution students if verbal warnings would be adequate.
- Have quick access to a first aid kit, and know basic first aid procedures.

Safety for the Environment: Guidelines for Collecting Plants and Animals

As a teacher conducting natural history activities with children, you have great power to influence their attitudes about plants, animals, and the environment. Whenever you can, model concerned stewardship of these resources. Several activities in this guide advocate collecting plants, plant parts, insects, or other natural objects. In many cases, the educational value of these activities supersedes the impact that removing a flower, a few leaves, or a few insect individuals could have on an organism or on the environment. There is, however, a big difference between collecting in a schoolyard or lawn, where most organisms will be fairly common, and collecting in a woodland or in any protected area, where you are more likely to encounter uncommon organisms, or even rare or endangered species. Even in a schoolyard, however, certain basic rules apply. The following list will give you some general guidelines to follow.

Guidelines for Plants

- Impress on your students that collecting any part of a plant in a national or state forest or park, or other protected area, is strictly prohibited and with good reason!
- *Never* collect woodland wildflowers. Woodland wildflowers have a slower reproductive rate and grow more slowly than many of the plants of the lawn and disturbed areas. Many woodland wildflowers have been growing in the same location for many years, and collecting or disturbing them can affect their survival.
- When collecting plants in the schoolyard, try to take only ones found in areas that will soon be mowed.
- In all cases, take only enough of a plant to serve the purpose of your lesson.

Guidelines for Animals

- As mentioned above, federal and state laws prohibit trapping or even possession of many wild birds and mammals. Bird nests, eggs, and even feathers are also covered by federal laws. It is best, therefore, not even to consider bringing wild birds or mammals into the classroom.
- Other vertebrates (reptiles, amphibians, and fish) are also best left where you find them. Observations of these animals outdoors in their natural setting will give more genuine information than watching their behavior in a confined setting indoors.
- If, however, you do wish to keep some organisms other than birds or mammals in the classroom for a short period of time, do so only if you have the knowledge to provide them with proper food, water, and other habitat requirements. Some insect cultures can be maintained indefinitely, but vertebrates—such as frogs, turtles, or snakes—should be released after a couple of days.
- If you collect any animals for classroom study, release them unharmed after your observations. Show students that you are releasing them or have students release the animals.

Steps in Planning a Schoolyard Inquiry Lesson

This section describes a process for planning an inquiry lesson in your schoolyard. At the end of the chapter, you will find a blank Schoolyard Field Trip Lesson Sheet, based on the steps in this section, which you can reproduce and use to plan your own lessons. Following the blank Lesson Sheet are two examples of schoolyard inquiry lesson plans; the plans were developed and carried out by teachers who used the planning format described here to field-test parts of *The MINTS Book.*

Step 1. Determine your objectives.

Determine your objectives for taking students on a schoolyard field trip, then choose a schoolyard subject to study and design your lesson to meet your objectives. An inquiry lesson in the schoolyard can accomplish several things:

- change the pace of classroom instruction;
- get students excited about science;
- provide an interesting introduction to a lesson;
- give practice in observation, measurement, or other science skills;
- teach students about a specific plant, animal, or feature that can be found in the schoolyard;
- support a concept included in your curriculum; and
- improve students' nature appreciation and environmental awareness.

Step 2. Survey your study site.

Content Check

This is a critical element in getting ready to take students outside. You must survey the site before your planned activity to see if the plant, organism, or physical feature of interest is present at the time you will be conducting your activity. Each schoolyard is unique and nature plays by its own rules. Don't assume that what you found last week or the same time last year will be there today. Go out and check! A quick survey can also yield pleasant surprises: You may discover some fascinating phenomena that you won't want your students to miss.

Safety Check

Survey your study site for potential hazards, following guidelines developed by your school and the additional tips listed in the safety section above.

Route check

Plan your route to and from your study site. Walk through it and evaluate the route for safety and for potential disturbances to other classes.

Step 3. Decide on a Format for the Inquiry Lesson

As does any lesson, an inquiry lesson needs a basic structure or organization. Schoolyard inquiry lessons have some additional "wrinkles," though, for these reasons:

- the lesson will involve activities both indoors and outdoors;
- collecting and recording information are key parts of the lesson;
- students will be involved in varied activities—some by individuals, some by small groups, and some by the whole class; and
- for much of the time, the teacher will not be the focus of the lesson or the source of information.

With these points in mind, here are several key questions to consider in organizing the lesson.

- What inquiry activity (or activities) will your students do to investigate the chosen topic and meet your desired objective(s)?
- How will you lead into the inquiry activity? (Some options include a short lecture, presenting students with a discrepant event, beginning with student observations, or asking students

what they know or wish to know about a topic.)

- Will the students work in one large group, in small groups, or as individuals? (It is highly recommended that a field trip longer than 10 or 15 minutes include components where students are working in small groups. Inside, you will probably find occasion to work within small groups as well, for example, during observation and measurement of collected specimens. Other inside activities will be more appropriate for individual or whole class work.)
- How will small groups be determined?
- How will information from the activities be recorded—class data sheet, group data sheets, individual student data sheets, or some combination?
- If students need a data sheet, can they make them, or will you supply them?
- What information or instructions—including inquiry questions—should be on the student data sheet?
- Will students need to make sketches?
- Will students need to make a graph?
- Will students be keeping any permanent record of their data or sketches in a science journal?

Step 4. Plan for Assessment

An inquiry-based science lesson focuses on processes and skills as much as, and often more than, on specific content. While science content will be learned in an inquiry lesson and can be tested in traditional ways, assessment of other learning from an inquiry lesson, especially skills development, requires different techniques. Clearly, a traditional knowledge-based multiple choice test will not do the complete job. On the other hand, paper and pencil tests can be designed to provide students with opportunities to demonstrate skills practiced during an inquiry lesson, such as observation, data organization, graphing, or basing conclusions on evidence. Evaluation of work done in the inquiry itself can also provide a measure of learning. A science log, or a portfolio of student work (which can include data sheets, sketches, written summaries, and other products) can be useful assessment tools, and they can also provide students with concrete evidence of their accomplishments.

Individual teachers can work toward additional strategies to assess the type of science learning emphasized by inquiry techniques. Many references are available for help in doing so. One that we recommend is the chapter on assessment tools in *Eco-Inquiry* by Kathleen Hogan (this book is listed in the Additional Materials chapter).

Step 5. Plan for Needed Materials

In a schoolyard inquiry lesson, much of your material—plant, animals, and other natural things—will already be waiting for you outdoors! But usually you will want to have certain materials to help your students do their investigations. In planning for materials, work through the following list of considerations:

- Will natural material be studied outdoors, or collected and brought indoors?
- If the material is to be brought indoors, what containers are needed?
- What simple tools could be included to enhance your students' investigations of the natural material? (Such tools could include hand lenses, rulers, insect-viewing boxes, plastic containers, and many other items. For a suggested list of simple, inexpensive, useful science tools, and information on how to acquire them, see the Additional Materials chapter of this book.)
- How will these tools be used?
- How will students be trained in their use?
- How will the tools be distributed, collected, and counted?
- How will the tools, containers, or other material be transported outdoors?
- How will students record information? (See the Sample Lessons chapter for sample student data sheets.)

- What personal items do you need? (This will depend on the lesson, but you might find the following useful: a tote bag; a clipboard with paper for taking field notes, or a field notebook; a sketch of your study area prepared beforehand; marking tape to mark plants or locations you study; pruning shears for collecting plant parts; and a whistle to which your students know to respond!)

Step 6. Plan a Line of Inquiry

Make an outline of the key questions that you could ask to encourage students to explore the environment and address the objectives of your lesson. The Lines of Inquiry questions in this book can give you ideas for developing your inquiry activity. Keep in mind, however, that the actual questions and the sequence they follow will likely be somewhat different from your plans. When real students are involved, their responses and their own questions will affect the direction of a lesson; that is, in fact, one of the objectives of an inquiry-based lesson. This does not mean that your planning was a waste of time! On the contrary, thinking through a possible sequence of questions and discoveries will give you a framework to *guide* the actual lesson as it develops.

A line of inquiry can include many types of questions. The different types of questions emphasize the different science skills needed to gather, process, evaluate, and apply information. We have described several types of questions below, grouped into the categories of gathering, processing, or evaluating/applying information.

Gathering Information

- Begin by asking students to make **observations** of some phenomena in the environment.
- Ask students to make **predictions** about what they will observe; they, the students, can see whether they were right. This generally is a good motivator, because students intrinsically enjoy solving puzzles or riddles.
- Questions that lead students to **compare** and **contrast** features will help students sharpen their observational skills and more clearly communicate their perceptions.
- Ask questions that invite students to **compare their observations to prior knowledge.**

Processing Information

- Ask questions that encourage students to **classify** or group their observations, objects, or information. Use questions that will help students find patterns.
- Ask students how they might **quantify** their observations, and what tools of science they could use to do so. (Supply these tools if possible.)
- Ask students to **organize** and **summarize** their data, observations, and facts, especially by using graphs and charts.

Evaluating and Applying Information

- Ask questions that will invite students to make **inferences** (or "educated guesses") about their observations. Such questions should encourage open-ended thinking and speculation, but the thinking should be based on evidence from their observations or on prior learning.
- Ask students if they have enough information to draw a **conclusion** about the object or phenomenon at hand. In essence, have them consider whether they can answer the questions that started the inquiry.
- Ask questions that challenge them to base any conclusions or answers on **evidence**.
- If the students' information does not result in a clear conclusion, invite students to develop a guess, or **hypothesis** to explain the observed phenomena or events. Encourage different hypotheses.
- Challenge students to determine how they could **investigate further in order to test their hypotheses**. Responses can include the design of controlled experi-

mental testing, library research, interviewing experts, or making other observations.

- Ask questions that invite students to **relate or apply the information** from this lesson to other science topics, to other subjects, or to their lives.
- As long as new questions arise, encourage students to make **new predictions** about what they might observe. This will set the stage for follow-up lessons.

At any one time in an inquiry lesson, several types of questions might be in operation. On the other hand, it's possible, depending on your objectives, to design a successful inquiry lesson that involves only one or two of the types of questions we describe below. A given lesson does not *have* to proceed through all the levels of questions or science processes.

Another model for developing a sequence of inquiry questions is the familiar "Bloom's Taxonomy": knowledge → comprehension → application → analysis → synthesis → evaluation. Use this model if you are familiar with it!

Step 7. Plan for Closing the Lesson

Decide ahead of time on a definite strategy for bringing the schoolyard inquiry lesson to a close. Part of any effective lesson is pulling together what has been learned, integrating the new knowledge, and using it as a foundation for action or further learning. The following are some general types of activities that can follow the inquiry part of a lesson.

- Students write a summary of what they learned, and compare that to their predictions.
- The class as a whole discusses what was learned and possible conclusions.
- Small groups summarize the information gathered, then present their summaries to the class.
- The class relates the new information to prior science knowledge.
- The class applies the new science information to a project in another subject.
- The class lists a new question (or set of questions) arising from the activity and makes plans to investigate the new question in another lesson.
- Individuals or groups are assigned to investigate further an unanswered, or new, problem.

The particular closing activity you choose will depend on your objective(s) for the lesson and on how far the actual inquiry proceeds. The types of questions identified in the previous section can help you identify how far your inquiry activity will go, and therefore what might be an appropriate closing activity. For example, suppose you want your students to practice the science skills of observation and classifying. In that case, you could plan an activity where the students investigate how many different types of plants are growing in the school lawn. The inquiry plan proceeds through observations of the different plant types to classification based on the observations (and perhaps some measurements). The closing activity, then, involves students organizing and summarizing their information by producing graphs.

Following are some other examples of possible closing activities appropriate to given objectives. These examples are based on lessons designed by teachers who field tested *The MINTS Book* and the procedure outlined in this chapter.

Objective	Inquiry Activities	Closing Activity
Study an insect habitat	Observe and measure the features of webs made by the Fall Webworm	Small groups of students construct and compare graphs of their measurements
Learn the major parts of an insect	Observe live grasshoppers; discuss their features, comparing them to human features	Students use a printed diagram of an insect to label general insect parts
Learn the parts of a plant	Observe and illustrate a goldenrod plant; compile a list of characteristics	Students are given an unfamiliar plant and asked to describe its features

There are many possible ways to bring your lesson to an effective close. But never let the inquiry activity simply end without involving students in processing it in some way that allows them to integrate their new learning into their existing base of knowledge and skills.

Additional Tips for Schoolyard Inquiry Lessons

Questioning Tips

- **Allow wait time.** Give students time to think about answers to questions. A good rule of thumb is to wait 2 or 3 normal breaths (or about 6-10 seconds) for students to formulate their answers.
- **Avoid telling students too much**. Let them gather their own observations and draw conclusions. Take a "Well...what do you think?" approach to their questions, even when you know the answer. Shift the focus onto student thoughts and responses rather than onto the teacher.
- **Encourage many responses**. Do not subtly communicate to students that there is a right answer when you are really looking for a list of possibilities. Use some open-ended questions to encourage thinking and participation.
- **Do not overly praise particular answers.** Exaggerated praise can stifle responses. Avoid sounding judgmental. Here are some sample responses that praise students but keep the focus on desired skills:
  "Good observation."
  "That's a good thought."
  "That is an appropriate hypothesis."
  "Based on what we know so far, that is reasonable."
  "All your responses are appropriate inferences." (If you prefer, use the term "educated guess" for "inference.")
- **Repeat what was said.** This acknowledges students' contributions of evidence and helps ensure that the whole group hears what has been said.
- **Redirect the inquiry if necessary.** Occasionally you may need to move the process along. One way to do so is by asking questions to encourage summarizing what was learned so far or what has been observed collectively.
- **Try to keep students from jumping to conclusions.** Students need to be able to consider observations and inferences objectively and critically. Here are some useful questions to help students evaluate evidence:
  "Is that an observation or an inference (an 'educated guess')?"
  "You've made an inference. Let's go back and ask what you observed as a basis for the inference."
  "What evidence do we have...?"

- **Ask questions to test inferences.** One way to do this is by asking students to compare the features or characteristics of a known object or phenomenon (say, the traits of insects) to the object or phenomenon at hand. Here's an example:
  "What are the features of all insects?"
  "Does this organism have all of these features?"
  "Does the organism have some of these features?"
  "What were the key features that supported your statement that the organism is an insect?"
  "If it's not an insect, what are some other possibilities?"
- **Encourage further exploration** of the subject in question. Encourage many ways of finding answers. You can challenge students to put their science skills into practice with these questions:
  "How could we find the answers to our questions?"
  "Pretending you have unlimited time and materials, design an experiment to answer this question."
  "Using materials available around the home or classroom, how could we design an experiment to answer this question?"
  "Where could we look in the library to find out more?"
  "Who could help us find out more?"
- **Encourage students to ask questions.** Your modeling of questioning will encourage similar thinking strategies by your students. It is all right if you do not know the answer to their questions. Encourage the spirit of finding out together!

Class Management Tips

- **Communicate your expectations clearly to your class.** This is your most important management tool. Students may not be accustomed to entering the schoolyard for activities other than play or physical education. Emphasize the difference between this academic activity and recess: Both are enjoyable experiences, but the purposes and so the expectations differ. Be sure they understand the goals of the activity and expected behavior before going on your field trip.
- **Define the physical boundaries** of the outdoor activity.
- **Use tools such as a student data sheet to help focus students' attention.** A data sheet, with key questions or simply spaces for observations or answers, can be a helpful class management tool. In the unstructured outdoor environment with its many distractions, such a data sheet can focus students' attention when things diverge. Student data sheets also allow you to monitor progress as you circulate from group to group and provide encouragement or directions. Several sample student data sheets are shown in the Sample Lessons chapter.
- **Involve your more difficult students by seeking out their observations early in the lesson.** When engaging in questioning, involve students who are sometimes less inclined academically to participate in the class by calling them by name and beginning inquiry activities with their observations. By involving such students from the beginning, you increase the likelihood of their participation in the lesson. Be sure to continue to solicit their responses throughout the lesson.
- **Have fun together!** Enjoy the break from classroom routine and create a sense of exploring the outdoors together.

If you are not already using inquiry questioning strategies, you will find that it takes practice, but you will be rewarded with improving skills over time. Plan brief forays into the schoolyard at first; as you and your students become more comfortable with your new roles, you can develop more lengthy and involved lessons. Enjoy your outdoor laboratory!

Field Trip Lesson Sheet

(to be used in conjunction with "Planning a Schoolyard Inquiry Lesson")

1. Objectives:

2. Site Survey:

Content?

Safety?

Route?

3. Lesson Format:

4. Assessment Methods:

5. Materials Needed:

6. Inquiry Plan — Key Questions:

7. Closing Activity:

Teacher-designed Lesson Plan 1: Queen Anne's Lace

This lesson was written by Pat Caldwell, who used it with a class of 27 fifth-graders at Newbern Elementary School in Pulaski County, Virginia, in September 1994. Ms. Caldwell based her lesson on the Queen Anne's Lace section of *The MINTS Book.* The lesson took one hour.

1. **Objective:** Recognize Queen Anne's Lace and learn about its features and history.

2. **Site Survey:**
Content? Plant found in overgrown area on edge of schoolyard.
Safety? Beware of Poison Ivy and thorns on blackberry and wild roses.
Route? Use rear exit, across blacktop to harvest plants from edge of unmowed area.

3. **Lesson Format:** Indoors, introduction for the whole class: Ask if they know of a lace-like plant. Then go outdoors, and in six small groups, gather plants, examine, and discuss questions

4. **Assessment Methods:** Discussion with whole group. Evaluation of information in drawing done in closing activity.

5. **Materials Needed:** Hand lenses and drawing paper for students.

6. **Inquiry Plan--Key Questions:**
Indoors:
Can you find a wild, white flower used by a queen and her ladies as a pattern for their delicate hand-lace? (Brainstorm; predict features.)

Outdoors, once plants have been found and harvested:
What do the plant's leaves look like?
How is it different from other plants?
Where did you find the plant?
Crush some leaves and roots and smell them. What garden vegetable do you think is similar to this plant?
Examine the flower head. How does it change when the plant goes to seed?
How are the seeds spread?

7. **Closing Activity:** Make a drawing comparing and contrasting the modern carrot plant with Queen Anne's Lace. List in words the similarities and differences.

Teacher-designed Lesson Plan 2: Goldenrod

This lesson was written by Cathy Ney, who used it with a class of 25 second-graders at Margaret Beeks Elementary School in Montgomery County, Virginia, in September 1994. Ms. Ney based her lesson on the Goldenrod section of *The MINTS Book*. The lesson took three one-hour class periods.

1. **Objectives:** Identify a goldenrod plant and its characteristics; use observation skills; and determine the relationship of insect visitors to the plant.

2. **Site Survey:**
Content? Plant found on edge of school property.
Safety? Inform children they are not to leave school property.
Route? Across the playground and ball field to the edge of the grass.

3. **Lesson Format:** Indoors, read students a plant book such as Arnold Lobel's *The Rose in My Garden*. Discuss the historical background of domestic flowers (roses, daises, etc.) as opposed to wildflowers. Have students illustrate a domestic flower in their log books. Use information from *The MINTS Book* to list goldenrod characteristics. Outdoors, students observe and collect goldenrod and insect visitors. Back indoors, students make observations about the plant and the insects.

4. **Assessment Methods:** Check student logs and assess discussion to evaluate accuracy of students' conclusions.

5. **Materials Needed:** Student log books, pencils, hand lenses, insect containers, water tubes, meter tapes.

6. **Inquiry Plan--Key Questions:**

Outdoors:
How can you identify goldenrod? Why is it called goldenrod?
Where did you find the plant?
Was the plant growing alone or were there other goldenrod plants there?
How tall is the plant? Why do you think it grows so tall?
Do you observe any insect visitors? Use the containers to capture some of these.
Have students collect plants, put the plants in the water tubes, and return indoors.
Look at the plant closely. How does the stem appear? How are the leaves arranged?
How many flowers are on the plant? Why do you think it has so many flowers? How is this flower similar to or different from your drawing?
Can you find any seeds? What do the seeds look like? How do you think new goldenrod plants are formed?
Have students examine and draw the insects they found on the plant.
Before you saw any insects, how could you tell there were some on the plant?
What do these insects eat?

7. **Closing Activity:** Discuss with students how they could apply what they've learned to other wild plants.

Chapter 2. The Parking Lot

Page	Topic Sections in the Chapter	Lines of Inquiry in the Section
15	**Introduction**	None
16	**Habitat Features and Natural History**	General Surface Features Energy Absorption Water Relations Plant Succession Animal Life

Introduction

The parking lot is a wonderful place to begin your explorations of the school grounds precisely because it would seem to be the last place one would go to study natural history. Admittedly, a parking lot is not teeming with life, and much of what one sees is not "natural" at all. But these attributes make the parking lot a great place to start observing and thinking about the properties common to all habitats. For example, dark asphalt causes temperature differences that can easily be measured; the movement of rain water falling on pavement is clearly visible; and the few plants or animals that can live on the parking lot draw attention to the habitat conditions needed for their survival. The altered, more extreme, and less diverse nature of the parking lot highlights such features, which may be less noticeable (at first) in a more natural setting.

The parking lot of your school can be an excellent environment to begin your study of local natural history. This is a very common habitat across this country, and paved areas collectively have a significant impact on our environment. An examination of this habitat can "pave the way" to better understanding and appreciation of other local habitats.

Habitat Features and Natural History

General Surface Features

The areas of interest in the parking lot are the paved (or gravel) parking area, the curbs, and surrounding sidewalks. In general, unless the school was built on a very flat location (unusual in southwestern Virginia), we can assume that heavy machinery has altered the parking area to its current grade. You may be able to find evidence of the original grade or surface features by looking at the surroundings. Sometimes the parking area has been cut into a hillside, or the top of a hill has been cut off. Other lots have been made by filling in a shallow dip or by pushing soil removed elsewhere to form a raised flat area.

If you have an asphalt parking lot on your school grounds, it is made up of at least two materials, tar and stone. Tar is a product of oil refining. Oil originated from the fossilized remains of plants and animals that were buried long ago. The ultimate source of energy for these **organisms**—as for all organisms today—was the sun, as plants captured this energy and used it to build new tissues (some of which animals ate) many millions of years ago. Theoretically, then, when you stand on an asphalt lot, you are standing on stored energy that reached the earth millions of years ago.

The stone that is added to the tar gives the surface durability to withstand the friction of car and truck tires. Without the addition of stone, the tar it would be a gooey mess in the heat of summer. While the tar is brought in from faraway refineries, the stone is normally of local origin. In southwestern Virginia, paving stone is likely to be limestone or **dolomite** dug from a nearby quarry. Dolomite is preferred because it is more resistant to weathering, due to a higher content of magnesium.

Like tar, dolomite and limestone represent the remains of organisms that lived long ago. The area that is now central and western Virginia was covered by shallow seas from about 545 million years ago until about 360 million years ago. During this time, some organisms living in the seas removed calcium from the water and deposited it in their shells or outer skeletons. When these organisms died, their remains fell to the ocean floor, collecting over thousands of years in large deposits many hundreds of feet thick. These deposits resulted in the limestone and dolomite rocks that underlie our area today.

Concrete sidewalks, as well, have their own tale to tell. You can observe that the texture and color is very different from the asphalt pavement. The surface is rough and has a sandpaper-like texture. The concrete sidewalk is made from a mix of cement and sand along with gravel. When cement is mixed with sand, gravel, and water, a chemical change occurs that leads to crystallization of the cement particles, bonding these substances together and producing a sort of "instant rock," the concrete. The gravel in the concrete sidewalk is not visible unless it is broken apart because, when the concrete was poured, the surface was smoothed with a trowel and the rocks settled into the mixture. The cement, which acts as a "glue" to fuse the other particles together, is made primarily from finely powdered limestone that has been "cooked" at high temperatures. The sand may be from river deposits or from ground sandstone. Sandstone is another kind of rock which can be found underlying southwestern Virginia and is also an important quarry stone. Sandstone represents the beaches of seas that existed millions of years ago.

Energy Absorption

The black surface of the asphalt absorbs energy from the sun, and even on a winter day you will notice that the asphalt is distinctly warmer than its surroundings. On a summer day, of course, it is sometimes unbearable to step onto the pavement in bare feet. A concrete sidewalk will also get hot but not as hot as the asphalt. In either case, if you jump into the grass nearby, you will feel relief. So in the parking lot we can contrast the energy absorption of at least three different surfaces—grass, asphalt, and concrete—and apply the concept that different colors and materials absorb different amounts of light and generate different amounts of heat. The heat-related properties of these surfaces can be readily investigated easily by students armed with thermometers.

The capacity of asphalt and concrete to absorb energy during the day can have significant local impact. The energy absorbed by these surfaces will radiate back into the air as heat. This helps explain why snakes are often run over at night by cars: In the cool of the night, some unfortunate reptiles come out on the warm pavement to maintain their body temperature (reptiles' body temperature varies with the surrounding temperature). Cities with large expanses of paved surfaces as well as concrete buildings absorb a great deal of solar energy during the day, energy that is released as heat. If you have been in a large city on a summer night, you may have noticed that the air does not cool down as quickly as it does in suburban or rural areas. You can verify this observation by examining local weather reports that frequently show city high temperatures higher than surrounding rural and suburban areas (the nights' lows are also often higher). The effect on the local ecology can be observed, too. Some plants in cities may begin to bloom in the spring long before the same plants would bloom in surrounding areas, and plants that would normally not be found so far north can be found thriving in some vacant lots or parks.

Water Relations

Another important physical property of asphalt pavement is that it is generally impervious to water. When comparing a paved surface to its original, unpaved state, we see a dramatic difference in what happens to rainfall in that area. Most of the water that falls on a parking area simply runs off the surface, while rainwater that falls on lawns, meadows, and forests has a chance to soak into the ground.

This difference can have a substantial effect on local streams. The rainwater that falls on building roofs, streets, and parking lots moves quickly into drains that often run directly into streams, by-passing the natural "filtration" that occurs as water percolates through soil. Following a substantial rainfall, the volume of flow in streams near paved areas can increase rapidly, partly as a result of the storm runoff from the paved surfaces. Higher and more rapid flows increase erosion in and around the stream. Streams subjected to high rates of erosion typically have sharply cut, steep banks, often with exposed tree roots.

Increased erosion due to runoff has an impact on things living in a stream. The soil sediments carried by the water are not necessarily toxic, but the build-up of sediments can degrade or even destroy the habitat of many gill-breathing organisms. Runoff can also have toxic properties when it carries with it road salt from winter treatments for ice, heavy metals from vehicular exhaust, or oil, gasoline, antifreeze, and brake and transmission fluids that can leak from cars. (You can see the evidence of leaking fluids in the middle of most parking spaces.)

Plant Succession

(Note: If you are unfamiliar with the term "succession," please see the Glossary for a definition.)

Things in nature are constantly changing. The parking lot provides an ideal environment to study an important process of change, **primary succession**, the process by which plants colonize new rocky (or rock-like) areas.

Parking lots, like other human-made structures, do not last forever. As soon as the parking lot is paved, the erosion process begins. The tar begins to "dry out" as certain chemical compounds evaporate.

Vehicular and pedestrian traffic, sun, wind, rain, ice, snow, and chemicals begin to break it down. Close examination of the surface using a magnifying glass or by running your fingers across it will reveal tiny particles of eroded pavement as well as material from the surroundings. These particles can act as agents to further contribute to erosion. Cracks may form under stress because of the expansion and contraction of the asphalt during temperature changes. During the winter, cycles of freezing and thawing can wreak havoc on asphalt and concrete surfaces. Each time water freezes in a crack it expands with enormous force. When it thaws and melts it can move deeper into the cracks. The potholes in our roadways form in this manner, and bridges must be engineered to account for expansion and contraction.

As a result of erosion—by the same processes that cause erosion in more "natural" habitats, such as a rocky mountain top—we can witness the beginning of soil formation in the parking lot. Sediments eroded from the surface as well as from the surroundings collect in the cracks, along curbs, or in depressions in the pavement where water puddles form when it rains. Some organic material (from plant or animal origin) is also deposited in these spots.

Tiny plant seeds are deposited by wind or water into the sediments collecting in parking lot cracks. The seeds that are most tolerant to extreme environments sprout when conditions are favorable, and the most hearty sprouts survive and begin to grow. As their roots penetrate into the sediments and their leaves spread upward and outward, these plants help retain even more soil particles. As some plants die and decompose, they enrich the developing soil. The plants that survive, however, begin to change the physical features of the environment in the crack, especially by providing shade to bring the temperature down and increase available moisture. In these ways, these first plants (called "pioneers") make the environment more hospitable for other plants that might not ordinarily have been able to grow there.

Succession refers to this process, where new plants (and associated animals) take advantage of improved conditions and are able to replace previous plants. Depending on how well-maintained your school grounds are, you will be able to see various stages of the succession process. Eventually, over a long period of time even a parking lot would revert to a more natural setting as it follows recognizable patterns of succession.

Animal Life

Many different kinds of animals may occupy the parking lot habitat at different times during the day and year. Tiny mites are often seen crawling on the surfaces of dry sidewalks, while during a heavy rain numerous worms may be found attempting to escape their flooded burrows. The weeds growing out of a crack, like an oasis in the desert, can harbor a variety of insects and spiders. As the plants in the crack become better established, more kinds of organisms may find a home there.

The parking lot also has many transient guests. Birds may land to pick at crumbs of breakfast dropped by teachers and students hurrying to class or bits of afternoon snacks that fall to the ground. At night, mice and rats may venture into the parking area seeking similar treats, while bats are frequently seen feeding on insects attracted by lights in the parking area. Trash cans in or around parking lots may also attract skunks, raccoons, or squirrels in search of food. Occasionally, an eager skunk may be found temporarily trapped in the bottom of a trash can.

Parking Lot Inquiries

Useful materials: thermometers (regular and maximum/minimum), buckets of water, kickballs, trowel, pots and potting soil.

General Surface Features

Take your students out to the school parking lot.

How has this area been changed over the past 200 years?

Reach down and run you fingers over this surface. Describe how it feels.

Look at the surface. How many different kinds of materials make up this surface?

What evidence can you point out to support your previous answer?

What are the original sources of the raw materials that went into making this surface?

Why are stones mixed with the tar?

How is the asphalt surface similar to the sidewalk? How is it different?

Energy Absorption

Provide students with thermometers and a data sheet for recording temperatures on different surfaces.

Place your hand on the asphalt, a car, the sidewalk, and in the grass. How do the temperatures of these surfaces compare?

Predict the temperature of these surfaces at different times of the day. How could we test these predictions using thermometers?

Make a graph or chart to show the differences among the surfaces and how the temperatures change during the day.

How can you explain the differences in temperature that you observed?

Predict how the temperatures will change at night.

Does the pavement appear to be hotter or colder than the air temperature?

What effect does paving have on air temperature around your school during the day? At night?

If you have access to maximum/minimum thermometers, these could be used to compare the effect of buildings and pavement on temperature. The thermometers can be used to compare high and low temperatures in town vs. in the country over several days.

What factors affect the temperature in your community as a whole?

Is the existence of buildings or pavement a significant factor?

How could you test this using our maximum/minimum thermometers?

Water Relations

Buckets of water can be used to observe how water travels over the parking lot. If you prefer, kickballs could be released at different locations to give an idea of the routes runoff water takes.

Where does water go when it falls on the parking lot?

Does all the water run off? What else can happen to it?

Where does the water that runs off ultimately go?

How is this different from the water that falls on the lawn?

How will the runoff affect a stream?

Imagine what this area looked like 200 hundred years ago. Imagine a sudden thunderstorm today and one 200 years ago. In which situation would you expect the stream to have the greatest flow?

Have the students examine the parking lot surface where cars have been repeatedly parked.

What can you see that would be carried by runoff water to a stream?

How would this affect the stream?

Plant Succession

Are there any cracks in the parking lot pavement?

Can you find any soil in cracks in the parking lot?

Where did the particles that make up this soil come from?

Can you find evidence of plant life in the parking lot?

How did the plants get here?

What conditions must plants be able to tolerate to live here? Can all plants tolerate these conditions?

Are the plants that are growing here the same ones that you find in the lawn?

Do these plants grow as fast as plants in the lawn? How could you test your answer to the preceding question?

Can you find some cracks with plants growing in them that appear to be older than the one you are looking at? How are these cracks similar? How are they different?

Predict what the parking lot might look like next year, five years, or ten years from now if it is not maintained.

With a trowel, try scraping the soil and debris from cracks in the sidewalk. Place this material in pots with vermiculite or sterile potting soil and keep moist for one to two weeks. Grow the plants that sprout.

How many different plants can you recognize?

Where did these seeds come from?

How did they get there?

Can you find plants growing nearby that look just like the ones you grew?

Do cracks in different parts of your school grounds have the same seeds in them? Design an experiment to answer this question.

Animal Life

What animals can you find living in the parking lot?
What makes the parking lot a suitable habitat for these animals?
Does time of day affect their activity? How could you test this?
What organisms might come to this area at night?
How might humans influence the number and kinds of organisms that might visit the parking lot? How could you test this?

Focus on the Features of Habitats

The following four chapters of this book concentrate on organisms found in various schoolyard habitats. The ideas about habitat features presented in this chapter on parking lots can help you understand the interactions that go on between any organism and its habitat. In any habitat, such interactions exert a large influence on where organisms live, what their features are, and how they survive.

Chapter 3. The Lawn

Introduction

The most conspicuous habitat of the schoolyard is the mowed lawns and play areas around the school buildings. At first glance, the lawn may seem to be rather one-dimensional, but closer examination reveals great diversity. The diversity of plants and animals will, of course, depend upon the diligence with which maintenance crews apply chemical controls. The variety and types of plants growing in the lawn also depend upon the nature of the environment bordering the schoolyard—whether it is a plowed field, forest, pasture, or developed area. Adjacent areas can be a source of seeds, which are carried by physical or biological means into the schoolyard.

The lawn **community** (the particular group of organisms found in the habitat) is artificially maintained by the expenditure of energy through mowing. Without this human controlled energy input, the lawn would follow a process of succession until it was finally replaced (in southwestern Virginia) by a **deciduous** forest community (deciduous trees are those that annually lose their leaves). In the following section on Grasses you will be introduced to how the lawn mower can favor certain plants and discourage others. The plants in the lawn are in constant competition with each other for sunlight, minerals, water, and soil. Depending upon the cutting height of the lawn mower, certain kinds of plants may be more successful than others in this competition. Many other factors will influence the plants' **distribution** (that is, where, and in what groupings, plants are found; for types of plant distribution, see the Glossary entry for "distribution").

The Lawn and Environmental Conditions

Close inspection of the lawn around your school will reveal not only diversity of plants and animals but also different environmental conditions. These differences in environmental conditions will contribute to determining the differing biological features. For example, a sunny area that is subjected to heavy student traffic or play—such as a well-traveled path or a baseball diamond—has very different environmental conditions from a shady, less-disturbed area. Only plants that can tolerate sun and traffic will be able to survive in the extreme environment at the edge of a baseball diamond. In shady, less-traveled parts of the lawn, a different assemblage of plants will be found.

The Variety of Plants in a Lawn

The number of different plants found in the average lawn is often surprising to the casual observer. It is not unusual, after searching only a few minutes, to find 15 to 20 different kinds of plants. Some of the more common and conspicuous plants that you will encounter are described in this section. Many of these plants are not native to the United States and have their origins in the herb and medicinal gardens of early settlers. Other plants were transported here inadvertently in a variety of ways, such as in hay for feeding animals on ships or in mud on the soles of shoes. Because of the variety of plants, the lawn is also home to many different animals that live on or feed upon the plants.

The lawn can be used as a hands-on model that illustrates the diversity of life and the interdependence of living things. For example, consider a lawn where **herbicides** (plant-control chemicals), mowing, and perhaps watering have been used to favor the dominance of one plant species, such as Kentucky Bluegrass. In such a situation, most of the rest of the things living in that community depend heavily on the health of the dominant species, in this case the Kentucky Bluegrass. A community so dominated by one species is generally thought to be ecologically unstable. Here's the reasoning. If the Bluegrass succumbs to a particular disease or event causing a catastrophic decline in its population, the effect on the rest of the community could also be disastrous. Plant-eating, or **herbivorous**, animals feeding on the grass would lose their food source, as would **predators** feeding on the plant eaters, and soil that was held in place by the thriving grass's roots could be washed away. Once students begin thinking about such connections in a familiar habitat, an analogy to the importance of maintaining biodiversity on our planet is easy to make.

Introductory Lawn Inquiries

These lines of inquiries involve observations outside as well as collection of lawn plants to take inside and examine more closely. Useful materials: zip-lock bags, hand lenses, rulers, meter sticks.

Identifying Different Environmental Sites in the Lawn Habitat

Take your students out to the lawn for observations. Instruct them especially to look for areas of contrast.

Does the lawn look the same everywhere?

Point out some areas that look different, and describe the differences you see.

Why are some areas different than others?

How is the environment different in these areas?

What could you measure to describe how the environment differs in different places?

Introductory Lawn Inquiries, continued

Lawn Plant Distribution

Can you detect patterns in the location of plants in the lawn? Are the distributions clumped, random, or uniform? *(See the Glossary, under "distribution," for these terms.)*

Do trees seem to affect the distribution of the plants? How can they do so?

What other factors seem to affect the distribution of plants?

How do humans affect plant distribution?

Discovering the Variety of Plants in the Lawn

How many plants do you think you would find in the lawn?

Write down a prediction of how many plants you think we could find.

Divide the class into groups of four. Give each group a plastic bag to collect plant parts. Allow approximately 10 minutes for the search, then return indoors with the plants.

Lay the plants out on a piece of paper and separate all the different kinds.

What features make plants look different?

What features did you use to tell plants apart?

How many kinds did you find? How does this compare to your prediction?

What are some unique or interesting features of each plant?

Look at a plant closely with a hand lens. What features are now visible that you couldn't see before?

Sketch a picture of your favorite plant, and describe the features of this plant.

How could you use the plants' features to put them into groups or categories?

Common Versus "Rare" Plants

Do some plants appear in larger numbers than others?

Which appear to be most common? Least common?

What is a rare species? Would you say that any of these plants are rare?

How do "rare" species in your lawn compare to endangered species in the world?

How are rare or endangered species protected?

Do the rare plants in your lawn need to be protected? If you needed to protect these species, how would you do it?

Why might it be good to have a lot of different kinds of plants in a habitat?

Grasses

Family: Poaceae, the Grass Family

The Grass Family is one of the largest plant families in the world. The family includes some of the world's most economically and ecologically important plants: Rice, corn, wheat, rye, barley, sorghum, sugarcane, and bamboo are all grasses. It would be hard to imagine today's societies without these plants. The seeds of grasses, also known as grain crops, are rich in protein, carbohydrates, and oils and provide the main food base for many cultures. Even in societies where beef is consumed in large quantities, forage grasses still provide the food base to raise these animals. In many parts of the world, grass is the dominant vegetation or ground cover.

Grasses have true **flowers**, but one has to look closely to find their flowers. You can observe these flowers on the ends of mature grass stalks that have not been mowed. Different kinds of grasses will have uniquely arranged flower clusters. Grass flowers characteristically lack the brightly colored and conspicuous petals we usually associate with flowers. Grass flowers also lack **sepals**. The actual reproductive structures usually include three **stamens** (the male, pollen-bearing part of the flower) with two feathery-tipped **stigmas** where pollen is collected. (You may be more familiar with the term **pistil**. The stigmas are part of the pistil, the female part of the flower.) A grass **leaf** is long and narrow with parallel **veins** (the tubular structures that carry materials to and from the leaves). The leaf wraps around a hollow **stem** forming a structure called a sheath. Where the leaf attaches there is a bulging joint which forms a distinguishing characteristic of the grasses—jointed stems. Bamboo shows this feature nicely.

Grasses and Mowing

In much of the eastern United States, grass as a ground cover has to be maintained by frequent mowing. In southwest Virginia, as in many other part of the country, an unmowed lawn would eventually revert to a deciduous forest, the type of **climax community** that results from succession in much of the eastern United States. There are, however, some natural grasslands in some limestone areas, and some grass habitats were maintained in the past by human-caused or natural burning. Grazing by livestock maintains the grass community in pastures.

In the driest parts of the United States, people who desire lawns must water them frequently or else the lawn will revert to a desert, cactus-dominated community. But in other parts of the United States and of the world, grasses are the dominant plants making up the climax community. In general, these grasslands exist without trees because there is not enough rainfall to support the growth of large woody plants, but there is enough rainfall to support the grass community.

Grasses are able to thrive despite frequent mowing, for several reasons. First, they have growth centers in their stems below the point where the leaves are attached. In other plants, the growth center is located at the *tip* of the stem. Removal of this tip would cause that part of the stem to stop growing; however, growth could continue at the tips of side branches. Mowing, therefore, eliminates many plants that would otherwise overtake and grow above the grasses. Because grasses have growth centers near the base of the stem, these plants are also able to tolerate grazing and frequent fires as well as mowing. These tolerances have allowed grasses to be highly successful during their evolutionary history.

Many grass plants in lawns rarely produce seeds because of the low height at which we maintain the plants. Nevertheless, the grass seems to be able to multiply efficiently. Depending on the particular type of grass, grass plants can reproduce vegetatively by means of underground or aboveground horizontal stems that form dense mats of plants.

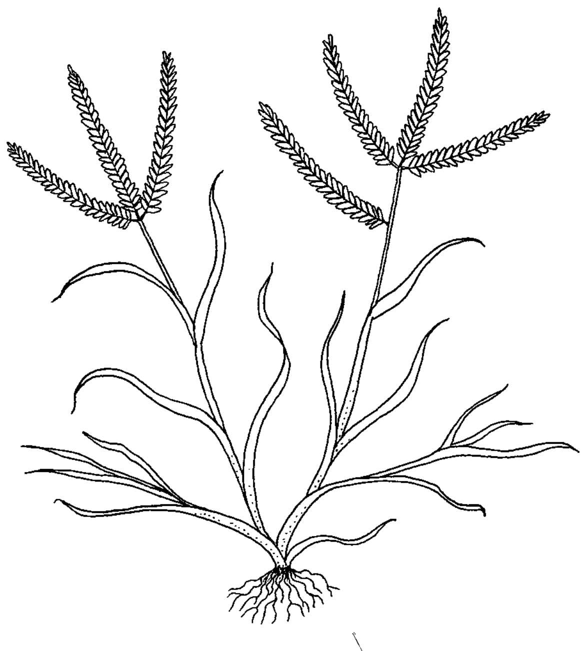
Another adaptation of grasses that has contributed to their success is their root system. Grasses have a network of many small roots, called a fibrous root system. This root system can extend both deep into the soil and far outward horizontally. This makes for a very efficient water- and nutrient-collection system. One study found the root system of a single rye plant to have a total combined length of 387 miles! Most of the living mass of grass plants occurs underground where water and nutrients are stored. This trait also enables the plant to survive grazing, fires, droughts, and frequent mowing. The extensive fibrous root systems of grasses and their relatively fast growth make grasses ideal for stabilizing soil and reducing erosion.

In short, while grasses have not adapted specifically to lawn mowers, they have over time developed many traits in response to other environmental factors. Many of these traits have made grasses tolerant of mowing, as well.

More than 1,400 species of grasses have been identified in the United States. Below we have described four species that are common in lawns in southwestern Virginia. The table at the end of this section summarizes some features that distinguish these four kinds of grasses. The drawings of each grass also point out distinctive features.

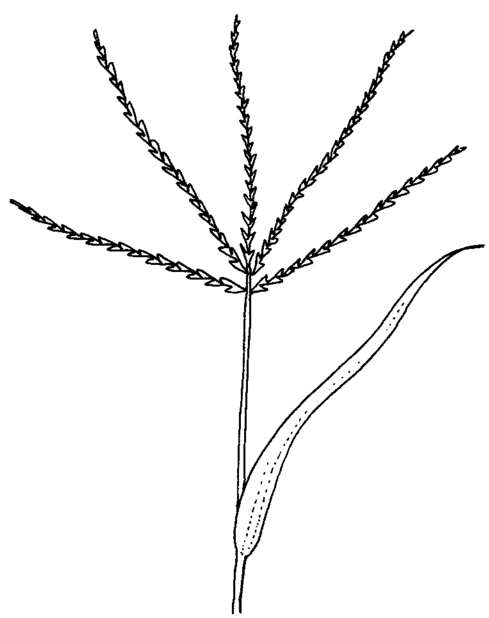
Common Types of Grasses

Goosegrass (*Eleusine indica*). This grass is typically found in areas that are experiencing environmental stress, such as around playground equipment, along the edge of pavement where cars park, or along a path. Goosegrass is sometimes confused with crabgrass, which is described next. Goosegrass can be distinguished by its flattened stems that usually trail on the ground and form a flat, mat-like growth.



Goosegrass

Crabgrasses (*Digitaria* species). This well-known type of grass is the scourge of many homeowners who try to keep it out of their yards. One reason this type of grass is so unpopular is that, unlike preferred varieties of grass, crabgrasses are **annual** plants (plants that complete their life cycle in one year) and die back with the first frost,

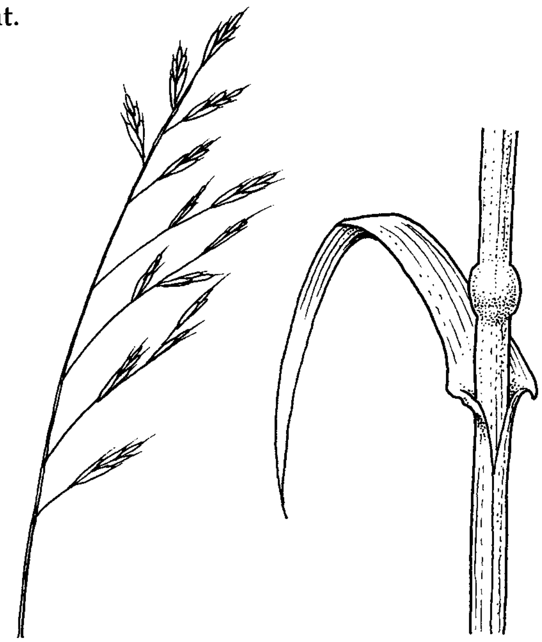


Common Crabgrass

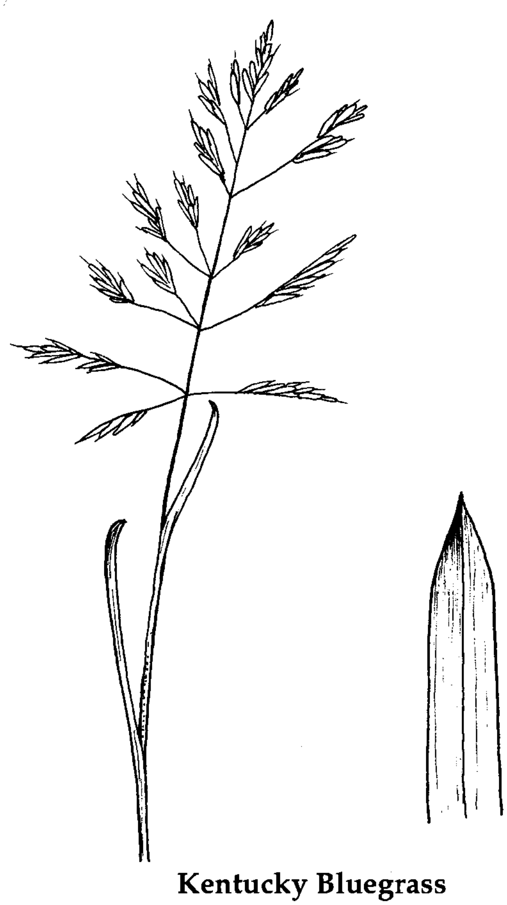
brown patches in the lawn and voids where other weeds may invade. Two kinds of crabgrass found in southwest Virginia are **Smooth Crabgrass** (*Digitaria ischaemum*) and **Common Crabgrass** (*Digitaria sanguinalis*) (which is more common). Both of these grasses grow in clumps or dense mats, are light green in color, and have flowers arranged on distinctive finger-like stalks.

Smooth Crabgrass

Tall Fescue (*Festuca elatior*). This grass and Kentucky Bluegrass are the most common grasses planted in southwestern Virginia. Tall Fescue is a **perennial**, so, unlike crabgrass, a single plant can grow back year after year. This grass is often favored in this area because of its tolerance of hot, dry weather. It is characterized by relatively wide (4-8 millimeters–about 1/6 to 1/3 inch) leaf blades, and flowers or seed heads appearing in tufts. Distinctive bulges along the stem will help you identify this grass (the bulges actually mark the base of the leaves, which wrap tightly around the stem for some distance). You may find Tall Fescue growing in dense patches in a Kentucky Bluegrass turf. The patches expand slowly during the growing season by producing new shoots around the edge of the mat.



Tall Fescue



Kentucky Bluegrass

Tall Fescue was originally introduced from Europe as a forage crop for cattle. Subsequently it spread rapidly into favorable habitats, sometimes to the detriment of native plants unable to compete with this grass' ability to spread and establish itself. Today, Tall Fescue is widely planted for lawns, parks, athletic fields, and roadsides.

Kentucky Bluegrass (*Poa pratensis*). This is probably the most popular and widely distributed of the grasses grown in lawns. It is famous for its lush growth, especially on the horse ranches in the limestone rich soils of Kentucky—the Bluegrass State! Over 700 varieties have been developed by horticulturists. In mowed lawns, the grass has relatively thin blades: less than 4 millimeters (about 1/6 inch) wide. If you look closely at the end of an *uncut* blade, you will see a distinctly boat-shaped tip. Mature plants that have not been mowed can also be identified by their distinctive pyramidal clusters of flowers or seeds. Kentucky Bluegrass is a perennial and spreads by a type of underground stem called a **rhizome,** so it appears less clumped than Tall Fescue.

What to Look For in a Common Schoolyard Grass

Kind of Grass	Distinctive Features
Goosegrass	Growth is mat-like Flattened stems
Crabgrass	Grows in clumps Light green color Flowers on finger-like stalks
Tall Fescue	Grows in clumps Bulges along stem
Kentucky Bluegrass	Growth is spread out (not clumped) Relatively thin leaves Leaves with boat-shaped tips

Grass Inquiries

Students will observe the lawn as a whole as well as individual plants and parts. Useful materials: plastic bags, hand lenses, trowel.

General Grass Inquiry

Is all "grass" the same?
What features do different grasses share?
How are grasses different from some other familiar plants?
Pick a blade of grass from the lawn and describe or sketch its features.
How many different kinds of grass plants can you find in the lawn?
Try looking at the lawn from a distance and look for changes in color or patterns in the observed textures of the lawn surface. Compare the blades of grass from these locations. How do they compare? Are they actually different kinds of grass?
What features did you use to tell the kinds of grasses apart?

Grasses and Mowing 1: Growth

How do grass plants grow?

How does a grass plant increase in height? Where is new plant material added?

Can you design a way to show how a grass plant gets taller?

How does this way of growing help grass plants to survive, despite frequent mowing that discourages the growth of other plants? How does this pattern of growth compare to other plants?

Grasses and Mowing 2: Flower and Seed Heads

Have students pick a blade of grass from an unmowed area and compare it to the grass in the lawn.

How are they similar? How are they different?

Do you think they are the same kind (species) of grass?

If they are the same, why do they look different?

How does mowing the lawn regularly affect the form of the grass plants?

Do the grass plants in the mowed area produce seeds? Why not? Compare them to grasses in the unmowed area. Do they produce seeds?

How can you explain the abundance and density of the grass plants in the lawn if mowing reduces seed production?

Do different kinds of grass in the lawn have different ways of producing new plants?

What evidence can you find to show that grass plants can reproduce themselves without producing seeds?

Grasses and Mowing 3: Grass Roots

Use a trowel to dig out square plugs of grass about 10 centimeters (4 inches) wide. Let groups of your students examine the plugs.

Describe the structure of the roots.

Try to remove some of the soil from the roots. Is it easy to do?

How does this property explain why grass is often planted on the sides of roads and highways immediately after construction?

Why is it important to plant grass at such sites as soon as possible?

Clovers (*Trifolium* species)

Family: Leguminosae or Fabaceae, the Bean Family

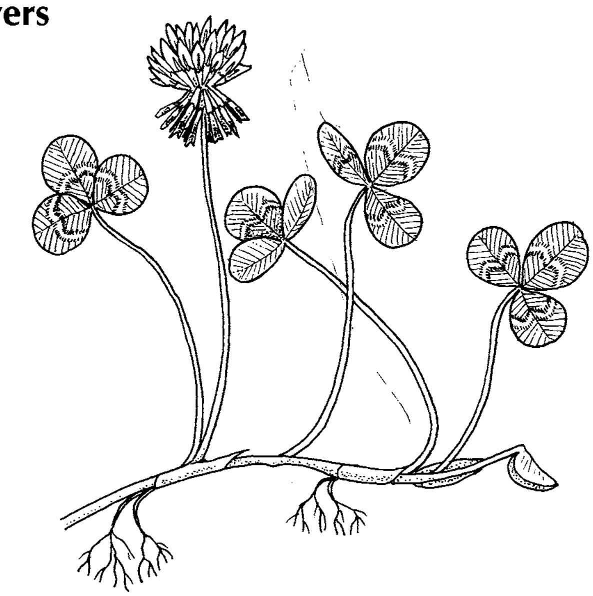
There are a number of different kinds of clovers, but two common and easily recognized clovers in southwest Virginia are **White Clover** (*Trifolium repens*) and **Red Clover** (*Trifolium pratense*). Both clovers have distinctive round **leaflets** (parts of a **compound leaf**) arranged in threes (occasionally, the "lucky" four-leaflet arrangement is discovered). In fact, the genus name *Trifolium* comes from Latin and means "three leaves." Both of these clovers may be found growing in lawns, fields, and unmowed or unkempt areas. The following chart shows how to distinguish White Clover from Red Clover.

	White Clover	**Red Clover**
Flowers	White or pinkish	Magenta or purple
Leaves and Stems	Leaflets found on separate stalks branching off a stem lying on the surface of the ground	Leaflets branch off upright stem
	Stems and leaves smooth	Stems and leaves hairy; leaflets often with whitish marks
Habitat	Most common in frequently mowed lawns	Most common in unmowed areas
Size	Tends to grow short: 7-10 centimeters (3 to 4 inches) high	Tends to grow tall: 15-60 centimeters (6 to 24 inches) high
Growth Habit	Perennial (comes back from roots)	Perennial

Growth and Distribution of Clovers

Red and White Clover differ in how they grow and, consequently, in which habitats they occupy. White Clover tends to be relatively low-growing, while Red Clover tends to be much taller. White Clover is able to grow, flower, and produce seeds in frequently mowed lawns because of its limited height. Mowing actually aids this plant in its competition for sunlight with other lawn plants by keeping clover competitors from reaching their full height.

In contrast, Red Clover is less frequently found in lawns, because it tends to be a taller plant and, if frequently mowed, is not able to

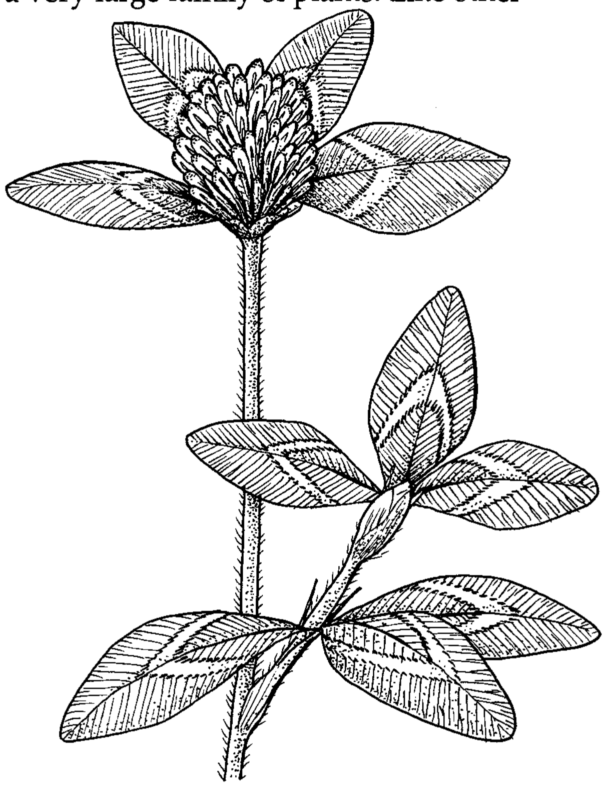


White Clover

reach its full reproductive potential. In less frequently mowed fields or unmowed meadows, Red Clover is much more common, because its height enables it to compete with other tall plants for sunlight. White Clover is found much less frequently in these areas, because its low-growing habit makes it an ineffective competitor for sunlight.

Another factor that explains the abundance of White Clover in lawns is its ability to spread vegetatively. White Clovers have a type of stem, called a **stolon**, that grows along the ground surface. From the stolon, separate leaf stalks and flower stalks arise. Observations of White Clover growing in a lawn will show that it grows in clumps. Closer examination of these clumps reveals that the blossoms and leaves of seemingly separate plants are growing from the stolon of a single plant. In contrast, Red Clover plants may have several stems, all growing upward, but these plants do not spread by stolons.

Clovers are members of the Bean Family, a very large family of plants. Like other members of this family, clovers are important as soil enrichers. The clovers have bacteria associated with their roots that are able to "fix" gaseous nitrogen from the air (which can not be utilized by plants) into nitrogen compounds that can be absorbed by plants. These "fixed" compounds are the same as those included in fertilizers and are essential nutrients for plant growth. The bacteria live in nodules in the roots of the plants. These root nodules can be observed on the roots of Red Clover.



Red Clover

Clover Flowers and Pollinators

In clovers, as in all flowering plants, sexual reproduction involves **pollination**: the transfer of **pollen**, containing the male sex cells or **gametes**, to the flower's **ovary**, where the female gametes are located. Clovers exhibit an interesting adaptation for increasing the chances for pollination to occur: gradual blooming. Close examination of clover **blossoms** will reveal that they are not single flowers but are actually made up of many small flowers. Not all of these flowers will open up at the same time. As a White Clover blossom matures, new **buds** are produced in the middle of the blossom and the buds on the outer edge open and enlarge. Once pollinated, the petals of the flowers (on the outermost edge) wither and turn downward as seeds in these flowers begin to mature. Row by row, the flowers in the blossom will enlarge, open, and then turn downward. All three of these stages can be observed in White Clover blossoms. Red Clover has a similar strategy of gradual blooming, but the flowers do not change shape.

This gradual-blooming strategy ensures that each day some clover flowers will be available to pollinators. If all flowers in the blossom opened at the same time and no pollinators visited the plant, the flower-making effort would be wasted. Having only a few flowers open each day increases the chances that at least some of the flowers in the blossom will be visited by a pollinator and be successfully pollinated.

Clovers, like many other flowering plants, have bright colors, sweet odors, and nectar to attract pollinators. Many bees, for example, rely on the sugar-rich nectar as their main energy source. Clovers also attract other **insects**—including many types of butterflies—and hummingbirds. Red Clover is pollinated mainly by large bumble bees, one of the few types of insects able to reach the nectar at the base of the flowers. (An interesting illustration of this is that when Red Clover was introduced in Australia, it did not become successfully established until the introduction of bees that could pollinate this plant.) White Clover is pollinated mainly by the Honey Bee, whose tongue is too short to reach the nectar in Red Clover.

Pollinators not only move pollen around on a single plant as they feed there, but they also transfer pollen from one plant to another. In the former case, **self-pollination** of the plant can occur; in the latter case, **cross-pollination** between two plants of the same species can occur. The distinct advantage of cross-pollination is that it produces individuals with more genetic variations. Such genetic variation helps enable a species as a whole to adapt to environmental changes. Self-pollination, on the other hand, produces individuals with little genetic variation, giving the species less adaptive capability.

Clover History and Uses

Both Red and White Clover are alien plants, that is, they are not native to this country. Settlers first arriving on the continent from Europe brought with them many seeds for their herb, medicinal, and vegetable gardens. It is likely that clover seeds were among their valued seed assets. As the land was cleared and the great eastern forests were cut down, suitable habitats for clovers were created, and clover invaded these new habitats and began growing wild.

Red Clover is commonly planted by farmers as a part of a system of crop rotation. The clover helps enrich the soil with nitrogen (as described above), and it can be used as pasture or hay for cattle, horses, and sheep. Clovers are also important in the honey industry, because clover blossoms are rich sources of bee-attracting nectar.

In addition to its agricultural importance, Red Clover has been used to make teas and wines. Clovers are also a nutritious food source for many wild animals, such as rabbits, groundhogs, and deer.

Clovers Inquiries

Find an area of lawn that has White Clover growing abundantly and use this for your initial field trip site. You may find some Red Clover in this area too, but unmowed locations along the walls of the building, under shrubs, or along a fence are where you are more likely to find mature Red Clover. Have your students examine individual clover plants. Useful materials: hand lenses, rulers, meter sticks.

Introduction to Clovers

How is clover similar to the other plants growing in the lawn? How is it different?

Are all the clovers in the lawn the same kind? Defend your answer.

Are the clovers growing in the lawn the same kind as the clovers growing in an unmowed area?

How are these two clovers similar? How are these clovers different?

Clover Growth and Distribution 1: Height

Which clover is more common in the lawn?
How can you explain this?
Which plant is taller? Which plant is shorter?
Which plant is able to flower and produce seeds even though it is subjected to mowing each week?
How often will Red Clover be able to flower and produce seeds when growing in a lawn?
Which clover is more common in an unmowed meadow?
How can you explain this?
Would the White Clover be able to get adequate sunlight in the tall grass?
Why is Red Clover able to compete for sunlight in the tall grass?
What will eventually happen to the Red Clover if shrubs and trees begin to grow in the unmowed field?
Predict what would happen to the White Clover population in a lawn if it were no longer mowed.
How might the Red Clover population in the same area change if mowing ceased or occurred only once or twice each year? Why?

Clover Growth and Distribution 2: Stems

How would you describe the distributions of the two kinds of clovers?
How can you explain the distribution of each plant?
Find a White Clover plant and trace it to its source. Hold the stem of the plant and trace its stem carefully along the ground separating it from the network of grass and plant stems. Describe the growing habit of this plant.
How do your observations explain the clumped distribution of the White Clover?
How many individual plants actually make up a clump of White Clover?
Find a Red Clover plant. Does the Red Clover grow in the same way?

Clover Blossoms

Have students use hand lenses to examine White Clover blossoms closely.
Look closely at and compare the blossoms from several White Clover plants. How many individual flowers actually make up a White Clover blossom?
Do all the individual flowers of the plant open at one time? What evidence can you find to support your answer above?
How are the flowers in the center of the blossom different from the flowers on the outside of the blossom?

Clovers Inquiries, continued

Find a blossom that has just begun to flower, and one that has finished or nearly finished flowering. What happens to the flowers in blossoms over time?
What disadvantage might there be for the plant to have all the flowers in the blossom open at the same time?
Compare the White Clover blossom characteristics to those of the Red Clover blossom. How are they similar? How are they different?

Clover and Pollinators

Why are many flowers brightly colored?
Smell a clover blossom. Describe the odor. Why do these flowers have a pleasant smell?
In addition to the odor there is a sweet nectar in the base of these flowers. What makes it sweet?
Have you ever tasted the nectar of a flower? *(Most children and adults in our area have experienced the sweet taste of the nectar of Japanese Honeysuckle; information on Japanese Honeysuckle can be found in the Vines section of the Fencerows chapter of this book).*
Why is this nectar so important to bees?
How is this energy source similar to our energy sources?
How do the plants benefit from this interaction?
What other organisms might take advantage of this energy source?
What organisms can you actually observe visiting these flowers today?

Clover History and Uses

How are clovers important to wildlife?
What organisms might feed on clover?
How are clovers important to farm animals?
How else are clovers used in agriculture?
Both Red and White Clover are native to Europe. How did they arrive here?

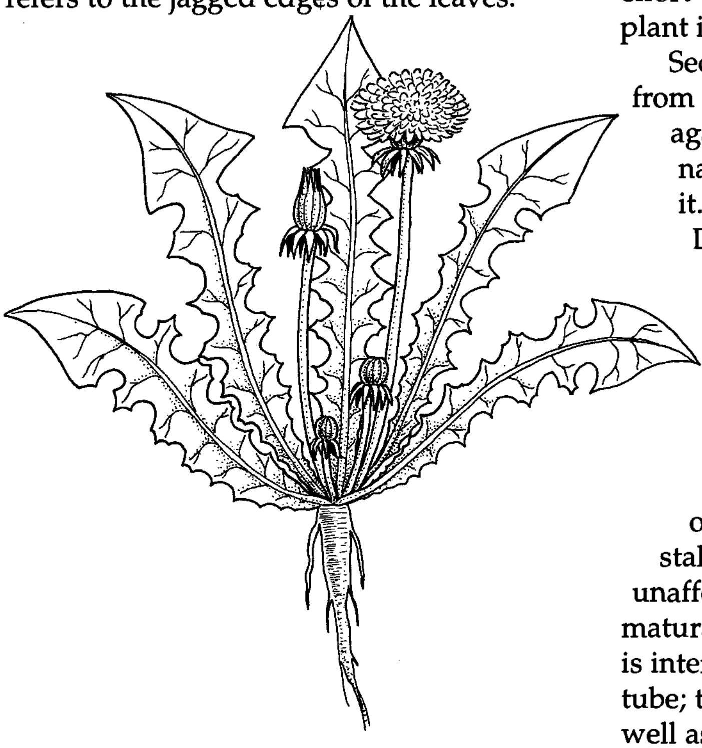
Dandelion *(Taraxacum officinale)*

Family: Asteraceae or Compositae, the Sunflower or Composite Family

The most commonly seen and easily recognized weed in the lawn is the Dandelion. Its yellow flowers catch our eye in the green expanse of a manicured lawn—but much to the chagrin of many lawn owners! These remarkable plants have adaptations to life in a cultivated lawn that rival those of any other plant, short of the grasses themselves.

Recognizing Dandelions

Dandelions are in the Composite Family, a large plant family that includes sunflowers, daisies, and many other common plants. A characteristic of this family is that the "flowers," including the yellow "flower" of the Dandelion, are actually blossoms made up of many small, individual flowers. Dandelion plants have irregular, toothed leaves that radiate out from a central point. The name Dandelion is said to have arisen from the French term *dent de lion* meaning "teeth of the lion'; this refers to the jagged edges of the leaves.



Dandelion

Hollow stalks also arise from this center, supporting flower buds that can be observed in several stages on a single plant.

Dandelion blossoms open in the morning and close each evening. Once all the individual flowers on the Dandelion have bloomed, the blossom will close again until the seeds inside have matured. Dandelion seeds have a seed body attached to a stalk with soft fibers radiating from the top. This structure allows the seed to be carried by the wind.

Survival and Success in Lawns

Dandelion plants have several interesting features that make them well adapted to life in mowed lawns. First, the plant has a long, thick taproot that is difficult to pull out of the soil. This adaptation helps keep Dandelions from being dislodged by grazing animals or by humans. In a homeowner's lawn or at school, elimination of this plant by digging it up is often a futile effort—unless the entire root is removed, the plant is likely to grow back!

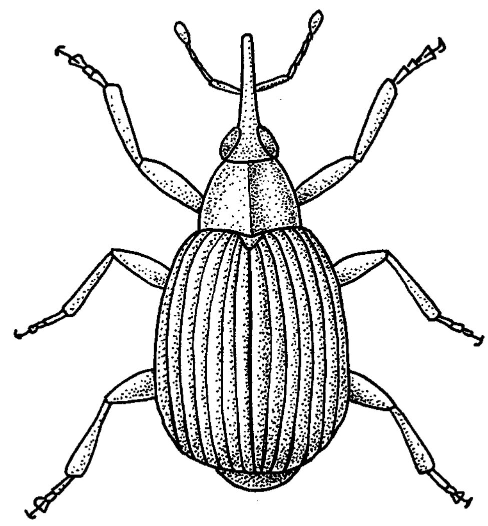
Second, Dandelion leaves, radiating out from a central axis, tend to grow flat against the ground, shading out the narrow blades of grass growing around it. Frequent mowing actually favors Dandelions over grass in their competition for sunlight by preventing grass from growing tall and shading the Dandelions. You may find that Dandelion populations are higher in mowed areas than in unmowed areas.

Third, the flower buds of Dandelions are formed on relatively short stalks, so many of the flower heads are unaffected by mowing, providing time for maturation of seeds. The flower stalk itself is interesting in that it occurs as a hollow tube; this construction provides strength as well as a degree of flexibility to breakage due to wind action or human activity.

Finally, the Dandelion seed head is adapted to develop rapidly and produce many wind-borne seeds. Once a Dandelion flower stalk has matured into a seed head, it undergoes a rapid and amazing transformation. In the space of just a few hours, the stalk will elongate, putting the seed head high in the air and maximizing the seeds' opportunity to be caught by the wind. Many home owners have mowed their lawn in the morning only to be greeted in the afternoon by a sea of Dandelion seed-heads waving to and fro. How could a plant grow so fast? We cannot explain this phenomenon by the production of new plant tissue by cell division: A plant could not possibly produce new cells this fast! Instead, the answer lies in Dandelions' ability to increase the seed head stalk through *elongation* of existing cells, by a rapid intake of water.

Weevils and Dandelions

If you are lucky, your class may be able to discover a fascinating creature living inside Dandelion flowers that are turning to seed. This creature is an immature stage, or **larva**, of a long-snouted beetle called a weevil. (Larvae are a developmental stage seen during **metamorphosis**; for more on this process in insects, see the Glossary entry for "metamorphosis.") The larva—known also as a "grub"—feeds on developing seeds inside the flower head. The weevil larvae can be found by collecting flower heads that have closed and gently teasing them apart. If a flower head is occupied, you will find a small, white grub with a brown head. The adult weevil is likely to have laid its eggs in the flower when it was open; after the flower closes, the grub hatches from the egg. In the developing Dandelion flower, the larva is hidden from predators, is protected from environmental extremes, and has a nutritious food source as it develops into a **pupa** and eventually into an adult insect.



Snout Beetle, a type of Weevil

If you put a number of flower heads with their stems in water in a closed con tainer, you may be able to observe the adult stage of this organism after the grub matures and pupates and the adult weevil emerges. Many types of weevils feed on seeds inside closed flower heads of different plants—clovers, for example, can house weevils. Weevils can be very destructive to agricultural plants, with perhaps the best-known example being the Boll Weevil, whose larval stage feeds on the seeds of cotton plants.

Dandelion History and Uses

It may surprise some, based on its wide-ranging distribution, that Dandelions are not native to North America! These plants, like many other common weeds, were brought to this country by early settlers. The plant had many medicinal and food uses, some of which are still practiced today. Its leaves have been eaten raw in salads or cooked as greens, its roots ground up and roasted to make a coffee-like drink, and its blossoms used to flavor wine. Dandelions have also been included in a wide variety of homemade remedies.

Dandelion Inquiries

Locate Dandelions in the schoolyard and have students work in small groups to examine these familiar plants. Useful materials: hand lenses, rulers, flower diagram. (A diagram of basic flower parts is included in the Glossary of this book, in the "flower" entry.)

Recognizing Dandelions

Look at a Dandelion leaf. Sketch or describe its shape.
How is it similar to the leaves of grass? How is it different?
How did this plant get its name?
Look closely at a Dandelion blossom (the "flower") with the hand lens. Sketch or describe what you see.
Break a blossom apart. Describe the parts that come out of it.
How many individual flowers make up one Dandelion "flower"?
How do individual flowers on the edge of the bloom compare with those in the interior?
Compare the parts of this blossom to the parts of a flower as shown in a flower diagram. Can you identify the parts?

Survival Characteristics 1: Roots

Can you pull up a whole Dandelion plant with its root system intact? Is it easy or even possible to do?
What would happen to this plant if a cow or sheep was grazing here?
How does the root help the Dandelion survive?

Survival Characteristics 2: Leaves

What do you notice about how the leaves of this plant are arranged? Do they tend to grow flat against the ground or straight upward like grass?
Why is it advantageous for this plant to spread out?
Look under the leaves of a large Dandelion. How much grass is growing around this plant compared to farther away from it?
Why is there less grass growing under this plant? What are these plants competing for?
Look at several Dandelion plants. Estimate the percentage of the plant that will be removed the next time a lawn mower passes over it.
How are the leaves of the Dandelion plant adapted for success?
How might mowing actually "help" Dandelions?

Dandelion Inquiries, continued

Survival Characteristics 3: Flowers

Where are the developing buds of the next flowers found on this plant?
How does this adaptation help make Dandelions successful in a mowed lawn?
How might this adaptation have helped the plant in days before human intervention?
Look at the stalk that holds up the flower heads. How is it different from the leaves?
Break off a flower stalk and look at it. How does this shape help it do its job?
What is the average length of a Dandelion stalk when it is flowering? How does this compare to the average length when it has turned to seed?
Can your group collect all stages of the Dandelion blossom and arrange them in order?

Survival Characteristics 4: Seeds

Have you ever seen a lawn that has been cut early in the morning show by afternoon of the same day numerous seed heads of the Dandelion waving in the wind high above the grass?
How can you explain what you have observed?
Using a ruler, can you measure the elongation of the seed-head stalks in centimeters per hour?
How does this particular adaptation add to the success of this plant in the lawn?
Look at a Dandelion seed head. How did this form?
Blow on a mature seed head. What happens? How does this help the plant form new plants?
Look at a single seed with a hand lens. Can you describe it? Try a sketch of it.
How far do the seeds travel? Hold one up high and blow it into the air. What else, other than your breath, affects how far it travels? *(Have the students observe the effects of the wind.)*
What will happen to this seed if it lands on a sidewalk or a rock or in the road? On bare dirt? On a dense lawn?
What will it need to survive?

Weevils and Dandelions

Take your class to a location where there are many Dandelion plants in various stages of flower/seed development. Ask your students to distinguish between a bud that will develop into a flower head and one that has already flowered. Ask each person in the class to collect a flower head that has closed.

Gently tease apart the flower head.

What do you find inside? Describe this creature.

What do you think it is? Do you think it is an adult or larva? Why?

What other larvae are you familiar with that have this form?

How could this organism have gotten inside?

What do you think it is doing in the seed head?

What is this organism feeding on? Why is this such a good food source?

How does the plant provide protection to the larva? What is it being protected from?

What will happen to the population of this insect if weed killers are used in this lawn? Explain.

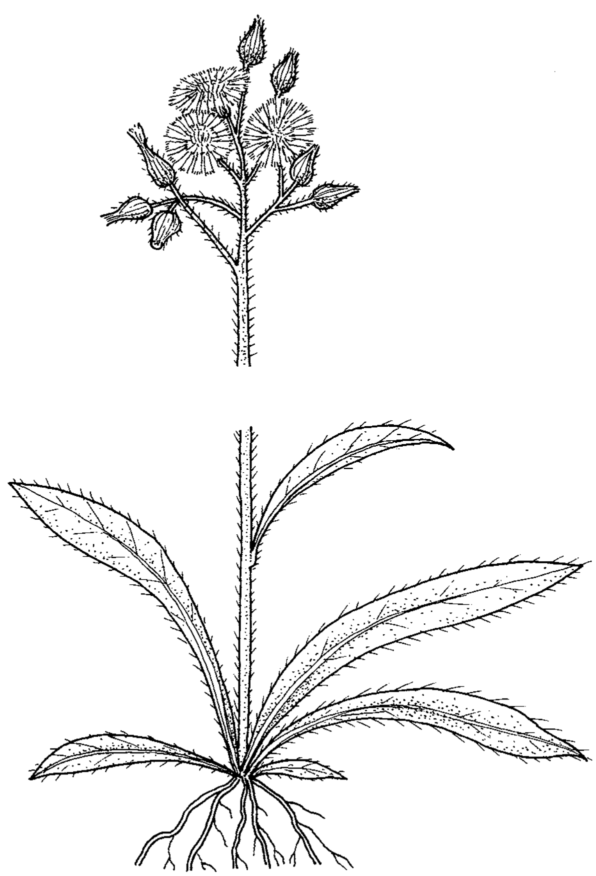
Hawkweeds (*Hieracium* species)

Family: Asteraceae or Compositae, the Sunflower or Composite Family

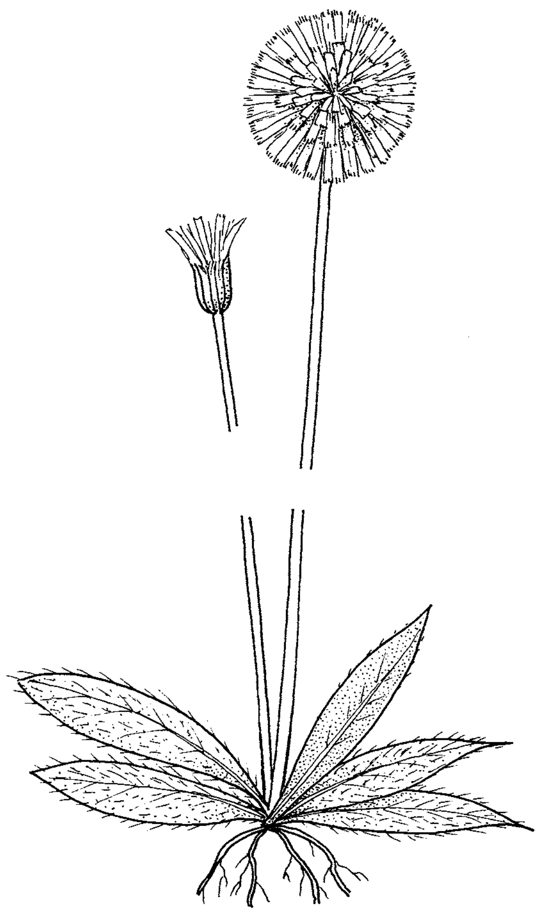
Hawkweeds often go unrecognized because of the similarity of their flowers to those of the Dandelion (see the preceding section on Dandelions). There are two types of hawkweeds that you are most likely to encounter in the lawn or surrounding areas: **Field** or **King Devil Hawkweed** (*Hieracium caespitosum*) and **Mouse-eared Hawkweed** (*Hieracium pilosella*). The origin of the scientific and common names for Hawkweeds dates back to Greek antiquity. Early writings include references to the belief that hawks landing in fields were feeding on hawkweeds to improve their eyesight. The root of the genus name *Hieracium* comes from the Greek word for "hawk," *hierax.*

Neither of these plants, which form only a basal cluster of leaves and thrive in disturbed sites and lawns, are native to North America; however, taller kinds of hawkweeds, which have leafy stems and grow in thickets and woods, *are* native. This is not surprising when we realize that the "natural" state of most of the eastern United States is woodland, and human clearing of the land created an ideal environment for the proliferation of introduced, "sun-loving" weeds of fields.

King Devil Hawkweed forms a leaf cluster similar to that of the Dandelion, with leaves radiating out from a center point and usually lying flat against the ground. Unlike



King Devil Hawkweed



Mouse-eared Hawkweed

the Dandelion, however, King Devil Hawkweed has oblong, *hairy* leaves with *smooth rather than jagged* edges. Flowering occurs May through August. The plant has many small, yellow blossoms on a single stalk. The blossoms may best be observed in an infrequently mowed lawn or on the edges of the building, often in poor soil. **Bracts** (modified leaf structures) attached to the blossom are covered with distinctive black hairs.

Mouse-eared Hawkweed is similar to King Devil Hawkweed, but the former has only one blossom at the end of each stem and lacks the black hairs on its stem and flowers. Mouse-eared Hawkweed leaves are smaller than the King Devil Hawkweed but have unusually *long, stiff hairs* on their upper surface. Underneath, they are covered with white fuzz or wool-like hairs. It is not hard to imagine how the common name relates to these leaves.

Hawkweed Growth

The common name for this plant may also be tied to comments by farmers in response to the plants' tenacious invasion of plowed fields and gardens. Once a plant is established in bare soil, it begins to spread aggressively by stolons (horizontal stems) that root into the ground and form new plants. Individual hawkweed plants do not compete well with other plants as vegetation gets taller, but, by forming a thick mat of overlapping leaves, hawkweeds can prevent other plants from growing and shading them out.

Hawkweed History and Uses

At one time, hawkweeds were used as a remedy for poor eyesight, but substantiation of this effect is difficult to find. In addition, Native Americans of northwestern North America reportedly used the leaves and stems of hawkweeds as a kind of chewing gum.

Hawkweed Inquiries

Check out your schoolyard to see if you have Hawkweeds as well as Dandelions available for study. (See the preceding section on Dandelions.) Assuming that your students recognize Dandelion flowers, the first line of inquiry below will help you create a discrepant event or puzzling situation for your students. The second line of inquiry can be done with hawkweeds alone. Useful materials: hand lenses, rulers.

Hawkweeds and Dandelions

Point out some hawkweeds in the schoolyard. Ask students if they can identify this plant. Most students, at first glance, will probably say that it is a Dandelion. Indicate that they have prematurely jumped to a conclusion and ask them to take a closer look. Point out some Dandelions (or show some you have collected) for comparison.

What are the features of the new plant?

How is the plant different from the Dandelion plant? How is it similar?

What features does the new plant have that are so markedly different from Dandelions as to justify putting the new plant in a separate group?

Hawkweed Inquiries, continued

How might this plant have gotten its name?
How do you think the hairs on the new plant might help it survive?

Hawkweed Growth

If you find more than one hawkweed plant growing close together, see if they are linked together. If so, you can pursue this line of inquiry.
How can you explain the plant stem connection between these plants?
How many above-ground stems does a single hawkweed plant produce?
Using a ruler, measure how far several stems extend before they put down roots and another plant with leaves is produced. What is the average length of the stems you measured?
Can you identify any variables that seem to affect stem length? Explain.
What would happen if these interconnections were cut?
How does this reproductive mechanism help this plant survive?
How does this growth pattern help it compete with other plants?
What evidence can you point out that indicates its success in competing with other plants?

Plantains (*Plantago* species)

Family: Plantaginaceae, the Plantain Family

Two kinds of plantains frequently occur in lawns or disturbed soil—**Common Plantain** (*Plantago major*) and **English Plantain** (*Plantago lanceolata*). Both display a distinctive ribbing running through their leaves. The leaves of Common Plantain tend to be oval or elliptical, while the leaves of English Plantain tend to be long and narrow or lance-shaped.

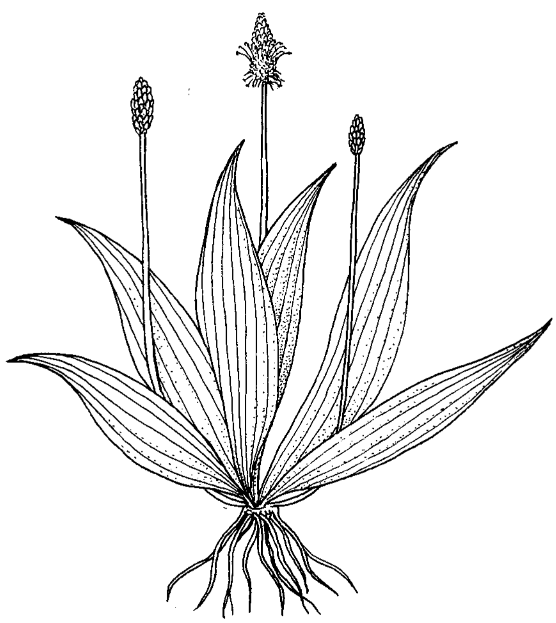
These two types of plantains can also be distinguished by their flower or seed stalks, when they are present. Common Plantain is sometimes known as "rat-tail" because of the long, thin shape of its flower or seed head. English Plantain, however, has a much shorter, more compact flower head.

Plantains are **biennials**, meaning they require two years to complete their life cycle. In the first year, the plant produces leaves that use energy from the sun to make food. This food, stored in the plant's thick tap root, is used in the second year to produce flowers and seeds.

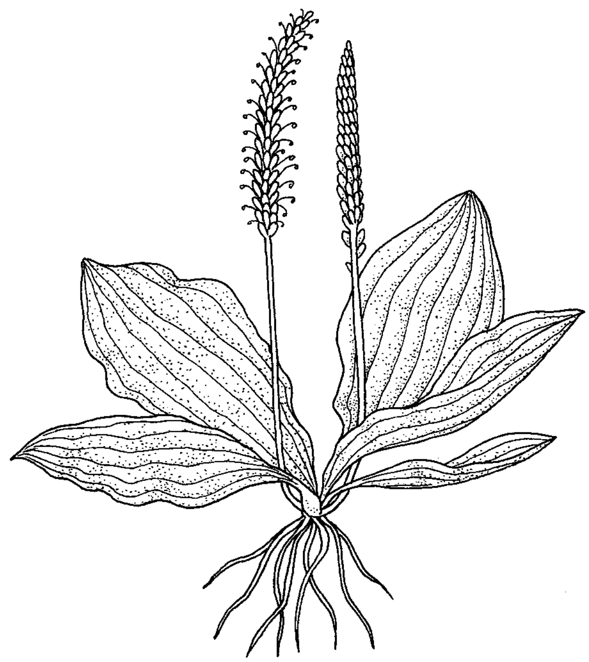
Plantains are particularly well-suited to life in frequently mowed lawns. When not mowed, other plants will quickly outcompete plantains. For this reason plantains are most common in mowed lawns and disturbed areas before other vegetation has become established.

Plantain History and Uses

When mixed with water, the seeds of English Plantain will produce a mucilaginous mixture that has been used as a fiber-rich laxative. Plantain has astringent properties, meaning it can cause constriction of blood-carrying capillaries in the body. For this reason it has been used in poultices for wounds, snake bites, and insect bites and stings. Some references also suggest that the plantain poultice may also have antiseptic properties (meaning it has the potential to inhibit microorganisms). The tender spring leaves of plantain can also be eaten, and the dried leaves have been used in teas. The seeds of both plantains are often eaten by birds and mice, and the leaves are a favorite food of rabbits.



Common Plantain



English Plantain

Plantains Inquiry

Examining and Comparing Leaves

Locate some plantain in the lawn. Show students one or two plantain plants and then ask them to fan out across the lawn and return with one entire leaf. Have the students compare the leaves that they found. Seeds are produced at varying times of the year. If the plants are producing seeds, use a similar line of inquiry to compare the seeds produced by the two kinds of plantain.

Feel the plantain leaves. Describe anything unusual or distinctive about how the leaves feel.

Are all the leaves that were collected identical? How are they similar? How are they different?

Could some of these leaves be grouped together?

Did you find different leaves in the same or different parts of the lawn?

Are the different leaves from the same or different kinds of plants?

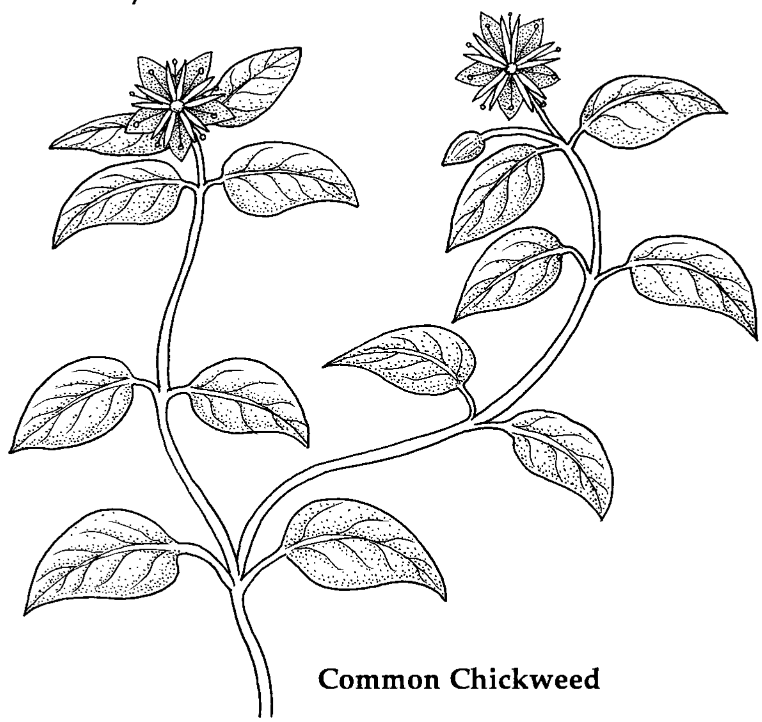
Are leaves from the *same* plant identical, or are there differences?

Common Chickweed *(Stellaria media)*

Family: Caryophyllaceae, the Pink Family

This ubiquitous plant is often found in large, dense patches in mowed lawns. Its low-growing habit and sprawling stem spare it from damage by lawn mowers. Like the Dandelion, Common Chickweed is so widespread it is hard to imagine that it, too, is not native to this country. Its tiny, white flowers may be observed throughout most of the growing season. This flower actually has five petals, but, because the petals are so deeply divided, there appear to be ten petals. This divided-flower appearance is characteristic of the Pink Family—the flowers appear "pinked" (cut).

After a Common Chickweed flower has been pollinated, it will close and turn downward. Open one of these drooping structures, and inside you will find developing seeds. These seeds are favored by chickens and other birds, giving rise to the name "chickweed"! Besides Common Chickweed, there are several other kinds of chickweed in Virginia and neighboring states.



Common Chickweed

Chickweed History and Uses

All above-ground parts of this plant have been used in salads or briefly cooked. Chickweeds remain green year round, adding to their value as a food source. Boiled greens have been used as a poultice for cuts and scrapes. Chickweed greens have been used to treat scurvy, a disease resulting from vitamin C deficiency.

Common Chickweed Inquiries

Go out into the lawn and look for the tiny, white flowers of Common Chickweed. Useful materials: hand lenses.

Chickweed Structures and Growth Habit

How is this plant similar to the grass around it? How is it different?

What must a plant be able to tolerate in order to be successful in a lawn habitat?

Explain how this plant can be so successful in a lawn habitat. What physical features make it successful in this habitat?

How would the lawn environment change if it were no longer mowed?

Common Chickweed Inquiries, continued

Would all the plants get taller? If not, which plants would get taller?
Would some plants grow taller at different rates?
What would happen to plants that could not grow taller or grew taller only very slowly?
What do you think would happen to the Common Chickweed population in general if the lawn was no longer mowed?
What does the word "common" mean?
How "common" (how many plants, how widespread) is Common Chickweed in this lawn?
Make a list of any other places where you find Common Chickweed. Based on your observations, do you think it really is "common"?

Chickweed Flower Features

Are all the plants flowering?
How long does a single flower stay open?
What happens after a flower has finished flowering?
Open up a flower that has finished flowering. What do you find inside?
Can you find all stages of the flower from bud to seed? If so, display these stages on a piece of paper.

Common Cinquefoil (*Potentilla simplex*)

Family: Rosaceae, the Rose Family

Another plant successful in lawns because of its low-growing habit, sprawling stem, and ability to thrive in poor soils is Common Cinquefoil, also known as Five Fingers. Besides Common Cinquefoil, there are a number of similar and closely related cinquefoils. The common name comes from the French word *cinque,* meaning "five," referring to the plant's leaves with five leaflets. The leaves have distinctly toothed edges and are sometimes mistaken for those of the Wild Strawberry, which has only three leaflets to each leaf (see the following section on Wild Strawberry). Common Cinquefoil has a five-petaled, yellow flower. In some populations, the petals of a flower that opened in the morning will fall off in the afternoon. You can test this by gently probing an open flower in the afternoon to see if the petals fall off easily.

Common Cinquefoil

Common Cinquefoil produces a stolon that creeps across the ground and sends roots down into the soil at intervals along its length. You may also be able to find a "tuberous enlargement," often largest in the fall, at the base of the stem of this plant; this enlargement may serve to store food for spring growth.

Common Cinquefoil Inquiries

Locate some Common Cinquefoil growing in the lawn. Useful materials: hand lenses, rulers.

Cinquefoil Structures

How is this plant similar to the plants around it? How is it different?

What are some of its features that enable it to be successful in the lawn?

Describe the structure of the leaf. Look at it with a hand lens.

In French, *cinque* means "five." What does the Common Cinquefoil's leaf structure tell you about how this plant got its common name?

Common Cinquefoil Inquiries, continued

Using Cinquefoil to Investigate Stems and Roots

Seed production is one way that plants reproduce. What is another way this plant can reproduce?

Describe or show the evidence that illustrates your answer.

As this plant's stem grows across the surface of the ground, what does it send into the ground? Where does this occur?

Use a ruler to measure the distance along the stem between rooting points. Find an average distance, and then compare the average for different plants in different locations. Do you find any differences?

Can you find evidence along the horizontal stem of points where roots have not yet developed but you suspect that roots may eventually form? If you do, how could you design an experiment to test your suspicion? (*One experiment would be to see if cut stems, placed in a jar of water, produce roots at these points.*)

How does the plant "know" to send roots down?

What environmental factors might stimulate root development?

Does the plant know which way is down?

Do roots ever grow up? How could you test this?

Wild Strawberry (*Fragaria virginiana*)

Family: Rosaceae, the Rose Family

Wild Strawberry is frequently found in lawns and is particularly conspicuous in the spring when the plants are flowering. Wild Strawberry can be recognized by its white, five-petaled flowers with yellow central parts. It has coarsely toothed leaves consisting of three leaflets. Like many plants that are successful in mowed lawns, Wild Strawberry grows and flowers close to the ground. It spreads vegetatively (that is, without sexual reproduction) by a long, creeping stolon in a manner similar to Common Cinquefoil.

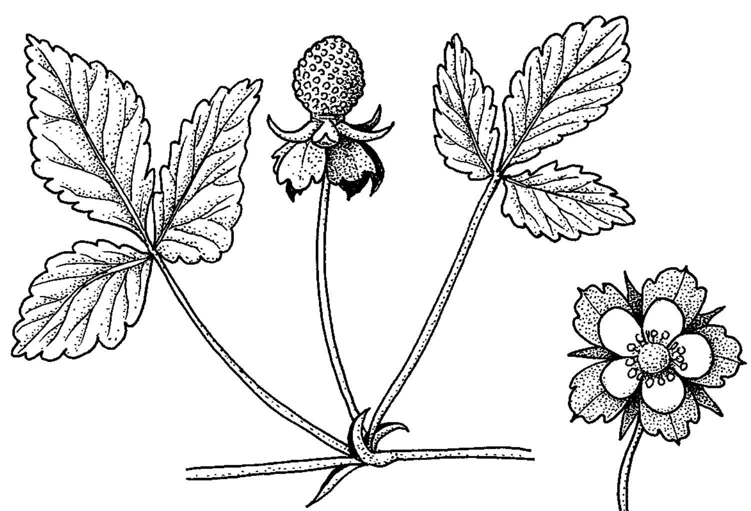
A Familiar Fruit

Wild Strawberry's **fruit** is the sweetest and most flavorful of all strawberries. The cultivated varieties are derived from this plant, but, apparently in selection for size and other commercially important characteristics, some of its flavor has been lost.

The "strawberry" itself is an interesting structure. Most of our familiar fruits are made-up of a sweet, fleshy matrix covering a seed or a number of seeds, as in a peach or an apple. Technically, the fruits of the strawberry are actually the small, dry, seed-like structures dotting the outside of the "berry." Each of these structures is actually a fruit with a dry, thin wall surrounding a single seed. The fleshy, sweet part of strawberries that people enjoy is actually an aggregate fruit, like a blackberry or raspberry but without the multiple fleshy parts of those fruits.

A similar plant one may observe in the lawn is **Indian Strawberry.** In contrast to Wild Strawberry, it has yellow flowers with green sepals. The sepals are longer than the petals themselves and have the appearance of small leaves rather than flower parts. Indian Strawberry originated in India. It also produces a fruit, but, unlike our native strawberry, the fruit has no flavor.

Wild Strawberry



Indian Strawberry

Strawberry History and Uses

The food value of strawberries is well known, and the plant's economic value is enormous. Strawberry farms are common in southwestern Virginia, and many people grow strawberries in their gardens. Some references indicate that a tea rich in vitamin C can be made from strawberry leaves.

Wild Strawberry Inquiry

Search your schoolyard to see if Wild Strawberry or Indian Strawberry is present. Useful materials: hand lenses.

Investigating a Familiar Fruit

Can you find a wild fruit in the lawn that is similar to strawberries in stores?

How does the fruit compare to strawberries you find in the store?

Look at the surface of this fruit closely with your hand lens. What do you observe on the surface of this structure?

Cut or break the fruit open and examine the inside. What do you find?

What do you *expect* to find inside a fruit?

What do you think the structures you observed on the outside are?

How is this fruit similar to an apple? How is it different?

With which other fruits could you compare or contrast it?

Why do plants have fruits?

Do many animals feed on fruits? Why? How can this help the plant?

Why are fruits often sweet or brightly colored?

Why are many fruits only sweet at the very end of their growing season?

What would happen if the fruits became sweet before the seeds could mature?

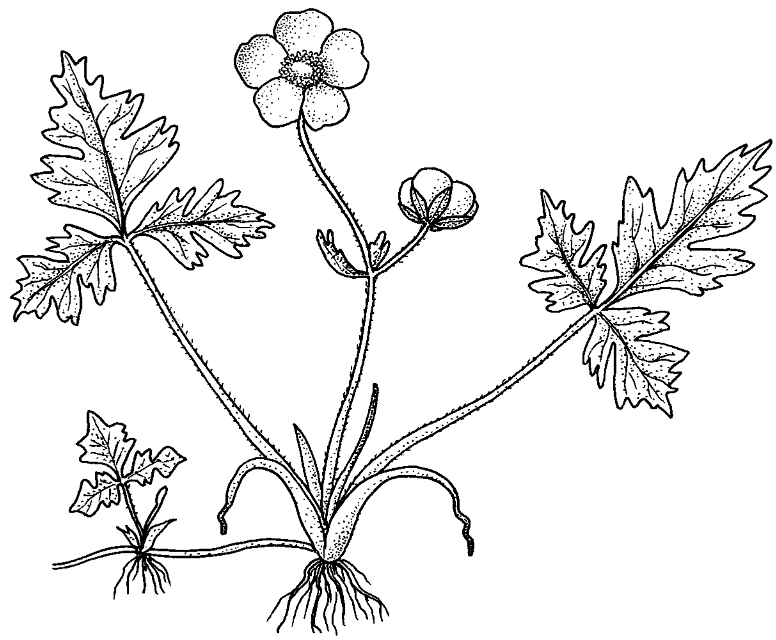
Buttercups (*Ranunculus* species)

Family: Ranunculaceae, the Crowfoot Family

⚠ *Some buttercups contain a harmful juice that can cause blisters.*

What youngster wouldn't recognize the brilliant yellow flowers of buttercups? Less likely to be known are the *poisonous properties of these plants* (more on that below).

Buttercups have shiny, five-petaled flowers with a distinctive, waxy texture. The reflection of the sun off this shiny surface gives a yellow appearance under your chin when you hold a buttercup there; as tradition has it, the yellow on your chin means "you really do like butter"! The leaves of buttercups are divided into 3 to 7 parts, which in turn are deeply divided. You can find buttercups in lawns as well as fields and gardens, particularly in moist areas. Because buttercups tend to grow tall, however, they do better where mowing is infrequent.



Buttercup

The flowers on a buttercup will generally last (if not mowed) from 4 to 9 days. They will open in the morning and close in late afternoon; on cloudy or rainy days, however, they may not open at all. If you pull a petal from a flower at its base, you can find the flap or scale that bees must reach into in order to obtain the flower's nectar.

The common name for buttercups comes from the shiny, yellow color of the flower. The family name, Crowfoot, refers to the shape of the leaves. Several kinds of buttercups can be found in our area. One example is **Tall Buttercup** (*Ranunculus acris*), which grows about 1/3 to 1 meter (1 to 3 feet) tall. The *acris* in the scientific name is from Latin meaning "acrid," and in fact *Tall Buttercup contains an acrid and harmful juice.* The juice can cause blisters in the mouth and intestinal tract. (In fact, one common name for Tall Buttercup is Blister Plant.) Livestock in a field will tend to avoid eating Tall Buttercup, allowing the plant to spread uninhibited while competing plants are grazed down. Other plant-eating organisms are similarly discouraged from eating buttercups.

Buttercup History and Uses

Because of its blister-causing properties, Tall Buttercup was once used by beggars to create sores on their faces and bodies to project a more desperate or needy image. Despite the drawbacks presented by buttercups, early settlers pickled the flowers, and some Native American tribes ground dried seeds into flour. A yellow dye was extracted from the root.

Buttercup Inquiries

⚠ ***Be careful of tall-growing buttercups.***

Look for buttercups flowering in spring and early summer. The bright yellow flowers are hard to miss! Useful materials: hand lenses, popsicle sticks.

Buttercup Structures

Examine and describe the leaf structure of this plant. Why do you think Crowfoot is the common name for this plant's family?

Use a hand lens to study a buttercup flower. Describe the parts of this flower. Can you find where the nectar is located?

Using Buttercups to Investigate Patterns of Flowering

Mark a plant with a popsicle stick stuck into the ground. Observe the plant several times during one day. How do the flowers change during the day?

When are the flowers open? When do the flowers close?

Do the same flowers open the next day?

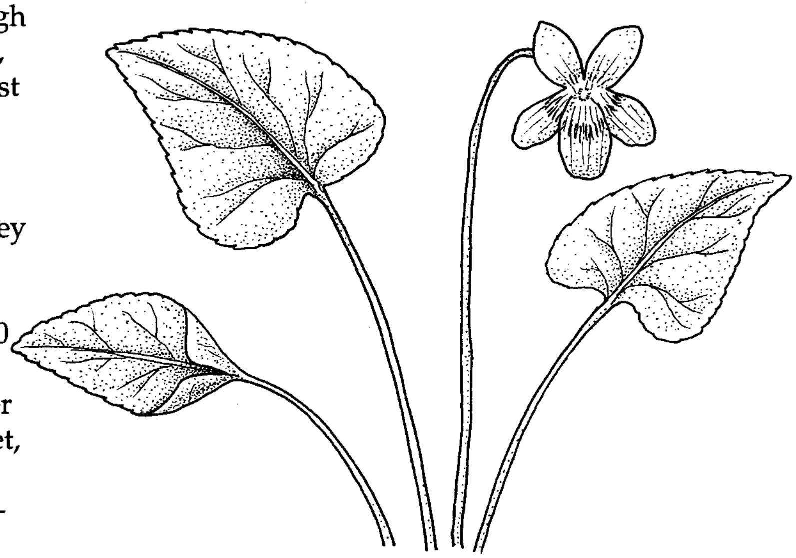
Does the weather affect when these flowers open?

How can you explain these observations?

Common Blue Violet (*Viola soraria*)

Family: Violaceae, the Violet Family

The Common Blue Violet's heart-shaped leaves with scalloped edges can be seen through most of the year, but this plant, along with other violets, is most conspicuous when flowering from late March to early June. Violets are most common in shady spots and moist soil. They may be found in lawns, along roadsides, in woods, and in open fields. There are some 500 species of violets, varying widely in leaf shape and flower color. The Common Blue Violet, with a five-petaled, blue-to-purple flower, is the most common violet in southwestern Virginia schoolyards.



Common Blue Violet

Violet Flowers and Pollinators

As is true for all violets, the Common Blue Violet's lower petal includes a slender, hollow projection, called a "spur," which extends to the rear of the flower. The nectar is stored in this spur. This lower petal, which creates a sort of landing platform for bees or other insects, is often marked with lines that may help guide bees to the source of nectar. You may observe bees flip themselves over after they land in an effort to reach the nectar. Pollinated flowers will form three-part fruit capsules containing seeds. As the capsules dry, the seeds are often forcibly ejected and flung some distance away. You can try to induce this action by taking a mature seed capsule indoors and placing it under a hot lamp.

Another interesting feature of violets is their unusual, non-opening flowers that develop near the base of the plant in late summer. A careful search at the base of the leaves will reveal these pod-like structures. These "flowers," which never open, produce seeds by self-pollination. In fact, most of the seeds produced by the plant are produced in this way.

Violets and Butterflies

The caterpillars of several kinds of fritillary butterflies, for example the **Great Spangled Fritillary**, feed on the leaves of violets, usually at night. The adults are medium- to large-sized butterflies whose brownish wings have a pattern of black spots or crescent-shaped markings on their wings. Silvery or white spots on the undersides of the hind wings are particular to this species. **Overwintering** larvae (meaning the insect survives the winter as larvae) become active in the spring, feeding voraciously on violet leaves for several weeks. Pupation then occurs, and adults emerge after a couple more weeks to feed and mate. Eggs are finally laid late in the summer. The eggs hatch and larvae become inactive after finding a protected spot in which to overwinter.

Violet History and Uses

While many people recognize violets, not many are aware of the great medicinal and food value they have had in the past. Collectively, violets have many properties that have led to many uses over the last 2000 years. The fragrant blossoms have been used in perfumes, bath oils, and colognes. They can also be incorporated into candies, jam, jellies, or syrup. The syrup has been used to treat coughs, congestion, and consumption. The leaves have been eaten in salads, as greens, and in soups and stews, although several references suggest using only blue-flowered kinds of violets for food. The leaves of some violets are mucilaginous and have been used as thickeners. The leaves are rich in vitamins. A half-cup serving of violet leaves is said to contain the vitamin C of four oranges and more than the recommended daily allowance of vitamin A.

Based on this information, it is no wonder that violets have been used since medieval times to treat a variety of ailments. Leaves, extracts, and juices from leaves of various species have been used to induce vomiting, for treatment of heart pains, and for treatment of boils, blisters, and other skin eruptions. Large doses of extracts from the roots of some species can cause nervousness as well as respiratory and circulatory depression.

Violet Inquiries

Look for violets blooming around your schoolyard in the spring.

Using Violets to Investigate Flower Structures and Pollinators

In what locations are they most common? Least common?
Are all the violets the same kind? Explain.
Examine, describe, and sketch the violet flower structure.
Are all the petals the same shape and size? How do they differ? How can you explain this variation?
If you happen to get the opportunity, watch an insect as it approaches a violet flower. What does the insect do? What is the insect *trying* to do?
How does the plant benefit from the insect?
Why do plants in general have "showy" flowers?
What are some different ways plant flowers attract insects?
What do the insect pollinators get from this relationship?

Violets' Unusual Non-opening Flowers

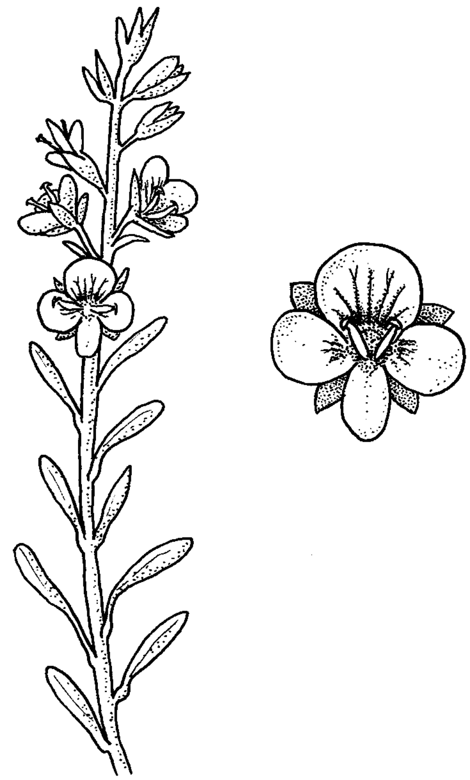
Look for non-opening flowers at the bases of violet leaves in late summer or early fall.
What do you find at the base of these plants?
What are these structures?
Open the structures. What do you find inside?
How do you think these structures formed?

Speedwells (*Veronica* species)

Family: Scrophulariaceae, the Figwort Family

A marvelous flower to observe with a hand lens is that of the speedwells. While the flowers are small and inconspicuous, they are delicately and intricately formed. The tiny flowers have two distinct stamens (the male parts of the flowers) and four petals. Three of the petals are roundish, while the fourth petal at the bottom of the flower is narrower and longer than the others. Close examination of speedwell flowers reveals extraordinary colors (blue, violet, or whitish) and patterns.

As is true for many lawn plants, speedwells' low-growing habit contributes to their success in colonizing schoolyards. There are 19 species of speedwells in the northeastern United States, with the following four species most likely to be found in the schoolyards of southwestern Virginia: **Birds-eye Speedwell** (*Veronica persica*), flowering the earliest; **Corn Speedwell** (*Veronica arvensis*), flowering later than *V. persica* ; **Thyme-leaved Speedwell** (*Veronica serpyllifolia*); and **Common Speedwell** (*Veronica officinalis*), which is more likely to be found in wooded or shady areas than in the lawn itself. Flower arrangement is an important feature in distinguishing speedwells. If you are interested in distinguishing the different kinds of speedwells, consult a field guide to wildflowers (see the Additional Materials chapter for some suggested field guides).



Thyme-leaved Speedwell

Speedwell History and Uses

The scientific name *Veronica* is believed to have been derived from the Greek words *Vera* for "true" and *eicon* for "image," or "true image." According to Christian legend, St. Veronica, for whom the plant is named, took pity on Jesus and wiped the sweat from his face on his way to his crucifixion, and a miraculous "true image" of Christ was revealed to her. The common name "speedwell" may come from the ability of some species to spread rapidly. Speedwells have been used in the past in bitter-tasting teas to treat a variety of ailments, most commonly for coughs and congestion.

Speedwell Inquiries

Look for speedwells in your schoolyard in early spring.
Useful materials: Hand lenses, simple map of the schoolyard.

Using Speedwells to Examine and Compare Flowers

Closely examine the flowers of this plant with a hand lens.
Sketch and describe the structure of a speedwell flower.
Carefully compare the plants you have found, especially the arrangement of the flowers. How many different kinds of speedwells do you have in your schoolyard?
How do you know they are different?
Make a key to the speedwells in your schoolyard, identifying distinguishing features of each.

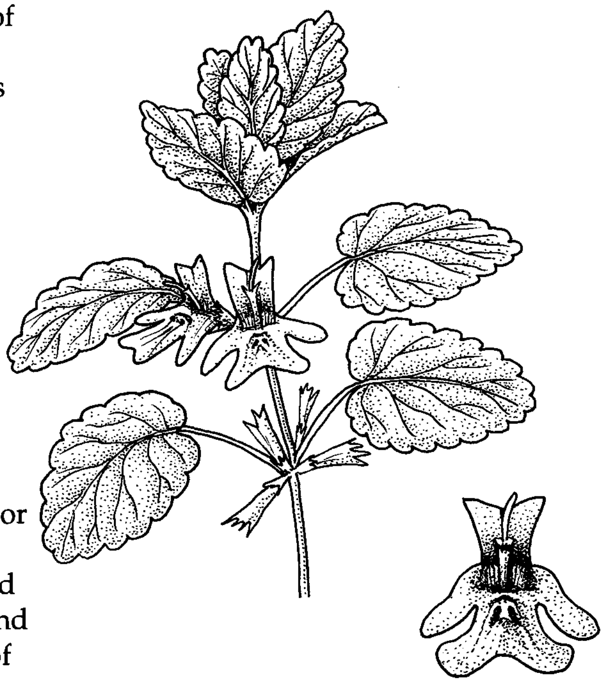
Mapping Where and When Speedwells Are Found

Map the location of speedwells in your schoolyard.
Where are speedwells most common? What environmental features seem to be favorable for their growth?
Make a chart showing when speedwells flower in your schoolyard.
Compare speedwell flowering times to those of other schoolyard plants.
Do all kinds of speedwells flower at the same time?
Why is it advantageous to different plants to flower at different times?

Ground Ivy *(Gleocoma hederacea)*

Family: Lamiaceae, the Mint Family

Take your class outside in late March or early April and you are likely to find one of the first flowers to bloom in southwestern Virginia lawns: Ground Ivy. Ground Ivy is frequently found growing in the lawn, particularly in shady, moist areas. A low, creeping habit allows it to thrive despite frequent mowing. The plant's unusual flowers can attract students' attention and stimulate a discussion of why some plants flower so early in the spring. (The advantage for early bloomers is that there is less competition for pollinators.)



Ground Ivy

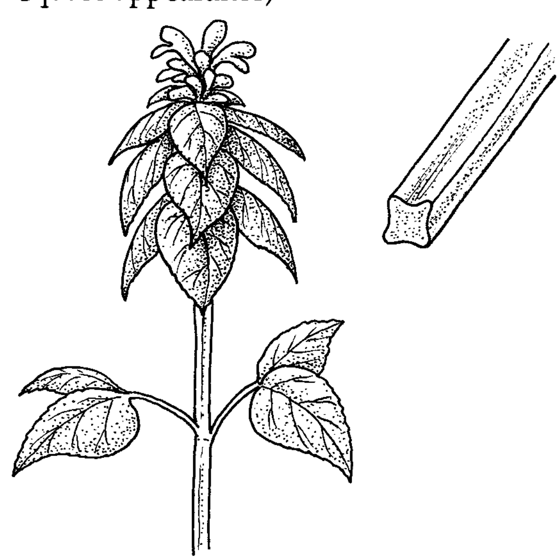
Flower Structure and Pollinators

Ground Ivy's unusual intricate purple or blue-violet flower is worth a closer look with a hand lens. The enlarged, three-lobed lower petal forms a landing site for bees and other pollinators. The reproductive parts of the flower are situated so that a nectar-collecting bee will brush against them, facilitating the transfer of pollen from one plant to another. These structures may actually push down against the bee's back as the bee pushes in to reach the nectar at the base of the flower.

Leaves With a Distinctive Aroma

Ground Ivy leaves are roundish with scalloped edges. In the absence of flowers, however, it would be difficult to identify Ground Ivy leaves, were it not for another distinguishing feature of the plant. The leaves have a distinctive, pungent aroma when crushed.

Another purple-blossomed plant in the Mint Family, which flowers at the same time as Ground Ivy and is often found in similar locations, is **Purple Dead Nettle.** Like Ground Ivy, it has purple flowers and its sprawling habit makes it somewhat tolerant of lawn mowing, but it is not quite as successful as Ground Ivy. Purple Dead Nettle' s heart-shaped leaves lack the distinctive aroma of Ground Ivy. The leaves often overlap at the end of a stem that is obviously *square* in cross-section. Pinch off a stem and roll it between your fingers and examine the break to observe this feature. (Ground Ivy also has a square stem, but the corners are rounded, resulting in less of a square appearance).



Purple Dead Nettle

Ground Ivy History and Uses

The other common name for Ground Ivy is Gill-over-the-ground, from the French word *guiller*, meaning "to ferment." Ground Ivy leaves were once important to beer-making in France as a flavor enhancement. The leaves also have been used in England to make a tea to treat "painters gout," an ailment suffered by house painters due to their exposure to paint with a high lead content. Rich in vitamin C, Ground Ivy helped counteract exposure to the lead. Ground Ivy has been included in the chick-weed poultice (described above in the Common Chickweed section of this chapter) used to treat cuts or sprains, and the pungent odors are said to help alleviate headaches.

Ground Ivy Inquiries

Look for Ground Ivy in shady corners of your schoolyard, where water drains poorly, and where the soil is particularly moist. Useful materials: hand lenses.

Flower Structure and Pollinators

Use a hand lens to examine a flower. Describe or sketch the shape of the flower.

How might the shape of this flower relate to its function (in pollination and reproduction)?

How many other plants can you observe in the vicinity that are flowering at this time?

Why might it be advantageous for this plant to be flowering now?

What pollinators can you observe visiting these flowers?

What is the behavior of these pollinators?

Aromatic Leaves and Uses of Ground Ivy

Pick a leaf from this plant and crush it between your fingers. Describe the odor.

What might be some possible uses of a plant with this quality?

Can you find another schoolyard plant that resembles Ground Ivy but lacks the aroma?

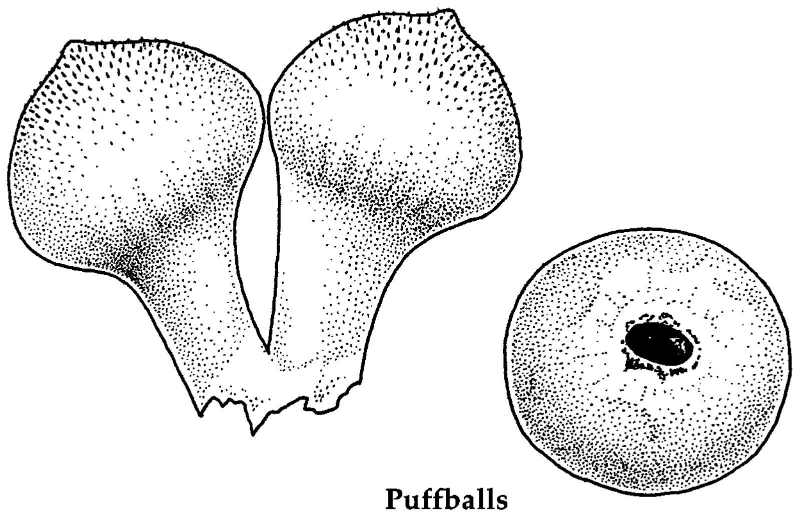
How has Ground Ivy actually been used in the past? How could you find out?

The other common name for this plant is Gill-over-the-ground. Can you figure out how this name relates to a former use of Ground Ivy?

Puffballs (*Lycoperdon* species)

Family: Lycoperdaceae

Some puffballs are poisonous.



Puffballs
Left: two fruiting bodies.
Right: one mature fruiting body.

Puffballs are among the most commonly observed mushrooms and are likely to be found in every schoolyard lawn at some time. Particularly after a soaking rain, white, round puffballs may suddenly appear. As these structures mature, they will increase in size and turn brown, and the outer layer will develop a brittle, papery texture. Depending on the kind of puffball, a hole may appear in the top, or tears will develop, and brown "smoke" may be released if the structure is squeezed. Puffballs can vary widely in size: Puffballs weighing as much as 40 pounds have been reported, while others may reach only a few centimeters in diameter.

Puffballs are a type of **fungus** (plural "fungi"). The structure that you observe above the ground is actually only a small part of the whole organism; the rest lies beneath the ground. The underground part consists of a network of fine threads called **hyphae** that absorb nutrition from decaying or living plant and animal material around them.

The role of the above-ground structure is reproduction. Each particle of the brown "smoke" that is released by the mature puffball is actually a tiny spore capable of maturing into a new fungus. A single puffball can produce millions of spores to be carried off by the wind, eventually to land and, if conditions are right, produce a new fungus.

Fungi often grow in close association with plants. In these relationships fungi are provided with energy-rich materials produced by the plants; in turn, the plants receive essential mineral nutrients assimilated by the fungi. Puffballs also show this phenomenon, and some species will grow only in association with the roots of certain types of trees.

Puffball Uses and Potential for Abuse

Puffballs, which may be as much as 25-percent protein, are a nutritious food source for organisms such as mice, squirrels, and deer. Like other fungi, puffballs play an important role in the food web as **decomposers**, converting dead plant and animal material into a form usable by other organisms. The decomposition process conducted by fungi returns essential nutrients to the soil as well.

As with any mushroom or fungus, one should never eat puffballs unless they are identified by a fungi expert.

Young puffballs (before the "smoke"-producing stage is reached) are often collected and eaten. Fungi experts can determine the edibility of young puffballs by cutting them in half and looking at the spore mass inside. A white interior indicates an edible puffball; a yellowish to dark brown interior indicates a mature, non-edible puffball; and a *purple* interior indicates a *poisonous* Scleroderma puffball. *This very basic information does not equip you to identify edible puffballs.* If anything, it shows how careful one must be not to mistake a dangerous mushroom for a harmless one!

Puffball Inquiries

⚠ ***Warn students about eating any wild mushrooms or other fungi.*** *Conduct this inquiry when puffballs are observed in the lawn after they have first come up and appear white and fleshy. Useful materials: glass jars.*

General Introduction to Puffballs

What are these white structures?
Would you put them in the same category as plants? Why or why not?
Where did they come from? How did they get here?
What environmental conditions may have stimulated their appearance?
What other environmental features seem to be associated with the location of the puffballs?
Where does this organism get energy to grow? Does this organism eat?
Does it need light? Water?
Are you looking at the entire organism? Where is the rest of the organism?
What is the function of this part of the organism?
How are puffballs and other fungi important to an ecosystem?
What would happen to the dead grass in the schoolyard if there were no decomposers, such as puffballs?

Observing Changes in Puffballs

Take the class outside each day for a few minutes to observe changes in puffballs. The students could measure size, number, color, and location of puffballs.
How do you expect this organism to change over time?
What changes do you observe?
How can you explain these changes?

Investigating the Development of Spores

Find a young (immature) white puffball. Bring it inside, cut it in half, and place the halves in a glass jar with the top open. Observe the puffball over several days, as the inside turns from white to yellow-brown to brown. After the puffballs have turned brown and brittle, ask the students the following questions:

How is the puffball different from the first day it was observed?

What happens when you squeeze or tap on this puffball?

What could this brown smoky material be?

If we know that the puffball is a reproductive structure, what could you say about the brown, smoky material?

How many particles would you estimate are in each cloud of brown powder? How could you find out?

If your class has access to a microscope, place some of the puffball powder on a microscope slide. Put a drop of alcohol (a wetting agent) on the powder, then add several drops of water. Add a cover slip, and observe the small, round spores under high power.

How many particles do you observe in a single field of view? Describe their structure.

Dispersal of Spores

How are puffball spores dispersed (spread)?

What would be the best conditions for dispersal?

What kinds of habitats and environmental conditions do you think would be suitable for growth of these spores?

What will happen to spores that land in unfavorable sites?

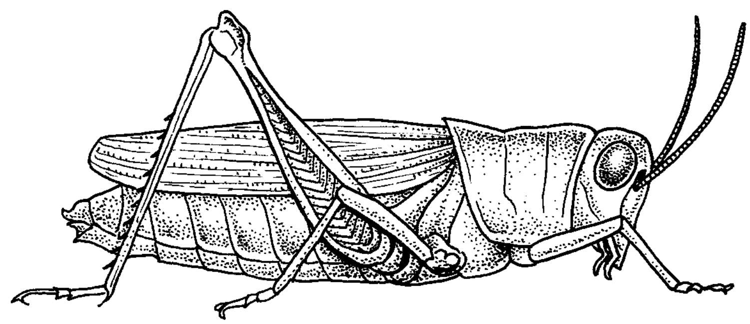
Why does this organism produce so many spores?

Is this characteristic of producing large numbers of offspring typical of other organisms in nature? Can you give examples?

Short-horned Grasshoppers

Insect Order: Orthoptera, the grasshoppers, crickets, roaches, etc.
Family: Acrididae

Grasshoppers are good organisms for observing the key features of insects: an **exoskeleton**; three main body parts (head, **thorax**, and **abdomen**); two antennae; six legs; and (in most insects) wings. (See the Glossary for an insect diagram, under "insect.") Well-developed hind legs enable grasshoppers to jump a great distance in a single bound. Grasshoppers' color varies, but they are commonly gray or brown. Grasshoppers have compound eyes made up of hundreds of individual lenses.


Short-horned Grasshopper

Short-horned grasshoppers are most conspicuous in the fall. They actually comprise a whole family of grasshoppers that contains many common species. In contrast to long-horned grasshoppers, whose antennae are often as long as their bodies, short-horned grasshoppers' antennae are usually less than one-fourth as long as their bodies. You may find short-horned grasshoppers in the lawn by planting one foot on the ground and sweeping the other foot across the top of the grass in front of you. If grasshoppers are present, you will see them jump and fly away from you. Look near the lawn edges where taller grass and weeds may be growing. You may wish to have a few students attempt to catch a grasshopper with a net or plastic jar. Placing a few grasshoppers in viewing boxes will aid your observations and inquiry. *Be careful, though*: reportedly a common defensive reaction of grasshoppers is to regurgitate a material called "tobacco juice," which can be an irritant.

While some short-horned grasshopper species do not make conspicuous sounds audible to humans, others kinds do, in two ways. Some species snap their wings in flight, making a crackling sound as they leap into the air. Others rub their hind leg against their wing, making a loud mechanical trill. You might ask your students to compare these sounds with the more melodious sounds of crickets.

Grasshopper History and Uses

Grasshoppers are protein-rich morsels for many organisms—other insects, spiders, snakes, birds, and even mammals. Their large numbers make them important components of food webs. Almost all grasshoppers feed on plants, with some kinds consuming specific plants and others feeding on almost anything. When grasshoppers occur in large numbers, they can have significant impact on a whole ecosystem. During 1874 to 1877, huge swarms of short-horned grasshoppers, numbering in the billions, darkened the skies as they migrated across many western states in search of food. They devastated crops and consumed virtually all available vegetation.

Short-horned Grasshoppers Inquiries

The best time to find grasshoppers in and around the schoolyard is when you return to school at the end of summer. The best places to look are in tall grass and overgrown areas on the edges of the schoolyard. Brush your hand or foot gently across the vegetation and watch for grasshoppers as they hop/fly away. Useful materials: insect-viewing boxes (or plastic containers and hand lenses), insect nets (commercial or homemade).

Grasshopper Structure and Function

Capture a few grasshoppers and put them in separate viewing boxes so that small groups of students can view them closely.

How many legs does the grasshopper have?

How do the legs compare? Which are similar? Which are different?

How do you think the front pair of legs is used by the grasshopper?

What is the function of the rear legs?

How is the structure of the legs (front and rear) suited to their function?

Look at the grasshopper's eyes. Describe what they look like. Compare the grasshopper's eyes with your eyes. How do they look similar? How do they look different?

How does the position of your eyes in your head differ from the position of the grasshopper's eyes? What might the grasshopper be able to do with eyes in such a position? How does this help the grasshopper survive?

Grasshopper Behavior

Observe the behavior of grasshoppers in the lawn.

What are some ways grasshoppers can escape predators?

Describe how a grasshopper in the lawn responds if you try to catch it.

Does the grasshopper jump once or several times in succession? Does the grasshopper jump in the same direction each time? How does the direction of each successive jump change?

Does the grasshopper use its wings to increase the distance of its leap? Does the grasshopper you are observing have wings?

Short-horned Grasshoppers Inquiries, continued

What does the grasshopper do after it lands to make itself less noticeable?
What features does the grasshopper have that help it to blend in with its surroundings?
How could you find grasshoppers if they did not jump?

Grasshopper History and Uses

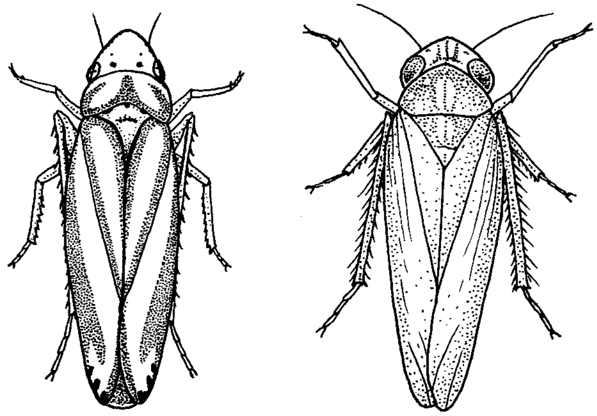
What organisms do you think might eat grasshoppers?
How important do you think grasshoppers might be as a food source for other organisms?
What do grasshoppers eat?
How have grasshoppers been important in the history of the United States?

Leafhoppers

Insect Order: Homoptera, the cicadas, hoppers, aphids, etc.

Family: Cicadellidae

Walk out on the lawn on a warm, sunny day in late spring or summer and gently brush your hand across the surface of the grass—you are likely to see tiny leafhoppers springing away! The leafhoppers are a large family of insects, with some 2500 species represented in North America, varying widely in color and shape. These organisms are similar, and closely related, to spittlebugs (see the Spittlebugs section in the Fencerows chapter.)



Leafhoppers

Leafhoppers feed on the juices in plant stems by piercing them with specialized mouth parts. Fluid is sometimes released though the rear end of the organisms, leaving drops known as "honey dew." Leafhoppers also lay their eggs in plant stems. Leafhoppers may cause significant damage to plants by removing large quantities of sap and impairing the flow of fluids to leaves. They also may carry diseases from plant to plant.

Leafhoppers Inquiry

Useful materials: insect-viewing boxes (or small plastic containers and hand lenses), insect nets (commercial or homemade).

Using Leafhoppers to Investigate Escape Behavior

Have your students get down on hands and knees and change their focus to observe events at ground level. Have students brush their hands across the grass and observe what organisms respond to this disturbance.

How do leafhoppers respond to this disturbance?

How far do they jump?

Do they jump more than once when disturbed?

In which direction do they jump when disturbed? Do they jump in the same direction every time?

Try to observe the leafhopper when it lands. What does it do when it lands? Is it easy to see? Why or why not?

Catch a leafhopper and place it in a viewing box. Describe or sketch its characteristics.

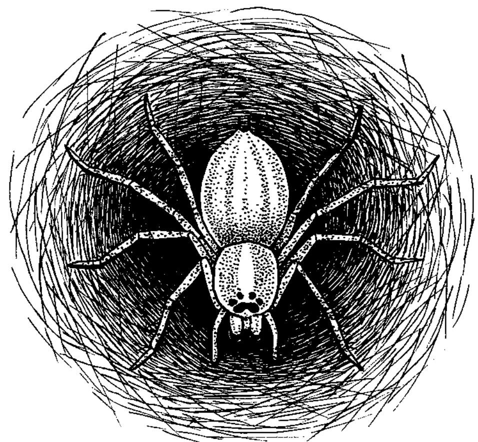
How does the leafhopper's body form, its color, and its behavior help it survive?

Grass Spiders

Class: Arachnida, the spiders, ticks, mites, scorpions, etc.

Family: Agelenidae, the funnel web weavers

The early-morning dew will often reveal the presence of grass spiders in a lawn. Hundreds of webs can often be seen. Grass spiders are in the family of spiders known as funnel web weavers. The web is made of irregular layers of spider silk radiating out from a funnel-shaped retreat where the spider lies in wait for prey. The funnel is open-ended, allowing the spider, if disturbed, to escape through the rear of the web. The web's function is to entangle passing insects. The spider feels the vibrations of an insect and runs out, bites its prey, and drags it back to the funnel.



Grass Spider

In the fall, grass spider females lay eggs under rocks or logs covered with a dense sheet of silk. The females die in the winter, but eggs overwinter and the young spiders emerge in the spring.

Grass Spiders Inquiry

Useful materials: flags or marking tape, cornstarch or other light powder.

Investigating Spider Webs and Spider Behavior

Look for grass spider webs in the early morning when dew is covering everything on the ground. If you are planning to take your class outside after the dew has evaporated, mark the location of the webs and mist them gently with a sprayer to make them visible. Cornstarch is also useful for highlighting web structure, but a heavy dusting may cause the spider to take down and replace its web within a few days.

How many individual webs do you see?

Describe the structure of the web.

How can you relate the structure of the web to how the spider might use it.

Can you locate the funnel in the web?

Can you locate the spider?

Are the webs of this spider sticky? Touch them and find out.

If you can see a spider in a funnel, how does it respond to your touching the web?

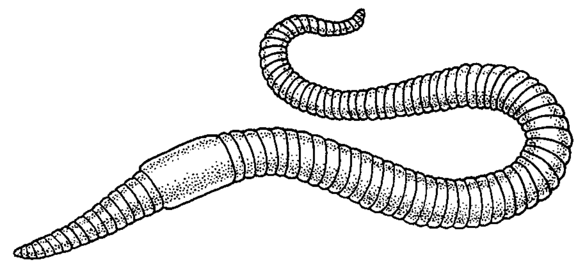
Can you trick the spider into responding as if an insect is in the web?

Can you find a small insect to drop into a web? How does the spider respond?

Earthworms

Phylum: Annelida, the segmented worms

Earthworms, or at least the evidence of earthworms, are likely to be encountered on a foray into the schoolyard. They may appear in large numbers on sidewalks or other paved surfaces following a heavy rain. Because earthworms breathe by taking up air through their skin, they will come to the surface to breathe when the soil becomes saturated. Many worms suffocate or are stranded in puddles, leaving their bodies littered across the pavement.



Earthworm

Earthworms in the Soil

Evidence of earthworm activity can be found by closely examining the soil surface of the lawn or other unpaved areas. If earthworms have been active near the surface, you are likely to see small piles of molded soil called casts. Casts are made up of soil that has passed through the worm's digestive system and deposited at the surface. Earthworms do actually "eat"—that is, *ingest*—the soil; however, they *digest* only the bacteria, fungi, and bits and pieces of decaying plant matter in the soil. Earthworms may ingest soil as they burrow in the ground, or they may come to the surface at night to feed on decaying plant material.

Earthworms have soft, segmented bodies and a "tube within a tube" body plan. A mouth, at the head end, connects via the digestive tube to the anus, at the rear end. The worms can move by holding one part of their body in place while extending another part forward. Tiny bristles called setae, which can be observed on the lower surface of the worm, helps give it traction and move through the soil.

While too much water can suffocate the earthworm, too little moisture is also detrimental. Earthworms will burrow deeper into the soil during the summer as the surface begins to dry out. During the winter, colder temperatures will also drive earthworms deeper into the ground. Richer soils will have higher populations of earthworms, while clay soils will generally have fewer worms.

Earthworms in the Ecosystem

Earthworms are important to nutrient cycling in the ecosystem because they help break down dead plants and animals, returning nutrients to the soil. They also improve soil quality by bringing material to the surface and aerating the soil through their burrowing actions. As much as 20 tons of soil per acre may be brought to the surface each year by a moderate population of earthworms in a field.

Earthworms play a vital role in making the energy stored in decaying plant and animal matter available to higher levels of the food chain. Earthworms incorporate this energy, and they, in turn, provide a source of energy to many mammals, birds, reptiles, and amphibians.

Earthworms Inquiries

Earthworms are excellent organisms to study in the classroom. You can collect your own or buy a box of fishing worms. Laboratory exercises for studying live earthworms and their behavior are easy to find in texts and library resources. A close-up classroom study of earthworms would complement your field study.

Earthworms and Spring Rains

A spring rain can provide an excellent opportunity to study earthworms as they are driven from their burrows and out onto paved areas. Take your class outside to study these worms.

Why are the worms out on the sidewalk?

How many worms occur on each square of sidewalk?

Calculate the number of worms on a large stretch of sidewalk by determining the average number per square of sidewalk and multiply by the number of squares.

What does this tell you about the number of worms living in the soil around the sidewalk?

Earthworms in the Soil

Look for piles of molded soil in between blades of grass. Ask students:

Where did these piles of soil come from?

What made them? Why are they here?

Can you find evidence to support your responses to the above questions?

How will this activity affect the soil?

What will be the result of this action over many years?

How are the activities of the earthworms beneficial to the soil and subsequently to the plants that grow there?

Earthworms in the Ecosystem

How are earthworms important to the lawn ecosystem?

Where would they fit into the food web of your schoolyard?

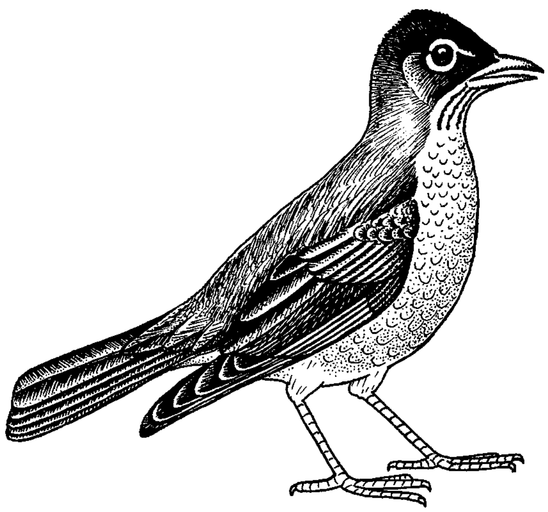
What organisms eat earthworms?

What do earthworms eat?

Predict how the local food web would be affected if earthworms were suddenly eliminated.

American Robin *(Turdus migratorius)*

Family: Turdidae, the Thrush Family



American Robin

For young school children, the American Robin (hereafter referred to simply as the "Robin") is probably one of the most familiar and easily recognized birds. A Robin is typically considered one of the first signs of spring, even though Robins often are seen in many areas much earlier. Robins will, in fact, spend the winter in southwest Virginia, as long as suitable berry-like food is available.

Both male and female Robins have the distinctive brick-red breast and dark gray back, while young or fledgling robins have a speckled breast. Robins may also be recognized by their sounds; they have a rich caroling song as well as other notes.

Robins are often observed in large flocks in the late winter or early spring on mowed lawns. You may observe Robins running quickly across the grass and suddenly freezing in their tracks with their head erect. You may also see them with their head tilted. While this may remind you of a person tilting their head to *hear* better, Robins are doing this to help them *see*, rather than hear, potential prey. They may hold this pose for a moment, then run forward a few steps to seize an insect or worm from the ground.

Robin Nesting

As the weather warms, the flocks will begin to break up as Robins pair off and defend territories and nesting sites. Nests are built on horizontal branches, in forks between tree branches, or on human-made ledges.

When selecting nesting sites, Robins do not seem to be overly disturbed by proximity to human activity, and you may find nests in trees or on sills near doorways. Robins are often the first nest builders in southwestern Virginia, and nest sites in evergreens are often selected because of the protection afforded by the foliage. Robins usually produce two or more **broods** (sets of young) each year, and the second nesting site may be in deciduous trees.

The nests are made up of mud, twigs, or straw with an inner lining of soft grasses. The birds may sometimes use other materials, such as bits of fabric, yarn, or string. You may want to make some of these materials available outside your classroom during the nest-building season to see what is used by the birds. A walk around the schoolyard in the fall, after the leaves have fallen off the trees, may reveal nests that were previously hidden by foliage.

If you see a Robin capture a worm in the lawn and fly off with it rather than eat it on the spot, it is likely that the bird has young in a nest to feed. Robins lay three to five blue-green eggs. The young are born after 13 to 14 days of incubation by the female. The female may leave the nest for ten minutes or so at a time to feed during incubation, and the male, who is usually close by in the day, may provide the brooding female with food. Males are reported to roost at night in flocks with other males. The young Robins will stay in the nest for 12 to 15 days, after which they may be observed following parents and calling for food.

Eating Like a Bird

Robins feed mostly on insects and worms in the spring and early summer, but rely heavily on fruits from the late summer through winter. Because of their fruit-feeding habits, Robins sometimes can do damage to cherry, blueberry, and other fruit crops.

Robin (and other Birds) Inquiries

The first two lines of inquiry may be conducted either outside or from the classroom window that overlooks a lawn area, when Robins are returning in the spring in large flocks. The third inquiry can be used when observing any kind of bird, especially an unfamiliar one. Useful materials: binoculars, field guide to birds. See the Additional Materials chapter of this book for suggested field guides.

Observing Robins

Point out a flock of robins.

What kinds of birds are these?

What features did you observe that allowed you to identify this bird as a Robin?

Describe all the features of these birds that you can observe. Especially see if you can observe any differences, perhaps slight, in feather colors.

Watch the birds and make a list of the behaviors you can observe.

How many birds are in this flock?

What are they doing on the lawn? What evidence do you have for your answer?

Do the birds change position in the flock? Choose a bird in the flock and watch how its position changes in the flock. (You may first want to try to note any variation in this particular bird's markings, to help you distinguish it from the rest of the flock.) Record your observations and compare them with your class mates.

Are there advantages to being in the middle of the flock compared to being on the outside edge?

Eating Like a Bird

As you watch Robins in the springtime, can you tell what they are eating? What guess can you make about their food?

How do they find their food? What observations can you make? Why do Robins turn their heads sideways when searching for food? How does this behavior relate to the orientation of their eyes?

What could they be eating if it were fall or early winter?

What effect do these birds have on other organisms in the ecosystem?

Would you say that the birds are beneficial to human interests or harmful? Support your answer.

What to Look For in a Bird

If your students are observing other birds less familiar than Robins, they will need to pay attention to certain features that help distinguish different birds. The following list of questions about key features can help them begin to identify a new bird. The list is based on the section "How to Identify Birds" in A Field Guide to the Birds *by Roger Tory Peterson (1980). Binoculars are needed to see some key bird features, but others will be apparent to the naked eye. A field guide to birds will be needed to tell you or confirm what you've found, once you've noted the important features. A data sheet for students to record bird features would also be helpful.*

How big is the bird? Compare this bird's size to a more familiar bird.

What shape is the bird's body? Its wings? Its bill? Its tail?

How does the bird fly? For example, does it glide? Hover? Dart from place to place?

Do you notice any particular behaviors (such as cocking its head or flicking its tail)?

Does it climb? Swim? Wade?

What are its distinctive marks? Look for color differences that show up as tail patterns, rump patches, eye-stripes or eye-rings, wing bars, or wing patterns.

What sounds does the bird make? Be sure to "observe" the bird with your ears and not just your eyes.

Chapter 4. Fencerows and Other Overgrown Areas

Introduction

The edge of the schoolyard provides areas of distinctive contrast to a neatly mowed lawn. Areas where mowers have not cut closely, along a fence, or in a nearby meadow all offer different and interesting habitats. For simplicity in this chapter, these areas will be referred to collectively as "overgrown areas." Overgrown areas differ from the lawn in several ways:

- Most obviously, the plants are taller. Some of the plants that are growing in the lawn may look very different when growing in an unmowed area, because mowing can stunt some plants' growth or prevent them from flowering.
- The taller plants in overgrown areas create markedly different physical features for the habitat. With taller plants, there is more shade, and ground level temperatures are generally cooler. The reduced light penetration and lower temperature can also mean a moister environment, including longer retention of moisture following a rain. These conditions are favorable for a wider variety of plants, compared to the lawn habitat.

- Plants that cannot compete well with the tall plants will occur less frequently in overgrown locations.
- On the other hand, some tall plants not found in the lawn at all, such as goldenrods, will thrive in overgrown areas. Vines also do well in this habitat. Shrubs will also take hold if more than a year or two goes by without mowing. In addition, trees may be found against the fence line where mowing cannot reach.
- The **litter layer** above the soil may be thicker and more complex, providing many kinds of smaller animals with good food, cover, and physical conditions.
- Finally, and perhaps of most interest, overgrown areas are constantly changing, more so than a lawn that is kept relatively constant by mowing.

A Place to Watch For Changes

The overgrown area you observe in the spring will be very different by the summer or fall. In the spring, you may find not only the first blooming plants of the year but also withered plants that bloomed the previous fall. Most plants that bloom early in the spring and thrive in cool, moist conditions will eventually give way to plants more tolerant of hot, dry summers. Fall conditions result in still different plants. Along with these plant community changes, the animal community also changes. Different organisms are attracted to the plants at varying times as the plants produce leaves, flowers, fruits, and seeds. Different insects, especially, will appear at different times as they go through their unique life cycles.

Fruits produced by plants in overgrown areas are of particular interest as a changing food source, because not all fruits have the same value to wildlife. Wildlife biologists classify autumnal fruits into two categories, high- and low-quality fruits, based on the fruits' fat content. High-quality fruits have a high fat content, making them an energy-rich food source and highly desirable for migrating birds and organisms seeking to store energy for a long journey or for the lean winter. The high-quality fruits are usually sought out and consumed before the low-quality fruits. Low-quality fruits, however, become important after high-quality fruits have been consumed, particularly late in the winter or during prolonged severe weather. Both high-quality and low-quality fruits are found (on different plants) in overgrown areas (specific examples will be noted later in this chapter).

Overgrown areas also change from year to year. Plants grow and produce more shade, which in turn alters many other physical features, often making the habitat more suitable for a wider range of plants. Random events may introduce new plants to the area as well. Seeds may be introduced by animals or transported by wind or rain.

The introduction of some non-native, or alien, plants can also radically change this habitat, especially by reducing the system's diversity, that is, the number of different kinds of plants (and consequently, animals). For example, Kudzu, a native of Japan, can virtually obliterate other plants as it climbs and carpets an area. (For more information on Kudzu, and on aggressive vines and diversity, see the Vines section below.)

As you study overgrown areas with your class, you will become more aware of the variety of living things occupying the habitat and how they change during the course of the year, as well as how they change over several years. The plants and animals influence the physical features of their environment, and, in turn, the physical features influence the kinds of plants and animals that are able to survive in a constantly changing, interacting system. You will find your observations of this changeable habitat to be very rewarding. Documenting your observations with photographs or maps can further enhance your experiences.

Vines

Please read the section below on Poison Ivy before proceeding with any investigation involving schoolyard vines.

Vines are ubiquitous features of fencerows and unmowed areas. Vines may appear in bushes around the building, in the steel mesh of playground fences, on a tree, or on the side of a building. Poison Ivy is a very common schoolyard vine, and one that all children should learn to recognize. But a number of other vines can also be found in the schoolyard, some of which are poisonous. The following vines are described later in this section: greenbriers, Virginia Creeper, Japanese Honeysuckle, Kudzu, European Bittersweet, American Bittersweet, and the bindweeds.

Vine Adaptations for Growth

Vines are unique in their adaptation for competing with other plants. Unlike many other plants, vines do not invest much energy in building tissues and parts to support the plants' weight. Instead, vines rely on other plants or structures to support their stems and leaves, while the vine diverts more energy into its own growth and reproduction. Vines are some of the fastest-growing plants, at least in terms of length. Kudzu, for example, can cover over 30 meters (100 feet) of fields or buildings in a single year.

Vines show several adaptations for attachment to and growth along surfaces. Some vines have small **aerial roots** that grow out from the plant's stem and wrap around objects they contact. Other vines have aerial roots with "sticky pads" on the ends that attach to trees, walls, or fence posts. Some vines lack aerial roots, but the vines themselves intertwine a post, barbed wire, or tree as they climb. And still other vines simply drape themselves across other plants, sending up shoots as they grow.

Aggressive Vines and Ecosystem Diversity

A study of some of these schoolyard vines can provide an excellent example of the negative effects that alien plants can have on natural areas. You have probably seen Kudzu along highways covering plants, trees, telephone poles, buildings, and even vehicles parked in one spot for awhile; it may well be doing the same in your schoolyard. These plants choke out all other plant life, native or otherwise. Similarly, Japanese Honeysuckle will choke out other plants along a fencerow. What are the possible consequences of such growth by vines?

These dominating plants reduce an ecosystem's diversity, that is, the number of different plants growing in the ecosystem. The number of different plants growing in a fencerow without Japanese Honeysuckle is usually greater than the number in a fencerow where the Honeysuckle is firmly established. Few plants can get through the intertwining vines that form a mat across the fence and onto the ground. Those that do merely provide a new surface for the vines to intertwine and climb. Trees and shrubs can literally become strangled by these vines.

The diversity of plants in an area affects the diversity of animals. For example, certain kinds of insects are adapted to feeding on certain kinds of plants; examples include tortoise beetles on bindweeds and Black Swallowtail Butterflies on Queen Anne's Lace (these plants and insects are discussed later in this chapter). The flowers produced by these plants also provide nectar for many organisms at different times of the year. Vines like Japanese Honeysuckle can greatly reduce this variety. As a result, suitable habitat for these other organisms is lost, at least on a local level.

Beyond the schoolyard, Japanese Honeysuckle can seriously impact woodland plants and even the regrowth of a forest itself. Honeysuckle has been widely introduced in many areas as a wildlife management tool, providing cover and food for game animals such as quail and turkey. Selective cutting of timber, while not necessarily having a direct impact on low-growing woodland wildflowers, may eliminate enough shade to make the habitat suddenly suitable for sun-loving alien plants like Honeysuckle. With increased light penetration, these plants can grow rapidly, choking out the native wildflowers. In some areas, moreover, foresters have been reluctant to cut down standing timber, out of concern for the potential of Honeysuckle to prevent seedlings from maturing.

For these reasons, Japanese Honeysuckle, Kudzu, and other aggressively growing vines can be a serious threat to native plant species. For more on Honeysuckle and Kudzu, specifically, please see the sections below.

Poison Ivy *(Toxicodendron radicans)*

Family: Anacardiaceae, the Cashew Family

Do not touch any part of this plant!

If your students learn to identify only one plant during the course of the year with you, Poison Ivy would be a good choice! Be aware that Poison Ivy is the "chameleon" of schoolyard plants; it can take *several forms*. While its leaves are generally oval in shape, ending in a point, they may have either smooth, slightly toothed, or wavy-edged margins. The leaf surfaces may vary from shiny to dull and from light to dark green. Young leaves may be tinged with red, while in the fall old leaves may turn a brilliant red. Not only do leaf shape and color vary, but so will the plant's growth habit, depending upon its environment. In a mowed lawn, it can grow as a low ground cover, sprouting up where stems have spread across the surface. On fence posts, Poison Ivy may appear almost bush-like, with its drooping branches spreading outward. Poison Ivy can also appear as vine, climbing 50 or more feet up trees, spreading branches along the way.

Poison Ivy

Regardless of these variable leaf and growth characteristics, however, you can trust the old adage *"Leaves of three, let it be"* to alert you to the presence of this plant. Rather than three *leaves*, however, the Poison Ivy leaf is a single compound leaf made up of three *leaflets*. During the summer you may find tiny, white to yellowish flowers not more than 2 to 3 millimeters (1/8 inch) in diameter, in clusters 5 to 8 centimeters (2 to 3 inches) long. In the fall, these develop into clusters of white berries about 6 millimeters (1/4 inch) in diameter. The vines send out aerial roots that cling to surfaces or other plants as they climb. As a result, *older Poison Ivy vines climbing a tree or a fence post may appear "hairy"*; this dense coverage of roots and fibers distinguishes them from other common woody vines. In the winter, you can identify a Poison Ivy vine by this hairy appearance, and by the presence of *waxy, white berries* (unless they have already been eaten by wildlife).

Poison Ivy's danger as a skin irritant is well-known but sometimes misunderstood. In sensitive individuals, skin inflammation, itching, and blistering can occur following contact with the oils released by this plant. Other individuals may not react to initial contact, but repeated exposures over time may result in more severe reactions. Some individuals may become sensitive after years of having had no reaction. As sensitive as some people may be, they will not break out with a Poison Ivy rash by simply being near it! *Direct contact* with the oils or with smoke from burning Poison Ivy is necessary. But handling pets or clothes that have had contact with the plant, and may retain some of the oils, can cause an outbreak in a sensitive individual. Contrary to popular belief, one cannot contract Poison Ivy from another's skin rash or from fluid released by blisters. Only the Poison Ivy oils themselves cause the reaction; once these oils have been washed away, the skin reaction cannot be spread.

The best thing to do if you think you have contacted Poison Ivy is to wash the affected area as soon as possible with strong soap or detergent and plenty of water. Delay washing too long, however, and the oils will have had an opportunity to bind to your skin and your body may begin reacting to them. Laundry detergent may be a good choice to use, because many of these products contain enzymes that break down proteins (the constituents of many of the more resistant stains in clothing). The same enzymes can help break down the active ingredients in Poison Ivy oils. A wide variety of over-the-counter medications and home remedies are used to treat an outbreak of the skin rash, but they only help relieve the discomfort and itching and will not affect the severity of the reaction.

Ecologically, the irritating oils produced by this plant act as chemical defenses against animals that might eat it. You may notice, however, that some leaves of a Poison Ivy plant may have been eaten, indicating that this defense mechanism is not effective against all animals. Poison Ivy's low-quality berries, as well, are toxic to humans, but nevertheless are fed upon by birds and mammals with no known ill effects.

Poison Ivy Relatives

The common names **Poison Oak** and **Poison Ivy** are sometimes used interchangeably, and some have debated whether these species are one and the same. Today, authorities in the field say that Poison Ivy and Poison Oak are, in fact, distinct species, but due to the highly variable form that they take, they are not easy to distinguish. Poison Oak tends to be more shrub-like and prefers open areas in sandy to gravely soil. In southwestern Virginia, Poison Ivy is by far more frequent than Poison Oak.

Another similarly toxic plant is **Poison Sumac**. As with Poison Ivy, all parts of Poison Sumac should be avoided. Poison Sumac leaves look nothing like Poison Ivy or Poison Oak: ts compound leaves are composed of *many*, not just three, leaflets. Fortunately, this plant prefers swamps and wet areas, so encountering it in a southwestern Virginia schoolyard is unlikely.

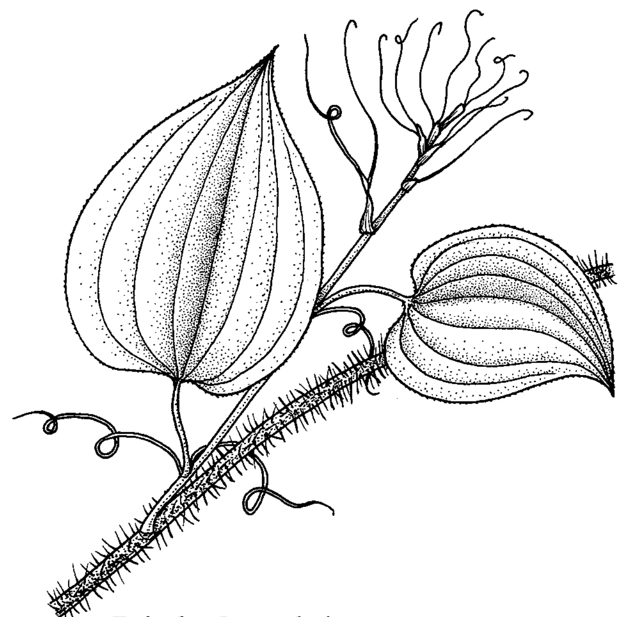
Greenbriers *(Smilax species)*

Family: Smilacaceae, the Catbrier Family

Be careful of thorns on these plants.

Greenbrier is recognized by its spiny stem and shiny, round to heart-shaped leaves with nearly parallel veins. In southwestern Virginia, some of these vines will stay green all year, making them quite conspicuous in fencerows during the winter. Greenbriers produce low-quality berries, typical of fall-produced fruits (see the discussion of low- and high- quality fruits in the introductory section of this chapter). The most common species in southwestern Virginia are **Common Greenbrier** or **Catbrier** (*Smilax rotundifolia*) and **Bristly Greenbrier** (*Smilax tamnoides*). Both of these greenbriers have thorns, but Bristly Greenbrier is distinguished from Common Greenbrier by *abundant bristly, often blackish thorns,* particularly numerous near the base of the stem. (See the illustrations, below).

Common Greenbrier



Bristly Greenbrier

Virginia Creeper or Woodbine *(Parthenocissus quinquefolia)*

Family: Vitaceae, the Grape Family

The berries of this plant are poisonous.

Virginia Creeper is easily recognized by its compound leaves with five leaflets radiating from a central point. Virginia Creeper may be observed climbing a tree trunk, fence post, or wall. The reason it can do this is that, in addition to aerial roots that entwine on contact, Virginia Creeper has adhesive pads at the tips of these roots. By means of these pads, the vine can climb even smooth surfaces (where other vines might not be able to grow) and bind quite tightly to them! Virginia Creeper produces high-quality, bluish or blackish berries. These fat-rich berries are highly desired by some animals, particularly migrating birds that require a lot of energy. *The berries are toxic to humans,* and their sour taste and pungent odor make them undesirable to many other mammals, as well. (See drawing on next page.)

Virginia Creeper or Woodbine

Wild Grapes *(Vitis species)*

Family: Vitaceae, the Grape Family

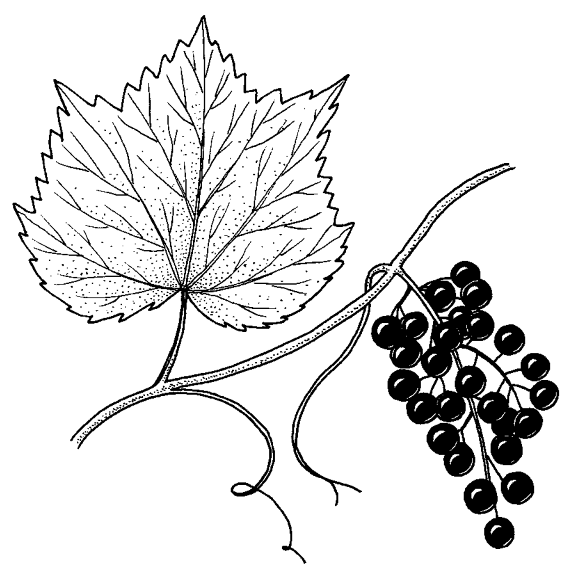
These long, thick vines, commonly seen rising to the treetops in forest edges and woodlands, are a favorite natural swing for children. The peeling bark of older grape vines distinguishes these plants from other vines. Some grape vines may be over 100 years old! The bark is a favorite building material for many song birds. The vines have lobed or heart-shaped leaves, which on some older plants are visible only in the tree tops. Grape plants climb by draping themselves across other plants and by attaching to them by means of modified branches called **tendrils**. Grape vine tendrils, like those of other vines, intertwine with other objects that they contact. The clusters of dark blue to black fruit are eaten by many kinds of birds and mammals; even foxes seek out this highly desired food source!

Dating back to ancient cultures, humans have long used grapes. Mention of grapes, vineyards, and fermentation of grapes can be found in writings thousands of years old, and Biblical phrases such as "the fruit of the vine" are referring, of course, to grapes.

A historical marker at Jamestown notes that the Virginia General Assembly in 1624 required every freeman to "plant a garden of from 1/4 to a full acre." It was stipulated also that he "include four mulberry trees and twenty vines in its plantings—the former for silk and the latter for wine." The word "vines" refers to grape vines, and the marker indicates the importance of grapes in early America.

It is interesting to note the influence of wild American grapes on the highly touted European varieties. The European grapes were nearly eliminated by a "plant louse" (or root aphid) that was unfortunately introduced from the New World in the late 1800s. The European Grape was saved by grafting vines onto root stocks of the relatively resistant North American species.

The most common wild grapes in southwestern Virginia are the **Summer Grape** (*Vitis aestivalis*), most common in fields and dry woods; and the **Riverbank Grape** (*Vitis riparia*), most common in moist soils.



Summer Grape

Japanese Honeysuckle *(Lonicera japonica)*

Family: Caprifoliaceae, the Honeysuckle Family

(Note: For convenience, this species of *Lonicera* will be referred to hereafter simply as "Honeysuckle," as it is most commonly known. There are, however, several other species of *Lonicera* found in Virginia and neighboring states.)

If you have never stolen a drop of sweet nectar from the base of the Honeysuckle flower, you need to try this delightful experience. But don't let the sweet nectar and pleasant flowers mask the true nature of this plant. It is an aggressive plant competitor. Honeysuckle can grow up to 10 meters (30 feet) in one year! It climbs by wrapping itself tightly around fence posts, trees, and any other plant that it contacts. It can quickly engulf everything around it. It can literally strangle other plants, weigh them down, break their branches, and completely enshroud them in Honeysuckle foliage.

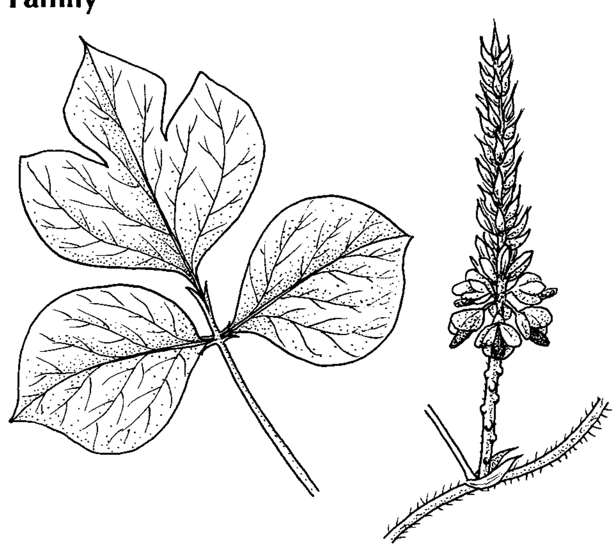
Honeysuckle can be positively identified by its distinctive white, tubular flowers (yellow in older blooms), which arise in pairs from joints all along the length of the vine. The leaves are oblong and the stems are hairy. Woody parts of old vines are often seen twisted and interwoven into schoolyard fencing, sometimes remaining for years. While the negative aspects of Honeysuckle have been discussed here and in the introduction to this section, the plant does have some redeeming qualities. The berries are a valuable food source for many birds, and the thick foliage provides cover for many animals.

Japanese Honeysuckle

Kudzu *(Pueraria lobata)*

Family: Leguminosae or Fabaceae, the Bean Family

This plant is probably recognized by most people from a distance rather than by close observation of its flowers or leaves. Swallowing trees, cliffs, telephone poles, signs, and abandoned houses, it is a familiar sight along highways in the southeastern United States. Kudzu was introduced from Japan at the turn of the century because of its perceived value for soil-erosion control and soil enrichment, its edible parts, and its leaves that could be used as cattle fodder and chicken feed. Kudzu has since run rampant in the warm, wet environment of the South, overgrowing everything in its path at rates reported as high as 100 feet per year! You may find parts of your schoolyard



Kudzu

covered by this plant. A close look will reveal a hairy stem; violet pea-like flowers in dense clusters, with a strong grape-like odor in late summer; and broad, compound leaves made up of three large leaflets. Its fruit, a brown hairy pod about 5 centimeters (2 inches) long, appears in the fall. As with Japanese Honeysuckle, Kudzu's rampant growth can make it a nuisance plant.

Kudzu has little known value as a wildlife food, although its new, green shoots are edible to humans. Kudzu also has another interesting quality: a potential for treating alcoholism. A tea made from Kudzu has been used for this purpose by the Chinese since 200 A.D. Researchers at Harvard Medical School have investigated this use of Kudzu roots. In the Harvard study, hamsters that had been conditioned to heavy use of alcohol reduced their alcohol consumption dramatically after receiving an injection of Kudzu extract. If similar results are found in clinical testing with humans, Kudzu could prove to be valuable in the fight against alcoholism.

European Bittersweet *(Solanum dulcamara)*

Family: Solanaceae, the Nightshade Family

This plant is poisonous.

This vine, with its brightly colored, conspicuous flowers *and its toxic properties*, is a common schoolyard resident in southwestern Virginia. The flowers have bright blue or violet petals that curl backwards, contrasting sharply with the bright yellow, cone-shaped structure formed by the plants' stamens. Another distinguishing feature of this vine is the unusual, *deeply lobed leaves found on older parts of the vine (see the drawing below)*. As in many members of the Nightshade Family, *all parts of this plant are poisonous!* Its common name reputedly comes from observations that the leaves change from bitter to sweet when chewed; the authors have not tried this and neither should anyone else! Teachers should be aware that the green berries, which turn bright red when ripe, can be as attractive to children as they are to birds that eat them. Livestock, too, have been poisoned by eating these plants.

European Bittersweet

American Bittersweet *(Celastrus scandens)*

Family: Celastraceae, the Stafftree Family

This is not one of the most noticeable schoolyard vines. It has neither large nor bright flowers, but small, greenish ones; it has no sharp thorns or spines that will grab your attention; and it has inconspicuous, oval leaves with jagged edges. Other than its orange fruits and bright red seeds displayed in the fall, this vine does not make itself known. Nevertheless, it is common in southwestern Virginia and likely to be seen during searches for schoolyard vines.

American Bittersweet is a native vine, but an alien plant, **Asiatic Bittersweet** (*Celastrus orbiculatus*), looks very similar. Asiatic Bittersweet, however, tends to form more massive growths than does the native species, which is much less invasive.

American Bittersweet

Bindweeds

Family: Convolvulaceae, the Morning Glory Family

Large, attractive, tubular flowers, similar to the familiar morning glories, call attention to this vine when in bloom. Bindweed vines are persistent in gardens, growing quickly in the disturbed soils of flower beds and landscaped areas. Bindweeds climb by draping themselves across other plants and by vigorously twisting around stems, twigs, and fences. Bindweeds are frequently found entwining shrubs at schools.

Two common bindweeds in southwestern Virginia are **Field Bindweed** (*Convolvulus arvensis*), which has arrow-shaped leaves and white or pink funnel-shaped flowers; and **Hedge Bindweed** (*Calystegia sepium*, or *Convolvulus sepium* in older books), with similar flowers and arrow-shaped leaves with squared lobes at the base.

An exciting thing about finding bindweed in your schoolyard is the opportunity to discover **tortoise beetles**. A section on tortoise beetles is included later in this chapter.

Field Bindweed

Vines Inquiries

⚠ ***Be sure students can recognize Poison Ivy and do not examine a vine without confirming that it is not Poison Ivy. Students should not attempt to collect samples of Poison Ivy vines. Students with known severe allergic reactions to Poison Ivy should not be anywhere near it! See the Poison Ivy inquiries below.*** *Useful materials: rulers or meter sticks, thermometers.*

Finding and Comparing Vines

How many different kinds of vines can you find?
Describe the features of each vine you have located.
What is the shape of the leaves? How are they arranged on the stem?
Describe the stem. What color is it? Is it smooth, hairy, prickly, or covered with bark?
Make a chart that compares the vines and their characteristics.

Vine Adaptations for Growth

How do vines grow?
How do vines climb?
Why do vines climb?
Compare the width of a vine's stem with its length. Do the same for other plants. Which plants have the smallest diameter stems compared to their length?
Why do vines seem to generally have small diameter stems compared to their length than other plants? How might this be an advantage for the vine?
How does the vine take advantage of other plants?
What specialized features do the different vines in your schoolyard employ to climb?
How fast do vines grow? Which vines in your schoolyard grow fastest? How fast do vines grow compared to surrounding plants? How could you measure this?

Aggressive Vines and Ecosystem Diversity

If you have Japanese Honeysuckle or Kudzu growing in your schoolyard, you can pursue the following line of inquiry.
Are these vines dominating their habitat?
Have these vines affected other plants growing in the area? Wildflowers? Trees?

Compare locations where vines are growing with areas where they are not growing. Where is there more variety of plants? Where is there more variety of insects? How could you measure this?

Does the answer to the above questions vary depending on the kind of vine?

How has Honeysuckle/Kudzu changed the environment?

How does Honeysuckle/Kudzu provide cover?

How does the temperature underneath a dense mat of Honeysuckle/Kudzu on a sunny day compare to the temperature in a sunny section of lawn? How is this important to other organisms?

What are the pros and cons of the presence of Honeysuckle/Kudzu?

Poison Ivy 1: Recognizing the Plant and Its Effects

⚠ ***Do not touch any part of this plant!***

Survey the schoolyard yourself for potential hazards. If you find Poison Ivy is abundant, take your class outside to learn the features of Poison Ivy and how it is distributed in your schoolyard. Begin by explaining to the class that you will be looking at Poison Ivy and that ***under no circumstances*** *are they to touch or brush any part of their shoes or clothing against it. Emphasize the danger of direct or indirect contact with this plant and how even individuals that are not sensitive to this plant can become so. You may want to begin a pre-trip discussion with your class by asking:*

How many have had a reaction to Poison Ivy? How many have not?

Where was the Poison Ivy to which you were exposed?

What were the symptoms of your outbreak?

What are some ways you dealt with the rash?

When you are ready to go outdoors, bring the class to a representative Poison Ivy plant.

What are the features of this plant?

How is it similar to the plants around it? How is it different?

What features would you look for to recognize this plant in the future?

What does "leaves of three, let it be" mean?

Vines Inquiries, continued

Poison Ivy 2: Form, Habitat, and Distribution

*Once you are sure students can identify Poison Ivy, walk around the schoolyard with them, looking for Poison Ivy plants. Provide students with a data sheet to keep a tally of how many examples of shrub-like, vine-like, and ground cover-like Poison Ivy you find. Have them describe or sketch the features of the habitat in which Poison Ivy plant is found. You may also wish to provide students with a schoolyard map (or have them make their own maps) and mark an **X** each time a Poison Ivy plant is found. The results can be compiled into a larger map to display for the whole school.*

Where is Poison Ivy found most frequently?
What are the features of the habitat in which it is found?
Does all the Poison Ivy you have seen look the same?
What are the different forms you have observed?
Which form is most frequent? Where is it found?
How does mowing relate to the observed form?

Poison Ivy 3: Life Cycle

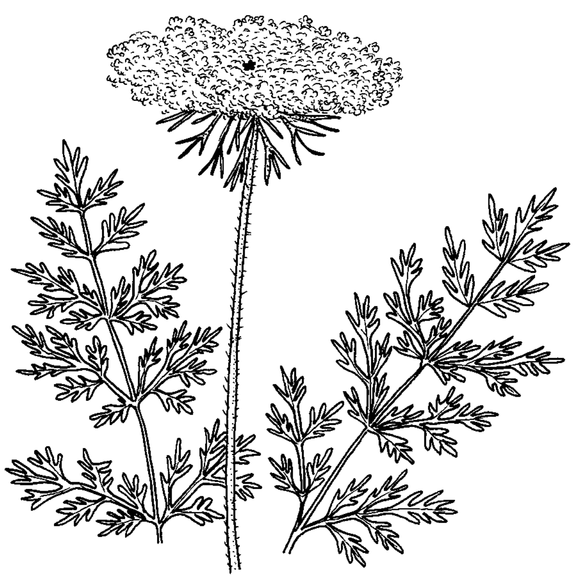
How does Poison Ivy change the growing season?
Is Poison Ivy a flowering plant?
During what months/season can you find Poison Ivy flowers?
How does Poison Ivy reproduce?
How does it spread?
If you observed flowers earlier in the season, how have they changed?
If you find berries on Poison Ivy, estimate the number of berries per plant.
Watch these berries during the course of the winter. Do they disappear? What has happened to them?
Can you find other plants with berries in the schoolyard? Compare the disappearance of these berries with that of Poison Ivy berries.
How do Poison Ivy leaves change over the season?

Queen Anne's Lace *(Daucus carota)*

Family: Apiaceae, the Carrot Family

This plant is not poisonous, but it can be confused with Poison Hemlock.

One of the best known of the fall wildflowers is the flat-topped cluster of lacy, white flowers of Queen Anne's Lace. In the middle of the cluster of creamy, white flowers you can also find a single, dark purple flower. The leaves are finely dissected and almost fern-like in appearance. Both the stem and leaves are hairy. When crushed, the leaves and the long, thick taproot of this plant suggest the odor of a carrot. Queen Anne's Lace is also known as Wild Carrot, and a subspecies of this plant is actually the ancestor of the cultivated carrot we know so well. The plant looks similar to Yarrow (see the section below on Yarrow) and Tansy (which has a *yellow* flower and finely divided leaves and is found in roadsides and waste places). Both of these plants, however, give off a strong *spicy* smell when crushed, rather than the carrot-like smell of Queen Anne's Lace.



Queen Anne's Lace

Flower Visitors and Seed Development

The flowers (and their strong odor) attract many pollinators, mostly flies and bees but also a number of other insects, including beetles and Black Swallowtail Butterflies (both the caterpillars and adults). This makes Queen Anne's Lace flowers an excellent location to observe insects. After pollination, the flower curls up into a nest-like shape; this structure provides a hiding place for many insects and spiders. When the plant's bristly seeds mature, they may be distributed by passing animals or the wind.

Queen Anne's Lace History and Uses

The common name of the flower is said (at least according to one legend) to date back to the days of King James I of England. His wife, Queen Anne, was fond of making lace and challenged her ladies-in-waiting to a competition to see who could make the finest lace. To determine a winner, they would compare their hand-made lace to the most intricate and exquisite pattern they knew—that of this flower. Alas, as palace competitions always go, all agreed that the queen's lace was truly the finest, and since then the name of the flower has been "Queen Anne's Lace."

Queen Anne's Lace was undoubtedly included in the herb and medicinal gardens of the early European settlers of this country and has long since escaped to grow wild in fields and meadows. The stringy and somewhat bitter root was eaten for centuries in both Europe and America. Early in the 1900s, scientists who were aware of the rich source of Vitamin A in the roots of Queen Anne's Lace manipulated this plant through selective breeding to produce a larger, more palatable root. The leaves and seeds were used to make therapeutic teas with a carrot-like flavor. *Do not sample this plant yourself, however*; its leaves can easily be confused with those of **Poison Hemlock,** which can be found in similar habitats in Virginia *and is definitely poisonous.* (A tea of Poison Hemlock leaves is said to have led to the death of the Greek philosopher Socrates.) The risk of mis-identification is too great to warrant human consumption of Queen Anne's Lace.

Queen Anne's Lace Inquiries

If you locate Queen Anne's Lace, your students can examine the flowers, leaves, and roots. Allow your students to pull up some plants by the roots only if you have an abundant stand. Here is a tip from a teacher and reviewer of this book: Using only shorter blooms for study may prevent some horseplay with taller plants! Useful materials: hand lenses, sketch paper.

Finding a "Wild Carrot"

What are the distinguishing features of Queen Anne's Lace?
What makes this plant different from other plants around it?
In which habitat is this plant most common?
Based on where you find this plant growing, describe the environm ental factors that are favorable for the growth of this plant.
Crush a leaf between your fingers and hold it under your nose. Describe the smell.
Look at the roots of this plant. Break a piece and hold it under your nose. Describe the odor.
What popular garden vegetable do you think came from this plant?
What features does this plant have in common with carrots?

Insect Visitors to Queen Anne's Lace

What insects can you observe visiting or resting on these flowers?
What are these insects doing? What behaviors can you observe?
What are they feeding on?
Make a table listing the insect visitors, descriptions, and behaviors. *(For help here, see the section on Discovering Insects later in this chapter.)*

Seed Development

Can you find all stages of this plant's development from flower to seed? Describe the changes that occur.

Note changes in this plant from fall to spring. Keep a notebook with observations and sketches.

How does the flower head change as it goes to seed?

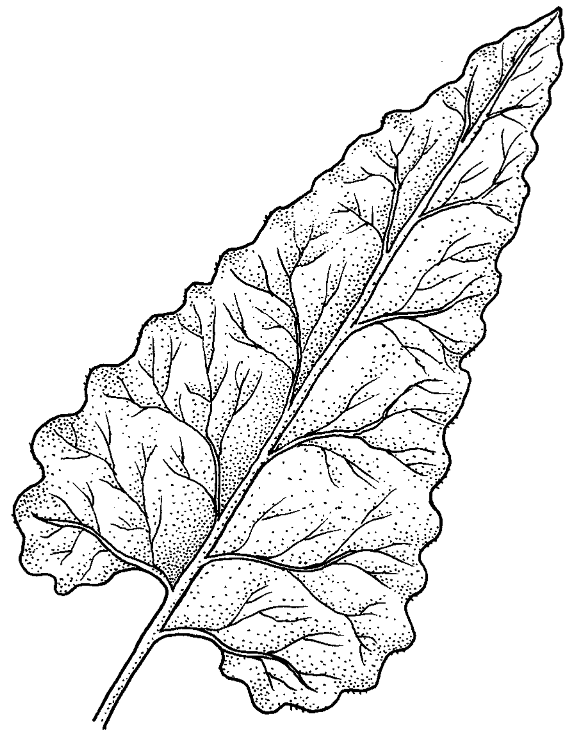
Collect some mature seeds from a flower head. Look at them closely with a hand lens. Sketch their features.

How do you think these seeds are disseminated? What mechanism might be involved? Create some experiments to test your ideas.

Common Burdock *(Arctium minus)*

Family: Asteraceae or Compositae, the Sunflower or Composite Family

After walking through an old field or along a forest edge in the fall or winter, you probably have removed the prickly seed heads of Common Burdock from your socks or long pants. In doing so, you have played an unwitting role in the seed-distribution strategy of the plant. Thanks to the success of Common Burdock in distributing its seeds, you are likely to have this plant somewhere in an overgrown area of your schoolyard. After wrestling one of these seed heads out of your socks or dog's hair, you can well imagine how this plant might have been accidentally introduced from Europe to this country. Even without these seed heads, however, you can recognize Common Burdock by the enormous heart-shaped leaves at its base--up to 46 centimeters (18 inches) long!



Common Burdock Leaf

Common Burdock is a biennial, so it requires two years to complete its life cycle. In the first year, the plant produces a cluster of large leaves radiating out from a center point. A thick taproot develops, storing energy captured from the sun through the process of **photosynthesis**. In the second year, a leafy stem grows from the taproot, and energy stored in the root from the preceding year is used to produce flowers and then seeds. The upper branching stems carry numerous, prickly flower heads in late summer. The end of each flower head displays a few, light pink, finely divided petals protruding from a green, rounded, prickly bract. By late fall, the plant's leaves and stems turn brown, and the leaves wither and fall off, leaving the seed heads--the "burrs"—standing out on the remaining branches.

Burdock Seed Heads (the "Burrs")

Burdock Burrs

Common Burdock seed heads or burrs are held on just strongly enough to prevent them from being blown off by the wind, but they are dislodged easily when fur or clothing brushes against them. Holding a burr in your fingers or against a piece of cloth gives an impression of its being "sticky." Close examination with a hand lens will reveal that they are not actually sticky, but are surrounded by stiff bristles, each with a tiny, sharp-tipped hook on the end. Due to the sharpness of these barbs, the burr will even "stick" to your fingers. Compare these seed heads to Velcro™ , and you will see startling similarities. Velcro™ was, in fact, invented by a Swiss engineer named George de Mestral, who investigated how burrs stuck to his pants so tenaciously. His observations led to the "hook and loop" configuration that is used in more products than we could name here. The word Velcro™ is made from the combination of the French words *velour*, for "velvet," and *crochet*, for "hook."

Open up a Common Burdock burr and you will find 20 to 40 seeds. When you pull the burr apart the seeds will separate and fall out. This is what happens when a fur-bearing animal tries to remove a burr from its fur. As the animal bites or scratches at the seed head, the burr will break apart, scattering seeds to new locations.

Burr Inhabitants

Sometimes, in late fall, when you open a burr you will find a number of seeds that do not separate and are seemingly glued together. If you break this apart you will find the white, grub-like larva of an insect inside. Adults probably laid eggs in the burr while it was flowering. The egg hatched after the burr matured, and the larva glued the seeds together and bored a hole through them as it ate. Inside the prickly burr, the larva has both a safe haven a highly nutritious food source. Seeds are nutrient-rich because they are designed to provide the **embryo** (the developing organism) with all it needs to begin growth.

Burdock History and Uses

Besides being the inspiration for Velcro™, Common Burdock is valued for food in Europe and is actually cultivated in Japan as a vegetable. Very young leaves can be eaten in salads or cooked as greens. The stems can be collected when young and eaten as a vegetable similar to asparagus. First-year roots, collected in the fall, can be eaten right away or dried and saved for later. Common Burdock has been used medicinally in tonics and poultices for treating a wide variety of ailments including gout, rheumatism, bruises, and even symptoms of contact with Poison Ivy.

Common Burdock Inquiries

Direct your students to examine a stand of Common Burdock in the fall or late summer. Bring some burrs inside for other investigations. Useful materials: hand lenses, plastic bags for collecting burrs, Velcro™, various materials for testing attachment of burrs.

General Plant Features and Interactions

Describe the features of this plant.

How is it different from the plants around it? How is it similar?

What features does it have that would help you distinguish it from any other plant?

Examine the leaves. Describe how they feel. How is the top surface different from the bottom surface?

Common Burdock Inquiries, continued

Describe the condition of the leaves. Is there evidence that otheorganisms have been feeding on the leaves?
Describe the evidence you found or any organisms that were present.
If you found evidence, but no organisms, make some guesses about what organisms may have visited these leaves.
Describe the nature of the habitat that these plants provide for organisms.

Burdock "Burrs"

After observing the Burdock plant, have students collect "burrs" and return with them to the classroom.
What are some properties of the burrs?
Try touching the burr to different surfaces/materials: paper, glass, cloth, tissue, etc.
To which materials do the burrs stick/not stick?
What makes them "stick"? Are the burrs covered with a sticky substance?
Use a hand lens to observe burrs. Describe or sketch what you see.
Relate these observations to the information you collected about what burrs will stick and not stick to. Can you explain why the burrs would stick to some substances and not others?

Burrs and Velcro™

How many people in class have something with Velcro™ on it ?
What does Velcro™ do? How does it work?
Examine a piece of Velcro™ with a hand lens. How is it similar to the Burdock burr? How is it different?

Burrs and Seeds

Why does the plant have burrs?
Take one apart. What do you find inside?
How many seeds can be found in each burr? Do they all have the same number of seeds? Find the average number of seeds produced (look at, say, 10 burrs).

How many burrs are on each plant? What is the total seed production? Why might there be so many seeds on each plant?
What kind of animals do you think might walk past Burdock plants? What animals do you think are the most common carriers of Burdock seeds? Why?
Where will seeds be carried to by animals?
Based on your observations of burr structure and seeds, make up a story about how Burdock seeds are dispersed.
How could you find out more about how seeds are distributed by Burdock?

Burr Inhabitants

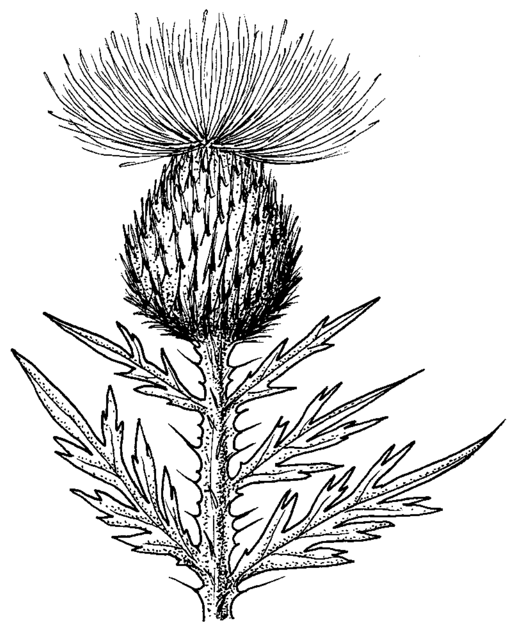
If you find Burdock seeds that are glued together, you can pursue this line of inquiry.
How is this bundle of seeds different from the individual seeds that fell out of your burr?
Break this bundle of seeds apart. Describe what you find inside.
What is this organism doing inside?
Why were the seeds interconnected? What caused this?
Why might this be a good place for this organism to live? What does the plant supply this organism?
How will this organism affect the plants? How many burrs were invaded? How many seeds were damaged?
Do you think this organism has significantly affected the plant you observed?

Thistles *(Cirsium species)*

Family: Asteraceae or Compositae, the Sunflower or Composite Family

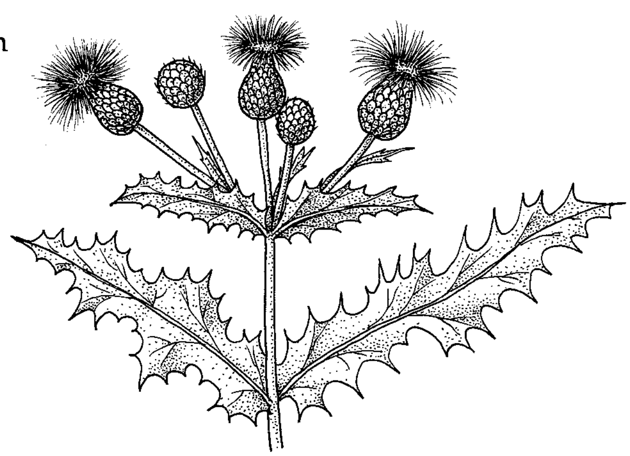
⚠ *Be careful of the spiny leaves of these plants.*

You might not want to touch the spiny leaves of thistles, but learning about these interesting plants is painless! Two kinds commonly found in southwest Virginia are **Bull Thistle** (*Cirsium vulgare*) and **Canada Thistle** (*Cirsium arvense*). Bull Thistle is the larger and spinier of the two and has larger, but fewer, flower heads. Canada Thistle is somewhat less threatening and has a smooth stem. Both have pale purple to pink flower heads and *spiny, Dandelion-like leaves*. (See also the section on Dandelions in the Lawn chapter.) Both thistles are aliens to the United States.



Bull Thistle

The sharp spines on thistles obviously help protect the plant from plant-eating animals, but in nature there always seems to be an organism that will take advantage of a unique niche, and thistles are no exception. **Painted Lady Butterfly** caterpillars feed on thistle leaves. Perhaps the caterpillars themselves benefit from the protection from predators that the plant provides. The caterpillars can be found on the underside of the leaves, where they make shelters from leaf hairs and silk. The brilliant brown and orange butterfly may be observed feeding on nectar from thistle flowers or laying eggs on thistle leaves.



Canada Thistle

Thistle Growth and Life Cycle

Canada Thistle was known in Europe as "Creeping Thistle" because of its ability to spread by underground runners. Canada Thistle is typically found in large clumps, while Bull Thistle is often solitary. Because of the nature of its root system, Canada Thistle is also hard to eliminate. Plowing a stand of Canada Thistle will merely break up its root system, and each buried piece can grow back into a new plant. Unlike the Canada Thistle, Bull Thistle is a biennial. In the first year of its two-year life cycle, it produces only leaves, growing close to the ground and radiating from a center point. In the second year, using energy stored the preceding year in a thick taproot, it produces a flowering stem and, eventually, seeds.

Thistle Seeds

Both kinds of thistle produce seeds that are spread by the wind--lofted into the air by soft, wispy, white hairs attached to the seeds. (Recall from *The Night Before Christmas* : "...like the down of a thistle.")

Thistle seeds are eaten by many birds, particularly **Goldfinches**, which can also be seen collecting thistle down for their nests. The thistle seed that is sometimes called "niger" and sold commercially for bird food is not from native thistles, but may be from as far away as India or Ethiopia.

Other Thistle Uses

You may be surprised to know that thistles are reputedly quite flavorful and good to eat. A pair of heavy gloves and a shovel are recommended for harvesting. After cutting the spines off the leaves and scrubbing the root, you can eat the leaves either in salads or cooked as a vegetable. Medicinally, thistle has been used in tonics and for its sweat-inducing properties, as well as in the treatment of dysentery.

Thistles Inquiries

⚠ ***Be careful of the spiny leaves of these plants.*** *Useful materials: flags or marking tape, bags for collecting thistle seeds, electric fan.*

Thistle Defenses

What is probably the first feature of this plant that you notice?
How does this feature of the plant help it survive?
Does this plant show any evidence of damage from other organisms? What evidence do you see?
If there is a nearby *grazed* meadow containing thistles, what do you notice about these plants compared to others around it in the meadow?

Thistle Growth and Life Cycle

Are the thistles you are observing growing individually or in clumps?
Can you explain why they might occur in clumps?
Do all the thistles that you have observed produce a stem with flowers? If not, how can you explain this?
Mark a plant for your students and have them observe the plant throughout late summer and fall.
Describe how its flowers change over time.
When do seeds appear?

Thistles Inquiries, continued

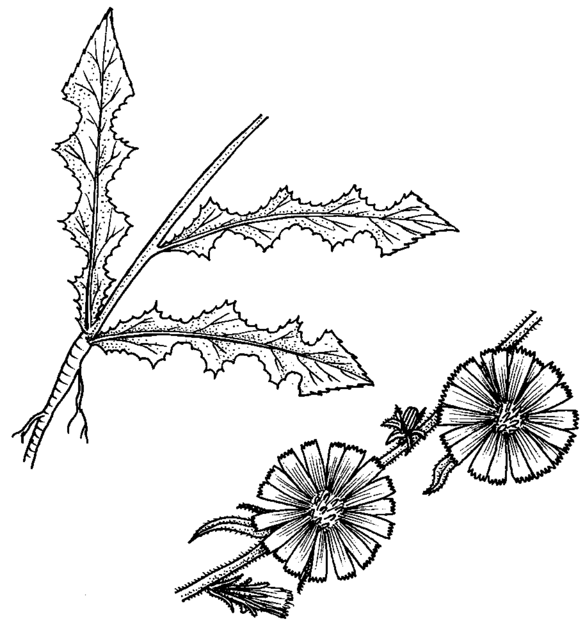
Thistle Seeds

Collect some thistle seeds and fibers. Describe how they feel.
How are the seeds dispersed?
How far does the wind carry these seeds, compared to other seeds?
How does the "down" of the thistle affect how far it travels?
Have your students try cutting the down at different lengths and measure how far they are carried by dropping at least ten seeds (of each length) in front of a fan, set up in a classroom or hallway.
Measure how far each seed travels, and determine the average distance traveled.
How does shortening the length of the down affect how far it is carried?
Design a table or graphs to organize your data.
Can you observe any animals using these seeds?
How do you think birds might use these materials?

Chicory *(Cichorium intybus)*

Family: Asteraceae or Compositae, the Sunflower or Composite Family

Most people probably recognize the name of this plant as a flavor enhancer in commercially marketed coffees, but few may realize that this plant grows commonly along roadsides and in fencerows. Bright blue flower heads on tall, spindly, practically leafless stems in late summer or fall identify this common plant. To find its leaves, look at its base, where jagged-edged leaves radiate from a central point. The flowers, which on some plants may be pink or white instead of blue, have square-tipped petals, also with jagged edges. A few flowers open each day, and the plant continues to flower from late summer into the fall. Each flower lasts only one day; on sunny days, a flower may open in the early morning and close again by noon. Seeds mature in the fall and are dropped from the stem, which remains upright and conspicuous throughout the winter. A long, thick taproot helps this plant thrive in the dry, poor soil in waste places and along roads where it is so frequent.



Chicory

Chicory History and Uses

Roasted ground Chicory root has been used extensively over the centuries, either as a coffee substitute or extender, particularly during hard times. It was used during the Civil War, when real coffee was too expensive or unavailable, and during World War II. Chicory has been sporadically popular as a drink in its own right, but its popularity waned as it became associated with being a "poor" person's drink. Chicory has been and still is cultivated commercially. Brought to this country by early settlers, its bitter-flavored leaves were used in salads and as cooked greens. Today, a scan of the coffee aisle in a grocery store reveals Chicory being touted as a flavor enhancer for several brand-name coffees.

Chicory Inquiry

Look for Chicory in overgrown places near your school. Useful materials: hand lenses, flags or marking tape, trowel.

Studying a Successful Alien Plant

Chicory was introduced to this country in the gardens of early settlers. It has since spread and grows wild all across the country. The following, rather long line of inquiry looks at various parts of Chicory, with a focus on how the parts have helped the plant be so successful.

Where is this plant most frequently found in your schoolyard?

Chicory Inquiry, continued

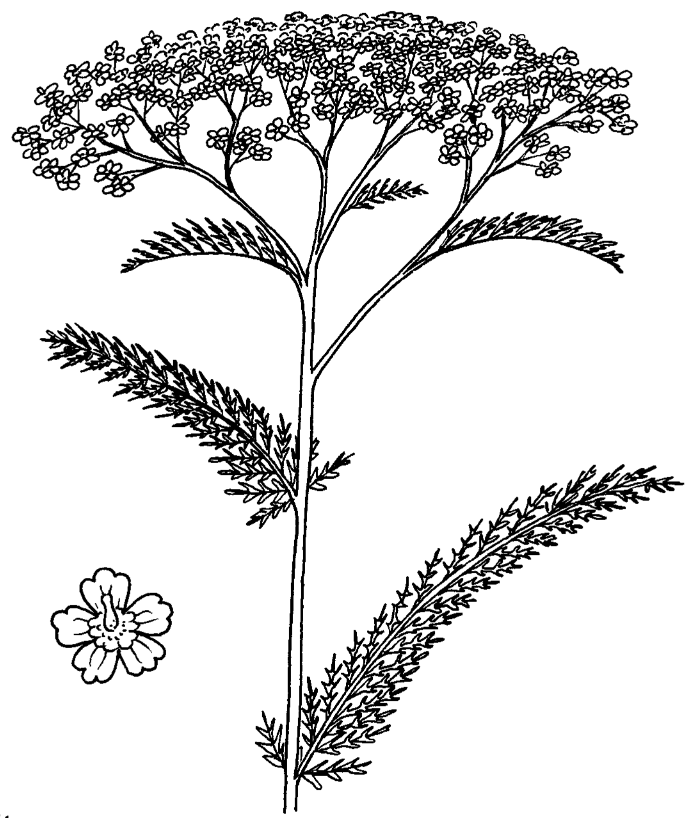
What are the characteristic features of this plant?
Gently tug a petal off a Chicory blossom. Look at this piece with a hand lens and compare it with the other parts of the flower.
What parts can you identify that are attached to the petal?
How many individual flowers actually make up a single blossom?
How many blossoms can you find on an individual Chicory plant?
Calculate the total number of *flowers* on the plant.
Do Chicory flowers have an odor that would attract pollinators?
What insect pollinators do you observe visiting this plant?
How does the number of pollinators visiting Chicory in a given time period compare to the number of pollinators visiting neighboring flowering plants?
Have students mark individual plants for closer study over time.
Compare the number of blooms in the morning and again in the afternoon. What do you notice?
Note or tag blossoms each day and record when flower buds open and when they close. How long do the blooms last?
How might this pattern of flowering, little by little, help the plant survive and reproduce?
Dig up a few Chicory plants for small groups to study.
How does its root compare to the roots of grasses?
Describe the features of the soil and habitat where you find this plant growing.
How might the structure of the root help the survival of this plant in this location?
Have students return to their marked plants after a few days to look for seeds.
Can you find mature seeds of this plant?
Describe their structure.
How are they dispersed?
How far can a seed be carried from the plant by wind alone? What will affect this distance?
Does the seed-dispersal mechanism you observed explain how it could spread so far, so fast? How else might the seeds be spread?

Yarrow *(Achillea millefolium)*

Family: Asteraceae or Compositae, the Sunflower or Composite Family

Crush the leaves of this plant between your fingers and you will be treated to a fragrant, spicy odor. Yarrow has leaves and flower heads that are sometimes confused with Queen Anne's Lace, but its aromatic leaves will quickly distinguish this plant from its look-alikes. Though not quite as delicate as Queen Anne's Lace, Yarrow also displays flat-topped clusters of white flowers. The scientific name of this species, *millefolium,* comes from Latin meaning "one thousand leaves," referring to its finely divided, fern-like leaves.

Yarrow shares certain characteristics with many of the plants we find growing at the edges of roads and in fencerows around schools: It is not a native species, it is particularly well-adapted to growing in sunny locations, and it is tolerant of poor soil and drought. You can often find Yarrow growing in clumps because it can reproduce by underground roots that spread horizontally through the soil and sprout new plants.



Yarrow

Yarrow History and Uses

Yarrow has a fascinating history of medicinal uses. Its genus name, *Achillea,* goes back to a Greek legend, according to which Achilles brought this plant with him into battle to heal the cuts of wounded men. For hundreds of years, Yarrow was used in poultices to stop bleeding, and its use was documented during the U. S. Civil War. Modern chemical analysis has since shown that Yarrow contains chemicals that do in fact act as hemostatic agents (chemicals that stem the flow of blood). Yarrow was used, typically in teas, by Native Americans to treat many different ailments. Again, chemical analysis shows that Yarrow contains over 120 different chemical compounds, suggesting why it might indeed have many different medicinal properties.

Yarrow Inquiries

Look for Yarrow plants growing in a fencerow or other overgrown area near your school. Useful materials: hand lenses.

Yarrow Growth Habits

Is Yarrow usually found growing by itself or does it sometimes occur in clumps?

If you find clumps of Yarrow, how can you explain why they grow this way? What are some possible explanations for this distribution?

Carefully try to pull up one plant and dislodge its root system. Can you trace its roots? How do these new observations help explain its clumped distribution?

How does this plant change from September through the winter? Make regular observations of a single plant and note changes in leaves, stem, and flowers.

Comparing Yarrow to Queen Anne's Lace

Queen Anne's Lace (discussed in a separate section in this chapter) often grows in the same habitats as Yarrow. If you find the two together, you can pursue the following line of inquiry.

Compare this plant to Queen Anne's Lace.

Do they grow in the same places?

Do the bloom at the same time?

Describe the structure of the leaves of these plants. How are they similar? How are they different?

Crush the leaves of each and smell them. How do they compare? Describe the odors.

Compare the flowers of these plants. How are they similar? How are they different?

Do you observe similar insect visitors on the two plants?

Goldenrods (*Solidago* species)

Family: Asteraceae or Compositae, the Sunflower or Composite Family

(Please note: Many species of goldenrod are found in southwest Virginia. The word "goldenrods" in this section refers to that group of plants collectively.)

A stand of goldenrods that you can visit with your classes in the fall is a fantastic resource. The abundant nectar and pollen produced by the numerous flowers attract a wide variety of creatures. Goldenrods are also host to several organisms that form **galls** (see below for more on galls). The bright yellow flowers of late summer and autumn on a tall, leafy stem up to 7 feet high, distinguish this plant in fencerows and edges of the schoolyard.

Goldenrods bloom during the fall hay fever season, and the plant is unjustly considered the cause of widespread nasal suffering. In fact, the leading contributors to pollen in the air are the less conspicuous **ragweeds**, which have drab, odorless, green to yellow-green flowers. Ragweed flowers rely on the wind to carry pollen from plant to plant, so they do not need bright petals, odor, and sweet nectar to attract insects. But because the wind is not as efficient or accurate as an insect carrying pollen directly from plant to plant, far more pollen is produced by ragweed flowers than by goldenrod flowers. Goldenrods contribute probably only one to two percent of the pollen found in the air during late August and September. A comparison of the structure of the pollen reveals that ragweed pollen is light and dry, blowing easily in the wind, while goldenrod pollen is sticky so it adheres to insect bodies.

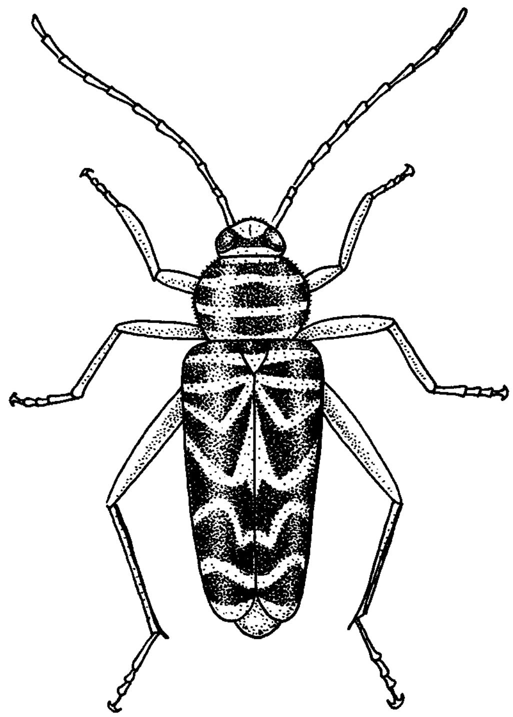
Goldenrod

Growth Habit and Life Cycle

Goldenrods are relatively inconspicuous until they begin to flower. They will grow back in the same spot year after year, with species like **Common Goldenrod** (*Solidago canadensis*) expanding through underground roots. These stands will often be so thick (and tall) that few other plants can compete with them. You can watch these plants throughout the school year as they flower, turn to seed, brown, and eventually fall and decay as new plants replace the previous year's growth in spring. Goldenrod seeds can be observed on the plants through late fall and winter; they have small tufts of "hair" facilitating their dispersal by the wind. These seeds are eaten by several species of birds.

Plant Visitors 1: Nectar and Pollen Feeders

Many different organisms can be found among the flowers of these plants in the fall, making goldenrods a rich find for your inquiring students. In addition to the bees, wasps, and flies that feed on the nectar and pollen, you may discover the stunning yellow and black **Locust Borer Beetle**.

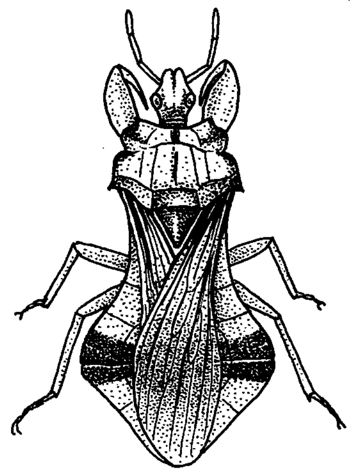


Locust Borer Beetle

This large beetle is attracted to the flowers to feed on the nectar and pollen, as well as to mate with others of its species that congregate there. The common name of this beetle comes from its habit of laying eggs in the bark of Black Locust trees. (See the section on Black Locust later in this chapter.) The eggs hatch in the fall and the larvae tunnel into the bark to overwinter. In the spring they bore deeper into the wood, then emerge as adults in the fall. You may also find other types of beetles on goldenrod flowers, such as the **Banded Longhorned Beetle** and **soldier beetles**.

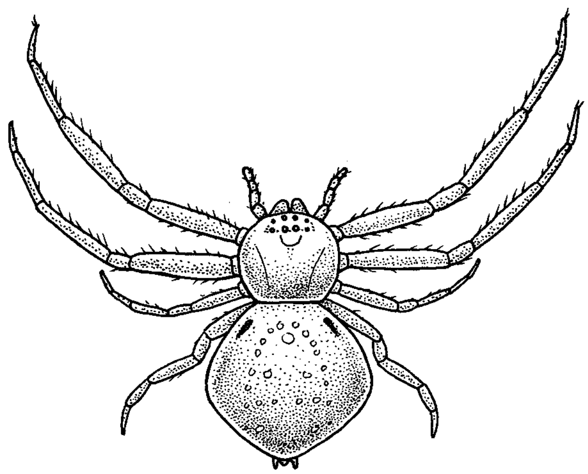
Plant Visitors 2: Predators

In addition to the animals that are actually feeding on the nectar and pollen, predators lie in wait in the goldenrod flowers to feed on the nectar-gatherers. **Ambush bugs** are intimidating-looking predators with an appalling (by human standards) feeding habit. An ambush bug, aptly named, lies in wait for its prey and, when it comes close, swiftly clamps down on some part of the quarry with its front legs. With its beak, it then pierces the exoskeleton of its victim and injects fluids. The fluids eventually kill the organism, while also digesting its insides. The ambush bug then sucks out this partially digested fluid. You may be able to find the hollow shells of past victims littering the area where ambush bugs have been actively feeding.



Ambush Bug

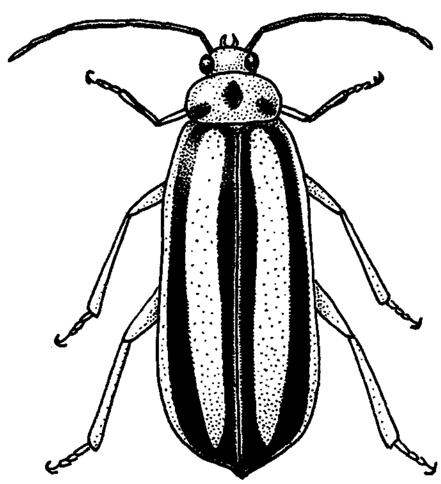
The **crab spider** is another predator you may find lurking in goldenro d flowers. Unlike many other spiders, crab spiders do not use silk to capture their prey, but use their long front legs to grab it. Their bite is capable of paralyzing the flies, bees, and wasps on which they feed. As with ambush bugs, these spiders' diet also consists of juices sucked from its prey. Crab spiders are so named because their legs extend out to the sides, crab-like, and they can move sideways (like a crab) as well as forward or backwards. Several species are able to change their color to yellow or white as they sit on different flowers. The only use of silk is by the male to bind the female loosely during courtship.



Crab Spider

Plant Visitors 3: Leaf Feeders

The leaves of goldenrod plants are also a food source for some insects. Several species of **leaf beetles** are found on goldenrods. One particular type can be found on the leaves in mid-to-late summer. These beetles are yellow-green, with three distinct black stripes running lengthwise across the wing covers, and black spots on their head and middle segment. Both the larvae and adults feed on leaves. You can observe holes and edges chewed in leaves where these beetles are present. When disturbed, these beetles will let go of the leaf and fall to the ground, where they scramble to take cover. Other leaf feeders can also be found, including a caterpillar that makes a tube-like structure of leaves.

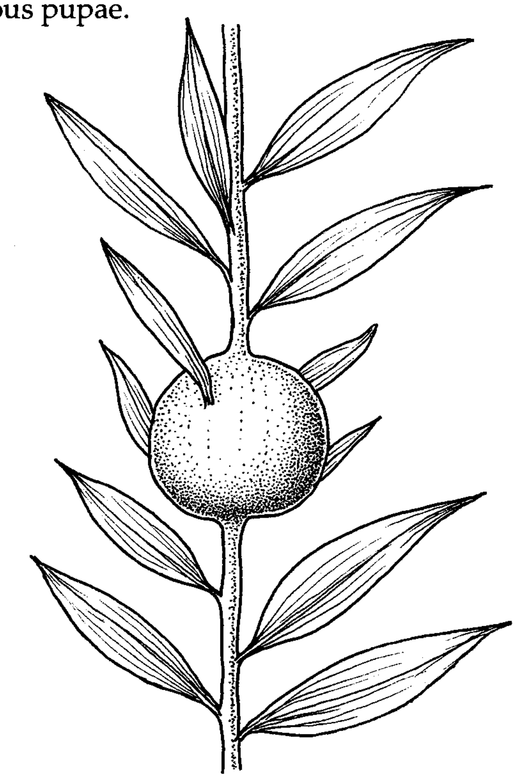


Leaf Beetle

Long-term Plant Visitors: Gall Formers

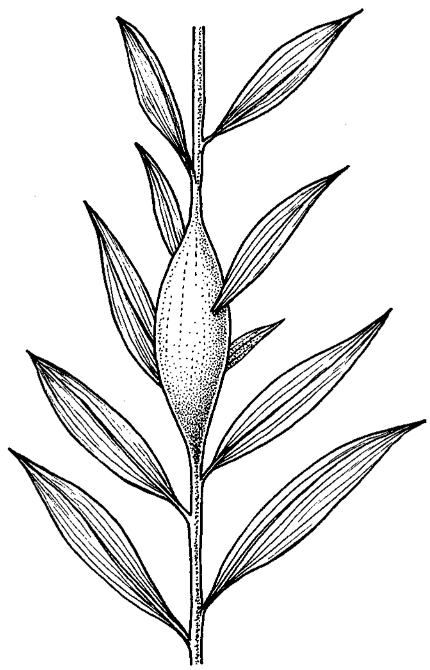
Goldenrod is also host to several gall-forming organisms. Galls are essentially tumorous growths on plants. A variety of organisms—insects, mites, and round-worms—can induce plants to form galls. The galls may take many forms, with three different kinds common in goldenrods.

Ball-like galls. These galls are recognized as a spherical enlargement on the stem. You can find them when the plant is still green or in fall and winter. These galls are formed by a type of **fruit fly** (see the Index, under Galls, for the scientific names of the gall-formers mentioned in this section). The larvae feed and pupate inside the gall, then emerge as adults in the spring. Woodpeckers and chickadees may peck into these galls in the winter in search of the nutritious pupae.



Ball-like Gall

Elliptical Galls. These galls are recognized by their elliptical shapes. This enlargement of the stem is caused by a type of **moth.** The larva of this moth feeds inside the gall and, before it is ready to pupate, bores a hole to the outside and covers it with silk. This allows the insect to get out when it changes into its adult form (the adults of this kind of moth do not have mouthparts suitable for boring through the hard gall).



Elliptical Gall

Bunch Galls. These galls look like a flower made of green leaves at the end of a goldenrod stem. This gall is formed by the larvae of a type of **midge** (the particular species depends on the species of goldenrod). Midges are small insects classified in the same order as flies and mosquitoes.

While galls are relatively easy to find, the gall-forming organism itself may not be. You can cut open galls with a sharp knife or razor blade to find the gall former, but often the galls will appear unoccupied. The gall former is often very small and not easy to detect, or it may have already emerged from the protection of the gall.

Bunch Gall

Many gall-formers are parasitized by other insects. For example, **ichneumon wasps** are able to use a long, thin, egg-laying appendage to penetrate an elliptical gall and lay an egg near the pupating insect. The wasp larva then emerges to feed on the moth pupa.

One final possibility can make your investigations of galls even more perplexing. You may find organisms that did not actually make the gall but that have taken up residence inside!

Goldenrod History and Uses

The plants have had much medicinal value for Europeans in the past, giving rise to the scientific name of this group, *Solidago*, roughly translated from Latin as "to make whole." One species of goldenrod was included in a recipe for a tea used by colonists as a substitute for imported tea during the days of the Boston Tea Party. Extracts or teas made from goldenrods have been used to reduce bleeding and treat wounds, as a stimulant and diuretic, as a remedy for colds, and even as a treatment for kidney stones and dysentery! The flowers of most goldenrods can be used to produce high-quality, yellow-green dyes.

Goldenrods Inquiries

If you find a stand of goldenrods on your schoolyard, it can be the source of many science lessons. Useful materials: hand lenses, insect-viewing boxes (or plastic containers used with hand lenses), insect nets (commercial or homemade), flags or marking tape, rulers and meter sticks, knife (for opening galls).

Introduction to a "Golden" Science Resource

What are the features of a goldenrod plant?

Describe or sketch the plant's stem. Does it branch? If you observe branching, where does it occur?

How does its height differ from the plants around it? Make some measurements to compare.

Why might this plant be found only in fencerows and old fields rather than in mowed lawns?

How might its tall growth habit be advantageous to this plant's survival in unmowed areas?

Based on where you observe this plant growing in the schoolyard, do you think that it prefers sunny or shady locations?

If you are observing the plant in the fall, during flowering, you can ask these questions:

How did this plant, goldenrod, get its name?

Describe or sketch the structure of the flowers.

Are there many insects visiting these flowers?

Why do insects come here? What do the insects gain?

What does the plant gain from insects?

Growth Habits and Life Cycle

Have your students mark plants and observe them throughout the school year.

How does a goldenrod plant change over time? Make a schedule and a chart to record your observations.

Do these plants tend to grow in clumps or singly?

What are some reasons that might explain why these plants grow in clumps?

How can you find out more about how these plants are distributed?

How fast do goldenrods grow? How could you measure this?

How do the flowers change over time? Make a chart or series of drawings to record changes in the flowers from bud to seed.

Goldenrods Inquiries, continued

Describe the structure of the seeds. Examine them with a hand lens. Based on your observations of seed structure, how would you expect seeds to be distributed?
Try dropping a number of seeds on a windy day and measure how far they travel. Compare this to other kinds of seeds.
How long do some seeds remain attached to the stems during the winter?
What happens to the goldenrod stems after they die?
Can you find goldenrod stems from the preceding year? If not, what do you think happened to them? Can you find any evidence to support your ideas?

Plant Visitors 1: Nectar and Pollen Gatherers

Use this line of inquiry when goldenrods are in full bloom in the fall.
Observe the flying insects that visit the flowers.
Describe the behavior of the insects that land on the flowers.
How long do they stay?
Do they interact with other insects?
Why do they visit the flowers?
How many different types can you see? Describe or sketch some of these insects.
How many insects visit the plants in a ten-minute interval? Make a chart to record your observations.
Does the number of insect visitors vary at different times of the day? When would you expect to see the most visitors?

Plant Visitors 2: Predators

Can you find some insects or spiders in the flowers that are not there for the purpose of gathering nectar or pollen?
How do you know they are not nectar or pollen feeders?
Can you observe what they eat or find evidence of their activities?
Describe the behavior of a predator in action.
How does their observed behavior help them be effective predators?
Do these organisms camouflage themselves? How?
Why might a goldenrod flower be a good place for a predator?

Plant Visitors 3: Leaf Feeders

Beginning in late July (before goldenrods have begun to flower) you may be able to pursue the following line of inquiry.

Look for evidence of the presence of insects on the leaves.

Describe or sketch the types of leaf damage you observe.

Can you find the organism(s) causing the leaf damage? Describe or sketch this organism if you can find it.

How many organisms can you find per plant? What is the average number per plant?

Long-term Plant Visitors: Gall Formers

This inquiry can be conducted throughout much of the year.

Can you find unusual structures or features on the goldenrod plants?

Describe or sketch these structures.

List the possible explanations for the presence of these structures.

Closely examine the gall for any evidence of something getting into or out of the gall. Describe/explain your findings.

Use a knife to cut open a gall.

Describe or sketch what you find inside the gall. Is the gall currently occupied?

How many different types of galls can you observe on these plants?

In a stand of goldenrods, how many plants have galls? How many do not?

Compare plants with galls and plants without galls. Do galls appear to have a negative or positive impact on plants?

What are some ways you could collect data to answer this question?

How would you arrange the information you collect?

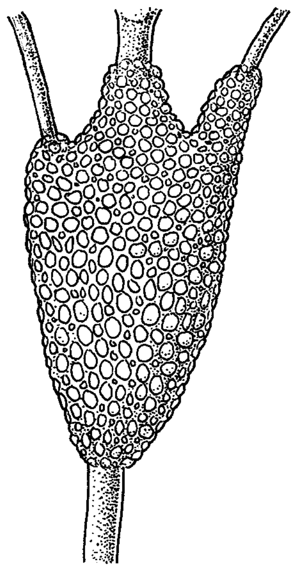
What questions do you have about galls? How could you investigate them further?

Spittlebugs

Insect Order: Homoptera, the cicadas, hoppers, aphids, etc.

Family: Cercopidae, the froghoppers and spittlebugs

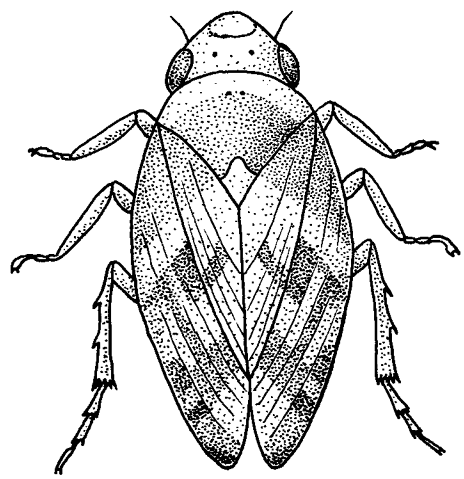
While on a nature walk, you bend over to observe more closely a flower in a lush meadow. Abruptly, you pull back, because you see a frothy mass clinging to the stem of the plant. "Who spit here?" you ask. But there is no need for disgust. What you have actually found is the unusual home of a developing insect—the aptly named spittlebug!



Where a Spittlebug Lives

How Spittlebugs Make Spittle

Spittlebugs are in an order of plant-feeding insects called Homoptera (for information on other homopterans, see the section on Leafhoppers in the Lawn chapter). Members of this group are characterized by beak-like, piercing mouthparts adapted for sucking juices from plant stems. An immature spittlebug, called a **nymph** (*not* a larva), grabs onto a plant stem upside down and pierces the stem with its beak. The spittlebug then feeds on the relatively dilute plant fluids. In order to receive sufficient nutrition, a large amount of plant fluids must be consumed. This generates a great deal of excess fluid. As the spittlebug is clinging to the plant stem upside down, the fluid wastes excreted from the organism's anus, along with a mucilaginous substance secreted through pores in its abdomen, will flow down over its body. Air moving through the insect's **tracheal tubes** (through which the insect gets its oxygen) helps turn this mix into a froth, which soon envelops the insect entirely. A search through this sticky mess with a twig or stout blade of grass will eventually reveal the hidden plant feeder.



Spittlebug

Discovering the Spittle Maker

Spittlebugs are easiest to find in late spring. They seem to be harder to find as summer begins, particularly if there are long periods without rain. A good place to find them in the schoolyard is anywhere you can find tall weeds. Look along the stems of these plants for the telltale spittle masses. One particular species is usually associated with clovers. Another place to look for different species of spittlebugs is on the leaves of White Pine. (A separate section on White Pines is found in the Trees chapter.) Probe inside the spittle mass to find the light-green spittle-maker. You can place the tiny creature on the tip of your finger and examine it with a hand lens. Spittlebugs are sometimes called froghoppers for their stout body, which is somewhat wider toward its rear end. This odd creature has almost a dinosaur-like appearance as it walks across your finger!

Spittlebug eggs overwinter on plant stems and hatch into nymphs in the spring. The spittle-producing nymph undergoes several **molts** (developmental points where the insect sheds its exoskeleton) before it becomes a winged adult. Adults continue to feed on plant stems, but adults do not create spittle. Several generations of spittlebugs may occur during a single year, so you can expect to find spittlebugs even in the early fall.

Why Spittle?

Scientists speculate that spittle protects the insect from predation. Predators may be discouraged by the sticky spittle or the effort required to find the potential prey in the spittle. In addition, the spittle may be important in providing a moist habitat for a developing spittlebug, protecting it from drying and direct sunlight.

Spittlebug Impacts

Although spittlebugs are common, they are not often a pest problem. Sometimes, however, a large population can seriously stunt the growth of clover or Alfalfa in a field. Other kinds of plant-feeding homopterans—aphids, for example—*do* cause significant damage to cultivated plants.

Spittlebugs Inquiries

Look for masses of spittle clinging to the stems of plants in weedy areas or in the needles of White Pines. Try to find at least one spittle mass for each group of 3 to 4 students to examine. If this is the first time your students have looked at spittlebugs, begin your line of inquiry by pointing out a mass of spittle and asking your students what they think it is. Useful materials: hand lenses, paper towels, water.

Discovering the Spittle Maker

What do you think made this material?

Using the rounded stem of a stout blade of grass or a twig, probe into the frothy mass to see if you can discover an explanation for the source of this material.

What did your careful search reveal? Did you find the organism that made the spittle?

How could the organism you found have made the spittle?

Use a hand lens to get a closer look. What is the organism doing in response to your actions?

Spend a few minutes studying this organism, and describe its features and behavior. You can gently pick up the organism and place it on the tip of your finger for a closer look.

Is this organism an insect? How do you know?

Spittlebugs Inquiries, continued

Is this organism an adult or immature insect? Explain.
How does this organism respond to your disturbing it?
Place the organism on a plant stem similar to the one you found it on originally. What does it do?

Exploring How Spittle is Made

How might an organism have produced this material?
What is the source of raw materials to make this foamy material?
How does the organism change this material? How do the properties of the new material compare to plant juices or sap?
What substance do plants manufacture through photosynthesis that would be desired by this organism?
How much plant fluid will this organism need to take in to gain enough energy (sugar) to survive?
What will happen to the excess fluid it consumes?

Why Spittle 1: Predators

Why does the organism make the "spittle"?
What benefits to the organism could this spittle have?
Could this material protect the organism against predators?
How easy was it for you to find the organism inside the spittle?
What animals might seek to eat the spittle maker?
What problems might these animals encounter trying to capture the spittle maker?

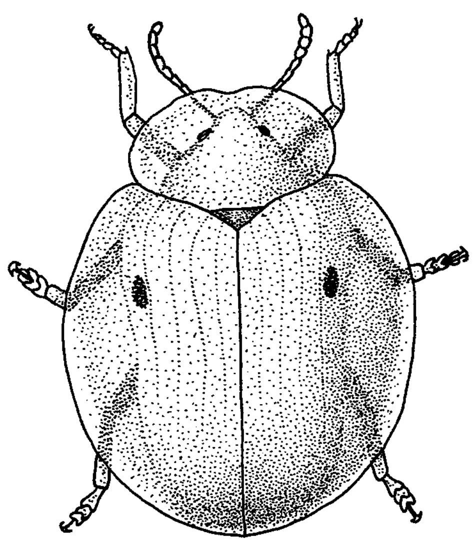
Why Spittle 2: Environmental Factors

How else might the spittle protect the organism?
Why might the spittle be important in protecting the organism from sunlight?
What are possible damaging effects of exposure to sun?
Have students place some spittle on one side of a paper towel and a few drops of water on the other side. Put the paper towel on a sunny windowsill.
How long does each take to dry? Which dries first? Why? How is this a benefit to the organism?
From this, what can you infer about how spittle might protect the organism from drying?

Tortoise Beetles

Insect Order: Coleoptera, the beetles
Family: Chrysomelidae, the leaf beetles

Disturb some bindweed, and if you see a speck of gold come flying up, you will witness one of the most stunning beetles that you will ever find in the schoolyard! (See the section on Bindweeds above in this chapter.) Catch this harmless beetle and observe it closely. The bright gold color of an adult tortoise beetle rivals pure gold in beauty and luster. Other tortoise beetle species (there are some two dozen species in the United States) display wide ranges in color and pattern, from a shiny red with black spots to brown or even striped. What they all have in common, however, are extensions of the exoskeleton that completely cover their sides and turn out flat at the edges, just like a turtle shell! The beetles measure approximately 1 centimeter (3/8 inch) in diameter.

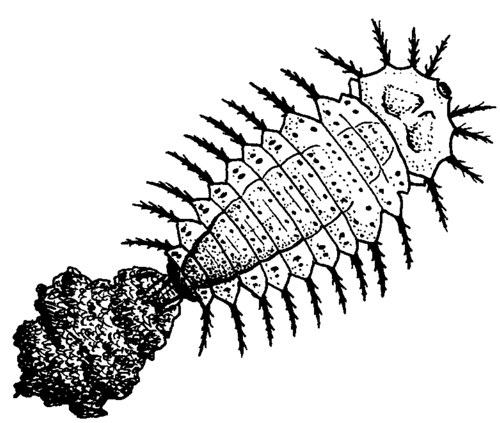


Tortoise Beetle Adult

Because adults overwinter in leaf litter, you can find the adults both in the spring and late summer or early fall. After the adults emerge from leaf litter in the spring, they may feed briefly on bindweed, then they mate and lay eggs. The larvae will feed on leaves for several weeks before they pupate; both the eggs and pupae can be found underneath bindweed leaves. Adults emerging from the pupae will feed on bindweed leaves again before seeking a place to overwinter.

Tortoise Beetle Larvae

A careful search of the undersides of bindweed leaves that are riddled with holes from the feeding activities of these organisms can reveal the unusual tortoise beetle larvae. The oval-shaped, spiny larvae are hidden under dark collections of fecal material and shed skins. Touch one of these organisms with the tip of a blade of grass, and the larva will respond by lifting the mass of material off its back and waving it at you! The dark mass is attached to two appendages at the base of its abdomen that hold the organism's previously shed skin. The function of this extraordinary behavior may be to deter predators. When an insect predator, for example, comes across a tortoise beetle larva, it will be confronted with dead skin and fecal material. This may discourage the predator and prevent it from picking up the right signals to initiate feeding behavior. The material on the tortoise beetle's back may act as visual, tactile, and odoriferous camouflage.



Tortoise Beetle Larva

Tortoise Beetles Inquiries

Look for a patch of bindweed that shows evidence of insect damage (holes in leaves). Observe these leaves for tortoise beetle adults or larvae. Useful materials: insect-viewing boxes (or plastic containers and hand lenses, insect nets (commercial or homemade), sealable plastic bags.

Examining Beetle Adults

Capture adult beetles and place them in viewing boxes or plastic containers so that they can be observed closely.

Look closely at the adult beetle with a hand lens. What are the features of the adult beetles?

What *insect* features does it display? How is it like other insects with which you are familiar? How different?

What behaviors of this beetle can you observe?

What did the beetle do when you tried to catch it?

What did the beetles that you were not successful in catching do to escape?

What evidence do we have that suggests that these beetles were eating the leaves? How could we prove this?

Place a bindweed leaf in your viewing chamber. How does the beetle respond to it?

What do you predict will happen if you leave the beetle and the leaf in the chamber overnight?

Leaf Cues to the Presence of Larvae

Have students observe bindweed leaves closely.

How have the leaves been damaged? Describe or sketch this damage. Is the damage to all the leaves similar?

Does the damage to the leaves appear to be caused by one type of organism?

How many leaves on the vine show evidence of being eaten by an insect?

Try to find the organism responsible for this damage. Carefully look underneath the leaves. Take nothing for granted! Carefully study every clue!

What do you find?

Tortoise Beetle Larvae

Have your students look underneath bindweed leaves for beetle larvae. The larvae are slow-moving, so you can hold a leaf upside down in your hand and use a hand lens to observe the insect.

Describe and sketch these unusual-looking larvae.

What material do these beetles have attached to their backs?

Gently nudge one of these larvae with the tip of a blade of grass. How does it respond?

What might be the purpose of this behavior?

Keep the larva and a leaf in a plastic zip-lock bag blown up with air overnight. Note changes in the leaf.

How much of the leaf was consumed overnight?

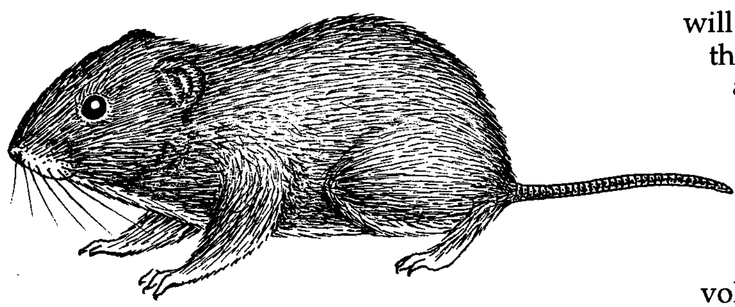
What *percentage* of the leaf was consumed? How could you measure this?

Using your measurements, discuss the impact these beetles have on this plant.

Meadow Vole *(Microtus pennsylvanicus)*

Mammal Order: Rodentia, the rodents

This rodent is sometimes called a field mouse, but it is not a mouse at all! Meadow Voles differ from mice in that they have stockier bodies, a shorter tail (measuring only about 1/3 their body length), and small, beady eyes. Meadow Voles are rarely seen, but it is easy to find their extensive network of hidden pathways.



Meadow Vole

Life in the Tall Grass

Voles are common wherever tall grasses and weeds predominate. Unmowed areas adjacent to your school or along a fencerow are likely places to find evidence of Meadow Voles. To find this evidence, reach down into the grass, pull back and separate plant stems, and examine the ground or soil surface. If Meadow Voles occupy this habitat, you will soon find a runway 3 to 6 centimeters (1 to 2 inches) wide. You can now follow this trail by "unzipping" the vegetation that forms the tunnel through which the Meadow Voles move. The runways will have many interconnecting branches as well as "dead ends." The trails may be worn and packed down to bare soil where Meadow Voles, as well as many other small animals, have made countless trips. In an acre of field these Meadow Vole "highways" may actually measure several miles in total length!

Wherever Meadow Voles have been frequently, you will find short sections of diagonally cut plant stems. Meadow Voles maintain their runways by clipping vegetation that sprouts up in the trail These clips of vegetation may serve as a food source when other food is scarce. These pieces may also be the result of a Meadow Vole cutting a plant stem to reach the seeds or flowers at its top. When a Meadow Vole cuts a tall plant stem at its base, the vegetation is often so dense that the cut plant cannot fall over. The Meadow Vole (safely hidden from view) will pull the plant stem down through the thatch and cut a piece off, pull it down again and cut the next section off, and continue in this manner until the succulent piece at the end is reached. Small, dark-brown feces resulting from the animal's feeding are another tell-tale sign of voles; the feces are left in clusters on the sides of the runways.

Voles have incredible reproductive potential. Consider these facts: Meadow Voles have litters of 4 to 6 individuals; they frequently mate again 24 hours after giving birth; they have a 21-day gestation period; and females can begin to have litters when 40 days old. Given these facts, a single female can produce nearly 100 offspring in a year, not accounting for the offspring produced by her offspring or her offspring's offspring! Meadow Voles give birth to their young in nests built of grasses and formed in a ball 15-20 centimeters (6 to 8 inches) in diameter. Winter nests are usually in sheltered locations in underground burrows or under rocks and logs, while summer nests are more often above ground in a dense patch of grass.

Meadow Vole Impacts

Voles can be very destructive to hay and other forage crops because of their population numbers and voracious appetites. Meadow Voles may consume up to 60 percent of their body weight each day. In turn, Meadow Voles are preyed upon heavily by snakes, weasels, foxes, and predatory birds. Meadow Voles make up to 85 percent of the diet of some hawks and owls. Because of predation, the average life span of a Meadow Vole is only 2 to 3 months.

Meadow Vole Inquiry

Survey your school site to see if you might have Meadow Vole habitat on your school grounds or in a nearby area that you and your students can safely investigate. Useful materials: meter sticks, sketch paper for mapping. (See also the House Mouse section, in the Roofs, Walls, and Eaves chapter, for other ways to study small mammal movements.)

Life in the Tall Grass

Reach into the grass and separate stems until you reach the ground surface. Hunt around until you see the signs of a runway.

Describe the pathway that you see.

How wide is it? Can you find where the pathway goes into a tunnel-like opening in the vegetation?

What does the pathway tell you about the organism that made it? Make a list of all the inferences you can make about this organism from studying this trail.

Can you find pieces of cut stems on the pathways? What cut these pieces of stem? How do you think they might eventually be used?

What other artifacts or evidence that some organism has been using this pathway can you find?

What is the function of these pathways? How are they used by Meadow Voles? How do they protect Meadow Voles?

Trace the pathways in a 2 x 2 meter area. Make a map of these pathways on a grid.

What is the total length of these pathways in your 2 x 2 meter area?

Measure the total area of your Meadow Vole study site, then use that value to estimate the total length of pathways in the Meadow Vole habitat.

Eastern Redcedar *(Juniperus virginiana)*

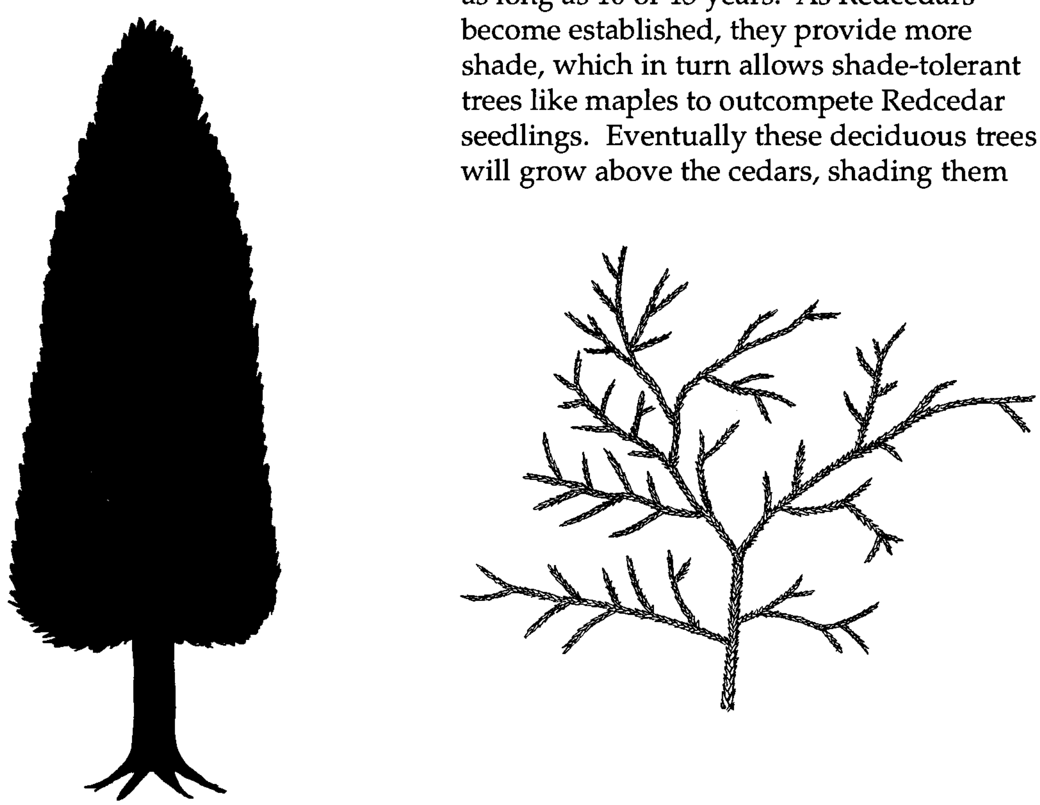
Family: Cupressaceae, the Cypress Family

Abandoned fields in Virginia are easily distinguished from maintained fields by the evergreen spires of Eastern Redcedar that will gradually take over the field. Redcedars can grow to a maximum height of around 18 meters (60 feet), and their trunks may reach a diameter of up to 0.6 meters (2 feet), but trees of this size are infrequent in southwestern Virginia today. This evergreen tree is often widest near the base, tapering to a point on top. Older trees, however, may not have this spire-like appearance. The bark on older trees is red-brown to gray in color and can be pulled off in narrow, vertical strips. Redcedar leaves vary from scale-like to small, prickly, projecting needles.

Signs of Succession

Open fields are ideal nurseries for Redcedars, which require a lot of light. Called "pioneer" trees because they are the first trees to colonize an abandoned field, Eastern Redcedars are able to grow in shallow soils and can tolerate heat as well as drought. These qualities allow them to outcompete other trees in the early stages of **secondary succession** in old fields (the process where, typically, a former pasture or cultivated field redevelops to its natural vegetation).

Redcedars can provide clues to how long ago a field was abandoned. A field with just a few small trees has probably been left unplowed or unmowed for only a few years, while a field with many tall Redcedars might have been uncultivated for as long as 10 or 15 years. As Redcedars become established, they provide more shade, which in turn allows shade-tolerant trees like maples to outcompete Redcedar seedlings. Eventually these deciduous trees will grow above the cedars, shading them



Eastern Redcedar Tree Profile and Twig

out, and the sun-loving Redcedars will begin to die off. When you find a wooded area with many weathered, gnarled Redcedar trunks on the ground and a few scattered unhealthy-looking Redcedars still standing, you can "read" the story of how a cleared field changed to a forest.

Redcedars are also indicative of limestone-derived soils. Redcedars thrive in soils rich in calcium, a component of limestone. Limestone is a sedimentary rock resulting from the collection of shells and calcium deposits of organisms living in ancient shallow seas. The breakdown of these rocks results in soils that are rich in calcium. Southwestern Virginia has many regions with limestone-rich soils, making the growth of Redcedars the typical first stage in succession of many old fields in this area. In your schoolyard, you are likely to find Redcedars growing along fencerows or in the less-maintained edges or corners of the campus.

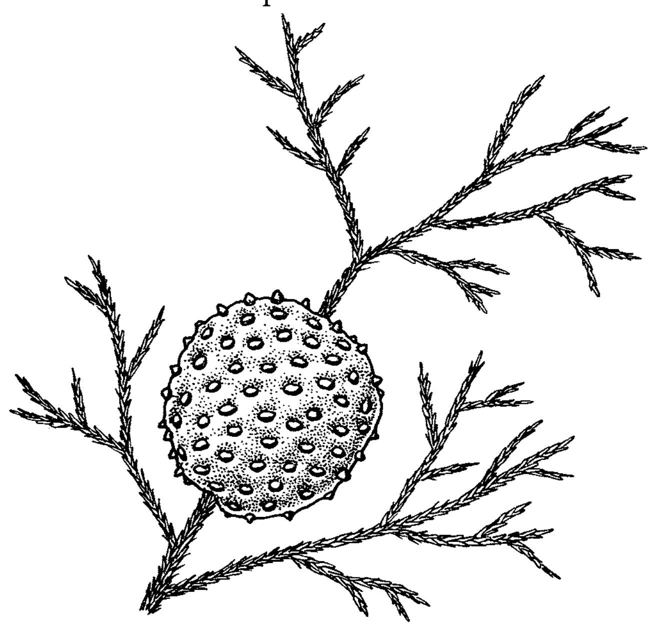
Reproduction from Cones, not Flowers

Reproduction in Redcedars occurs by transfer of pollen from small, inconspicuous male **cones** to larger female cones. The male and female cones are usually on separate trees. The result of successful pollination is fragrant, bluish, berry-like structures that enclose the seeds. *Please note:* These structures are not true "fruits"; that term refers only to the seed-bearing structures of flowering plants. Redcedars and other **conifers**, or cone-bearing plants, do not flower and so do not produce fruits to enclose the seeds. Instead, conifer seeds are contained in the mature female cone. For convenience here, the seed-bearing structures in Redcedars and other conifers (for example, in a later section on White Pines) will be referred to as **seed cones**.

Redcedars and Other Organisms

Like so many other trees, Redcedars are important to wildlife in different ways. The dense foliage and close-knit branches provide excellent cover, nesting, and roosting sites for many birds, such as Robins, Mockingbirds, and various sparrows. Though considered low-quality because of their limited fat content, Redcedar seed cones are the favorites of many birds, particularly the **Cedar Waxwing**, whose name reflects an appetite for the berry-like seed cones of Redcedar trees. (See the discussion of high- and low-quality fruits in the Introduction to this chapter.)

The seed cones are so readily eaten by birds that old fields are quickly seeded as a result of the birds' feeding activities. The seeds pass undigested through the birds' digestive systems. As the birds perch on fence wires, the birds' concentrated droppings—with the seeds—fall in a straight line along the fencerow. It is not surprising, then, to see a row of tall Redcedars dividing a field long after any evidence of the original fence has rotted away. Redcedar seed cones are also sought out by mice. Wherever mice go, they scatter their droppings; these droppings contain the undigested Redcedar seeds. The next time you look at an old field with Redcedar trees scattered throughout, consider how effective the seed-dispersal mechanism of this species has been.



Cedar Apple Rust Gall

Redcedars are an alternate host of **Cedar Apple Rust**, a fungus that produces an unusual gall. A search through Redcedar branches will often reveal the strange, mottled-looking growth caused by the fungus. After a rain, you may find numerous gelatinous threads hanging down from these galls.

Redcedar History and Uses

The first recorded observation of Eastern Redcedar was at Roanoke Island, Virginia, in 1564. The early colonists soon discovered that Redcedar lumber is avoided by virtually all wood-eating insects, making it useful for fence posts and log cabins. The wood was also valued for furniture-making, yielding pleasant red patterns when polished. Eastern Redcedar was commonly called Pencil Cedar because, at one time, virtually all pencils where made of the heartwood of this tree!

We probably know it best as the aromatic wood lining cedar chests or closets. Shavings or blocks of Redcedar wood are often placed in drawers for their pleasant smell and to discourage cloth-eating moths. Red cedar shavings are also popular as bedding in cages for small mammals.

An Appalachian remedy for respiratory illnesses involved inhaling the vapors from a steaming bowl of Redcedar seed cones, leaves, and twigs. The bark, twigs, and seed cones can be boiled to produce a khaki-colored dye.

Eastern Redcedar Inquiries

The following inquiries can be conducted if you have Eastern Redcedar trees in or near your schoolyard. You might begin an inquiry about Eastern Redcedars by considering where you find them growing. Help students learn to identify their characteristic features. Once these features are recognized you can identify Eastern Redcedars even from a great distance.

Using Redcedars to Learn About Conifers

Bring your class to an Eastern Redcedar.

What makes it different from other trees around it?

How is it similar to/different from other evergreen trees?

How is it similar to/different from non-evergreen trees?

Back away from the tree and describe or sketch its general shape.

Again compare it with trees around it. How is it shaped differently from the other trees?

Look for the berry-like cones on these trees. Describe these structures.

Squeeze one between your fingers. What do you observe? What do you smell?

What do you find inside a cone? How many seeds can you find in each seed cone?
How might the outer covering of these seeds aid their dispersal?
How does this dispersal mechanism relate to where you find Redcedars?
If you find a Redcedar that does not have these seed cones, while others nearby do, what might be the reason for this?

Signs of Succession

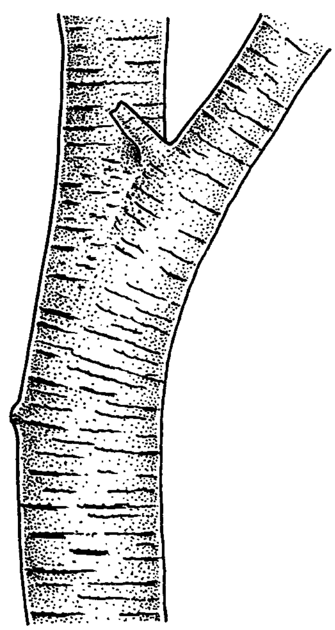
Redcedars often are the first trees to grow in abandoned fields in our area. Introduce the idea of a "pioneer species," then have your students investigate succession using Redcedars.
At school, home, and other places you go in the next week, list all the places you see Redcedars. Sketch or make notes about the places where you find them.
In what kinds of habitats did you find Redcedars?
Did you see other kinds of trees growing there?
How can Redcedars affect the physical features of a habitat (light, moisture, temperature) to make it more or less suitable for the growth of other plants and trees?
In turn, how will changes in plants affect animals?
Considering all that you have observed and learned about Redcedars, explain how these trees can make a field a better habitat for wildlife.

Black Cherry *(Prunus serotina)*

Family: Rosaceae, the Rose Family

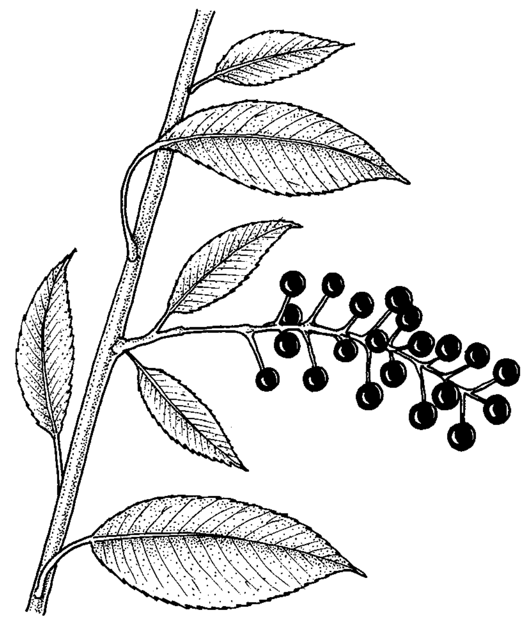
One of the most valuable and common schoolyard trees is the Black Cherry. (You or your students may know this tree by other names, such as Wild Black Cherry or simply Wild Cherry.) Black Cherry trees may grow to 25 or 30 meters (80 to 100 feet) in forested areas, with tall, unbranched trunks reaching for the sunlight of the upper canopy. In fencerows, though, rather than growing tall and straight, they will often produce a divided trunk with many spreading branches.

The bark on younger tree trunks and branches is reddish-brown to almost black and peels off like layers of old newspapers. A key identifying feature of this tree are the horizontal rows of narrow, elongated bumps on the smooth, dark bark.



Black Cherry Bark

Black Cherry leaves are elliptical to lance-shaped, tapering to a point, with a finely toothed border. Leaves are arranged alternately on the twigs rather than opposite one another. In the early spring, the tree produces numerous small (approximately 10 millimeters, or 3/8 inches, wide), 5-petaled flowers clustered on short leafless shoots. These will give way to numerous cherries, also about 10 millimeters wide. The thin layer of edible pulp, surrounding a large pit or stone (containing the seed), is juicy but slightly bitter in taste.



Black Cherry Leaves and Fruits

Black Cherries and Fencerows

Many factors are involved in explaining why Black Cherry trees appear so frequently in fencerows. The tree produces a huge number of fleshy fruits with indigestible seeds. The fruits are highly preferred by birds and mammals that spit out, regurgitate, or excrete the seeds, sometimes far from the original source. Fencerows receive many of these seeds, because fencerows offer many attractions to birds and mammals. Birds often perch on fences while singing to attract a mate, while staking out territory, or while eating within the safety of their perch. Mammals, too, often seek the cover afforded by the vegetation in fencerows. Seeds will be excreted or dropped on the ground during these visits.

Once dropped in a fencerow, Black Cherry seeds can stay viable for a long time, germinating when conditions are favorable. The fencerow is a suitable habitat for germination to occur because of the shade and moisture retention provided by tall vegetation. The annual decay of tall weeds and the collection of wind-blown leaves provides a natural mulch to foster the development of seedlings. The soil is not trampled by animal traffic along the fence, so the roots of seedlings can grow into the soil more easily. And, last but not least, the blades of lawn mowers cannot reach all the plants growing at the edge of the fence, so seedlings are not cut down during mowing.

Value to Wildlife

Black Cherry fruit has enormous value to wildlife. As many as 70 kinds of birds feed on this fruit, often to the exclusion of all other foods as long as the cherries are available. Many mammals avidly consume the fruit, too. Skunks, raccoons, and even foxes may visit trees in your schoolyard at night in search of sugar-rich cherries.

Black Cherry trees provide for wildlife in other ways, too. In winter, deer browse tender twigs, and rabbits may gnaw the bark at the base of the trees. Bees and many other kinds of insects gather large quantities of nectar and pollen from the flowers. Many kinds of herbivorous insects (some of the more conspicuous ones are discussed below) consume the leaves. Finally, birds can find suitable nesting sites in the crotches of the branches, hidden by the dense foliage.

Black Cherry History and Uses

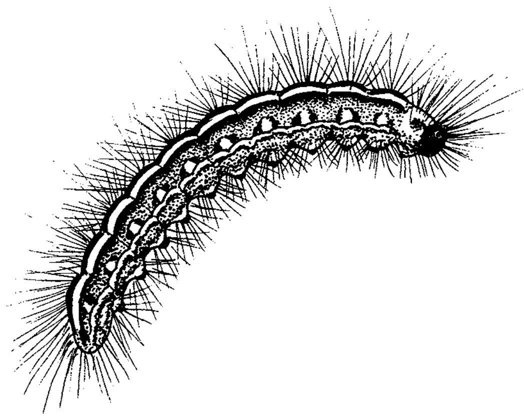
Black Cherry wood is highly desired by woodworkers. It produces reddish, fine-grained, hard lumber that can be finished to a high luster. Early in this century, large, tall Black Cherries were common and were used to build almost anything around the home. Demand for the fine wood for furniture, paneling, and cabinets soon consumed many of these trees. You will see many simple country cabinets sold at auctions and antique stores made of cherry. Today, the value of the wood, through supply and demand, has gone up so much that it is used only in fine furniture, expensive tools, and technical items.

Organisms Associated with Black Cherry Trees

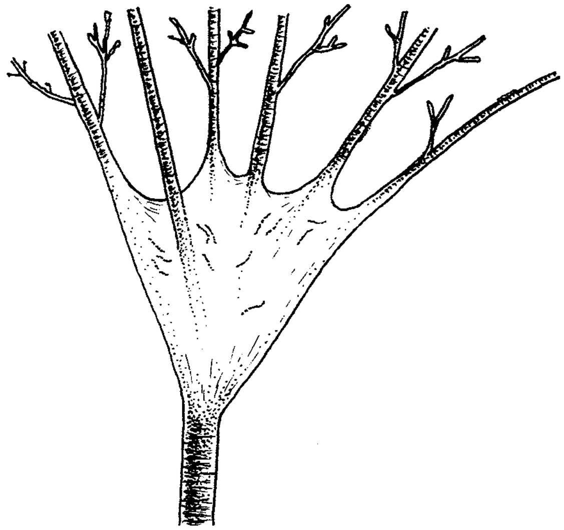
⚠ ***Do not touch any "hairy" caterpillars, such as the Eastern Tent Caterpillar.***

Early in the spring, white "tents" in the crotches between branches call attention to the **Eastern Tent Caterpillar**. The silky home, built by a colony of caterpillars, is common in Cherry and Apple trees. Caterpillars spend the night hours in the tents, then leave the refuge periodically during the day to feed on leaves. Often the caterpillars will trail a silk thread behind them as they go out on their foraging trips. The tent's most important function may be to help regulate caterpillar body temperature, by creating a **microclimate**. When the sun rises, the tent can act as a miniature greenhouse: The sun's rays pass though the silk, warming the air and caterpillars inside. On cool spring mornings, this enables the caterpillars to become active and begin feeding earlier than other leaf-eating insects. By returning to the nest during the day, the caterpillars may further increase their body temperature, increasing their rate of digestion and their efficiency at converting leaf material into body mass. Similarly, the tent may retain heat at night, keeping the caterpillar's metabolic machinery running. The caterpillars, like other insects, must molt in order to grow, and they do this at least five times. During the molt stages, the caterpillars become inactive. The tent may both provide protection from predators at this vulnerable stage and help maintain humidity, favorable to the newly molted larvae.

Caterpillars work communally to build the tents with loosely organized layers of silk. The caterpillars may enter and leave



Eastern Tent Caterpillar



Eastern Tent Caterpillar's Tent

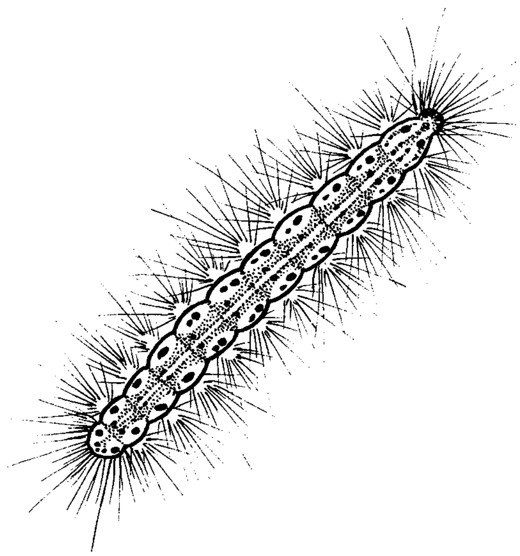
the tent through multiple openings. Layers are added as the caterpillars grow, providing new living spaces. Abandoned inner layers will contain droppings and shed exoskeletons.

When fully grown, caterpillars will leave the refuge to find a protected location to form pupae, enclosed in silk cocoons. Inconspicuous, brown adult moths (wing span about 2.5 centimeters, or 1 inch) emerge in mid-summer to mate and lay eggs. The eggs are laid on twigs in a single-layered mass of 200 to 300 eggs, enveloped in a dark-colored, hard, water-resistant coating. These eggs, which will not hatch until the following spring, are most easily discovered after the leaves have fallen from the tree.

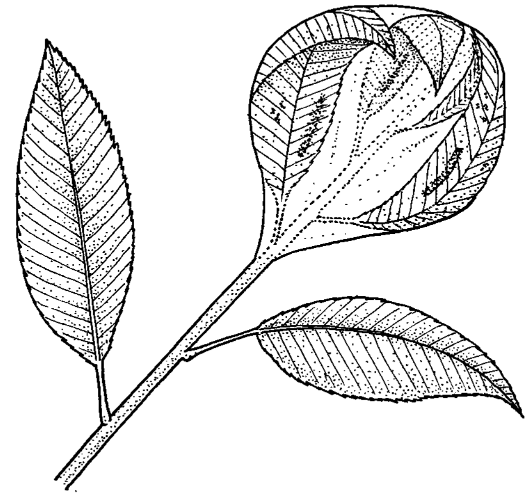
It may surprise students that the silk bought in stores is very similar to the silk produced by these caterpillars. Commercially produced silk cloth is made from fibers unraveled from the cocoons of the "**silkworm**," an Asian moth species.

After the Tent Caterpillars have finished feeding and left the tree in search of places to pupate, another caterpillar, the **Fall Webworm**, will invade the trees. Like the Tent Caterpillar, the Fall Webworm is often found in cherry trees, but it can also be found in Apple, ashes, and willows. While driving along country roads, you have probably seen tree after tree with branches and leaves enveloped by white web tents. Like those of the Tent Caterpillar, the webs or tents of the Fall Webworm are made up of a silk produced by the larva. But Webworm webs differ from those of Tent Caterpillars in several ways: Webworm webs are built on the ends of branches rather than in the crotch at the base of branches; Webworm webs are built around leaves that serve as the Webworms' food source, while Tent Caterpillar tents do not enclose their food; and Webworm webs are often much larger (they can be up to three feet long).

Fall Webworms feed almost exclusively on leaves inside their tents, while Tent Caterpillars leave the protective structure to feed. As the Fall Webworm caterpillars grow and consume all the available leaves enclosed in the web, they will work during the night to enlarge the web and include more leaves. Reaching their maximum size after 5 to 6 molts, caterpillars leave the tree to find a crevice or other suitable hiding place to pupate. The pupae overwinter, and adult moths hatch in late spring to mate and lay eggs. Fall Webworms are in the Tiger Moth Family, the same family as the stout, red and black "woolybear" caterpillars that are often observed crossing sidewalks or



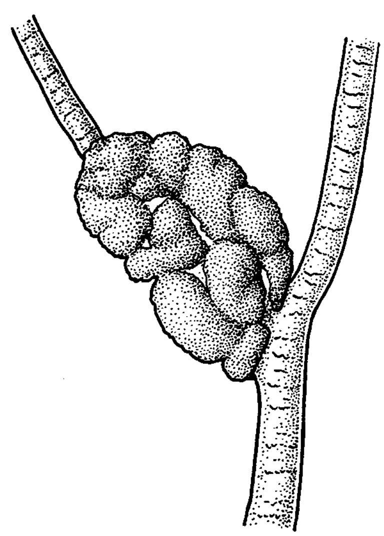
Fall Webworm



Fall Webworm on Cherry Tree

pavement in the fall. Fall Webworms can do extensive damage to trees, even though it is not unusual to find birds or wasps preying on the insects.

Another debilitating invader of Black Cherry trees is a fungus that produces a gnarly growth known as **Black Knot**. This is commonly found on Black Cherry, as well as on other trees in the *Prunus* genus, such as Peach and plums. Black Knot is most easily observed in the fall and winter after leaves have fallen, but it can be found year-round. The fungus initially causes black, swollen deformations of the bark and the layer of wood just underneath the bark. A sticky resin sometimes accompanies these growths. The fungus attacks the bark and growth layer of the tree and causes the cells of the tree to grow out of control in a manner similar to the growth of a tumor or cancer cells. The fungal cells, in the form of microscopic tubes or hyphae, penetrate and feed on the tree. The fungus can eventually spread throughout the tree, destroying its value for lumber and weakening it to the point that it can die or succumb to other diseases and pests.



Black Knot

Black Cherry Inquiries

Look around your schoolyard to see if you have Black Cherry trees. A web tent or a gnarly black growth on a twig is a good indicator of this species and is worth a closer look. Useful materials: thermometers, pruning shears.

Tree Inquiry

Depending on the season you can observe twigs, buds, flowers, fruits, or leaves. For more lines of inquiry on these structures, see the Tree Parts section of the Trees chapter.

What are the characteristics of this tree?

Pick a leaf from a Black Cherry tree. Tear it and describe its odor.

What are the features of the bark on this tree? How is its bark different from that of other trees?

What are some ways that Black Cherry trees are valuable to have on the school grounds?

What are some ways these trees are valuable to wildlife?

How is this tree important commercially?

If you have a woods nearby and can find Black Cherry in the woods and a fencerow, compare the trees growing in each place.

How does a Black Cherry tree growing in a forest differ from one growing in the fencerow?

Which do you think has more value for lumber (building material), a Black Cherry tree growing in a fencerow or one growing in forest? What makes you think so?

Insect Home 1: Tent Caterpillars

⚠ ***Observe but do not directly handle Tent Caterpillars or any other hairy caterpillars. Many hairy caterpillars use their hairs as a protection against predation, and stinging or skin irritation can result if the insects are handled.***

If you have Black Cherry trees on your school grounds or close to your school, watch for the appearance of Tent Caterpillars in the spring. Look for their white tents or webs in the crotches of branches.

How large is the tent?

What built the tent?

From what is it made? What is the nature of this material?

What other organisms make similar material?

What is the relationship between this material and the silk you buy in stores?
Can you see caterpillars inside? How many?
What else can you see inside?
Why do they build this structure? How does it help them survive? ow could you test these ideas?
How does the nest change in size over time? How could you measure these changes?
How many layers does it have? What can you find inside these layers?
When do you find caterpillars inside the tent? Do they stay in the tent all day? When do they leave? Why do they leave? What do they do?
What are the features of the caterpillars themselves?
Take the temperature inside and outside the tent. How do they compare at different times of day? How do they compare on sunny vs. cloudy days?
How might the tent help the caterpillars regulate their temperature?
Tents that you find in the fall will be abandoned. You can take apart one of these tents and examine it for clues to the life history of these organisms.
Your students might find other organisms, such as spiders, in or around tents of Tent Caterpillars or Fall Webworms. Warn students to be careful when investigating tents.
What do you find in the tents?
What clues about the life of these organisms have been left behind?
What "story" do these clues tell?

Insect Home 2: Fall Webworm

When you return to school in September, the Tent Caterpillars will have completed feeding but in their place you may find the tents or webs of the Fall Webworm. Look for webs that enclose the ends of branches including the leaves. You may also see evidence of predation. Watch for birds and wasps that attack webs in search of the caterpillars.
Do you see any animals that are trying to eat the Fall Webworms?

Black Cherry Inquiries, continued

How do the predators catch the caterpillars? How do they enter the web? How often do they return? How do the caterpillars respond?

Later in the fall, the caterpillars will leave the web. Where do they go? Can you find any evidence? Can you find any pupae/cocoons?

Use pruning shears to cut down the branches holding a web after the caterpillars have left it late in the fall. Study it and gently tease it apart to learn more about how it was constructed.

What evidence or remains of organisms can you find in the web?

What can you infer about these organisms from studying the web?

What impact do these organisms have on the tree?

How could we estimate the number of leaves that are eaten compared to the total number on the tree?

Black Locust *(Robinia pseudoacacia)*

Family: Leguminosae or Fabaceae, the Bean Family

Be careful of thorns on the twigs of this tree, and on the Honey Locust (discussed below).

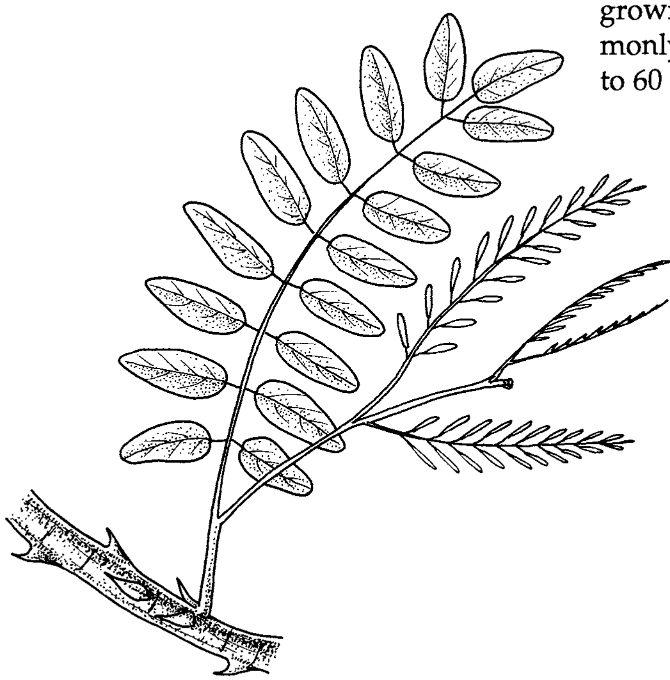
You are likely to find Black Locusts growing almost weed-like in parts of your schoolyard. This tree reproduces rapidly, not only by producing seeds but also by sprouts that arise from the roots. A stand of locust trees in a corner of a schoolyard may actually be clones of a single tree, each tree being genetically identical, if not actually physically linked through their roots.

Locust Structures and Growth

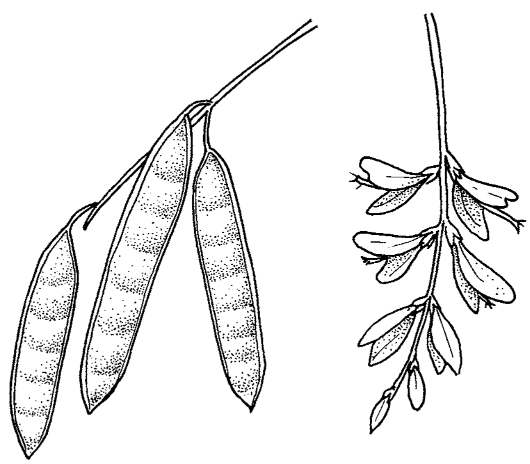
Several key features can help you confirm the identity of this tree. Black Locust has compound leaves with 7 to 20 small, oval leaflets arranged in pairs along a long axis; the axis is an extension of the **petiole,** the structure that attaches the entire leaf to the tree. Remember that, in a compound leaf, an individual leaf is made of numerous leaflets; do not mistake the smooth-edged leaflets, 2.5 to 4.5 centimeters (1 to 1.75 inches) long, for individual leaves. If you trace the axis of the leaf back to the twig from which it arises, you will find the base of the petiole flanked by *a pair of threatening thorns*—another distinguishing feature of the Black Locust. The stout thorns are present year-round and are most conspicuous on younger trees. Also, the petiole is thickened at the base and breaks cleanly from the twig; individual leaflets, however, lack these features.

Fragrant, white flowers, 2 to 3 centimeters (about 1 inch) long, hang in long (20 centimeters, or 8 inches) clusters from the branches in the spring. These flower clusters attract many pollinators, particularly bees. The fruit produced by the Black Locust is a dark brown pod, 10 to 15 centimeters (4 to 6 inches) long, containing 4 to 10 kidney-shaped seeds.

Black Locusts are considered to be fast-growing but short-lived trees. They commonly attain heights of 12 to 24 meters (40 to 60 feet). The bark of younger trees and



Black Locust Branch



Black Locust Seed Pods and Flowers

branches is gray to brown, spotted with tiny, white bumps. Older branches and stems have deeply furrowed bark forming long, vertical, inter-connecting ridges.

Locust History and Uses

Black Locusts are in the Bean (or Legume) Family, which also includes peas, beans, and clovers. Members of this group all have nitrogen-fixing bacteria associated with their roots; these bacteria are able to fix gaseous nitrogen in the air into a form usable by plants. (See also the discussion of nitrogen fixation in the Clover section of the Lawn chapter.) Because of this ability, the tree's fast growth, and the capacity to spread rapidly by root sprouts, Black Locusts are often planted as part of land-reclamation strategies for strip-mined soils. Many birds and mammals feed on Black Locust seeds, including game animals such as rabbits and deer.

Black Locust wood has several properties that make it useful for a variety of different functions. The wood is very durable, even when in direct contact with the ground. Young Black Locusts—about 10 to 13 centimeters (4 to 5 inches) in diameter—are frequently cut for fence posts, because they are hard, strong, and long-lasting. The wood of most other trees, when in contact with the soil, quickly becomes invaded by fungi and wood-eating organisms. Some Native Americans living on the coastal plain of Virginia had Black Locust trees growing around their homes. These trees, far out of their natural range, were believed to have been planted by Native Americans who wanted to have easy access to the wood for making bows and constructing homes. The strength and elasticity of Black Locust made it ideal for carving bows. Historians suggest that the Native Americans showed the colonists how to use Blacks Locust logs as corner posts for their homes, a suitable use because of the durability of the wood even when in the ground.

Black Locust wood is not bad for burning in a fireplace or wood stove, either. It burns hot and produces little smoke. For this reason, it reputedly was a favorite with moonshiners, who needed a hot fire to boil the mash in their stills, but wanted little telltale smoke to reveal their location and intentions.

The tree was named Black Locust by Jamestown settlers, because it looked similar to the Carob tree or Old World Locust. Later, another valued property of the wood was discovered, adding to the historical significance of this tree: Black Locust wood neither shrinks nor swells appreciably when wet or dry. Furthermore, it becomes harder when exposed to air! These features made it ideal for use in wagons (such as those used by settlers traveling to the West), and in ship building.

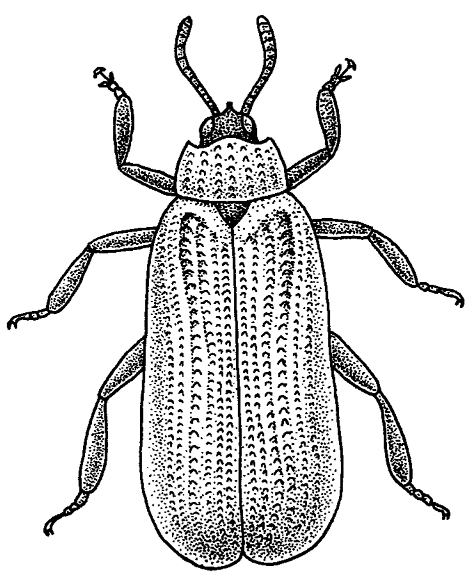
Black Locust is closely related to the **Honey Locust**, which has *thorns even longer than the Black Locust*. The Honey Locust was sometimes called the Confederate Pin Tree, because its thorns were used to pin together the uniforms of Confederate soldiers.

This book has often discussed how plants, birds, and mammals were introduced from Europe, how they have proliferated here, and how they have impacted local species. While one of the authors was traveling in Switzerland one summer, his Swiss guide pointed out the cursed "Robinia" (the common name for Black Locust in Southern Switzerland), named after the naturalist Vespasian Robin, who first cultivated these trees in Europe in the mid 1600s. (Note, also, that this is the origin of the scientific name, *Robinia*.) The Swiss guide said they grew like weeds everywhere, particularly along roadsides, choked out all other plants, and were impossible to eliminate (due to root sprouts). So here we have an example of a native North American plant impacting the local ecology of a country in Europe. Two sides to every coin!

Organisms Associated with Black Locust

Two kinds of beetles are commonly found on Black Locust trees. One species is not so easily seen in the tree because it bores deep into the wood, while the other can hardly be overlooked in late spring and early summer because of its numbers and leaf-feeding habit. The first beetle, the **Locust Borer Beetle**, is sometimes seen in its adult form, feeding and mating on Goldenrod blossoms. (This insect is also discussed in the section on Goldenrod, earlier in this chapter.) In September and October, after mating, the adults lay eggs in crevices in the bark of Black Locust trees. The eggs hatch and the larvae immediately bore into the bark, where they will remain until temperatures increase in the spring. As they become active, they bore into the sapwood and heartwood of the tree. A keen observer may find wet marks on the bark or sap oozing from the spot where larvae have bored into the wood in the spring. The larvae pupate within the wood and emerge as adults in late August and early September. These beetles most often attack younger trees, causing damage to the tree internally as they excavate tunnels or galleries through the wood.

The other beetle commonly associated with Black Locust trees is the **Locust Leaf Miner**. This insect causes damage much more visible than that caused by the Locust Borer Beetle. If you examine the leaves of Black Locusts in the spring, you are virtually guaranteed to find these beetles on the leaves, often in large numbers. Adult beetles are 6 millimeters (about 1/4 inch) long, and are a dull orange with a black stripe down their backs. Adults overwinter wherever they can find protection from the cold, often in the leaf litter at the base of the tree. The adults feed on the underside of the leaves, causing what is called "skeletonization" of the leaves. The beetles feed on the softer cells of the leaves, leaving the harder cells of the leaf veins intact; a "skeleton" of the leaf remains.



Locust Leaf Miner Beetle

Locust Leaf Miners mate in early June, and they can often be observed in pairs, in "piggy-back" fashion, on the leaves. Flat, oval eggs are laid on the undersides of leaves. After the eggs hatch, the larvae begin to chew their way into the interior of the leaf. The larvae seem to prefer the outer half of the leaflet. The damage from their feeding activities will appear as irregular yellow and opaque blotches on the leaf; careful observations can reveal the flattened, yellowish larvae within the leaf. The insects continue to feed in between the top and bottom layers of the leaf until the larvae pupate. Pupation occurs inside the leaf. Adults emerging the pupae will also feed on the leaves, causing more skeletonization.

By late summer, Black Locust trees can appear severely damaged. Early in the fall, the brown tops of Black Locusts make them easy to pick out against a background of other trees. While the trees look nothing short of terrible then, each spring the trees seem to rebound from the effects both of Locust Borer Beetles and of Locust Leaf Miners.

You can observe Locust Leaf Miner Beetles closely by locating a stand of Black Locust trees on or near your schoolyard and quietly approaching the branches. Without touching the branches or leaves, look carefully for the black and orange beetles on the leaves. Gently lift a leaf to look underneath it—but be prepared for the beetles' defensive strategy! When disturbed, they will quickly fall off the leaf and disappear into the grass or litter below when disturbed. If you are interested in collecting these beetles, place a tray underneath a branch and tap the branch with a stick; the insects will fall into the tray.

Do not forget, as you look for the insects mentioned here, that these are not the *only* insects that feed on or mine Black Locust leaves or bore into the wood. These are only two of the more common or conspicuous ones in southwest Virginia; you are likely to find many others. Furthermore, you may even discover other insects that are predators or **parasites** on the tree-eating insects. For example, several types of parasitic wasps will lay their eggs inside the Locust Leaf Miner while it is still in the leaf (after these eggs hatch, the wasp larvae feed on the beetle).

Black Locust Inquiries

⚠ ***Be careful of thorns on locust trees.***

If you have Black Locust trees on or close by your school grounds, you will be able to pursue the following lines of inquiry. The Trees chapter of this book has other inquiries you can pursue with Black Locusts.

Locust Structures: Leaves and Thorns

Have your students examine a leaf that you, not they, *collect from a Black Locust tree.*

Describe the structure of this leaf.

Black Locust trees have leaves that are actually made up of 7 to 20 leaflets. If you did not know this, how could you distinguish between a leaflet and a whole leaf? *(Use a twig, if this could help the explanation.)*

Now have the students observe (but not touch) leaves on the tree.

Trace a leaf back to the branch.

What do you find at the base of the leaf? Describe these structures.

How might this adaptation help the plant survive?

Investigating the Value of a Wood: Locust Decay Resistance

An interesting long-term study would be to place a locust log on the ground in a relatively undisturbed section of your schoolyard, along with similar-sized logs of other trees. Have your classes examine these logs once a year and record their observations for the next year's class.

Which log shows the most evidence of decay? The least?
What evidence of decay can you point out in the different logs?
How have the logs changed from previous years?

Locust Leaf Miners 1: Impacts on Leaves

Have your students examine Black Locust leaves that have been eaten by insects.
How have these leaves been damaged?
Do the leaves show different kinds of damage?
Which part of the leaf shows the most damage?
Count the number of leaflets that show evidence of damage and the number of leaflets that show no evidence of damage. What fraction or percentage of leaves has been damaged?
How many of the leaves show damage in the outer half of the leaflet? How many in the inner half?
How can you explain your observations?
Can you locate a Leaf Miner larva inside the leaf? Describe or sketch the larva's features.

Locust Leaf Miners 2: Beetle Behavior

Carefully examine Black Locust leaves. Can you find adult beetles on the leaves?
Without touching the branches or disturbing the beetles, observe their activity for a few minutes. What do these beetles "do"?
Can you observe any beetles feeding? Can you determine what the beetles are eating? Can you find any evidence of their feeding activities?
What happens if you disturb one of these beetles? Try touching the leaf that one of these beetles is on *(be careful of thorns!)*. How does the beetle respond?
How can you explain this behavior?
What other organisms can you think of that have a similar defensive mechanism?
Knowing this bit of Locust Leaf Miner behavior, design a trap that you could use to collect live Locust Leaf Miners.

Discovering Insects

Remember that many insects can bite, sting, or give off irritating substances. A good general rule is to look instead of touching or grabbing.

As well-prepared as a guide book can be to alert you to particular plants and animals that you can find in your schoolyard, some of the most fascinating discoveries will be those that you and your students make. If you are interested in learning more about insects, you can easily go outside your classroom and make discoveries that would go beyond the scope of this book. There are simply too many kinds of insects to describe all the different ones that you might find.

How can you find these insects? Where do you look? A systematic survey of the grounds is very likely to reveal all sorts of insects and evidence that they have been at work. Try the following—our suggestions for the "Top 10 Ways to Find Insects." Once you've had some practice, you and your students can create your own "Top 10" list of ways and places to look!

1. Change your focus as you go outside. Look for small things, for things that are moving quickly, and for things that are not moving.
2. Look under logs, rocks, and pieces of bark.
3. Brush your hand or foot across mowed grass, watch for movement, then carefully watch where the escaping insect lands.
4. Look on the sides of school buildings or under eaves, especially around lights.
5. Look at flowers in bloom, particularly on calm, sunny days. Look for pollinators flying from flower to flower, as well as for insects that might be living in or on the flowers. Look inside flowers that have turned to seed.
6. Look carefully at the leaves of trees, shrubs, and **herbaceous** (non-woody) plants. Look on top of the leaves, underneath the leaves, on the twigs or stem, or in crevices in the bark.
7. Look for damaged leaves as evidence of insects: leaves that have been eaten; leaves with holes in the middle, edges missing, or skeletonization; leaves that have been folded, rolled up, or stuck together; or evidence of leaf-mining larvae inside leaves.
8. Look for eggs, egg cases, cast skins, or cocoons as evidence of insects.
9. On trees, look for holes or sawdust as evidence of borers. Underneath bark, you may find intricate patterns carved in the surface of the underlying wood by bark beetles.
10. Dig into soil, look at plant roots, and look in decaying leaves or rotting wood.

When observing insects, try to determine what they eat as well as how they eat. Insects have many specialized feeding habits. For example, mosquitoes seek a blood meal, while mud dauber wasps feed only on spiders (mud dauber wasps are discussed in the Schoolyard Wasps section of the Roofs, Walls, and Eaves chapter). Some insects, like dung beetles, feed on manure, while many others eat plants. Keep in mind that some insects may feed on many different types of plants while others feed only on one type. For example, Japanese Beetles may be found on several different plants around your school, while the Pine Tube Moth is only found on White Pines (the Pine Tube Moth is discussed in the White Pine section of the Trees chapter). Carefully examine different types of plants to locate different insects.

Don't feel that you have to know the name of the insects you find or all about the insect's life history in order to introduce it to your class! There is a great deal you can learn along with your students about a particular insect by watching its behavior, noting the features of its habitat, and perhaps watching it feed or interact with insects of its own kind or other kinds. You can find out more about insects you observe by recording field observations, bringing the insect into the classroom for closer observations, or referring to books.

Some of the insects you find in a certain location or on a particular plant may remain at that place only momentarily. Others can be found at that place for days or weeks. A praying mantis for example, will continue to move from plant to plant in search of prey, while Monarch Butterfly caterpillars will remain on milkweed plants. You may find large numbers of insects on a particular plant. For example, in early summer you many find hordes of aphids on the stems of rose bushes. But you may find only one individual caterpillar or beetle on a different plant!

Take time to *watch* the insects you find in a natural setting. Provide some structured opportunities for students to do this. Provide them with charts and prompts to make some careful observations, then have them discuss their observations within small groups as well as with the whole class. Encourage your students to speculate on their findings and invite alternative explanations or hypotheses for observed phenomena. Discuss and pursue ways to find out more definitive information about these fascinating creatures.

Finding Insects by Habitat

Many sections of this book discuss various insects and their habitats. The following table identifies a few other places to look for certain insects.

Plant/Habitat	Insect	Comments
Junipers, Yews	Scale Insects	Look for small waxy or scale-like flecks on leaves and twigs; examine with a hand lens.
A variety of trees, including White Pine*	Bagworm Moths	Look for hanging "bags" along underside of branches; you may see a fascinating life cycle!
Deciduous leaves	Miscellaneous leaf miners, leaf rollers, leaf folders, and leaf eaters	Look at and characterize the damage; do some detective work. Can you find the culprit?
Stems of many plants in tall, weedy areas	Aphids**	Look for tiny insects of various sizes, shapes, and colors.
Milkweed	Monarch Butterfly (all stages); Milkweed Bug	Look for black and orange patterns on the insects.
Boxwood	Boxwood Leaf Miner	Open blisters in leaves to find yellow-orange larvae between leaf layers.

* See the White Pine section in the Trees chapter.
** See also the information on aphids in the White Pine section of the Trees chapter.

Discovering Insects Inquiries

Refer to the previous sections for general instructions on finding and observing insects. See also the next section of this chapter for some suggested ways and materials for collecting insects. Other useful materials: insect-viewing boxes (or plastic containers and hand lenses), plastic zip-lock bags, general diagram of insect parts (an insect diagram is included in the "insect" entry of the Glossary).

Insects and Habitat

Have your students record the numbers of insects found in different places in the schoolyard. A chart will help them organize the information.

Where in your schoolyard did you find the most kinds of insects?

Did you also find the greatest number of *individuals* there?

What are the features of the habitat where you found the most insects?

How do the surrounding habitats differ?

What does this tell you about insects?

Evidence of Plant-eating Insects

What leaf damage can you find that suggests the presence of insects?

Why do you think that the damage you observed might have been caused by insects?

What else might have caused the observed damage?

Does the damage to the leaves follow a pattern? (There may by holes in the leaves, edges missing, only tips of leaves affected, or many other possibilities.)

Does there seem to be only one type of damage?

Can you find the culprit(s)? If you can not find the culprit, can you explain why not? What are some possible explanations?

Insect Survival Strategies

What are some of the ways that insects you have observed protect themselves from predators?

Describe the color patterns of some insects that you find. Do the insects have colors that help them blend into the background or are the insects brightly colored?

How might drab colors help certain insects survive? How might bright colors help other insects survive?

What behavior patterns might help insects survive?
Describe and record how some insects respond when you disturb them. ***(Do not try this with wasps or bees!)***

Insects Structures

Have students study an insect closely, using an insect-viewing box or a hand lens.
What features of the insect can you see using magnification that you cannot see with your naked eye?
How is the structure of an insect's body different from yours? How is it similar?
What special features does it have? How might these features or adaptations aid the insect in survival?
What structures can you observe that are probably used by the insect to "sense" its environment?
What "senses" do you have? Does the insect have similar senses? What evidence do you have to support your answer?
How many different body parts can you identify? Describe each part.
What special structures does the insect have to help it move in its environment? Describe the structure and explain how it might be used.
Are all the *appendages* (the structures sticking out from the body, for example, the legs) the same size, shape, or structure? How do they differ? How does their structure relate to what they might be used for?
Do insects breathe? What evidence can you observe that suggests insects do breathe?
What mouth parts can you see on the insect you are observing? Describe these structures. What is their function? How are they used? How do they relate to what you know about this organism's feeding habits?

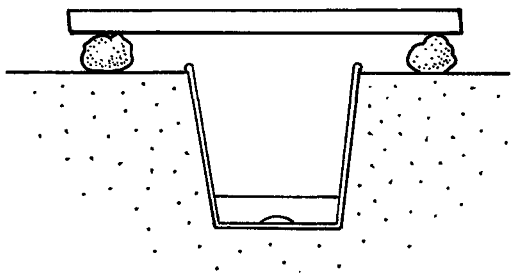
Insects and Humans

How do the insects you have observed interact with humans (directly and indirectly)?
How do insects damage desirable plants?
How are insects often "controlled"?
How do these control measures affect other insects or the environment?
What are some other ways you might control insects?

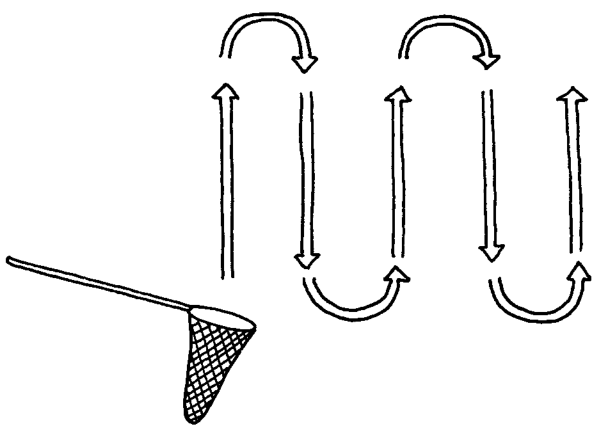
Collecting Insects

Here are some different ways you can collect insects around your schoolyard. The more ways you use, the more kinds of insects you will find!

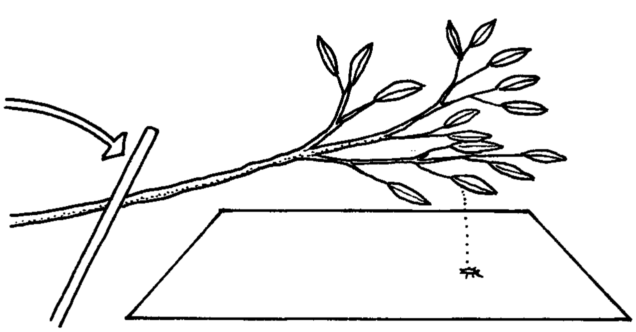
Pit Fall Traps. Use a yogurt cup or a container of similar size, bury the cup so that the rim is even with the surface, and pour about 2 centimeters of a liquid detergent into the bottom of the cup. Cover with a board propped up on stones. *Please note! This technique will result in dead insects.*



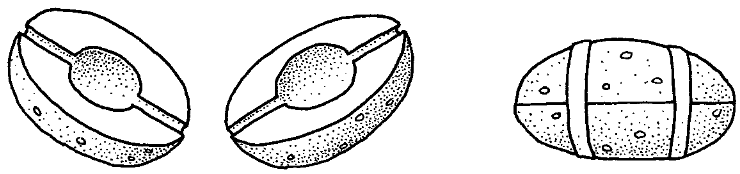
Sweep Nets. See 'em and chase 'em down!
Sweep the net repeatedly, back and forth across tall grass or a meadow.



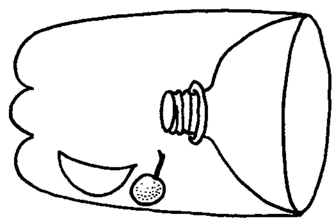
Beating Tray. Hold a piece of white poster board under a branch or bush and shake or tap the vegetation with a stick. Collect insects that fall onto the paper.



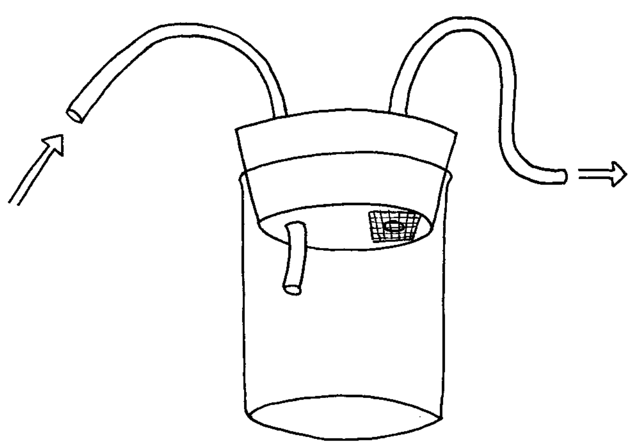
Potato Trap. Cut a potato in half and hollow out the inside with a spoon. Create an opening at each end. Put it back together and fasten with rubber bands. Check periodically for insects that have entered through the openings to feed on the potato.



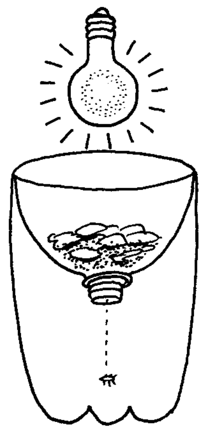
Bottle Trap. Cut the top off a 2-liter soda bottle and place it back in the bottle in an inverted position. Bait this trap with different foods to capture different kinds of insects.



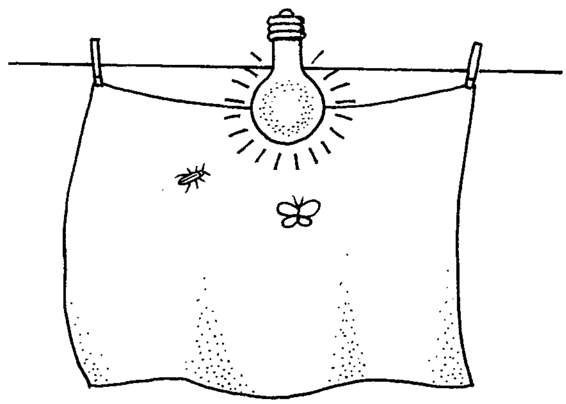
Aspirator. There are many possible variations of this theme. Basically you need a jar with a tight-fitting cork lid and two plastic or rubber tubes protruding from the lid. This works best if you use a short piece of metal tubing (such as plumbing tubing) to go through the cork, then attach the plastic tubing to the metal. Cover the jar-end opening of one tube with a small screen. Put the end of this tube in your mouth and use it to "vacuum-up" small insects from leaves or other places.



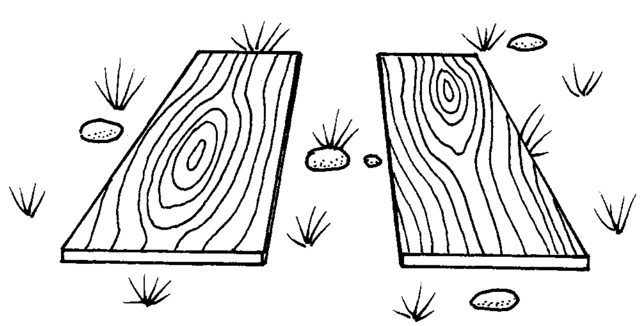
Berlese Funnel. Cut the top off of a 2- or preferably 3-liter soda bottle to create a funnel. Set the funnel in the bottom of the soda bottle. Collect moist leaf litter, soil, or mulch and place it in the funnel. Place a lamp over the funnel. Organisms will migrate away from the drying effect of the light and fall into the jar. As this apparatus will be inside, be prepared for some insects possibly to escape into the classroom.



Light Trap. Suspend a white sheet vertically outdoors and shine a strong light on its surface at night. Be ready to try to capture insects that either fly around or land on the sheet. An insect net will help here!



Board Attractors. Lay some old boards out in various locations. Let them sit undisturbed for a couple of weeks and then look for organisms underneath them.



Chapter 5. Roofs, Walls, and Eaves

Introduction

Certainly the most prominent feature of the schoolyard is the school building itself. In combination with paved areas, the building affects temperature, runoff, and microclimates in the schoolyard, creating new habitat conditions. (See also the discussion of these topics in the Parking Lot chapter.) In addition, the building itself provides other habitats. The effect of a particular building depends on several factors, including the building's materials, structure, and compass orientation.

Raw Materials in the School Building

Many school buildings are built from cinder block or brick and cement, and they typically have flat, gravel roofs. Glass windows, of course, often make up much of the wall surface. The block and brick surfaces provide tiny cracks and crevices in which small plants can take hold and small animals can take refuge. From the perspective of many animals, the walls, except for the smooth glass surfaces, are rough and easily climbed. Windows provide additional nooks, corners, and ledges—potential retreats for animals.The building materials also affect the temperatures that plants and animals experience. The walls of the building that are exposed to the sun can act as "heat sinks," absorbing heat during the day and radiating it out at night. How much heat is absorbed depends upon the orientation to the sun, the color of the surface, and the physical properties of the material. Different materials have different rates of absorbing and radiating heat.

Structure and Orientation

The structure of the building can modify the local climate of the schoolyard, depending on the orientation of the building to the sun and prevailing winds. Virginia's geographic location dictates that prevailing winds come from the west (winds and weather patterns generally move west to east across the United States). The west-facing sides of the building act as a windbreak, protecting the eastern part of the schoolyard from the brunt of storms and winds. Differences also occur between the north- and south-facing walls, because of their orientation to the sun. North-facing walls and lawns receive less direct sunlight than southern exposures, and more of the north side of the schoolyard is shaded. This difference will be especially noticeable in winter and spring.

These differences in exposure to wind and sun will influence the plants growing around the building, most dramatically in early spring. Grass will become green and flowers will appear on the southern side of the building first. It is not unusual to find plants against the southern wall remaining green throughout the winter, and you may even find Dandelion blossoms appearing in February! But on the north side, growth and development of similar plants will be delayed. On the other hand, different plants may prefer the north side, because the shade of the building decreases evaporation and the ground and walls are more often moist. On the north side, you are more likely to find moss growing on the ground and perhaps on the sides of the building. A green tinge to soil and building surfaces may indicate the presence of **algae** (single-celled plants, often visible in multi-cellular colonies). Other plants that prefer moist soils also may be found growing here.

Activity at the Building's Edge

The edge of the building, between the walls and the ground, is a special habitat. To a large extent, what lives here depends on whether or not an overhang is present. If the building has a wide overhang, rainfall may rarely fall directly on the ground near the building. This habitat may then be too dry for most plants. A few plants that can tolerate the dryness may gain a foothold here. Plants may creep in from the edge of the lawn, their roots trailing back away from the building to capture water. If there is no overhang, however, the lawn may grow right up to the edge of the building. Depending on moisture and the presence of litter (both natural and human), you may also find at the base of the wall certain small animals (centipedes, millipedes, some insects, and others) that prefer damp places.

Maintenance crews will sometimes spray herbicides on the building edge so that regular grass trimming is not required. This opens the door for pioneer plants to invade this zone after the effect of chemicals has dissipated. Depending on when the last spraying occurred, the plant community in this zone may differ markedly from other parts of the lawn. Certain plants thrive here because of either the lack of competition with other plants or their ability to grow in relatively dry soil.

Other Habitats a Building Provides

The eaves, overhangs, doorways, and covered walkways of the building also provide habitats. Here, protection can be found from wind, sun, and all forms of precipitation. Spiders, wasps, and birds take advantage of the shelter afforded by these habitats. Doorway and walkway lights that are left on all night add another dimension to the habitat. At night, many flying insects are attracted to these lights, providing spiders and even bats with a plentiful food source. Shelter, web-attachment sites, and lights to attract prey make these areas ideal locations for spiders. Similarly, various wasps take advantage both of the shelter and of structures for attachment of their nests. Furthermore, some species of these wasps feed exclusively on spiders! In addition, in the early morning you may still find moths resting on the walls near the lights.

Vents, light fixtures, and poorly attached molding all may provide openings for larger animals, such as birds, to gain a foothold. Twigs or scraps of weeds or string hanging out of a broken light fixture reveal the presence of a nesting bird. Droppings on the wall or collecting on the sidewalk below are conspicuous clues to the location of hidden nest sites. Robins, for example, (see the section on Robins in the Lawn chapter) are quite tolerant of humans, and they will nest in trees in protected areas created by the building, in shrubs, or on human-made ledges.

The school building offers a close, often protected vantage point for observing the lives of schoolyard organisms. Finding those organisms, and learning about how they use the building and adjacent areas for habitats, can open your students' eyes to the adaptability and ingenuity of nature.

Introductory Roofs, Walls, and Eaves Inquiries

These lines of inquiry introduce students to the presence of habitats on the school building and to the effects of the building on habitats adjacent to it. Useful materials: hand lenses, thermometers, compasses, rulers or meter sticks, plastic cups, graduated cylinders or other water-measuring devices, a map of the building's exterior.

Investigating the Structure of the School Building

Make a chart listing the materials, description, and estimated percent of each material that makes up your building.

Do these materials indicate that the building designers took advantage of local resources? How?

Introductory Roofs, Walls, and Eaves Inquiries, continued

Try investigating and tracing the "natural history" of common school building materials (such as brick, stone, wood).
Place your hand against the wall of the building. Does the wall feel warm or cold? Does the wall feel warmer or colder than the surroundings? How can you explain your observations?
Run your fingers across the surface of the building. Describe its texture.
Examine the texture of the surface with a hand lens. If you were a tiny organism, how would the surface appear to you?
What habitats can you identify on and around the building? What are their physical features? Predict what organisms you think could take advantage of these habitats.

Investigating the Building's Effect on Temperature

Have your students use compasses to determine the north, south, east, and west sides of your building, and mark this on maps of the building exterior. Ask them to make predictions about the expected temperatures around the building, then go out with thermometers and collect actual data. Try taking temperature readings at varying distances from the base of the building, as well as on different sides of the building, at the same time of the day.
What is the temperature at different locations around the building? Make graphs of your data.
Study how the temperature changes on one side of the building during the course of the day. Repeat for different sides of the building and compare your results.
How can you explain the patterns you observe?
How will these patterns affect other physical features?
How will these patterns affect the distribution, activities, and growth of living things?
On a windy winter day, on which side of the building would *you* rather stand? Why?
How would the side of the building you choose be different from the other sides?
Can you find any evidence that other organisms have made the same choice as you?

Investigating the Building's Effect on Snowmelt

You can take advantage of a snowfall by pursuing the following inquiry. You can also do a variation of this inquiry with heavy frost.

Where does the snow first melt?

Where does snow last the longest?

Where is snow deepest?

Make a daily chart showing the changes you observe in the snow cover at various locations around your building.

How can you explain your observations?

Investigating the Building's Effect on Humidity and Moisture

Have your students measure rates of evaporation around your building. Place cups with measured amounts of water in them around your building or arrange them in a line, at one-meter intervals, moving away from the building. Measure and record the change in the amount of water in each cup after 24 hours. (For more details on a similar activity, see Sample Lesson #5: Trees, Temperature, and Evaporation in the Sample Lessons chapter.)

What observations and inferences can you make based on this experiment?

How does this information help explain the distribution of plants and animals around your building?

Can you find moss or algae growing around your building? Where is it found? Why?

Investigating the Building's Effect on Plants

Examine the ground/soil at the edges of the building. Is it the same all around the building? If not, how does it differ?

How do things change as you move away from the side of the building?

Is the ground dry or moist near the building? Does if differ on one side of the building or another?

If the building has overhangs, how do the overhangs affect the ground underneath them? Is the ground dry/moist/shaded?

Are the plants *at the edge* of the building the same as those farther away? Are there plants growing at the edge that you do not see elsewhere?

Do you notice any differences in the plant community *at one side* of the building versus another side?

Introductory Roofs, Walls, and Eaves Inquiries, continued

How could you quantify the differences you have observed?
In early spring, add these questions:
Where around your building is grass greenest?
Where does it grow fastest?
Where do flowers first appear in the spring?
How can you explain these observations?

Finding Animals on the School Building

Have your students search the school building (not the grounds) for animals.
What animals can you find on or beside the building?
Where did you find these animals?
What are the features of these animals?
What were they doing? What behaviors did you observe? What do you think were the functions of these behaviors?

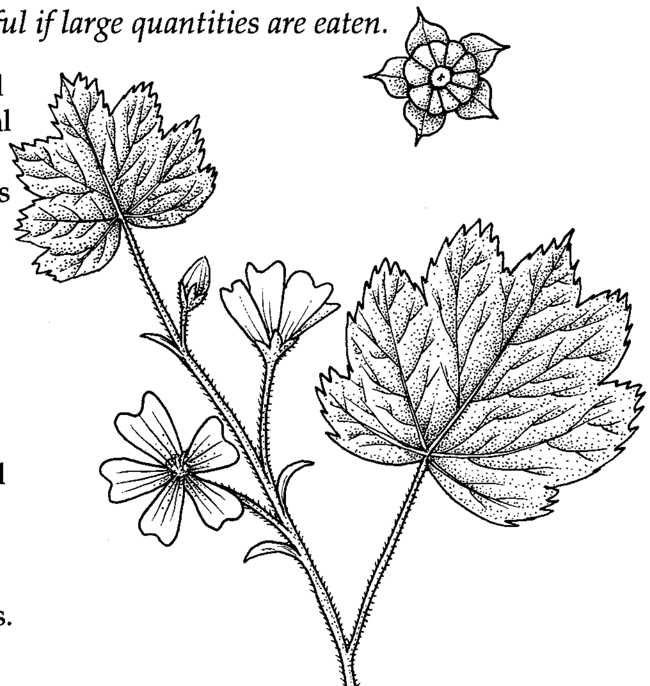
Investigating Shadows

Have students go outside in the morning, walk around the building, examine the location of shadows.
Map the location of these shadows, and record the temperatures in the shade and in the sun.
Go out in the afternoon and again map the locations of the shadows and record the temperatures in the shade and in the sun.
How does your morning information compare with the afternoon information?
Measure the length of one of the shadows at the same time of the day each week during the course of the year.
How does it change?
How does the shade created by your school building affect plants and animals?

Common Mallow, or Cheeses *(Malva neglecta)*

Family: Malvaceae, the Mallow Family

This plant may be harmful if large quantities are eaten.



A search along the edges of your school building or around shrubs is likely to reveal Common Mallow, a somewhat curious plant. Able to thrive in poor conditions, it is often found near or under the eaves of the building in bare soil. Common Mallow is seldom found in the lawn, however. This may indicate that the plant does not compete effectively with surrounding plants, including grasses, in the struggle for light, water, nutrients, and space.

Common Mallow

The name and identity of this plant will be easy to remember after you have examined its unusual fruit. Peeling back the plant's green sepals reveals a round and slightly flattened fruit with many segments. The fruit resembles a wheel of cheese; hence, one of the plant's common names is Cheeses! Each fruit segment contains a seed (see the drawing below). Common Mallow produces attractive, white or lavender, five-petaled flowers from April through October. Round, scallop-edged leaves arise from a creeping stem.

Mallow History and Uses

This plant is in the Mallow Family, which includes economically important plants such as Cotton, as well as decorative plants such as Rose-of-Sharon. The roots of a related species called **Marsh Mallow**, which grows in wet places, provides a gummy substance that in the past was vigorously whipped with sugar to produce marshmallows! Today, store-bought marshmallows are made from sugar and gelatin. Some references indicate that Common Mallow has excellent flavor as a cooked green or potherb, but these same sources also recommend (in the same breath) that *large amounts of it not be eaten.* Some related species, when consumed in large quantities, have caused poisoning in livestock.

Common Mallow Inquiries

Look for Common Mallow growing around the foundation of your school building.

Finding a Plant Growing in Relatively Poor Conditions

Where do you find this plant growing?
Is it ever found in the lawn?
Describe the features of the habitat in which this plant is most frequently found.
What are some reasons that might explain why this plant is not usually found in the mowed lawn?

Seed Production

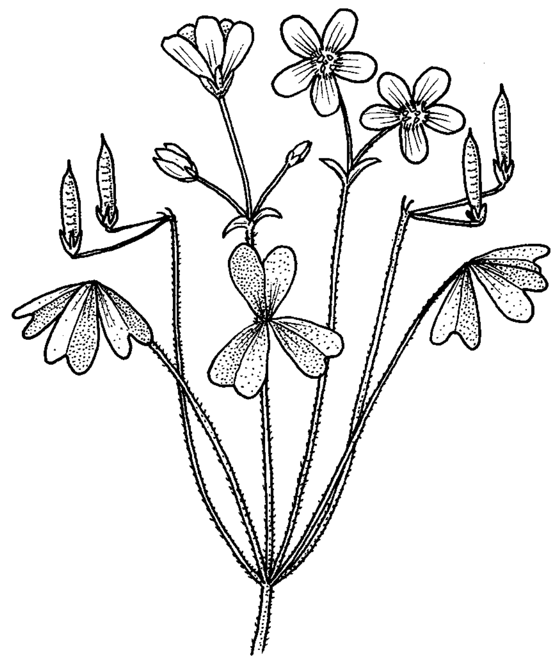
Describe the features of the flower of this plant.
Can you distinguish the main reproductive parts of this flower?
What structure develops after the flower is pollinated?
What does the fruit contain? Break one open and describe what you find inside.
How many seeds per segment does it contain? How many seeds per fruit? How many fruits per plant? What do you estimate as the total number of seeds per plant?
Do all the plants you observe produce the same number of seeds?
What do you predict would affect seed production?
How could you test your predictions?
How is the number of seeds produced by this plant important to its survival?
Why do you think this plant is called "Cheeses"?

Yellow Wood Sorrel, or Sour Grass *(Oxalis stricta)*

Family: Oxalidaceae, the Wood Sorrel Family

This plant contains a substance that can be harmful if eaten in large quantities.

Yellow Wood Sorrel can be found throughout the lawn, but it is seen quite frequently in sidewalk cracks, along curbs, and along the edges of building walls. Its yellow, five-petaled flowers can be observed on mature plants growing in unkempt edges of the lawn or along buildings. The leaves are divided into three heart-shaped leaflets and are often mistaken for those of clovers. Some leaflets may appear folded. The stems are covered with fine, white hairs.



Yellow Wood Sorrel

Yellow Wood Sorrel History and Uses

Like so many schoolyard plants, this clover-like plant came from Europe. Yellow Wood Sorrel is also known as Sour Grass because of the distinctly sour or lemony flavor of its leaves. Acids in foods are perceived as having a sour flavor, and the sour taste of plants in this family (the Wood Sorrel Family) comes from oxalic acid. *Oxalic acid can be harmful in large quantities, so Yellow Wood Sorrel should not be eaten as the main component of a salad.* Several references, however, indicate that it may be used as an herb in salads, soups, and stews. Some Native Americans used partially chewed leaves to make a poultice to relieve toothache pain.

Yellow Wood Sorrel Inquiry

Look for Yellow Wood Sorrel around the edges of your building, against the walls, around flower beds, or in cracks in the parking lot or sidewalk. Useful materials: hand lenses, basic flower diagram (see the Glossary for a flower diagram, in the entry for "flower").

Examining a Common Sidewalk Plant

Look at the leaves of this plant. What shape are they?

What other plants in the lawn can you find that appear similar to this plant?

Compare this plant to a clover. How are these plants similar/ different?

What other features of this plant can you observe?

Have your students examine a flower with a hand lens.

How many petals does the flower have?

What other parts can you see?

Look at the parts of a flower as shown in a flower diagram. Which of these parts can you identify on the flower you are observing?

Where does this plant appear to be most frequent?

Can you explain why it occurs in some locations but not in others?

Terrestrial Isopods

Class: Crustacea, the crustaceans (crabs, lobsters, shrimp, etc.)

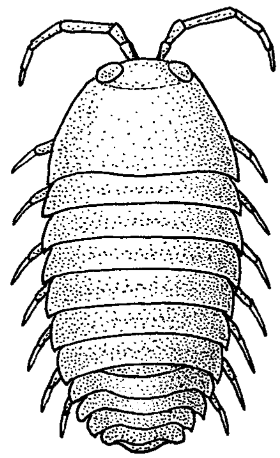
Order: Isopoda, the isopods

Pull back the tall grass that is matted up against a damp corner of your building and you may uncover some "cousins" of lobsters, crabs, and other **crustaceans**—the terrestrial (land-living) isopods! Terrestrial isopods are crustaceans that have adapted to living life on land. Like other crustaceans, terrestrial isopods breathe with gills, which limits their habitat to moist places where their gills will not dry out.

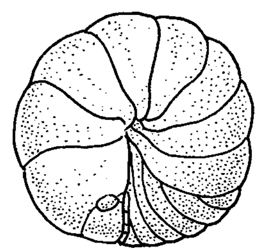
Isopod Characteristics, Habitats, and Behavior

The terrestrial isopods are oval-shaped, have a slate-gray exoskeleton, and measure 5 to 15 millimeters (about ½ inch) long. One conspicuous pair of antennae (a second pair is present but not easily seen) and 7 pairs of legs also help identify these organisms. These isopods can release a acrid-smelling secretion as a defense against predators. Females carry from 10 to 150 eggs underneath overlapping plates between their legs. Growth occurs, as in insects and spiders, by molting (shedding the exoskeleton). Terrestrial isopods feed on all kinds of decaying plant or animal matter, rotting fruits, fungi, and their own wastes as well as wastes of other organisms. Isopods avoid being out in the open, thereby reducing the chance not only of drying out but also of being consumed by predators.

The two kinds of isopods that you will find in the schoolyard are easy to distinguish. **Pill bugs** (*Armadillidium* species) will roll up into a little ball or pill when disturbed, hence the common name "pill bug." This serves as a defense against predators and is similar to the strategy of the Armadillo, an armored mammal, who likewise rolls up to protect its soft underside from attack.

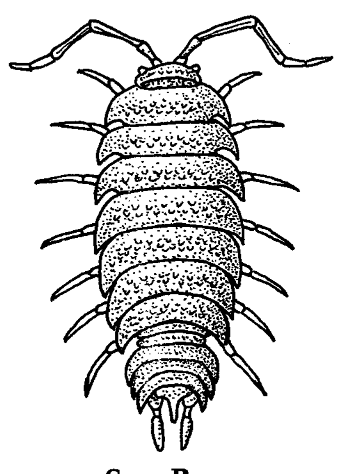


Pill Bug



Rolled-up Pill Bug

Sow bugs (*Porcellio* species) are similar to pill bugs but are somewhat flatter, and they lack the ability to roll into a ball. Sow bugs have two tail-like appendages, which are not obvious on pill bugs, that can help you distinguish sow bugs from pill bugs at first glance.



Sow Bug

Terrestrial Isopods Inquiries

Look for terrestrial isopods around the foundation of a shady side of your building. You may find them underneath tall grass matted against the wall. Look around drain spouts or under debris around the building—rocks, bricks, boards, and pieces of trash that have settled down against the soil or on the grass. You can even create some appropriate habitats by leaving some bricks, boards, or logs along a damp side of your building. Check underneath such structures after a week or two. Useful materials: petri dishes (or plastic containers) for observing isopods, rulers, plastic containers and potatoes for making traps, insect diagram (see the Glossary for a basic insect diagram, in the entry for "insect").

Finding Isopods

Have your students search the building exterior for isopods.

Where did you find terrestrial isopods around your building?

What were the features of the habitat where you found them? Did you find them in moist places or in dry places? Warm sites or cool sites?

What were the isopods doing when you found them?

How did the isopods respond to your presence?

How could you organize this information in a chart or data table?

Comparing Isopods to Insects

Have students look at an isopod closely with a hand lens. (You can place an isopod in a petri dish or empty plastic container for close observation.)

What features can you describe?

How big are these animals? Use your rulers to measure.

How many legs do they have?

What other body parts can you distinguish?

Is this animal an insect? How do you know?

How is the animal different from an insect? How is it similar?

What other animals, besides insects, have body features similar to isopods?

To what kinds of animals do you think the animal in your container is related? Explain.

Investigating Isopod Distribution by Trapping

Your students can use some traps to capture isopods and learn more about their distribution and movements around your schoolyard. Two good traps to use are the pit fall trap and the potato trap, both of which are illustrated in the Collecting Insects section of the Fencerows chapter. Have students place several of these traps around the schoolyard in a variety of habitats.

Which traps captured the most isopods?

What other organisms did you find in the traps?

Make a graph showing the locations of the traps on one axis and the number of isopods on the other axis.

Which habitats seem to have the most isopods?

What other inferences can you make based on your data?

Why were isopods attracted to these traps?

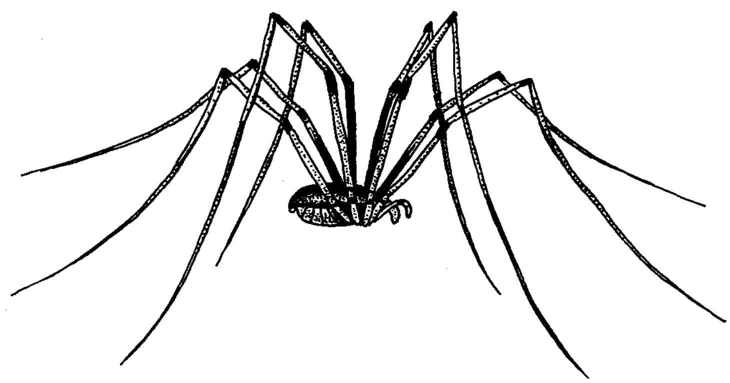
Try to "think" like an isopod: Explain why you went into the traps you did.

Harvestmen

Class: Arachnida, the spiders, ticks, mites, scorpions, etc.

Order: Opiliones

The well-known, leggy harvestmen are surprisingly not true spiders! Spiders have two main body parts and are able to produce silk, but harvestmen do not have these features. (See the section on Spiders below in this chapter, and the section on Grass Spiders in the Lawn chapter.) Harvestmen have a single body part made up of a head, thorax, and abdomen all fused together. This body is carried low to the ground by eight long, thin legs. Harvestmen have a pair of stink glands on each side of their body; these glands are used for defense. If you pick up a harvestman by its legs and rub its underside, you can smell the distinctive odor it emits. (The experience of one author doing this revealed an odor distinctly like almonds!) The front legs seem to be used for a sensory function, while the other three pairs are used for walking.



Harvestman

There are approximately 150 species of harvestman in North America. Some are **scavengers**, feeding on dead animals and refuse, while others are predators, feeding on such living things as small insects and mites. You may find harvestmen on the walls and edges of the building, most often on damp or shady sides. Because harvestmen do not overwinter, they are inconspicuous until they reach their adult size late in the summer. Occasionally you may find large numbers of them together in the fall during the harvest season—hence their name "harvestmen"! Harvestmen are often called "**daddy-longlegs**," but this common name is also used for a type of true spiders. This is an excellent example of how common names for organisms can be confusing. Harvestmen are *not* called daddy-longlegs in this book.

Harvestmen Inquiries

Look for harvestmen in the fall. Pay particular attention to the walls and foundations of the school building. Look also in flower beds, in shrubs, and on tree trunks. Useful materials: clear plastic containers.

Locating Harvestmen

Where around the school building are harvestmen found most frequently?

List all the places in where you observe harvestmen.

Make a map of the school grounds and mark an "X" where you observe harvestmen.

What were the physical features of the habitats where you found harvestmen?
What environmental variables seem to influence the distribution of harvestmen?

Observing Harvestmen

Capture harvestmen and place them in a clear plastic container so that your students can observe them closely. When your students finish their observations, have them release the harvestmen where they were found.
How many legs does a harvestman have?
How do the length of its legs compare to the length of its body?
How many times longer are the harvestman's legs than its body? Compare this to the legs/bodies of other animals, such as a bee, a dog, or a horse.
How long would *your* legs be if they were proportionately the same length as those of the harvestmen?
How many body parts do harvestmen have?
Harvestmen are not true spiders. What makes them different from spiders? Find information about the characteristics of spiders and compare the characteristics of harvestmen.
Watch a harvestman as it moves around. Are all of its legs used for the same function?

Harvestmen Behavior

What were harvestmen doing when you observed them? Can you explain the functions of the behaviors you observed?
What do harvestmen do if you disturb them?
Try gently touching a harvestman's leg with a pencil. How does it respond?
Does it make a difference if you touch a front leg or a back leg? Its body?

Harvestmen Defenses

You may be able to detect harvestmen odor in a jar or container where you have confined a harvestman. If you carefully pick up a harvestman by its legs and rub its underside, you can also detect the odor.
What are some ways organisms defend themselves?
How do you think a harvestman defends itself?
Can you detect an odor from the harvestman?
What might be the function of this odor?
How might it help harvestmen survive?
What other organisms (plant or animal) use odors for defense?

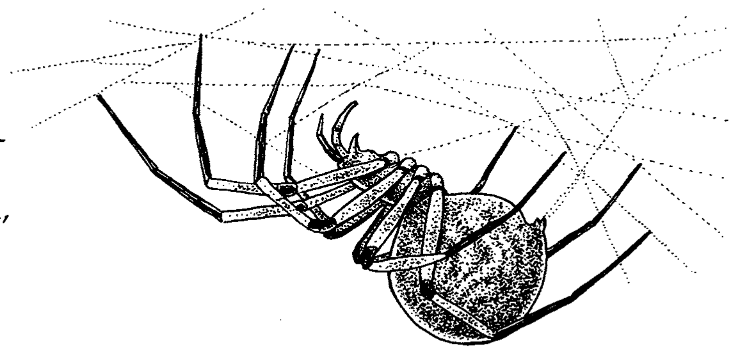
Spiders

Class: Arachnida, the spiders, ticks, mites, scorpions, etc.

Order: Araneae, the true spiders

There is excellent spider habitat in the doorways and window overhangs of your school building. The corners provide sites for attaching webs, and the overhangs and walls provide protection from wind, rain, and passing animals that can damage webs. Furthermore, many doorways are lighted through the night, attracting insects to the spiders' webs. It would be hard to imagine any spider going hungry in this habitat.

Many different spiders can be found in or around a school, but one that is well-suited to doorways of schools is the **American House Spider** (*Achaearanea tepidariorum*). This spider is a "cobweb weaver." Cobweb weavers build irregular webs that seemingly lack any organized pattern, rather than building webs with the classic, symmetrical pattern. The spider can be found either hanging upside down in the center of the web or hiding in a crack or crevice nearby.



American House Spider

The American House Spider belongs to the Comb-footed Spiders Family. Members of this family have comb-like hairs on the fourth leg. This comb is used to wrap silk around prey that is entangled and snared by the sticky web. The spider then bites the wrapped prey and sucks out its body fluids. Different species in this group vary widely in their appearance, but patches and streaks are characteristic of the group.

Spiders Inquiries

With your students or before a lesson, survey your school building for the location of spiders and webs. Many spiders around your building will be high off the ground in the upper reaches of doorways and window covers, but others may be behind a downspout or in a corner where your students can observe them closely. Useful materials: map of the building exterior (with windows, doorways, overhangs, lights—students can make this), sketch paper.

Spider Locations

Where do you predict you would find spiders?

Using the map of the building exterior, mark an "X" wherever you find a spider or evidence of spiders around the outside of the building.

Where did you find spiders? Where were spiders or evidence of spiders most common?
What structural features of the building seem to be preferred by spiders? Why do you think this is so?
Were spiders or the evidence of spiders more frequent around light fixtures than other locations? Can you explain this?
What advantage could there be to the spider to be close to the lights?
What have you observed around outdoor lights in the summer?
If you were a spider, where would you build your web? Why?

Spiders and Web Structure

Students may discover and be able to compare different types of webs, from the cobwebs of the American House Spider to the funnel webs of grass spiders (see the Grass Spiders section in the Lawn chapter).
When you think of a spider web, what do you picture in your mind? How would you describe it? Sketch your idea of a spider web.
Are all spider webs the same?
Do all spiders make similar kinds of webs? Can you find different kinds of webs around the building or in the schoolyard? Describe or sketch the webs you find.
How do the webs you found compare to your idea of a web?

Observing Spiders in the Webs

If you find a spider in a web, you can follow this line of inquiry.
Where is the spider located?
What is the advantage to the spider to be located where it is?
If the spider is in its web, is it hanging upside-down or right-side up?
Is the spider carrying, or can you observe in the web, a spherical, silk-covered object? What could this be?
Can you find any other evidence of the spider's prey in the web? Below the web?
How do spiders know if a prey item is in the web?
Can you trick the spider into thinking that there is an insect trapped in the web?
What happens if you touch the web?

Schoolyard Wasps

Insect Order: Hymenoptera, the ants, bees, and wasps

As you know, wasps and bees can sting!

Underneath the eaves of your building, in nooks above windows, and in doorways you are likely to see two of the most conspicuous types wasps: the solitary, mud-nest-building **mud dauber wasps**; and the paper-nest-building **Vespid wasps**, which in many cases are **social insects**. These wasps get protection from sun, wind, and rain by building their nests in protected areas of buildings. Building their nests off the ground also provides protection from mammals, such as skunks or raccoons, that would feed on the developing larvae in the nest if they could reach them. You may find these nests are more frequently located on southern exposures. More sun reaches such areas—warming the air around the nests and allowing the wasps to be more active—than if the nests were on the north side of the building.

Observing Wasps Safely

Wasps are most aggressive when they sense that their nests are threatened, so the insects should be observed only from a safe distance. If you are lucky, you may have a nest built under the eaves of a window in your classroom, where wasp activity can be observed from indoors, close-up and in complete safety. After several hard freezes in late fall or early winter, abandoned nests can be observed closely in place or removed from the building for closer study. *(Err on the side of caution—be sure that the wasps have left the nest permanently or have been killed by the cold!)* Vespid wasps do not overwinter in nests; the young **queens**, who will establish the next year's nests, leave the old nest and spend the winter in sheltered spots (such as logs). You may, however, find other insects or even spiders in an old Vespid wasp nest. Mud dauber wasps, on the other hand, overwinter as larvae in their mud nests. A good winter activity is to document the number, kinds, and location of wasp nests around your building.

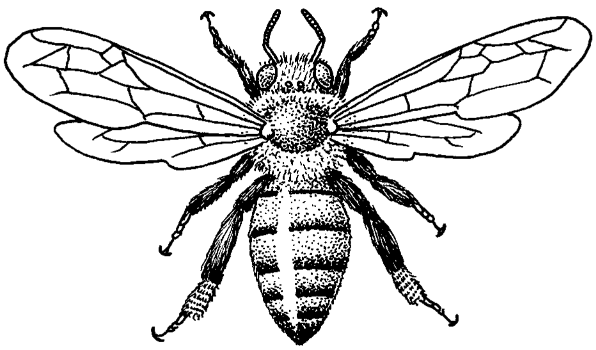
Social Insects

Many insects have little interaction with one another except to mate; once having laid their eggs, these insects provide no further care for their young. But social insects provide a great deal of care for their young, and members of a species have complex interactions. Solitary bees and wasps, such as the mud dauber wasps, represent the first step in the development of social insects, in that they build nests and provide minimal care for their young. They place an egg in a chamber provisioned with food for the developing larva, but otherwise they do not interact with their offspring. True social insects—termites, ants, some bees, and most Vespid wasps—live together in colonies. These colonies have members divided into **castes**, or divisions of labor. In general, these castes are made up of the queen, a reproductive egg-laying female; **workers**, sterile females who gather food, build the nest, and care for the young; and males whose main function is to mate with queens to form new colonies (in Honey Bees, these males are called **drones**).

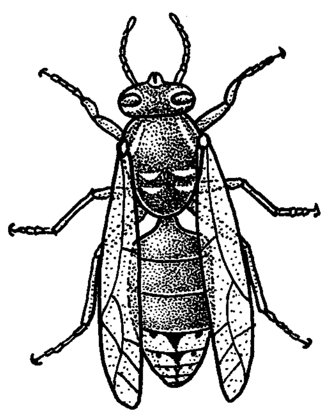
The social Vespid wasps construct six-sided paper cells that house eggs, larvae, and pupae. The eggs and larvae are cared for by the workers. Workers feed the larvae regurgitated food until the larvae are ready to pupate, then the larvae are sealed into cells. Eventually adult wasps emerge by chewing through their paper covering. Eggs usually take 5 to 8 days to hatch, larvae develop into pupae in about two weeks, and about 10-15 days are necessary for the adults to develop and emerge.

A Note about Bees and Wasps

The words "bees" and "wasps" are often used interchangeably, but these words actually refer to two very different groups. In general, bees have shorter, stouter bodies than wasps, and bees are often quite hairy. (Bees have branched hairs, an adaptation for collecting pollen.) Wasps tend to be much longer and more slender, and they do not have conspicuous hairs on their bodies. Many wasps have shiny or almost metallic-colored bodies, and they typically have a narrow joint between their thorax and abdomen (seen prominently in "thread-waist" wasps). Vespid wasps, specifically, can be identified by wings folded longitudinally (along the length of the body).



Honey Bee



Vespid Wasp, wings folded

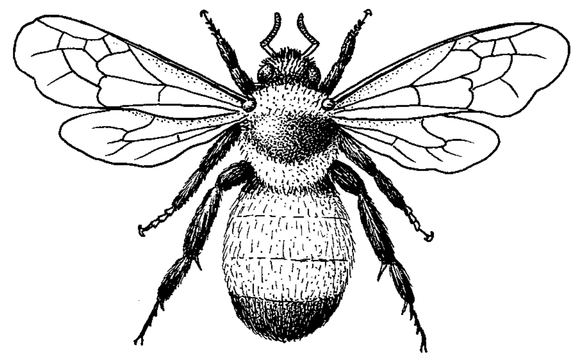
As you study wasps that are commonly found on or around buildings, keep in mind that there are many thousands of species of wasps. Most wasp species are actually solitary individuals, living as parasites and predators of soft-bodied insects. These parasitic and predatory wasps are important in controlling insect populations.

A Note on Stings and Bites

Of great interest to students, and also an area of many misconceptions, is the subject of stings. Both wasps and bees have the ability to sting rather than bite. Biting implies the use of mouth parts to pierce the skin. Horse flies, for example, do not sting but bite, drawing blood from their host to nourish their eggs. Mosquitoes "bite" by using mouth parts modified in such a way that they function like a needle on a syringe to draw blood. In the case of mosquitoes, the female does the biting, seeking a high-protein blood meal to nourish developing eggs. (Male mosquitoes do not bite.)

Wasps and bees, on the other hand, actually sting rather than bite. The purposes of the sting are self-defense, defense of the nest, or prey capture, but not nourishment directly. The stinging is done by a specialized structure at the base of the abdomen. This structure is actually a modification of an egg-laying device, so only sterile female bees and wasps have the ability to sting. Because the smooth, sharp, and narrow stinger on wasps can be extended and retracted repeatedly, wasps can sting more than once. With each sting, venom is injected.

Honey Bees, on the other hand, have a stinger that is barbed rather than smooth. Once the barb has been poked into an unfortunate recipient, it is difficult to remove. The bee is sometimes brushed away, tearing the stinger from the bee's abdomen. A poison sac frequently is observed at the opposite end of the stinger. When this happens, it is advisable to remove the stinger as quickly as possible by lifting it out *without squeezing the poison sac.* The venom injected by the sting is, of course, very painful, and will cause varying degrees of inflammation and swelling, depending upon the individual. The venom is actually a protein; individuals can become sensitized to this protein and develop rapid, severe, and sometimes life-threatening reactions to the sting. Very sensitive individuals (who are rare) may require treatment within minutes of a bee or wasp sting or face a life-threatening allergic reaction. And a final word: *Yes, bumble bees can sting!*



Bumble Bee

Solitary Wasps: Mud Dauber Wasps

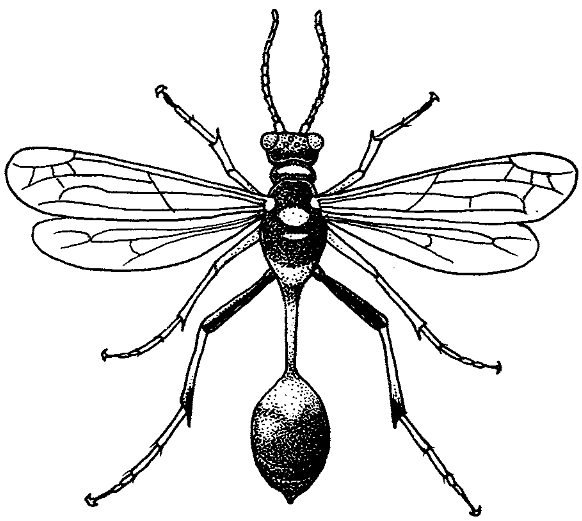
Family: Sphecidae

Globs of mud in the corners or doorways, under eaves, and in other sheltered locations around your school building are the handiwork of this fascinating group of wasps. Mud daubers are solitary, not social, wasps; they live on their own and do not have a structured social order. Mud daubers build cells of mud, in each of which they lay a single egg, provision it with food, then seal the cell; a single female wasp will produce many mud cells. The food is usually spiders that have been captured and paralyzed through venom injected by the wasp's stinger. Paralyzed spiders are packed into a cell; when the larva hatches from the egg, it feeds on the paralyzed spiders. The larva grows and eventually pupates inside the cell. When it becomes an adult, it emerges from the cell by boring a hole to the outside (in many nests you can see the holes from which the adults emerged). The female's role in providing for the offspring ends with sealing the mud chamber. Male wasps mate with the females but otherwise are not involved in rearing the young.

Adult wasps may be observed collecting mud that they mix with their saliva to make the nest-building material. You may also observe the wasps hunting for and catching spiders to provision the nest. (For an entertaining description of mud dauber nest construction—complete with commentary on the fate of the spiders—see page 378 of Anna Comstock's *Handbook of Nature Study*. The reference is listed in the Additional Materials chapter of this book.)

Three kinds of mud dauber wasps are common in southwest Virginia: **Yellow Mud Dauber**, **Blue Mud Dauber**, and **Organ Pipe Mud Dauber**. During the winter (after several hard freezes), nests can be removed (with varying degrees of success) from the walls by sliding a putty knife underneath them. The contents of the nests will reveal many interesting clues to the life history of the wasps. You may find eggs, paralyzed spiders, dehydrated spider parts, shed skins, developing pupae, parasitized pupae, and possibly other inhabitants.

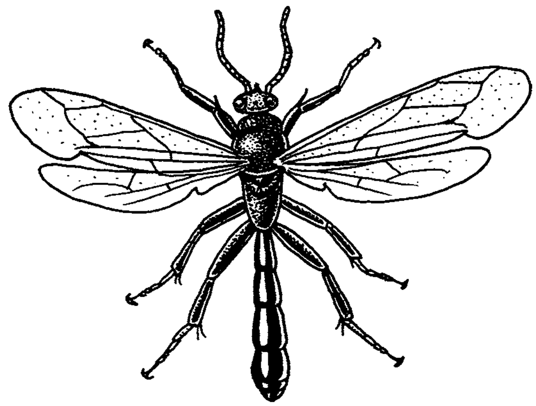
Yellow Mud Dauber (*Sceliphron caementarium*). This wasp is a "thread-waist" wasp, aptly named because of its distinctly narrow "waist" that connects the abdomen and thorax. Adults are black to brown with yellow markings, yellow legs, and clear wings. This mud dauber builds its nests in clumps. Close examination of cells will reveal mud layers carefully added in symmetrical arcs.

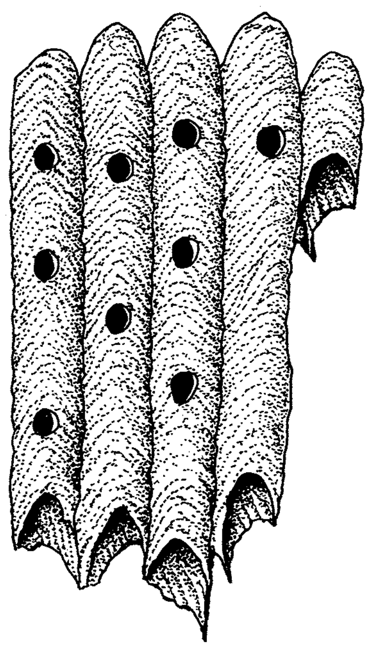


Yellow Mud Dauber

Blue Mud Dauber (*Chalybion californicum*). This is also a thread-waist wasp, but it differs from the Yellow Mud Dauber in that it has an almost metallic blue body with bluish wings. This species is the freeloader of the wasp world: It does not build its own nests, but rather it refurbishes the old nests of other mud daubers. Instead of collecting mud, it will gather water and use this to dissolve the mud of existing chambers to repair and seal ones that it will use. As a result, this species expends considerably less energy in building nests, and more of its energy can go to egg production and food gathering.

Organ Pipe Mud Daubers (*Trypoxylon* species). These shiny black wasps are most easily distinguished by the nature of the mud nests they build. Instead of randomly building cells in clumps, as the Yellow Mud Dauber does, this wasp organizes the cells in long rows. Once several rows are completed the nest has the appearance of a pan flute or a pipe organ. Later, as wasps emerge, rows of holes will appear, making the structure even more flute-like.





Organ Pipe Mud Dauber and Nest

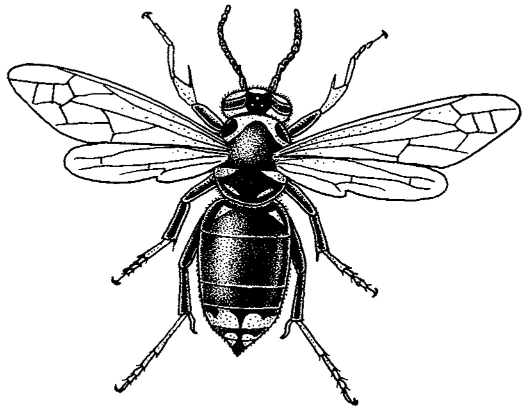
Social Wasps

Family: Vespidae

The Vespid wasp group includes **hornets, yellow jackets**, and **paper wasps**, all of which build paper nests. The paper to build the nests is made by collecting bits of wood from various sources, chewing it, and mixing it with water and a glue-like saliva. As described above, the social order is made up of three castes—queens, workers, and males. These wasps are carnivorous and feed largely upon insects, especially soft-bodied forms. Wasps may be observed hunting for prey in weedy fencerows, collecting wood on outdoor decks or wooden hand rails, or collecting water on the edges of puddles. Young queens overwinter by burrowing into rotten logs or into the ground under leaf litter. Queens are often seen in early spring, flying around under the eaves or along the walls of buildings, looking for an appropriate place to build a nest. Southern exposures seem to be preferred.

Baldfaced Hornet (*Dolichovespula maculata*). This hornet typically builds nests in the branches of trees or bushes, or under the eaves of buildings. These nests are often seen in trees after leaves have fallen off in autumn. They can be safely collected during the winter after an extended freeze and brought to school for closer study.

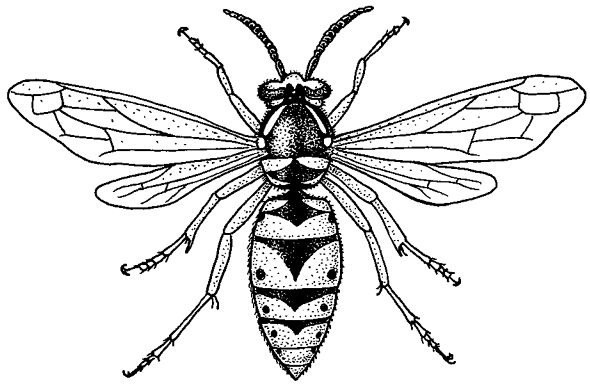
Looking closely at the surface of the nest, you will see bands of many different colors. Each small band of color represents the work of an individual wasp. Material is deposited by the insects in bands on the edge of the nest; the different colors indicate different sources of wood. If you cut into the nest wall, you will find that there may be up to eight overlapping layers of paper, up to 5 centimeters (2 inches) thick. The "dead" air spaces between these layers provide good insulation both on hot summer days and on chilly spring and fall nights, in the same way the air spaces in sleeping bags or quilted down ski jackets insulate us from the cold. Inside the nest you will find up to four tiers of cells—the chambers for eggs, larvae, and pupae. Adults are black and white and will rarely interact with you unless they feel their nest is threatened—*then they will respond aggressively.*



Baldfaced Hornet

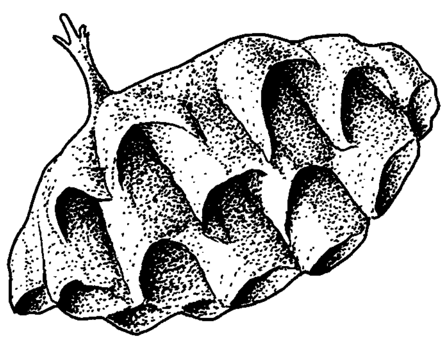
Yellow Jackets (*Dolichovespula* species and *Vespula* species). Yellow jackets will most commonly build their nests underground in natural crannies or abandoned mammal burrows. They will also build nests in the hollow walls of buildings when they can find an entrance. Some kinds of yellow jackets, in addition, build nests in trees. *We are most often stung by these aggressive wasps when we inadvertently play or work near their nests.* Nest locations can be observed by watching for wasps dropping into and rising up from a hole in the ground or wall.

Yellow jackets feed on insects, which are a protein-rich food source for the developing larvae. In the fall, however, egg-laying is reduced or stops altogether, and some of the remaining larvae may actually be eaten rather than being nurtured. After they finish caring for the larvae, yellow jackets no longer focus on protein-rich food sources. Instead, yellow jackets search for substances rich in sugar (an excellent source of energy). In their search for sweets, they are led to fruits, flowers, and most conspicuously to our picnic tables! Sodas and peanut butter-and-jelly sandwiches seem to be favorites in the fall as these determined wasps harass people relentlessly. Yellow jackets' conspicuous presence in the fall is a result not only of increased numbers late in the season but also of a change in their feeding habits.



Yellow Jacket

Paper Wasps (*Polistes* species). The favorite nest-building site for these wasps seems to be high under the eaves of houses and other buildings. Paper wasp nests will probably be the most common social wasp nests found under the eaves of your school building. In contrast to hornets' nests, the cells in paper wasp nests are not enclosed in large, paper-like ovals.

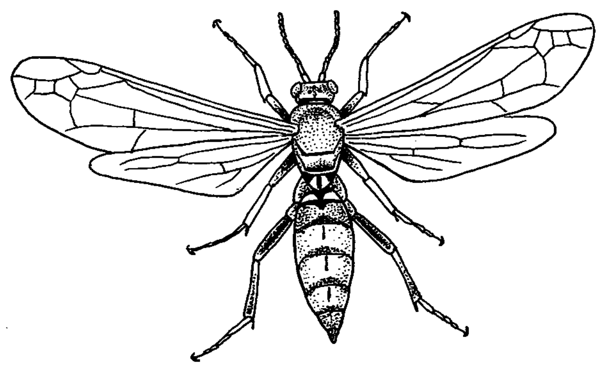


Paper Wasp Nest

Attachment of the nest by the single narrow stalk means only a single point of entry has to be defended against crawling predators. At least one wasp species is reported to coat this stalk with a chemical insect repellent. This, however, does not protect the wasps against one of their major types of predator, birds.

The development of a paper wasp nest begins when queens emerge from winter hiding places in the early spring. On warm days, these insects can be observed drifting underneath the eaves of a building in search of a suitable nest site. Once a site has been selected, the queen builds a few paper cells attached to the site by a thin stalk. Eggs are laid in these cells and the larvae soon hatch. The larvae are tended and fed by the queen until they pupate. The nest is expanded and workers finally emerge from pupae to help the queen build cells and to tend the eggs and larvae. Cells are begun by the queen, and the workers then finish them off. If you bring an old nest down in the winter you can observe newly started cells on the edges; up to 150 hexagonal cells in a single tier may be constructed.

Adult paper wasps have brown bodies and wings, relatively long legs, and the most slender bodies of any wasps in the social-wasp group. In the fall, these wasps can be observed feeding on the nectar and pollen of goldenrod blossoms.



Paper Wasp

While paper wasps do not *appear* to be as aggressive as the hornets and yellow jackets, *paper wasps account for a greater number of stings than hornets* (entomologists who reviewed this book noted that yellow jackets are considered to be the Number 1 stingers, paper wasps second, and hornets third). The appearance of paper wasps as less aggressive is probably due, at least in part, to paper wasp nests being smaller and usually located farther away from human interactions.

Schoolyard Wasps Inquiries

⚠ ***Observe wasps from a safe distance, do not harass them, and do not disturb a nest before several hard freezes. Additional safety notes are given within specific lines of inquiry.*** *Useful materials: compasses, sketch paper for making maps, hand lenses, putty knife, newspaper or other paper to compare to nest materials.*

Wasp Nest Locations

Do a pre-trip survey of your school to determine how many and what kinds of wasp nests you have around your building. Winter or early spring are, of course, the safest times to do such an activity; in general, however, the nests are usually so high up that wasps are not threatened by people on the ground, and you can observe safely by keeping your distance. Many times nests are in doorways and go unnoticed until we begin to look for them. In this case, the wasps are often accustomed to having people go in and out the doors all day long. Whether and how you pursue this line of inquiry will depend upon what your pre-trip wasp nest survey shows. Select from the following questions to develop an inquiry that suits your situation.

How many different kinds of wasp nests can you find/observe around your school building?

How do these nests differ? How are they similar?

What substances do the wasps use to build their nests?

What is the function of a wasp nest?

How do wasps' nests change over the course of a year?

Do the wasps use their nests during the winter?

Where do wasps go in winter?

Have the students make a map of the outline of your school building.

Identify significant features on your map--doorways, overhangs, air-conditioning units, covered walkways, etc.

Make a key for your map, using a different symbol for each kind or category of wasp nest.

Determine north, south, east, and west on your map.

Mark on your map the location of the wasp nests around your school.

Where are wasp nests most frequent?

What kinds of structures seem to be preferred by the wasps? Why do they build their nests around these structures?

What advantage is there to the wasps to have their nests high off the ground?

What organisms might try to get into wasp nests? For what purpose?

Do different kinds of wasps (based on differences in nest construction) seem to prefer different habitats?

Comparing Bees and Wasps

What are the differences between bees and wasps?
Compare, for example, a Honey Bee to a yellow jacket.
How do they differ? How are they similar?
How can we find out more about these differences?

Mud Dauber Wasp Nest Construction

Do a survey of your school building to determine if and where your students can find mud dauber nests. This line of inquiry begins once students have found a nest.

Why is there mud on the walls of the building?
What made these structures?
Describe the structures. What are their shapes? From what are they made? What other features do you notice?
Where do the wasps get the material to build their nests?
Have you ever seen wasps collecting this material?
What do you think they do to it to put it in a form they can use?
What is the function of the nest?
What makes this a suitable place for these wasps to build their nests?
What do you think would happen to these nests if they were exposed to rain and wind?

If you are doing this inquiry in winter, and you are able to scrape off a mud dauber nest with a putty knife, continue with these questions.

Look closely at the "mud" structures with a hand lens. Describe what you see.
What patterns can you see?
Can you explain from these observations how the mud nests were built?
What is inside the mud nests? How can you explain the presence of the things you find? What is the "story" here?
Do all of the chambers you observed have a hole in them? How do the contents of sealed chambers differ from one with a hole? How can you explain these observations? What do you think is the function of the hole?
How can you find out more about the life history of these wasps so that you can better explain your findings?

Baldfaced Hornet Nests

⚠ ***It is not recommended that you take your class anywhere near an active Baldfaced Hornets' nest. These insects are aggressive and will respond vigorously to perceived threats to their nests. This line of inquiry is designed for studying nests that have been taken indoors long after the occupants have left or have been***

Schoolyard Wasps Inquiries, continued

killed by winter cold. Don't try to take in a nest too early! *Hornets' nests are usually discovered after leaves have fallen off the trees. Ask around and you are likely to find someone who knows where a nest is, or ask the biology teacher at your local high school if he or she has an extra nest (hornets' nests are often brought to biology teachers).*

Tear a small piece of the outer covering off the nest. Tear a small piece of newspaper off a newspaper. Examine both with a hand lens. Pay particular attention to the torn edges.

How do they compare? How are they similar? How are they different?

Where does the insect get the materials it needs to make the paper of the nest?

Where did the newspaper manufacturer get the materials to make paper?

How is the Baldfaced Hornet's process of making paper similar to commercial paper-making? How is it different?

Describe the color patterns on the surface of the nest. How can you explain why there are these patterns?

Carefully take apart a section of the nest wall. Describe or sketch its structure.

From how many layers of paper is it made? How are these layers interconnected?

How does the nest wall structure help the hornets survive?

What do you find inside the nest? Describe or sketch the structure of the cells. What is the function of these cells?

How many hornets do you think lived in this nest?

Why is it important to stay away from these nests in the summer?

Yellow Jacket Behavior

⚠ ***Yellow jackets can be aggressive if their nest is disturbed.*** *It is* not *recommended that you seek out encounters with yellow jackets. But if you are on a fall field trip and eat a picnic lunch outside, these wasps are likely to seek out an encounter with you! Actually, they are looking for the food that you have made so readily available. Here is a possible line of inquiry into what these often unwelcome visitors are doing.*

Why are yellow jackets attracted to us?

What are they seeking?

How did they find us? How did they know we were here with food?

Are they very persistent?

What do these wasps "do"? What are their behaviors?

Will these wasps sting you?

What are things you can do that might *increase* the possibility of being stung? What are some things you can do to *reduce* your chance of being stung?

Are the wasps "mean"? How can you explain their behaviors in terms of survival of this species?

Paper Wasp Nests

⚠ ***As with the other wasps, avoid getting close to these nests until they have been exposed to several hard freezes.*** *If you are lucky, you may have a paper wasp nest that your students can observe through the windows of your classroom, in complete safety. The following line of inquiry, however, is designed for the closer study of an* abandoned nest *that has been taken down during the winter.*

Describe the structure of this nest.

Why are there many individual "cells"? What happens in the cells during warm weather?

Do you know what a hornet's nest looks like? How is this nest different from a hornet's nest? How is it similar?

Describe the shape of the individual cells in this nest. Do all the cells have the same shape?

How do you think the wasp knows how to make cells of this shape?

If students observed the nest attached to the building:

How was the nest attached to the structure where it was built?

What advantage does this give?

Have the students tear a small piece of material from the nest and look at it closely with a hand lens. At the same time, have them examine a small piece of newspaper.

How does the wasp nest material compare to the newspaper?

From what materials is the paper in your newspaper made?

What do you think is the source of materials for the paper wasp nest?

Make a chart comparing weight, color, texture, absorption of water, and resistance to tearing.

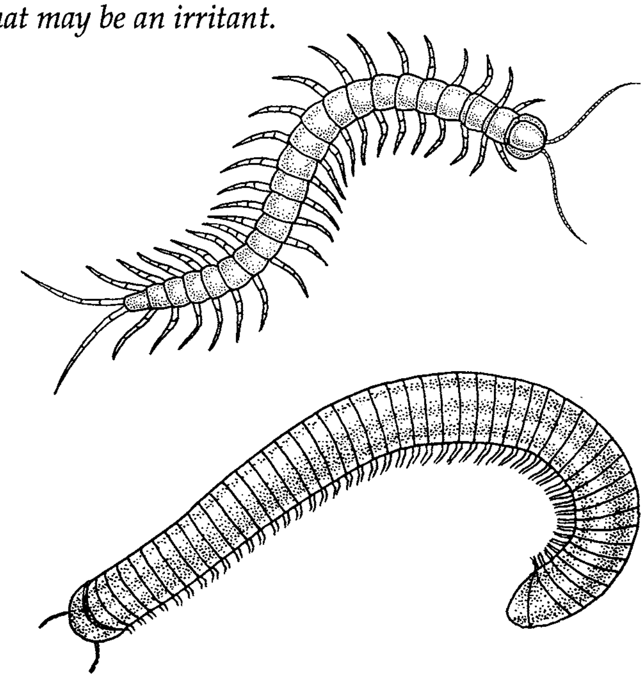
Which is the "better" paper? Imagine you are a paper salesperson and make a "pitch" for one paper over the other.

Centipedes and Millipedes

Classes: Chilopoda, the centipedes; and Diplopoda, the millipedes

Centipedes can inflict a painful bite, and millipedes release a foul-smelling substance that may be an irritant.

Where you find sow bugs and pill bugs (see the section on Terrestrial Isopods above in this chapter), you will probably also find centipedes and millipedes. Around a school building, centipedes and millipedes can be found under stones, bricks, or boards. These animals can also be found wherever there is a moist layer of decaying leaves: The millipedes will be feeding on the decaying material, while the centipedes will be searching for prey. While centipedes and millipedes are similar in many ways, they have many different features, too. Because these two groups are often confused, comparing and contrasting them can be the basis for student inquiry lessons.



Centipede (top) and Millipede

General Features

Like insects, spiders, and isopods, these organisms have segmented bodies, an exoskeleton, antennae, and many legs. The names "centipede" and "millipede" come from Latin, where *centi-* means "one hundred," *milli-* means "one thousand," and *-pede* means "foot." Hence the common names—"hundred footers" and "thousand footers." Neither of these groups of animals, however, actually have the number of legs implied by their names, although millipedes generally do have more legs than centipedes. Millipedes have two pairs of legs per segment, while centipedes have only one pair. The body form of millipedes and centipedes differs in several other ways, as well. While both have long, many-segmented bodies, with legs that move in rhythmic undulating patterns, the legs of millipedes are much shorter than those of centipedes. Millipede bodies are usually rounder, while centipede bodies tend to be flat. Millipedes have shorter antennae, while centipede antennae are often long.

Feeding Habits

The place of each of these organisms in the food web helps explain some other differences between these two groups. Millipedes are herbivores or decomposers, feeding on dead or decaying plant material and the fungus growing on them; centipedes, though, are predators. Millipedes tend to move slowly, while centipedes are fast, enabling them to be more effective at capturing prey. Centipedes may prey upon insects, slugs, worms, and terrestrial isopods. As predators, *centipedes are capable of inflicting painful bites.* A pair of sharp claws located behind the head on the first segment are used to seize prey and inject a poison. In contrast, plant-eating millipedes have neither speed, jaws, nor stingers with which to defend themselves. Instead, when threatened *millipedes curl up into a spiral and release a foul-smelling substance.* Millipedes are generally dark in color (although some are brightly marked), while centipedes are sometimes bright red.

Centipedes should never be handled directly by students. A centipede can be captured and placed in a plastic container that can be taped shut and then passed around for a closer look. Release the organism unharmed when you are finished studying it. *Care should be taken after handling millipedes not to touch your eyes or mouth and to wash hands immediately*: While the millipedes' protective secretions are released in tiny quantities and are not known to be toxic to humans, the secretions of some millipedes can cause eye irritation.

Centipedes and Millipedes Inquiries

⚠ ***Students should not touch centipedes or millipedes. Use gloves or some instrument to handle centipedes, and wash your hands after handling millipedes.*** *Useful materials: hand lenses, plastic containers.*

Comparing the Features of Centipedes and Millipedes

Collect centipedes and millipedes around your building. Place the animals you collect in separate plastic containers, taped shut, *for students to view with a hand lens.*

Compare and contrast the two organisms.

List all the features that you can observe that these organisms have in common, and all the features that are different.

Make a chart comparing such features as color, number of body segments, number of legs per segment, length of legs, antennae, body length and shape.

If you were a centipede running for Top Centipede, what key features would you use to let voters know that you weren't really a millipede?

Moving Around with Dozens of Legs

Describe the problems you might have in walking across the room if you suddenly found that you had 30 or 40 legs.

What are some ways your 30 or 40 legs would have to move for you to accomplish this task smoothly without tripping over your legs and falling down?

Is there more than one solution to this problem?

Watch some millipedes or centipedes as they move in a plastic container. Describe how these animals have solved the problem of using so many legs.

Centipedes and Millipedes Inquiries, continued

If you are really adventurous, take your class outside and have them stand single file. Then reach forward and place their hands on the waist of the next person. Instruct the line to move forward.

How does it work? What happens? Why is this difficult?

What happens if you vary the distance from the person in front of you?

What are some ways to solve this problem? Try them!

Can you (the class) imitate how centipedes and millipedes solve the problem?

Millipede Habitats and Food Preferences

You can attract millipedes and learn more about them by creating habitats. A good type of trap to use is this: a plastic container, with the lid punched full of holes, and with vegetable peelings from potatoes, carrots, or apples. Have your students number the containers, then place these around your school building above the ground in various locations: along the building, under bushes, in sun vs. under shade, in leaf litter, etc. (Other organisms will be attracted too.)

Make a chart to record how many millipedes you found in each container.

Which sites had more millipedes?

What kinds of peelings are most attractive to millipedes?

Did you find what appear to be different kinds of millipedes? If so, how are they different?

What other organisms do you often find associated with millipedes? How can you explain this?

House Mouse *(Mus musculus)*

Mammal Order: Rodentia, the rodents

See the safety information below on mice spreading diseases and on pesticides.

It is appropriate to include the House Mouse in this chapter because these animals are intimately associated with human habitation. Of all the mice species, this one is most commonly found indoors. Like other mice, the House Mouse is secretive and does not move around until after dark or until it is quiet. Most often the evidence of these animals' nocturnal movements is dark, spindle-shaped droppings, about 5 to 6 millimeters (1/4 inch) long. These droppings will be scattered almost anywhere the mice have been. Tables, shelves, and window sills all may be littered with droppings, as mice are good climbers and efficient foragers.

House Mice tend to move indoors in the fall and will build nests out of shredded paper, cloth, or grasses. In the spring, many mice will move outdoors to be closer to food sources, such as a field of grain. House Mice have a reputation for being able to adapt quickly to almost any available food source, and they will feed on anything from grains and vegetables to meat, glue, or even soap if nothing else is available! House Mice have grayish-brown fur scattered with black hairs. The color of the fur is lighter underneath. The tail is about as long the body and, like the ears, is nearly hairless.

House Mouse

House Mice are not native to North America. They probably were introduced in the 16th Century as stowaways on ships carrying explorers and colonists from Europe. The white laboratory mouse was derived from this brown species, but the behavior of white mice bears little resemblance to that of the wild House Mouse or of other mouse species.

House Mice breed from March to October and are capable of 5 to 10 litters per year, with 5 to 7 mice per litter. Young are able to reproduce within 6 weeks, giving this species an incredibly high reproductive potential. Because these mice live in such close contact with people and their food, they are a greater health hazard than most other rodents. *House Mice are capable of carrying and spreading many diseases.* The abundance and high reproductive rate of the House Mouse also result in significant economic impact in grain fields and storage areas.

Your school's proximity to farmers' fields, especially grain fields, will largely determine your local House Mouse population. The number of mice in and around your school will also depend on food availability and on whether the mice can get into your building. Mice are able to squeeze through remarkably small holes or cracks, making it difficult but not necessarily impossible to control their access.

Controlling Mice

⚠ *Always read and follow the label directions before you buy, use, or store a pesticide for mice or any other problem. The information below is not meant as an endorsement or recommendation for use of any particular brand of product.*

In some schools, "anti-coagulant" baits are used to control mouse populations within the school building. Anti-coagulant baits work slowly by disrupting the ability of blood to coagulate or "clot." Mice that repeatedly feed on the bait eventually build up lethal quantities of the toxin. In contrast, "single-dose" baits contain poisons powerful enough to kill the rodent in one dose.

For use in schools and homes, baits that contain anti-coagulants are recommended over single-dose baits, because anti-coagulants are safer to handle and there is less risk to children and pets. Moreover, single-dose baits are sometimes ineffective, because rodents are able to detect the presence of the poison before they ingest a lethal dose. Mice and other rodents display feeding behaviors that help protect them from ingestion of toxic substances. Typically, when a rodent samples a new food, it will only take a few bites and continue foraging elsewhere. If the rodent gets sick following ingestion of the new food, it will form a long-lasting "taste aversion" to the substance or flavor and avoid it. This is why, for a single-dose toxic bait to work effectively, it must have enough toxin to kill the mouse after only a mouthful. *This also makes single-dose baits particularly dangerous to handle and distribute!* In addition, single-dose baits increase the possibility that the poisoned rodents, if they leave the building to die, may pass on potentially toxic levels of poison on to other animals (predators or scavengers) that might eat the rodents. Anticoagulant toxins, on the other hand, work slowly, foiling the protective taste-aversion strategy of the rodents. The anticoagulant baits are safer to use where children or pets are present, because they act slowly and would have to be ingested repeatedly to have a lethal effect.

House Mouse Inquiries

⚠ ***House Mice are capable of carrying and spreading disease. Caution children to wash their hands and face after handling any items with which mice may have been in contact.***

Feeding stations and smoked paper can be used for studying mice (and other small animals) around your school. These can be placed around the school to detect movement and feeding. Keep in mind that rodents tend to keep near structures rather than going out into the open, so place smoked paper or feeding stations accordingly.

***Feeding stations** have food, nuts, grain, sunflower seeds, etc. in a dish. The dish is covered by a box or aluminum pan, weighted down with a stone or brick to prevent access by birds or large mammals. Holes about 5 centimeters (2 inches) in diameter are cut at ground level to allow access by mice. Leave feeding stations out for at least one week. Try placing feeding stations in a variety of locations around your building. Sunflower seeds are a good choice of bait, because they are easy to get, favored by many animals, and easy to count when measuring feeding activity.*

***Smoked paper** can be made by holding a piece of paper well above a candle **(children should not do this)**, but it can more safely be made by sprinkling copier toner dust on a piece of white paper and shaking off the excess.*

Investigating Feeding Habits of Mice

Place feeding stations in various locations and have your students check them. Try different kinds of food.

Count the number of seeds placed in each feeding station. Create a data table to record observations.

How many of the feeding stations show evidence of having been visited? What is the evidence?

How many seeds are missing?

Which feeding stations have the most missing food? Which have not been disturbed?

Why have some feeding stations been visited while others have not?

Has food been consumed on the spot or was it taken away (or both)? What evidence can you find to support your answer?

What are some natural food sources around the building that these animals may be feeding on?

What are some food sources of human origin that these animals may be eating?

What predators may be feeding on these animals?

Do mice really like cheese? How can you find out?

Investigating Animal Tracks

Place smoked paper at the entrance of the feeding stations.

What do the tracks left on the smoked paper tell you? Make a list of all the things you can infer about the visitors to your feeding station.

Study the track marks. Can you distinguish the front feet from the rear? How are they similar? How are they different? How might their differences in form relate to their function?

How far apart are the front feet from the rear feet? What can this tell you about the size of the organism?

What other factors will determine how far apart the tracks are? How far apart will they be when the animal is walking? Running?

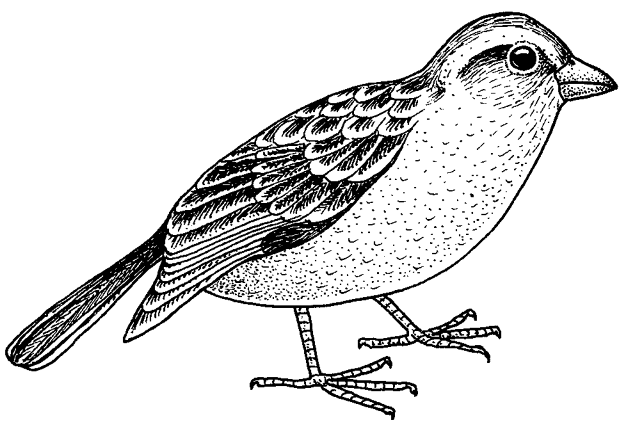
Can you tell from the tracks how many organisms visited the feeding station? If there are multiple sets of tracks, can you tell if it was the same animal or different animals?

Under what conditions in nature are you likely to find good tracks of animals?

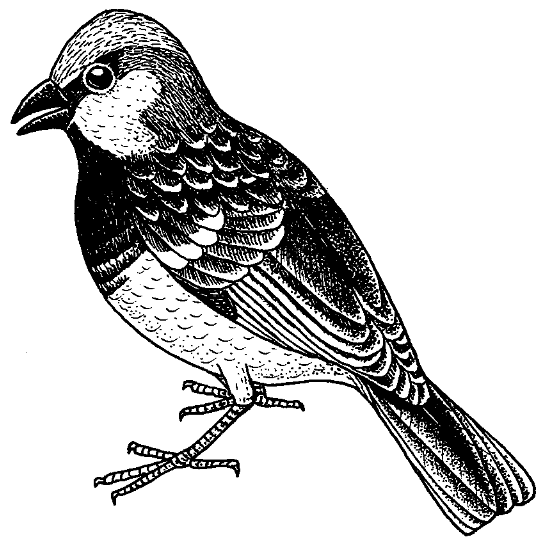
House Sparrow, or English Sparrow *(Passer domesticus)*

Family: Ploceidae, the Weaver Finch Family

House Sparrows are small birds, less than 13 centimeters (5 inches) long. Males can be distinguished from females by their black throats and white or gray cheeks--most prominent during the spring breeding season. In the fall this black bib may be partially masked by the gray tips of new feathers that replace those lost during the late summer molt. Females and juveniles are streaked with dull brown and are dull white to gray below.



Female House Sparrow



Male House Sparrow

House Sparrow Nests and Behavior

As reflected by their common name, House Sparrows most commonly build their nests in association with buildings and houses. A broken light fixture, a hole in the eaves, a shutter, or a rafter are all places you might find a House Sparrow nest. On occasion, a nest or group of nests may be seen in trees. House Sparrows are not really classified as in the same family as sparrows, but rather are included in the Weaver Finch Family. As their name implies, weaver finches weave materials together to make their nests. Grass, string, bits of paper and other trash are woven together to make the relatively large, ball-shaped nests.

To find House Sparrow nests, look for pieces of nest material hanging from an opening or from behind nooks and crannies. Also watch for unusual activity. Birds flying back and forth from the same location around your building may indicate a nest site. A nest may also be close by if you see a male perching in one spot and chirping loudly and rhythmically; this behavior is typical of a male attempting to attract a female to its nest site. Nests are used throughout the year. In spring and summer, broods are raised in the nest, while in winter the nest may be used for roosting at night. Peak nest-building occurs in the spring, but repair and cleaning take place throughout the year, and the birds may build a new nest for each brood.

After courtship, the female lays 4 to 6 eggs (1 per day), then begins 12 days of incubation. The female spends the bulk of this time incubating the eggs, but the male may take over during brief absences. All the eggs hatch at about the same time. The nestlings will remain in the nest—fed by the adults—or another 15 to 17 days, after which they will leave the nest as a group. These young birds will fly after adults and beg for food until they learn to feed themselves. They will often form flocks with other juveniles. The female may begin the next brood as soon as the young leave the nest.

House Sparrow History and Effects on Native Species

House Sparrows are also known as English Sparrows and were, in fact, first introduced to this country from England in 1850. As U.S. cities grew, and as this growth dramatically changed local habitats for birds, native bird species withdrew to less-disturbed areas. House Sparrows were introduced by well-intentioned citizens to fill the perceived void left by the withdrawal of native species. House Sparrows are now found throughout North America and compete with native species for food and nest sites, often to the detriment of the native populations, especially native birds that nest in cavities in hollow trees or other structures.

House Sparrows are very aggressive in their interactions with many song birds: Common behaviors include taking over prime nest sites, tearing up existing nests, destroying eggs, and pushing out nestlings. The history of the House Sparrow provides a classic example of how an introduced species can gain a foothold in a new environment and spread rapidly, outcompeting native species.

Attracting Birds

The easiest way for your class to have the opportunity to observe House Sparrows—and many other birds—is to set up a feeder outside your classroom window. Placing a bird feeder outside your schoolroom window will soon result in noisy visits by House Sparrows. They often move about together in large groups and are very aggressive toward other kinds of birds. When feeding at a bird feeder, they will drive off other visiting birds.

While House Sparrows are likely to be frequent and conspicuous visitors to your feeder, many different birds may also visit, depending on the location of the feeder, the feed you use, the time of year, and other factors. Many books give information on feeders, and you can also get information from local stores that sell bird seed and feeders or from local birding clubs.

House Sparrow Inquiries

You can pursue a number of different bird-watching inquiries, depending on opportunities that present themselves. The suggested inquiries below for House Sparrows can be adapted for other birds that might visit a feeder. A journal documenting observations may be an ideal way for older children to learn about these birds. Younger children can record information on checklists or charts with the class or on their own. Useful materials: bird feeders and various kinds of feed, binoculars, a bird field guide (see the Additional Materials chapter of this book for suggestions on field guides).

Observing Sparrows

Have your students watch House Sparrows around the building and grounds and, if one is available, around a feeder.

Do House Sparrows appear singly or in groups?

How many sparrows are in a group?

Are they quiet or noisy? What sounds do they make?

House Sparrow Inquiries, continued

Do they land on the feeder and stay there or constantly move about?

Where do they go when they are not on the feeder?

Why do they keep moving? How might this behavior be valuable to their survival?

House Sparrow Behavior

Have students watch House Sparrows as they visit a feeder.

What do House Sparrows do? Describe what you see them doing.

Can you describe certain behaviors that they seem to repeat over and over?

Choose a particular behavior to observe and measure. How often does the particular behavior occur? How long does the particular behavior last? What factors seem to influence the occurrence of this behavior?

Do they eat the seeds at the feeder or do they fly off with them?

Do they tend to feed more at the feeder or on the ground below?

What kinds of seeds do the House Sparrows prefer? Could you design an experiment to investigate this?

When do the House Sparrows come to the feeder? Are there certain times of the day when they are most frequent? Design a chart to help you investigate this.

How do House Sparrows respond to other birds around them or at a feeder? What do House Sparrows do when other birds are at the feeder?

Do other birds feed at the feeder when House Sparrows are present?

Birds and Energy Needs

These questions go beyond the information contained in the text. Once students are familiar with House Sparrows, you can use these questions to get students thinking about how birds in general survive.

Which requires more energy: sitting still or moving about? Flying or hopping?

How does temperature affect the amount of energy used by a bird?

What are sources of energy for the House Sparrow? For other birds? Make a chart showing different kinds of birds and their source(s) of energy.

What will happen to the bird if the amount of energy it uses exceeds the amount of energy it takes in?

What weather conditions place birds at greatest risk of having energy demands exceed its energy intake? Why?

What advantages might there be for staying in a group? What are the disadvantages?

Chapter 6. Trees

Introduction

One of the authors remembers being quite confused the first time an adult told him, "You can't see the forest for the trees!" In the study of natural history, ideally one would try to "see" both the forest *and* the individual trees, because there is much to learn from both. A given schoolyard, of course, might not have a forest or even a small woodlot nearby, but most schoolyards will have at least some trees. So for the purposes of schoolyard investigations, we consider a wooded lot, a stand of trees, or even a single tree a "tree habitat." Just one large tree in your schoolyard can provide many opportunities for investigation and exploration.

Tree *parts* also provide many subjects for study. Trees vary widely in the features of their trunks, bark, leaves, flowers, fruits, and other parts. Some tree parts—such as flowers and fruits—are only visible at particular times of the year, but at *any* time of year *some* part of a tree will be available for study. A later section in this chapter presents more detail on tree parts.

The Appalachians nurture the most diverse forest vegetation in the eastern United States and are home to well over 100 native species of trees. In addition, many more non-native trees have been introduced. So there is enormous variety in what you and your students may discover around your schools!

A Seasonal Note

Like most of the plants and animals mentioned in this book, trees provide many warm-weather opportunities for inquiry. But teachers are sometimes at a loss for winter science lessons or activities. Trees are good for study and inquiry anytime! The suggested inquiries in this chapter should give you several ideas to keep your students practicing science skills in winter. (Please see the Seasonal Guide near the end of this book for other suggestions on winter topics.)

Introductory Tree Inquiry

The Importance of Trees

Start a study of trees by beginning with students thinking about how important trees are to us.

Why are trees important?
What do you like about trees?
How is a tree important to you on a summer day?
What economic value do trees have? How are trees used by people?
How are trees important to the air we breathe?
What animals use trees? How?
What other plants use trees? How?
Can you think of any living things that are *neither* plant nor animal? If so, how do they use trees?

Trees and Their Surroundings

Trees affect their physical surroundings and other nearby organisms. The following paragraphs describe a number of ways that trees do so.

- **Effect on sunlight and temperature.** A tree provides shade in a location that would otherwise be exposed to full sun. With less light penetration, temperatures are lower than the surroundings, and organisms living underneath the tree are shielded from heat and water loss.
- **Effect on soil moisture.** Evaporation from the soil surface underneath a tree is reduced, so this soil *may* be moister than surrounding soil. On the other hand, trees require a lot of water. Huge quantities of water are lost through openings in tree leaves in the process called **transpiration.** A large tree has a vast root system that may be roughly equated to the size of the crown (the spread of the branches) above the ground. These roots can absorb so much water that, during extended periods without rain, you may find that the soil under a large tree is actually dryer than the soil in surrounding areas.
- **Effect on wind.** A tree may serve as a windbreak, reducing the force of the wind and sheltering organisms from the dangerous effects of winter wind. Humans also benefit from trees serving as windbreaks. Various factors determine the value of a tree as a windbreak, including how fast it grows, its shape, its strength, and whether or not it is a deciduous tree.
- **Competition with other plants.** Plants that are growing under a tree compete with the tree for light, water, and nutrients. For example, you may notice that grasses grow less densely underneath some trees than in surrounding areas. In many cases the cause of this will be some combination of reduced light penetration and the use by the tree of available water and nutrients.
- **Benefits to other plants and fungi.** Some kinds of plants may be found in *greater* numbers underneath a tree, because they can tolerate the conditions (lower light, for example) under the tree more effectively than other plants (such as the grasses). Trees can provide places and support for other plants to grow. Some plants, rather than putting energy into making hard or woody tissue, rely on other plants or structures to support their weight, diverting their energy into rapid growth, and elongating their stems. Japanese Honeysuckle, Poison Ivy, and grape vines are common examples of plants that will climb, wrap around, or drape themselves on trees. (See the section on Vines in the Fencerows chapter.)

  Trees also provide special habitats for other small plants. In southwestern Virginia, mosses and **lichens** growing on the bark are readily found on the shady sides of trees. Fungi can be found growing on or under trees. Certain mushrooms, the above-ground reproductive structures of some types of fungi, may be found only under certain types of trees. Below ground, a type of fungi called mycorrhizae often live intertwined with tree roots in an interdependent relationship; neither fungus nor tree is able to grow well without the other.
- **Habitat for animals.** Trees provide perches, hollows, and nest sites for many different kinds of animals. Use of trees by birds is most familiar, but trees are also used by amphibians, reptiles, and mammals. Among amphibians, some salamanders, such as the **Red-backed Salamander**, use the underground tunnels left by decaying tree roots as retreat sites when conditions on the forest floor become too harsh (in hot, dry summers, for example). Some salamanders also climb trees at night to feed on insects or other **invertebrates** on

the trees' bark, and some frogs spend much of their lives in trees. Among the reptiles, some snakes primarily live in trees. The **Rough Green Snake**, for example, hunts from tree branches and occasionally lays eggs in tree cavities. Mammals may dig burrows underneath the roots of trees, make nests in the branches, or find hollows inside the tree to occupy.

Trees also provide many nooks, crannies, and crevices for many smaller animals. The deeply furrowed bark of many older trees provides places for insects to hide, lay eggs, or form pupae—and consequently, for birds to forage. Underneath the bark, **bark beetles** excavate tunnels and chambers, while other beetle larvae burrow deeper into the wood of the tree. Branches and leaves provide habitats for many other organisms.

Trees also provide building material (twigs and strips of bark) for bird and mammal nests, while insects such as paper wasps use wood from trees to make paper for their nests.

- **Food for animals.** Tree leaves provide food for an enormous array of insects. Some feed directly on the leaves while others are predators that eat the leaf-feeders. The leaf-feeders may mine the inner layers of the leaf, pierce the leaf and feed on fluids, or physically chew up the entire leaf. Some of these insects will hide underneath the leaves, fold them or roll them into homes, or camouflage themselves by looking exactly like a leaf or twig.

  Many trees are flowering plants, so a variety of flowers are produced by trees. Some tree flowers provide nectar that attracts pollinating insects. (Other tree flowers are wind-pollinated and may produce a large amount of pollen, much to the distress of allergy sufferers.)

  Trees produce huge quantities of different fruits—nuts, berries, and acorns—and seeds, which are nutritious and important food sources for many birds and mammals. In large forests, the number of acorns produced from year to year has a major influence on the health and population growth of many game animals, such as deer, turkey, and squirrel. Many insects also utilize tree fruits for food, and particular insects' life cycles are synchronized with the development of the fruit.

- **Role in soil nutrient cycling.** As with soil moisture, soil nutrients are affected greatly by trees. Trees absorb large amounts of nutrients such as nitrogen, potassium, calcium, phosphorus, and magnesium. Much of this material ends up in the tree leaves. Leaf fall and subsequent decomposition return these essential materials to the soil for use not only by trees but by other plants as well. The leaf litter accumulating under a stand of trees creates a habitat for various organisms; many of these, including bacteria, fungi, and many animals, are involved in decomposing the litter, while others feed on the decomposers.

  While leaf fall is most often associated with deciduous trees, conifer needles also fall off eventually and produce leaf litter. Coniferous leaf litter has different effects on soil and soil organisms, especially because it can affect the soil acidity, as indicated by soil **pH**. Coniferous leaves tend to be more acidic than deciduous leaves. Higher acid levels tend to slow decomposition, so the needles of conifers tend to take longer to break down.

Changes as a Tree Ages

As a tree ages and dies, the ways that it provides or affects habitat change but do not become less important. The growth of trees may slow or cease due to changes in its environment. Possible changes include shading from other trees, drought, physical damage to the trunk or roots by natural or human causes, or attacks by bacteria, fungi, or invertebrate pests. Under such conditions, we say the tree is "stressed." Stressed trees are often targeted by insects, many kinds of which seem to thrive on trees in a weakened state. It is not unusual to find insect pests in far greater numbers on trees experiencing environmental stress than on nearby healthy trees. As insects invade a weakened tree, the activity of woodpeckers and other predators attempting to reach these insects creates even more new habitats and points of entry.

Fungi also attack a tree as it ages. Thread-like fungal fibers penetrate the tree, releasing enzymes that help break down the wood and change it into a form the fungi can use. It is only when the fungi form conspicuous reproductive structures, like those of the plate-like shelf fungi, that we realize the fungi are there.

When a tree falls, it becomes a rotting log and home to even more organisms of decay and decomposition. New kinds of habitats for other organisms become available as the wood continues to break down. Worms, slugs, pill bugs, centipedes, millipedes, salamanders, and snakes all might be found in or under a log. As the wood continues to decay, it will eventually become indistinguishable from the soil around it.

Trees and Their Surroundings Inquiries

⚠ ***When investigating trees, be on the lookout for Poison Ivy vines attached to the tree or growing nearby. See also the information on Poison Ivy in the Vines section of the Fencerows chapter. Also, remember that certain trees, such as Black Locust (discussed in the Fencerows chapter), have thorns.*** *These lines of inquiries investigate different ways that trees influence certain aspects of their surroundings. Keep in mind, however, that, although the inquiries look at individual aspects of a tree's surroundings, in reality a tree is affecting all these aspects simultaneously.*

The concept of a ***transect*** *can be useful in measurements of trees' effects. A transect is simply a line along which you make observations or measurements or take samples. A transect line can be set up by tying a string to a tree trunk and stretching it away from the trunk. Measurements, such as temperature, can then be made at measured points along the string to help quantify the effects of shade, etc.*

Useful materials: rulers or meter sticks, string, thermometers, soil thermometers (or roasting thermometers), trowel or shovel, anemometers (commercial or homemade—see Trees and Wind below), shoe boxes, Berlese funnel, pH paper.

Investigating Habitats and Food Provided by a Tree

Have your students go out to a large tree growing in your schoolyard.

Imagine this schoolyard without this tree.

How would this location be different if the tree were not here?

How would places to hide or eat be affected?

Examine the tree and describe how it provides *habitats* for animals, such as insects, amphibians, reptiles, birds, and mammals.
How do trees provide *food* for animals?
What parts of this tree could be eaten by different kinds of animals? Can you find any animals eating parts of the tree?
Can you find evidence that parts of this tree have actually been eaten?
What are some organisms that you can think of, or that you can identify through library research, that are associated with trees? Make a chart or poster to arrange this information.
What organisms can you *actually find* on the tree?
How does the habitat provided by trees change during the year?
How does the food provided by trees change during the year?
How do the habitat and food provided by a tree change as the tree *ages*?

Trees and Sunlight

Consider having some students use a deciduous tree to pursue this line of inquiry, while other students use an evergreen tree.
How does the tree affect the amount of light that reaches the ground underneath it?
Measure the area covered by the tree's shadow at different times of the day. Make a chart or graph to record and summarize the data.
How does the area affected by the shadow change during the course of the day?
How might plants living under the tree respond to these daily changes? How might animals respond?
How will this tree's shadow change with changing *seasons*? How could you measure this?

Trees and Ground Surface Temperature

Start by having students make predictions about the effect of trees on the temperature of the ground surrounding the tree, and how this will vary with distance from the tree. Then, on a sunny day, have students measure the temperature at 1-meter intervals from the base of the tree by placing a thermometer face up on the surface of the ground. Have different groups do this for different transects or directions from the tree.
Make a graph showing the temperature changes, and describe the patterns you observed.
How might the temperature variation you observed affect where plants and animals are likely to be found?
How would you expect the temperatures you observed to change during the *day*?

Trees and Their Surroundings Inquiries, Continued

How would you expect the temperatures to change during the *year*?
Try this same experiment, but measure air temperature one meter off the ground. Keep all thermometers shaded. How do your results compare?
As a closing or follow-up activity, set up a temperature scavenger hunt. Designate boundaries, then turn your students loose with thermometers, pencils, and paper to find the hottest and coolest places in the schoolyard.

Trees and Soil Temperature

Soil thermometers can be purchased at a reasonable cost from a science supply company or from (probably) your local farm or garden supply store. A soil thermometer looks just like a kitchen thermometer used for taking the temperature inside a roast or turkey. Alternatively, you can measure soil temperatures by using a trowel to cut a crease in the soil wide enough to insert a thermometer into the ground. Be sure to measure the temperature at the same depth every time.
How do soil temperatures vary as you move away from the tree?
How will this variation affect plants growing here? Animals? Soil organisms, such as earthworms?
Where are soil temperatures the highest in your schoolyard? Lowest? How can you explain these observations?

Trees and Soil Moisture

How do trees affect soil moisture?
How do sunlight and temperature affect moisture in the soil?
Where would you expect the soil to be moistest? Least moist? Why?
How could you measure soil moisture to test the hypotheses or guesses you just made? How will recent rains affect your measurements? How will time of day affect your measurements?
Do trees compete with surrounding plants for moisture? What might be the effect of such competition?
Even though a tree provides a lot of shade, how could it actually cause the soil to be drier underneath it compared with farther away? Can you find any evidence that this actually is happening?
How much water do you think a large tree needs daily to survive? See how your prediction compares to values given in reference books.
(For more on water use by trees, see the line of inquiry entitled "Leaves and Water Loss" in the Tree Parts section of this chapter.)

Trees and Wind

Inexpensive anemometers (wind-speed measuring devices) can be made from index cards, paper clips, and coat hangers. The Delta Education company of Hudson, New Hampshire, publishes a booklet on how to make them (this source is listed in the Additional Materials chapter of this book), or you may find instructions in other references. If you are able to find or make anemometers, have your students use them to investigate how wind and wind speed are affected by trees on your school grounds.

Where are the windiest locations on your school grounds? The least windy locations?

What factors affect the wind speed on your school grounds?

What impact do trees have on the wind?

How important is wind to plants and animals?

What is "wind chill"? How dangerous can wind chill be to animals?

Do you have any sites on your school grounds where the wind is significantly affected by a stand of trees?

Do you have locations where planting a stand of trees could serve as a "windbreak"? What factors would be important for you to consider to answer this question?

How could these windbreaks save money for your school?

What kind of trees would you choose to plant in a windbreak? What qualities of the tree type would be important to you in making this decision?

Competition Between a Tree and Other Plants

How does the shade produced by a tree affect the plants that grow underneath it?

Do all plants require the same amount of sunlight in order to grow?

Can you find any plants that are growing under the tree but are not growing elsewhere?

Can you find plants that are growing in full sun but not under the tree?

How could we quantify these observations?

How do we know that the plants we find under a tree are there because of the *shade* created by the tree? What evidence do we have?

What other *tree influences* might affect the plants found around the tree?

What other *non-tree influences* might affect these other plants?

Trees and Their Surroundings Inquiries, Continued

Leaf Litter and Decomposition

⚠ ***When collecting leaf litter, caution students to be on the look-out for spiders, centipedes, or other stinging or biting organisms that might be hidden in the leaf litter*** *(see also the section on Millipedes and Centipedes in the Roofs, Walls, and Eaves chapter). If you have a stand of trees in your schoolyard, you will have a source of leaf litter with which to investigate decomposition and recycling of the materials needed for plants. Using a shovel or trowel, carefully place cross-sections of leaves and soil in shoe boxes so that groups of three or four students can examine the leaves, either outdoors or back in the classroom. Be sure not to disturb the integrity of the layers.*

Describe the material in your box.

How does the material change as you go downward through the layers?

When do you think the leaves on the top fell to the ground?

What will happen to these leaves on the top over time? How do you think they will change?

Find some partially decomposed leaves in the litter layer. How are they different from the leaves on the top? How have they changed? Which parts of the leaves decompose first?

What factors do you think affect leaf decomposition?

What kinds of animals can you find in the leaf litter? What are these organisms doing here?

What does this habitat provide for animals?

Why is the decomposition of leaves so important in a forest ecosystem?

What would the forest look like ten years from now if decomposition suddenly halted?

How is decomposition of leaves important in recycling nutrients (materials needed by plants and animals)?

What materials are returned to the soil through decomposition of leaves?

How can you find out more about nutrient cycling?

Comparing Deciduous Leaf Litter to Coniferous Leaf Litter

If you have both a stand of deciduous trees and a stand of coniferous trees, you will have an excellent opportunity to compare different types of leaf litter. Take your students to both sites and have them walk on both types of litter and make their own observations.

How are the two types of leaf litter similar? How are they different?

Walk across each. How do they feel under your feet? Which is spongiest? Why?

Have your students measure out equal amounts of leaf litter from the two sites and mix these into equal quantities of water. Use pH paper to measure the pH of the solutions.

How does the pH compare at first?

How does the pH in the water change over several days? How can you explain this?

What is the effect of acidity on plants and animals? How could we find out?

How do the plants growing beneath conifers differ from those growing beneath deciduous trees?

How do the animals living in conifer leaf litter differ from those in deciduous leaf litter? *(You can use a Berlese funnel to separate organisms from the litter. See the description of a Berlese funnel in the Collecting Insects section of the Fencerows chapter.)*

How can you explain these differences?

Tree Parts

⚠ *As mentioned in the preceding section, "Trees and Their Surroundings," watch for Poison Ivy growing on or around trees.*

The different and distinct parts of trees offer a rich resource for learning about plant structures and functions in general, as well as about how trees specifically interact with their ecosystems. Tree parts are also a handy resource for learning about natural *diversity*, for two reasons. First, there is great variation among trees in leaves, reproductive structures, roots, trunks, branches, buds, and bark. Second, each kind of tree typically has many organisms associated with it, from fungi to insects to birds and mammals. Some of these organisms are unique to a particular kind or family of trees, while others may be less discerning. Investigations into tree parts lead easily into learning about the organisms that inhabit or make use of those parts.

This section is divided into seven topic areas: **tree shapes, trunks, bark, leaves, twigs, flowers**, and **fruits**. Collectively, these topics offer dozens of inquiry possibilities over all seasons of the year. We have compiled a number of possible lines of inquiry on these topics. Most of these inquiries require only minimal specific content information, because the questions ask about the particular characteristics of the trees and tree parts that students find and observe in their schoolyard. Before presenting the lines of inquiry, however, we have included some basic content points on each of the topic areas.

Tree Shapes

- Tree species often have characteristic shapes, which in many cases can be used to identify the kind of tree.
- But growth conditions will affect shape. Trees growing out in the open, with plenty of available light, tend to branch more laterally than trees of the same species growing within a forest.

Trunks

- The trunk is the main stem of the tree.
- As the stem, the trunk provides an attachment point for branches and leaves, and it contains a system of tubes used for moving materials back and forth from the leaves and branches to the roots.
- The trunk grows laterally as well as vertically. In temperate climates, the lateral growth results in the annual rings that can be used to estimate a tree's age. In the tropics and subtropics, however, trees grow multiple rings each year.
- Different kinds of trees have different arrangements of branches on the trunk.

Bark

- Bark is a protective covering over the trunk and branches. Removal of bark or holes in the bark makes a tree vulnerable to diseases and to insects.
- Different kinds of trees often have bark with characteristic color, patterns, or odor.
- The bark tends to be thicker on lower portions of the trunk and branches.
- Many animals—mostly insects—live in or under bark, sometimes on a specific kind of tree.
- Algae, mosses, and lichens are kind of plants that can be found growing on tree bark. In addition, some kinds of fungi--which are not plants--grow on tree bark.

Leaves

- Leaves are the main site where the tree makes food in the process of photosynthesis.
- Most flowering trees are "broad-leaved," meaning they have flat or broad deciduous leaves. In southwestern Virginia, most of the broad-leaved trees are deciduous, meaning they shed their leaves in the fall. Some other broad-leaved trees, however, such as hollies, are evergreen. Most conifers have

needle-like or scale-like evergreen leaves. These leaves are shed periodically, although not all at one time.

- Needles may be in bundles or arranged along a twig in a characteristic way, such as spirals or circles (known as "whorls") around the twig.
- In broad-leaved trees, leaf shape, arrangement, type of edge, and other features all vary depending on species, but the features follow recognizable patterns. These are important characteristics in identifying trees.
- Broad-leaved trees may have **simple** or **compound** leaves. Simple leaves are made up of only one blade; compound leaves have many blades, called **leaflets**, making up a single leaf. The distinction between leaves and leaflets is important in distinguishing many types of trees.
- Two key features indicate a leaf instead of a leaflet: 1) If you break off a leaf, the twig has a "leaf scar" where the leaf was attached, showing a cross-section of the tubes that carry water and nutrients to and from the leaf; and 2) leaves have buds at the base of their attachment stalk, whereas leaflets do not.
- Leaf veins are extensions of the material-transport tubes in the stem (which are seen in cross-section in the leaf scar). They carry water and nutrients to the leaf, and carry food produced in photosynthesis away from the leaf to the other parts of the tree.
- Broad leaves have openings through which gases (such as carbon dioxide) can be absorbed. In addition, however, water can be lost from the tree through these same openings. This water loss, known as transpiration, has important consequences for water use by the tree.
- Deciduous leaves change color in the fall when green-appearing pigments—the ones most involved in photosynthesis—break down and reveal pigments of other colors (such as yellow, red, or orange).

Twigs

- Twigs are extensions of the trunk and branches, and so they are part of the stem of the tree.
- Twigs are where new growth and development of tree parts occurs. Buds on the twig develop into new shoots (young stems), leaves, or flowers. Before the new growth or development occurs, the buds protect the immature structures.
- Buds and leaf scars on twigs are important characteristics used to identify deciduous tree types in winter or early spring, when leaves are not present.

Flowers

- As in all flowering plants, a tree's flowers are where sexual reproduction takes place.
- A given tree may have only one type of flower, with male and female parts, or may have separate male and female flowers. In some kinds of trees, male and female flowers are found on the same tree, while in other kinds of trees the two types of flowers are found on separate trees.
- Regardless of the type or location of flowers, pollination is necessary to get pollen from the male flower (or flower part) to the female flower (or flower part). Wind and animals, especially insects, are the two main means of pollination.
- Flowers' showy colors, fragrances, and energy-rich nectar are ways that plants attract pollinators.
- Most schoolyard evergreen trees, such as pines and cedars, are conifers and do not flower. (For more on this topic, see the section on Eastern Redcedar in the Fencerows chapter.)

Fruits

- Fruits are the structures that contain a flowering tree's seeds.
- We usually think of "fleshy" fruits like an apple, but there are many kinds of tree fruits, including acorns, walnuts, and the "keys" of maple trees.
- If the tree does not flower, it will not produce a fruit. Conifers, such as pines and spruces, do not have flowers, so they do not produce fruits. Conifers' seeds are contained in seed cones, rather than in true fruits.
- Fruits play a role in the spreading, or dispersal, of a tree's seeds. As with pollination, seed dispersal in many trees relies on animals and wind (depending on the kind of tree). The winged fruit of maple trees is a good example of how to spread seeds by wind; those of cherry trees are a good example of how to spread seeds by animals, especially birds. (For more on this topic, see the section on Black Cherry in the Fencerows chapter.)

Tree Shapes Inquiries

Useful materials: Field guide to trees (see the Additional Materials chapter of this book for suggested references).

Characteristic Shapes of Trees

From a distance, look at the shapes of several different types of trees (*e.g.*, a cedar, a spruce, an oak).

How do their shapes differ? How are they similar?

How are the branches arranged on the tree?

Do trees of the same type have a characteristic arrangement of branches? Explain.

Can you look at trees and find patterns that distinguish one tree from another? Try sketching the general pattern of these trees.

See if other students can use your pattern to identify the tree type. What features did they use to help them identify the tree by shape alone?

Factors that Affect Tree Shape

What factors affect the shape of the tree?

How does growing against the side of the building affect the shape of the tree?

Compare the shape of a tree growing in the forest with the same kind of tree growing in an open field (choose a type of tree you can easily identify). How do the shapes differ? What could cause the difference?

Walk around your school grounds. Can you identify trees whose typical shape seems to have been affected by something? How have they been affected? What factors influenced their shape?

Tree Trunks Inquiries

⚠ *Watch for Poison Ivy growing on tree trunks. Useful materials: string, rulers or meter sticks, flexible tape measures.*

Measuring Tree Trunks

Diameter and circumference are two easy measurements for comparing trunk size. As a standard for comparing the mass of trees, professional foresters and ecologists measure the "diameter at breast height," or DBH.

How "thick" is the trunk?

What are different things we could measure to compare the thickness of the trunk?

How could you measure the diameter/circumference?

If you only had a piece of string and a ruler, how would you measure the circumference?

Where is the trunk widest or where is the circumference greatest? How does the circumference change as you move up the trunk? Why is this so?

If you want to compare the diameter/circumference of different trees, where on the trees would you measure?

How do the trunks of different trees compare?

What is the function of a tree trunk?

Tree Age

If there are any cut or fallen trees in or near your schoolyard, you can estimate their age by the well-known method of counting the annual growth rings. Alternately, ask a parent who cuts wood for burning in a wood stove to cut some 4 to 8 centimeter slices (cross-sections) of wood from the un-split trunk of a fallen tree. Request at least 10 slices so that students can work in groups of 2 or 3.

How many years old was this tree when it was cut?

How do you know?

Did the tree grow the same amount each year?

In which year did it grow the most? The least?

What might cause a tree to grow a lot in one year and very little in another year?

List all the factors that you can think of that might affect how well a tree grows.

What else can the tree rings tell you about the life of this tree?

Where in the world would you find trees that do **not** show annual growth rings? In these places, what climate factors make the difference?

Tree Trunks Inquiries, continued

Age of Conifers

The age of many conifers can be determined by counting the number of whorls (levels) of branches radiating out from the trunk of the tree. A new whorl of branches is added each year; the distance between whorls indicates a year's growth of the trunk. White Pines show this most conspicuously (see also the section on White Pines, later in this chapter).

How old is this tree?

How tall was the tree 3 years ago?

How tall was the tree when it was 5 years old?

Has it grown the same amount in height each year?

Choose two years in the life of the tree, one when it grew a lot and one when it grew less. Look for weather records and compare the rainfall, snowfall, and average temperatures of those two years.

Tree Bark Inquiries

Useful materials: field guide to trees showing photos of bark (see the Additional Materials chapter for suggested references), drawing paper, crayons (with wrappers removed).

Features and Functions of Bark

Take your class outside to examine the bark of a tree.

Describe or sketch the bark.

What color is it?

How does it feel?

Peel or break a *small* piece of bark off the tree. Smell it. Does it have a distinct odor? Try snipping off a small piece of twig and peel back the bark and smell it, too. Does it have a distinct odor?

How thick is the bark? Is it the same thickness everywhere? How does the bark thickness change going up the tree?

How does the bark of the tree you are looking at compare to the bark of surrounding trees?

What is the function of bark? What if the tree did not have any bark?

Can you find any places on the tree where the bark was disturbed? What do you think caused this?

What effect does bark damage or loss have on the tree?

Does bark grow back over a damaged place? Can a tree heal itself?

What are some natural ways that trees are damaged? What are some human-influenced causes? How could human-caused damage be reduced?

Bark Inhabitants

Have your students examine the bark of a tree for organisms or signs of organisms living there. Be sure to look for eggs, egg cases, pupae, cocoons, and cast skins. In addition, you may find wastes from wood-burrowing insects or the remains of tunnels cut in the wood. You may also find plant inhabitants on the bark: lichens, moss, or algae (a green tint indicates algae).

What organisms can you find on the bark of the tree you are observing?

If the tree is dead and you can peel back loose pieces of bark, look for organisms or clues to the presence of organisms that may have been there.

Sketch the organisms that you find.

Where did you find organisms or signs of them?

Describe or sketch the habitats that bark provides for various small organisms.

Bark Rubbings

Have students make bark rubbings by placing a piece of paper against the tree and rubbing it with the side of a crayon (with the paper wrapper removed). If possible, have a field guide to trees available for students to compare photos of different trees' bark.

Describe the pattern produced by your bark rubbing.

Compare and contrast bark rubbings from different trees.

Exchange bark rubbings with another student. Can you find the tree or type of tree from which the rubbing was made? What were the key features that allowed you to identify it?

Could you identify a tree by observing the bark?

Do some kinds of trees have more distinctive bark than others?

As a project, make a collection of bark rubbings from different trees and display them beside the leaves of those trees.

Tree Leaves Inquiries

The possibilities for inquiry lessons based on leaves are not quite as numerous as the leaves on a tree, but almost! Deciduous trees will probably offer more options, but don't neglect the evergreens, especially in the winter. Useful materials: field guide to trees with good photos of leaves (see the Additional Materials chapter for suggested references), hand lenses, marking tape to tag twigs, weighing balances, graph paper, pH paper,

Tree Leaves Inquiries, continued

water, Cobalt Blue Paper (see "Leaves and Water Loss" below for information on Cobalt Blue Paper), plastic bags, graduated cylinders (or narrow clear containers), rulers.

Investigating the Needle-like Leaves of an Evergreen

Are the needles arranged in bundles?
If so, how many needles are there per bundle?
Compare the number of needles in 10 randomly selected bundles. Does the number of needles in a bundle vary on the same tree?
If the needles are not arranged in bundles, how are they arranged on the tree?
What is the shape of an individual needle? Can you roll it in your fingers?
Break a needle in the middle and look at its cross-section. How many sides does it have?
Do the needles from different kinds of evergreens have different cross-sectional shapes?

Investigating the Broad, Flat Leaves of a Deciduous Tree

How are the leaves attached to the tree: opposite each other, in an alternating pattern, or circling the twig?
Is the leaf made up of a single leaf blade or of many leaflets?
Examine the leaf carefully. What is its overall shape?
Look at the edges of the leaf. Are they smooth or "toothed" (jagged)?
Compare several leaves from the same tree. Are they all alike? How do they differ? What features do they all have in common?
Sketch or describe the pattern of veins.
What is the function of a leaf?
What do leaves need to do their job? Where do they get the materials to do this job? How do these materials get to the leaf?
Compare the top and bottom of a leaf. How do they feel? How do they differ?
Use a hand lens to look at the leaf surfaces and edges closely. What does the hand lens reveal that you had not noticed before?

Comparing Leaves from Different Trees

Students will need to know the difference between a leaf and a leaflet (see the background information on leaves above, or the "leaf" entry in the Glossary). A systematic way to compare leaves is a **dichotomous key,** *found in many field guides. A dichotomous key poses a series of questions about progressively more specific characteristics. For example: Are the leaves* *deciduous or evergreen? If deciduous, are the leaves simple or compound? And so on. See if your students can develop their own.*

Compare leaves from different trees. How are they similar? How do they differ?

Take leaves from many different trees. How could you group them?

What features allow you to distinguish the leaves of one tree from those of another?

Can you come up with a system of questions and answers to distinguish leaves from different trees? Try it!

Observing Leaf Growth and Development

Have your students tag a branch of a tree and watch the buds daily to see how they change and how leaves develop.

How do the buds change over time?

What eventually appears from the buds?

How do the leaves change over time?

How fast do the leaves grow? Measure one each day and record its change in width and length.

Tree Leaf Math 1: How Many Leaves?

Lead your students through this procedure for estimating the number of leaves on a tree. The estimate can then be used in the other "tree leaf math" inquiries that follow.

Look at a tree and make a guess of how many leaves are on the tree.

Estimate of the number of leaves: Count the number of leaves on one or more branches; determine the average number of leaves per branch; then count or estimate the number of branches.

Record your estimates on a class list. How much do the estimates vary among the class?

Can you think of a better way to make an estimate?

Tree Leaf Math 2: Weight of Leaves

If your students have made an estimate of the number of leaves on a tree ("Tree Leaf Math 1: How Many Leaves?" above), they can then estimate the weight of leaves on the tree. You can encourage students to work out their own plan to do this, but here is the basic procedure: 1) Use a balance to weigh enough leaves to get a reliable reading; 2) divide by the total number of leaves you weighed to get an average *weight per leaf; 3) multiply this value by an estimate of the number of leaves on the tree to get an estimate of the total weight of leaves.*

How many grams/kilograms/pounds do you think the leaves in a tree weigh?

Tree Leaves Inquiries, continued

Design a method to estimate the weight of leaves in the tree.
Does the total weight of the leaves surprise you?
What does the weight of these leaves tell you about the nature of the branches and trunk?
What might happen to a deciduous tree if the leaves did not fall off before winter snow (or ice) falls?

Tree Leaf Math 3: Leaf Area

If your students have made an estimate of the number of leaves on a tree, they can then estimate the total area covered by the le aves. The area of a single leaf can be estimated as follows: Place the leaf on graph paper; trace the outline of the leaf; count the number of squares inside the outline (use fractions for partially enclosed squares); then multiply the number of enclosed squares by the area of a single square. Graph paper with 1-centimeter squares works well. The area of one leaf can be multiplied by the estimate of the total number of leaves on a tree to estimate total surface area. Note: Plant scientists measure only one *side of hardwood leaves in estimating the* functional *area, because the top surface accounts for most of the photosynthesis carried out by a leaf.*
What do you think is the area of a single leaf (the top side only)?
Using graph paper, devise a way to measure the area of a leaf.
Do several leaves and determine the average surface area.
Now, what do you think is the *total* area of the leaves on a tree? How could you estimate this?
If you stretched this area out on a playground, how much area do you think it would cover? Express your answer in square meters, then mark off this many square meters in the play ground. Are you surprised?
How does it help a tree to have a large total leaf area?

Leaves and Water Loss (Transpiration)

Method 1: Your students can measure water loss through leaf openings (transpiration) by the following method. Place a plastic bag around a group of leaves at the end of a branch and tie the bag off tightly with a piece of string or a "twisty-tie." Leave the bags on for one day or longer, then return to measure the water in the bags. If you have access to graduated cylinders, use them for this measurement, as the amounts of water will be small. If you don't have graduated cylinders, you can compare relative amounts of water in each bag by pouring the water into any narrow, clear container and measuring the height of the water column with a ruler. Try putting bags on the branches of different trees in similar locations.

What do you see in the bags?
How did water get in the bags?
Is there enough water in the bags to measure?
Which trees released the most water?
What effect did location of the trees have on the amount of water lost?
What effect does the sun have on the amount of water that is lost from the leaves?
Do you think placing the bag around the leaves affects how much water is lost by the leaves compared to having no bag on the leaves? Do you change the environment of the leaves by putting a bag on them?
If you did this experiment again, what weather conditions might you want to record?

Method 2: Another way to measure transpiration is to use Cobalt Blue Paper. Cobalt Blue Paper turns pink when exposed to moisture. If you time how long it takes for a piece of Cobalt Blue Paper that is clipped to a leaf to turn pink, you will have a rough measure of the rate of water from the leaf. Use paper clips to fasten strips of Cobalt Blue Paper to living leaves (make sure the surfaces of the leaves are dry). You may wish to sandwich the Cobalt Blue Paper between the leaf and a piece of clear plastic wrap. Cobalt Blue paper can be purchased from a science supply company. A local high school biology teacher can probably help you find a source of Cobalt Blue paper.
Does paper attached to the top of a leaf change as fast as the one clipped to the bottom of a leaf? Why?
Does the location of the leaf on the tree affect the rate of transpiration? If so, how?
How does the rate of transpiration change under different weather: sunny vs. cloudy, dry vs. humid, or windy vs. calm?
Do you think different plants have different rates of transpiration? How could you find out?

Are Leaves Waterproof?

Can water soak into a leaf?
What happens if you drop some water onto a leaf?
What happens if you drop some water onto a paper towel? Onto a piece of wood? Onto your skin?
Make a chart to compare the results of dropping water on various materials.
Try leaves from different trees (or other plants) and see if the results are the same.

Tree Leaves Inquiries, continued

Leaf Colors

In the fall, have your students collect a representative leaf from a tree every couple of days as the colors change from green to various colors to brown. Have the students save the leaves and make a chart showing the changes. For ways to save leaves, see the section entitled Ways to Record Leaf Features for Further Study, at the end of this chapter.

How many different colors can be found?

Do certain trees display certain colors in the fall?

How many different colors appear in the leaves of a single tree?

Do all the leaves on a tree change color at the same time?

Describe the pattern of colors shown by the leaves on a tree. How can you explain this pattern?

Compare leaf-color patterns for several trees. What factors seem to affect the color change?

Tree Twigs Inquiries

Twigs can be studied all year, but they make an especially good subject in winter. A tree field guide will give you information on the important features of twigs. Useful materials: tree field guide, pruning shears, marking tape or tags for labeling twigs, hand lenses.

The Features of Twigs and Buds

Have your students examine the twigs of a tree. If it is likely that the tree you are looking at will be pruned back soon, you may wish to remove a few twigs to allow students to view them more closely in small groups. To minimize damage to the tree, always use pruning shears (not scissors) to leave a clean cut when collecting twigs.

What features can be observed on the twig?

Are buds present?

What are the parts of a bud? Take one apart and look at the parts with a hand lens. Describe what you found inside.

What did you learn about buds by taking one apart?

How are the outer layers of the bud different from what is inside? What is the function of these outer layers?

What other features can you observe on the twig? Can you find a structure that shows where leaves were previously attached?

Comparing Twigs from Different Trees

Collect short *sections of twigs from different trees in your schoolyard after leaves have fallen from the trees. Label the twigs, keeping track of the type of tree from which the twigs were collected. Give these twigs to students to see if they can find the tree(s) from which the twigs were taken. You could also set up a matching game indoors.*

How are the twigs you see similar? How are they different?

What features can you use to help you match twig to tree?

Describe these features for the different twigs or trees.

Is it hard or easy to tell trees apart by their twigs alone?

Try grouping different tree types based on their twigs.

Check a tree identification book to see how scientists group trees and tell them apart according to twigs. Try coming up with your own system!

Twig Growth Rates: Comparing Trees

On several different types of trees, have students mark a twig, measure the length of the twig in the spring before the buds have opened, then measure the length of the same twig before the end of school in June. Record how much the twigs of the different tree types grew in that time period.

Which trees grew fastest in this time period?

Why do some trees grow faster than others?

Which type of tree would you plant in your yard if you want to have some shade as soon as possible?

What other features of the tree would you consider when deciding what tree to plant in your yard?

Tree Flowers Inquiry

Springtime in southwestern Virginia is ideal for enjoying—and investigating—flowering trees! Useful materials: tree field guide showing flowers, hand lenses.

Finding and Describing Tree Flowers

On a late spring day, designate boundaries in the schoolyard where students can search for flowering trees.

Do trees have flowers?

Do *all* trees have flowers?

Find five different trees in the schoolyard, and record whether the trees have flowers or not.

Do the trees you found without flowers *ever* have them? When?

What kinds of trees can you find in the schoolyard that *never* have flowers?

Bring the class to an area where there are trees in flower. Have individuals or groups examine some of the trees. Provide data sheets for students to record information while examining different trees.

Does the tree you are studying have obvious or hard-to-see flowers?

What are the features of the flowers?

Are all the flowers on the tree the same, or are there different types?

How can you explain the difference in flower forms?

Do male and female flowers appear on the same tree or on different trees?

What are the functions of flowers?

What features do the flowers have to attract pollinators?

Can you observe pollinating insects visiting the flowers?

If the flowers do not attract pollinators, how is pollen carried from tree to tree?

How do wind-pollinated trees increase their chances that pollination will occur?

Tree Fruits and Seeds Inquiries

Useful materials: window fan, cardboard boxes.

How Trees Spread to New Areas

Bring students to a fruiting tree.

Describe the fruit produced by the tree.
What is the function of a fruit?
How many seeds does this fruit contain?
How are the seeds spread? Are animals involved in the seed dispersal? What animals? How are they involved?
How many seeds are produced by the tree? How could you estimate seed production?
Why do trees produce many seeds?

Measuring Fruit and Seed Fall

Place boxes at varying distances from the trunk of a tree in fruit. Return with your students periodically to make observations and records.

How many fruits fell into the different boxes?
How many total seeds were contained in these fruits?
How could you use this information to determine how many seeds this tree produces?
How does this tree's fruit and seed production compare to other trees?

Measuring Wind Dispersal

Have your students collect different seeds from different trees and drop them in front of a window fan in your classroom.

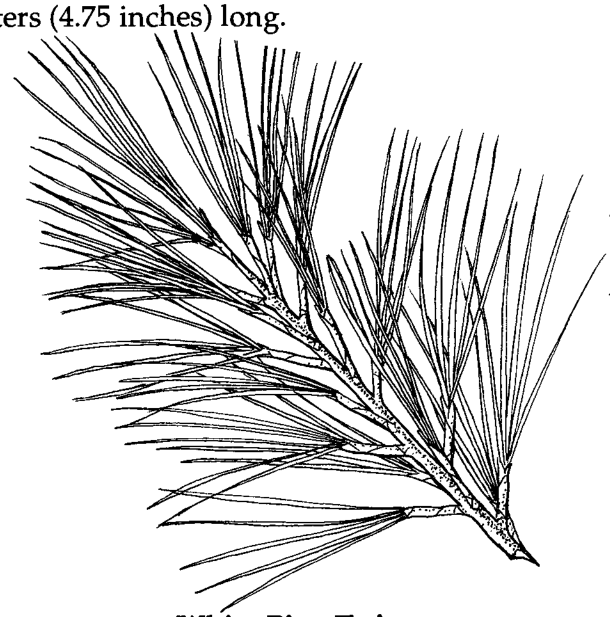
Record how far each type of seed travels when dropped in front of the fan.
Which seeds travel the farthest?
Design a graph to communicate your results.
Which seeds do you think are best adapted for being spread by the wind?
What features do they have that help them take advantage of the wind?
Design your own wind-spread seed.

White Pine *(Pinus strobus)*

Family: Pinaceae, the Pine Family

We often see White Pines planted, individually or as a hedge, around homes, businesses, and schoolyards. But White Pines are also an important component of Appalachian forests, and these trees can be seen scattered throughout coves and hardwood stands in the mountains of southwestern Virginia. Not considered a shade-tolerant tree, White Pine will sprout from seeds and grow rapidly when sunlight becomes available in natural or human-made clearings. But as the pines grow taller, and as shade-tolerant hardwoods also grow, new White Pine seedlings will not be able to sprout in the shady understory. For this reason, a stand of White Pines growing in a forest typically has trees all of the same age. White Pines will eventually give way to other species through the natural process of forest succession.

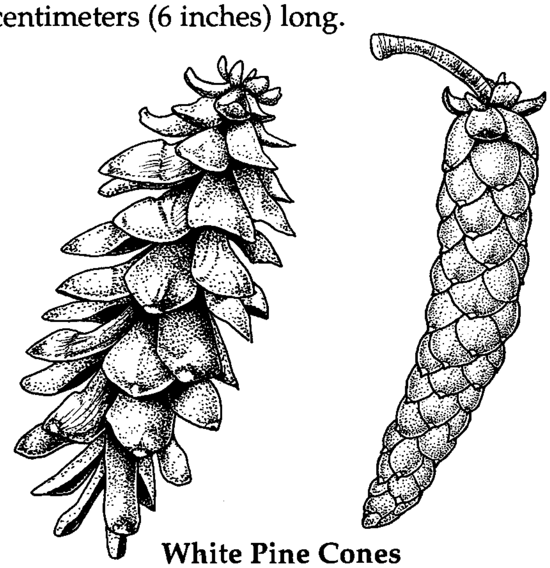
Look at a White Pine twig and you will see needles arranged *in bundles*. White Pine can be distinguished from all other pines in southwest Virginia by the number of needles in the bundles. White Pine is the only pine commonly found in our area that has *five needles in a bundle*. These slender, blue-green needles are around 12 centimeters (4.75 inches) long.



White Pine Twig

White Pine bark is gray and smooth on younger trees, but thick and deeply furrowed on older trees. Young trees have branches all the way to the ground, while more mature trees often will have lost these lower branches. The branches typically are arranged in whorls (circles) around the trunk; each whorl of branches is produced in a given year, so the distance between whorls indicates a year's growth of the trunk.

The male and female cones of White Pine occur on branch tips in early spring. The male cones fall after shedding pollen, while the female cones develop over a two-year period. The distinctive mature female cones are cylindrical, curved, and about 15 centimeters (6 inches) long.



White Pine Cones

White Pine History and Uses

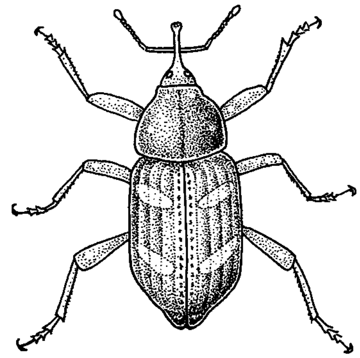
Planted widely as windbreaks, as visual barriers, for landscaping, and on Christmas tree farms covering many acres, White Pine is often seen outside of the forest. On tree farms throughout southwestern Virginia, one sees acres of neat rows of short, conical trees. So it may take imagination to think of this tree as it once was—one of the most majestic of forest trees. Towering as high as 67 meters (220 feet), with trunk diameters of up to 1 meter (3.5 feet) or more, the long, straight trunks of these trees were of great value to the ship-building industry in colonial times. Each tall mast on sailing ships required a single timber in one piece. In England, timbers of this length became so scarce that the king claimed for the crown all White Pines in the colonies that were 24 inches or more in diameter. When found, these trees were to be marked on the trunks to identify the king's ownership of the tree. The tallest White Pine today can be found in Porcupine Mountains State Park, Michigan, and is 48.1 meters (158 feet) tall. White Pines growing to heights of nearly 30 meters (100 feet) are more typical, however.

While no longer treasured for ship masts, White Pine still has great value for lumber and furniture. White Pine boards, 30 centimeters (12 inches) wide, are sold as shelving board in local hardware and lumber stores. The wood is also used for construction lumber and for pulp wood to make paper. It is a soft wood that is easy to cut and smooth, but it can be also be dented easily, so it is not often used in fine furniture or flooring. You can find, however, many antique pieces and reproductions made from "knotty pine."

White Pine and Other Organisms

White Pine seeds are consumed by many birds as well as rodents. Like other evergreens, White Pines provide year-round cover for wildlife. In addition to finding evidence of larger animals in and around White Pines, you will also find a number of other organisms (especially insects and fungi) that target this tree for food or a place to live.

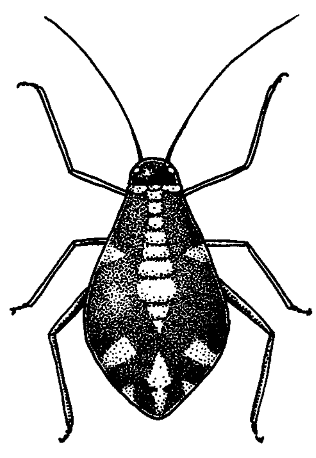
White Pines may suffer significant damage from the **White Pine Weevil**, the larvae of which tunnel into and destroy the terminal growing tip of the trees. This results in trees with little commercial value, because the stems grow crooked. Another organism, which can eventually result in death of the tree, is the **White Pine Blister Rust**, a fungus that causes swollen cankers on stems and branches. When reproducing,



White Pine Weevil

this fungus forms yellow-orange blisters that release millions of tiny spores.

Another common insect on White Pines is the **White Pine Aphid**. This black aphid can be found on the tender tips of new twigs throughout spring and summer. During the winter and early spring, you can find the insect's shiny black eggs glued in single file rows to the edges of the tree's needles. You may also find cast skins still clinging to branches throughout the year. The aphids feed by puncturing the twig with mouthparts adapted especially for this function, and then sucking out plant juices. They usually do not occur in numbers large enough to cause long-term harm to the tree, but a large infestation can retard growth of larger trees and kill seedlings. Young aphids are similar in appearance to adults except they are smaller. You may observe several sizes (indicating different ages) of aphids on the branch.



White Pine Aphid

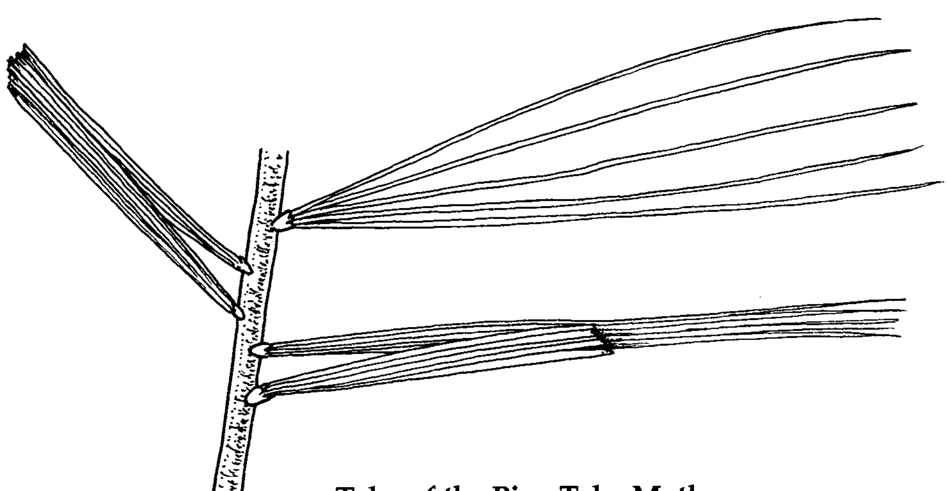
Often accompanying the aphids are ants feeding on the honeydew produced by the aphids (honeydew is the sugar-containing liquid waste secreted by aphids as they feed). In this cooperative relationship between different species, the ants benefit by gathering the sugary wastes and, in turn, the ants may protect the aphids from predators that might otherwise eat the aphids.

Another effect of the feeding activities of the aphids may be the presence of **sooty mold**. Sooty mold is a black, mildew-like fungus that grows wherever the honeydew from feeding aphids may fall. Branches below the feeding aphids often appear blackened by this relatively harmless mold. The mold is considered harmless because it gets nutrients strictly on the honeydew and not from the tree. It could, however, harm the tree by blocking sunlight, thereby reducing photosynthesis.

A careful search through White Pine needles at any time of the year may reveal some stage of the life cycle of the fascinating **Pine Tube Moth**, or at least some evidence that it was present. (This insect may not be very common in some parts of Virginia.) Look for bundles of needles that have been secured together in a tube; some or all of these needles may have been cut to half their length.

The Pine Tube Moth makes its home in a tube of pine needles that it glues together with silk threads. In this protective tube, the moth undergoes its life cycle. After making the tube, the larva (a caterpillar) will cut in half one of the needles making up the tube. This needle will be dragged into the tube, where the caterpillar will begin eating it by chewing on the end (sword-swallower style). During this stage in the insect's life cycle, a pine needle can be observed extending out from the middle of the tube. The caterpillar will continue feeding on the needles making up its tube until they all have been cut in half. The caterpillar will then leave this tube behind and build a new one. This process continues until the caterpillar is ready to pupate. The pupae, like the larvae, can also be found in the pine tubes.

An examination of White Pine trees, depending upon the time of the year, can reveal various pieces of evidence of Pine Tube Moths: abandoned tubes, tubes with actively feeding larvae, tubes with pupae, tubes with pupal cases where adults have emerged, or tubes where the larvae or pupae have been attacked by predators or parasites. Pine Tube Moths overwinter as pupae, and emerge in the spring as rather inconspicuous brown-winged adults that mate and lay eggs. The larvae may be found throughout the summer and will be largest just before they pupate in the fall.



Tube of the Pine Tube Moth

White Pine Inquiries

You probably will not have to search long to find a White Pine on or near your school grounds. Encourage your students to note other places they find White Pines. Useful materials: hand lenses, rulers or meter sticks, graph paper.

Characteristics of a Familiar Conifer

You may want to begin your study of White Pines by having students examine some of the identifying characteristics of this coniferous, evergreen tree.

How is this tree similar to other trees around it? How is it different?
How is it different from other nearby evergreens?
How are needles arranged on the tree? Look closely.
How many needles are found in each bundle?
Can you find any other pine trees with the same number of needles in each bundle?
Can you find any pine cones associated with your tree?
Does the tree have more than one kind of cone?
What is the function of the cones?
Can you find any seeds inside cones? If not, why do you think there aren't any?
What structure do flowering trees have that performs the same function as cones in conifers?

White Pine Aphids

Have your students help you check the White Pines in your schoolyard to see if you can find aphids, their eggs, or their cast skins on the trees. Be sure to look carefully among the growing tips of twigs.

Describe the organisms you find on the branches.
What are they doing there? Why might this be a good place for them to live?
Look at them closely with a hand lens. Are they all the same size?
Can you tell what they are eating?
Look closely at the base of the abdomen of these insects. Can you see a drop of liquid? What do you think this is?
Are there any ants on the branch with the aphids?
Do they seem to be interacting with the aphids on the branch?
Do the ants appear to be harming the aphids in any way?
Do the aphids try to get away from the ants?
How do the ants respond if you nudge a few aphids with your finger or a stick? Do the ants appear to become more active or less active?
How can you explain the relationship between the aphids and the ants?

White Pine Inquiries, continued

Pine Tube Moth

Have your students examine the leaves of White Pines to try to discover evidence of Pine Tube Moths. Instruct your students to look for needles forming a tube. Collect some of these tubes from the tree and compare them.

Do any of the tubes have a single needle in the center of the tube? If so, give this needle a gentle tug.

Does it come out of the tube easily?

What is preventing it from coming out of the tube easily?

Carefully take your tube apart. Take care not to squash anything that might be inside.

Study the tube construction as you take it apart. What holds it together?

What do you find inside? Carefully study your evidence.

What story appears to be told by the evidence you found?

Return any larvae you may have found to the tree unharmed.

Where in branches are Pine Tube Moth cases found most frequently? Lower branches? Higher branches? The ends of branches? In the interior of the tree?

Without destroying Pine Tube Moth cases, systematically note where Pine Tube Moth homes are found on a particular branch.

Do the tubes appear to be distributed randomly on the tree or do they tend to be found in certain places?

How to Determine Tree Height

Here are some fun ways to determine the height of a tree without actually climbing to the top with a tape measure. Try them out and see which works best for you and your students.

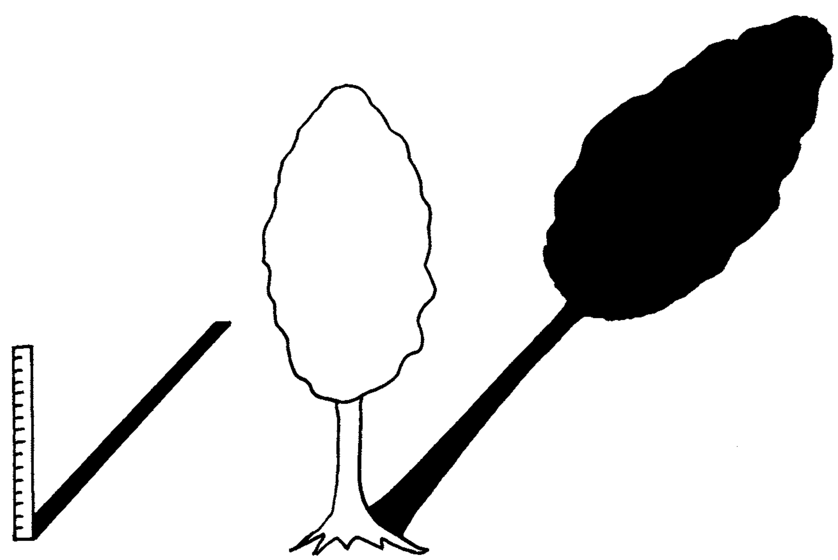
Tree Height Method 1

Hold a ruler or a meter stick perpendicular to the ground and measure its shadow. Then measure the length of the shadow of the tree you want to measure.

The height of the tree is:

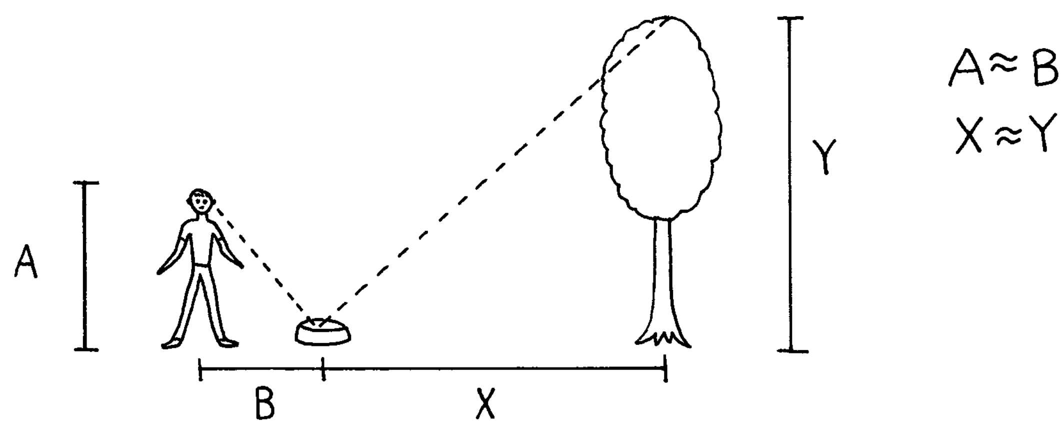
$$\frac{\text{Length of ruler or meter stick shadow}}{\text{Length of ruler or meter stick}} = \frac{\text{Length of tree shadow}}{\text{height of tree}}$$

$$\text{Height of tree} = \frac{(\text{Length of tree shadow}) \times (\text{Length of ruler or meter stick})}{\text{Length of ruler or meter stick shadow}}$$



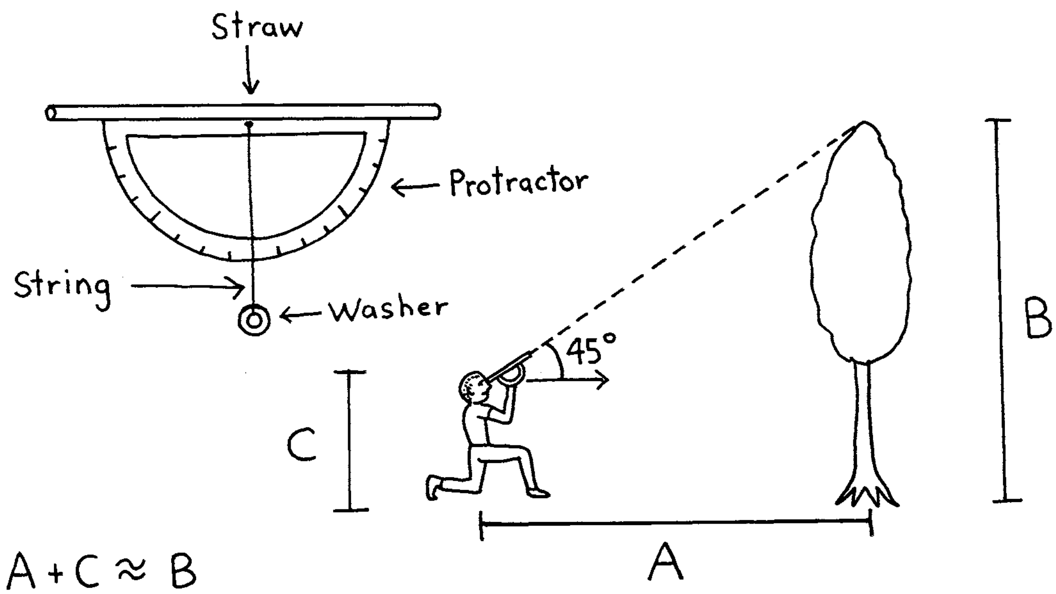
Tree Height Method 2

Place a pan of muddy water on the ground near the tree whose height you want to measure. Stand away from the pan the same distance that your eyes are from the ground. While standing straight, look for the top of the tree reflected in the pan. If you cannot see the top of the tree in the pan move yourself and the pan backward or forward until you can (while still standing straight and looking in the pan.) The height of the tree will be the distance from the pan to the tree! Why does this work?



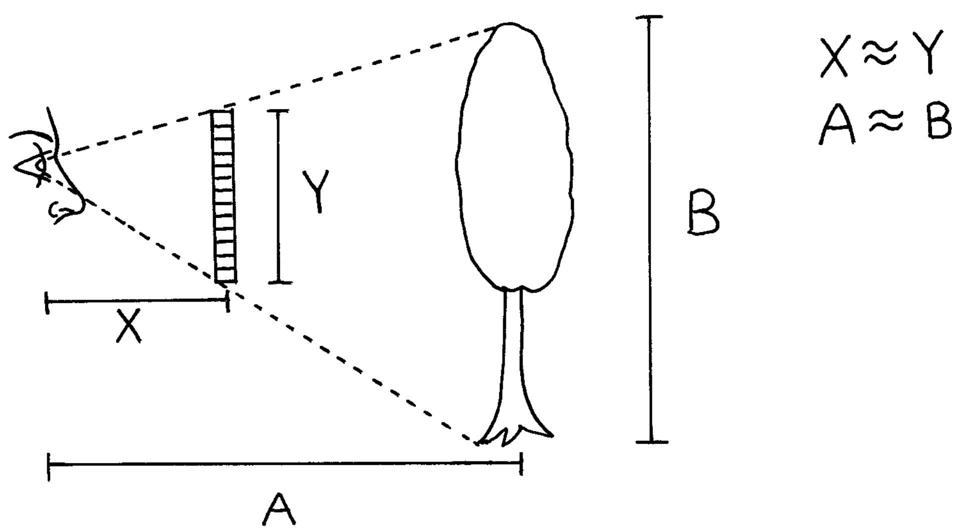
Tree Height Method 3

Make a clinometer with a straw, protractor, weight, and a string as shown. Back away from the tree while sighting the top of the tree through the clinometer, until the clinometer shows a 45-degree angle. The height of the tree will be approximately the distance from you to the tree. To be more accurate, measure the distance from the ground to your eyes. The estimated height of the tree is then this distance added to the distance to the tree. Why does this work?



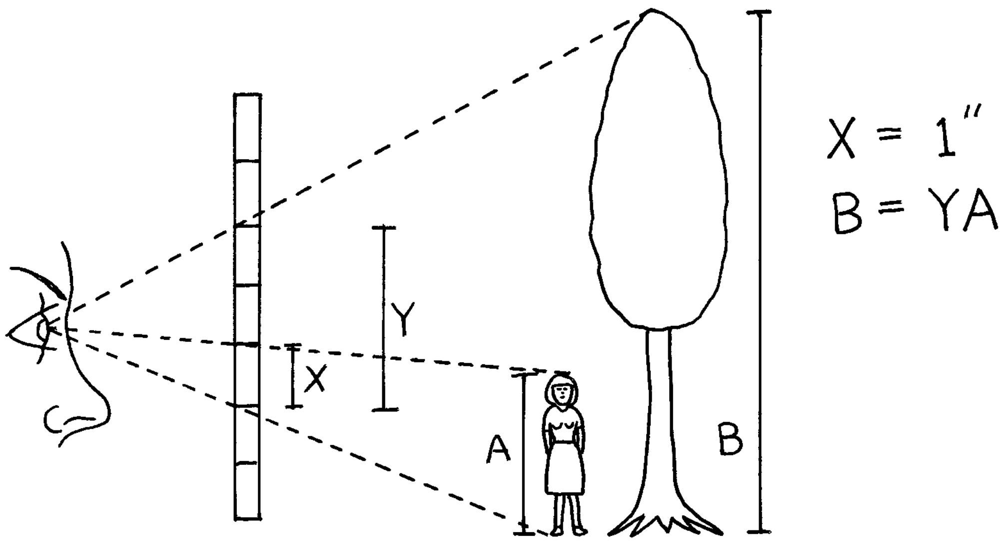
Tree Height Method 4

Use a 30-centimeter (12-inch) ruler. Face the tree whose height you want to measure. Hold the ruler out in front of your eyes, so that its distance from your eye equals its length. Hold this position and walk backward or forward until the top end of the ruler appears aligned with the top of the tree and the bottom of the ruler is aligned with the base of the tree. The height of the tree will be equal to the distance you are from the tree! (Any stick, pencil, or ruler between 15 and 35 centimeters long will work with this method.)



Tree Height Method 5

Measure the height of one student. Instruct this student to stand next to the trunk of the tree. Hold a ruler in front of your eye and back away from the tree until one inch on the ruler is equivalent to the person's height. Count how many inches tall the tree appears. The height of the tree can now be determined by multiplying the number of inches times the student's height. (Instead of a student, you can substitute any object—a board, meter stick, pole, broom, or any other object of known height.)

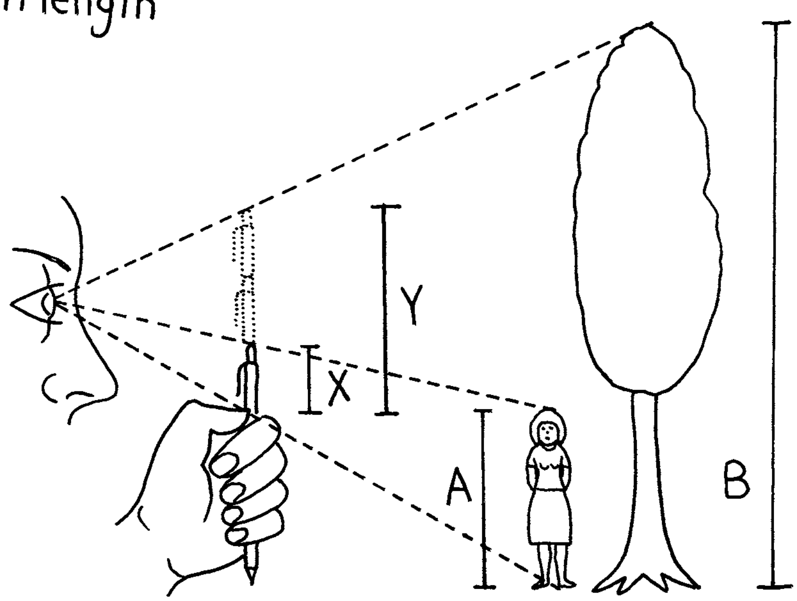


Tree Height Method 6

This method is similar to Method 5 above, except that instead of a ruler, one holds a pen or pencil in hand. Stand away from the tree and sight across the top of the pen or pencil so that it is lined up with the top of the person or object that is against the tree. With the pen or pencil so aligned, move your thumb down until it is now in line with the bottom of the tree. Now move the pen or pencil so that you count how many of these lengths the tree is tall. Multiply this number times the height of the person or object you measured initially.

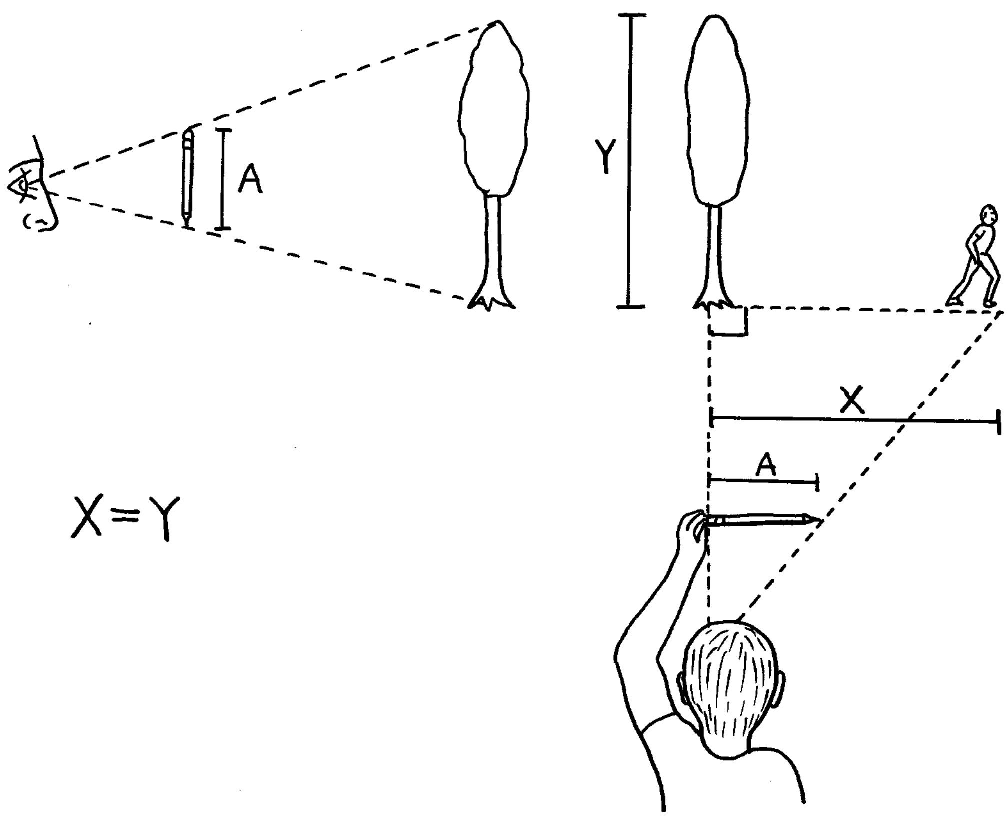
X= 1 pen length

B= YA



Tree Height Method 7

You will need a partner to use this method. While holding a pencil about 30 centimeters (12 inches) from your eye, walk away or towards the tree you are studying until the top of the pencil is in line with the top of the tree, and the bottom of the pencil is in line with the bottom of the tree. Without moving away from the tree, turn your pencil sideways so that the bottom of the pencil is centered on the base of the tree. Ask your partner to walk from the base of the tree; stop your partner when he or she is in line with the other end of the pencil. Measure the distance from the tree to your partner and you will have the height of the tree.



Ways to Record Leaf Features for Further Study

Method 1

Simply place a leaf between the pages of an old phone book. The leaf will dry flat and smooth.

Method 2

A leaf can be kept temporarily by placing the flattened leaf between two sheets of waxed paper, overlaying with a cover sheet, and ironing at *low* heat. When the wax cools, it will bind the sheets together. You can capture the color of fall leaves with this technique and mount them on the windows of your room.

Method 3

Basically the same as Method 2, except sticky sheets of clear acetate are used instead of wax paper. Ironing is not needed.

Method 4

Make a print of the leaf by rubbing the leaf with shoe polish and then pressing it against a sheet of white paper. Ask an art teacher if he or she has printing materials or other suggestions for how to make the prints.

Method 5

Push the leaf into a thin layer of clay. Kiln dry and use a paint or stain to bring out details.

Method 6

Place the leaf on a sheet of paper and spray with an aerosol paint. Remove the leaf and keep the paper with the outline.

Method 7

Place leaves on a photocopy machine under a piece of clean white paper and photocopy. Experiment with contrast and size!

Method 8

Use a large stamp pad. Place the leaf on the stamp and gently press against the leaf so that all parts of the leaf have contacted the inky foam of the stamp pad. Carefully remove the leaf and press it against a sheet of paper.

Method 9

This method is called a "spatter print." Place the leaf on a piece of paper and dip an old toothbrush in india ink or a poster paint. Gently shake the excess ink or paint from the brush. Using a butter knife or a popsicle stick, draw the knife or stick towards you across the upright bristles of the tooth brush. The paint will spatter from the brush away from you and across the leaf and paper. Aim the spatter so that you create an evenly distributed pattern across the paper. Remove and discard the leaf and let the paper dry.

Method 10

Make leaf rubbings by placing a leaf with the underside facing up underneath a piece of paper. Rub the paper with the side of a crayon with the paper removed.

Method 11

Press a leaf with its underside up in a small, flat-bottomed, disposable dish. The tops of various disposable food containers from the kitchen will work, or you could make a cardboard ring and place this on top of a flat piece of cardboard. Mix and pour Plaster of Paris onto the leaf in the container you have prepared. Allow to harden about 30 minutes and then remove the leaf. To avoid problems removing the leaf from the mold, you may want to try rubbing the leaf lightly with petroleum jelly before you make the cast.

Chapter 7. Sample Inquiry Lesson Plans and Data Sheets

Sample Lessons

This section contains five sample inquiry-based lesson plans. One sample is given for each of the five habitat chapters (Chapters 2-6). All follow the format outlined in Chapter 1, Planning a Schoolyard Inquiry Lesson (two additional sample lessons, written by teachers, are provided in that chapter). The chapter and section of the book containing related content information and lines of inquiry are identified at the top of each sample.

List of Sample Lessons

1. Parking Lot Habitat Features
2. Plant Variety in the Lawn
3. Recognizing Poison Ivy and Where It Grows
4. Paper Wasp Nests in Winter
5. Trees, Temperature, and Evaporation

Sample Lesson 1: Parking Lot Habitat Features

(Related chapter/section: The Parking Lot / Habitat Features and Natural History)

1. Objectives: Students will recognize the parking lot as a habitat created by humans; describe the physical features of this habitat; explain how physical features determine the plants and animals found there; and find and describe organisms living in the parking lot.

2. Site Survey:
Content? Use whatever conditions and organisms are found in the parking lot.
Safety? Choose an area of the parking lot where traffic is light. Survey area ahead of time for broken glass or other potentially hazardous trash. Identify the boundaries of the study area for students, and place cones to discourage traffic from entering the area. Caution students to be alert for vehicles entering the area and to act as if vehicle operators cannot see them.
Route? Identify and write here the particular route you will take at your school:

3. Lesson Format: Indoors, the whole group discusses features of habitats in general and whether parking lots are habitats. Outdoors, the whole group makes observations, then small groups complete the Parking Lot Habitat Features data sheet (see below). Back indoors, the whole group discusses questions about the parking lot features, and how they apply to organisms that might be found.

4. Assessment Methds: Check small-group data sheets; evaluate participation of small-group members during activities; and evaluate individual participation in discussions.

5. Materials Needed: Clipboards, data sheets (see below).

6. Inquiry Plan—Key questions, with teacher instructions in italics:
Indoors, ask students (and possibly have them write answers) to the following questions:
What do you think of when you hear the word habitat?
List habitats that come to mind.
How would you describe your own habitat?
Does something have to be "natural" to be a habitat?
List the general features found in any habitat.
Would a parking lot be a habitat?
Tell students you will be exploring a familiar habitat, but looking at it in a new way. Then go outdoors to the parking lot study area. Have students sit or kneel down and begin by closing their eyes and running their fingers across the surface of the asphalt. It is important that you model how to observe the surface closely. Let students know you are interested in hearing their observations rather than specific answers.

Observe the parking lot as if you were a scientist who has just discovered a new habitat. Collect as much data as possible on this habitat.

Using the data sheet in your small groups, determine and record the physical features of one specific area of this habitat (one area per group).

Use both sight (aided by hand lenses) and touch to examine this surface.

Students now work in small groups to collect data, using the data sheets. Once the data sheets are completed, return indoors to continue the inquiry discussion with the whole group.

How did you describe the surface?

If the surface were smooth, what would it be like to drive a car on it, or walk on it in the rain?

How many different materials made up the material in the pavement? What evidence do you have to support your answer? Can the class agree on an answer?

What do you think are the sources of these materials? How could we find out more about the sources?

(In addition to checking books and encyclopedias for more information on parking lot materials, you could contact local pavers and rock quarries. Having students contact these sources might be a good learning experience.)

How did the parking lot surface temperature compare to the air temperature?

Did you find water on the parking lot? Where? How long do you think it will stay?

How much of the school grounds is paved? Estimate the percentage of the total school grounds that is paved.

What might happen to a seed that falls on the pavement?

Where on the pavement might animals live?

7. Closing Activity: As a group, review what the students know about the physical features of the parking lot environment. Ask them to make a list of what organisms need to live; compile a class list on the blackboard. Then ask them to evaluate how well the parking lot environment can meet these needs. This sets the stage for a follow-up lesson where students predict what organisms could live in the parking lot, then search the area to see what they actually find.

Parking Lot Habitat Features

Feature	Your Group's Observations	Other Groups' Observations
Texture of pavement		
Number of materials making up the pavement		
Names of materials in the pavement		
Any loose materials on the surface? List them.		
Temperature of pavement to touch (hot, cold, or warm)		
Temperature of pavement compared to air: hotter or colder?		
Did you find water? Where?		
Was the area you studied in sun or shade?		

Sample Lesson 2: Plant Variety in the Lawn

(Related chapter/section: The Lawn / Introduction)

1. Objectives: Students will be able to appreciate the diversity of plants that can be found in the lawn habitat and recognize differences between plants.

2. Site Survey:

Content? Use a lawn area that is not intensively managed. Late spring to late summer/early fall is the best time for this lesson.

Safety? Survey the lawn for potential hazards, such as trash, holes, insect nests, and Poison Ivy. Designate a study area and identify the boundaries of the area for students. Be sure each student knows how to identify Poison Ivy. Caution them that, if they are in doubt about a plant, don't touch it. Caution them not to put *any* plant in their mouths.

Route? Identify and write here the particular route you will take at your school:

3. Lesson Format: Indoors, the whole class discusses the idea of diversity of plants and animals in different habitats. Students predict how many different plants could be found in the lawn, then they go outside to investigate. Outdoors, small groups work to collect as many plants as possible in 10 minutes. Back indoors, small groups examine and sort the plants to determine how many different ones they found. The whole group discusses what features can be used to identify different plants.

4. Assessment Methods: Evaluate the participation of group members during activities and evaluate individual participation in discussions; check student drawings to see if the students applied information learned about plant features.

5. Materials Needed: Large plastic bags, hand lenses, data sheet (see below).

6. Inquiry Plan—Key questions, with teacher instructions in italics:

Introduce the lesson by discussing the diversity of plants and animals in the world and in particular habitats. You may wish to show students pictures of habitats commonly recognized for their great diversity, such as a rain forest. Ask them to look at the pictures, point out animals and plants that they see, and guess how many different organisms they might find at that location. Now, invite them to think about the lawn outside their own school.

How many plants do you think you would find in the lawn outside?

Write down on your data sheet a prediction of how many plants you think we could find.

Divide the class into groups. Give each group a plastic bag to collect plant parts. Discuss that they should never collect woodland plants, but the lawn will be mowed anyway, so it is acceptable to collect plants there. Instruct students to work together in a group to collect a leaf or other representative part of each new plant they encounter. Challenge the groups to find as many different kinds of plants as they can. Encourage students in a group to work with their other group members and avoid duplication. Designate boundaries for the search area (wire flags work well for this), then give them approximately 10 minutes for the search. Return indoors with the plants.

Lay the plants out on a piece of paper and separate all the different kinds.

What features make plants look different?

What features did you use to tell plants apart?

How many kinds did you find? Record this on your data sheet. How does this compare to your prediction?

What are some unique or interesting features of each plant?

Look at a plant closely with a magnifying glass. What features are now visible that you couldn't see before?

Sketch a picture of your favorite plant, and describe the features of this plant.

How could you use the plants' features to put them into groups or categories?

7. Closing Activity: Assign each group to choose one plant. The group will identify the plant and study its natural history and use by humans. The background information in this book may help students get started. Other sources of information are listed in the Additional Materials chapter. Students could also interview family, friends, farmers, or others to find out more about their plant and people's experiences with it.

How Many Different Plants in a Lawn?

1) Predict how many different types of plants you expect to find.
2) Use plastic bags to collect one sample of each different type of plant you find in your designated area. You have 10–15 minutes to look.
3) *Watch out for Poison Ivy!* If you have any doubt about a plant, ask your teacher before touching it!

Location	**How many different plants do you predict you will find?**	**Actual number of different plants found**

Write here any notes or questions on what you saw.

Sample Lesson 3: Recognizing Poison Ivy and Where It Grows

(Related chapter/section: Fencerows and Other Overgrown Areas/Vines)

1. **Objectives:** Students will be able to identify Poison Ivy in three forms; they will know to avoid Poison Ivy in all forms and in all seasons; and they will be able to predict where Poison Ivy is likely to grow.

2. Site Survey:
Content? Survey the schoolyard for Poison Ivy.
Safety? Do not touch any part of this plant! Be sure you can identify it (see the information in the chapter and section identified above.)
Route? Identify and write here the particular route you will take at your school:

3. **Lesson Format:** Indoors, the whole class will discuss experiences with Poison Ivy and why it is important to be able to identify it. Outdoors, the class will survey the school grounds for Poison Ivy in three forms, noting and recording the locations and habitats where Poison Ivy is found. Back indoors, the class will discuss how to avoid problems with Poison Ivy in the future.

4. **Assessment Methods:** Evaluate individual participation during activities and in discussions; check student data sheets and maps of Poison Ivy location for use of observation and record-keeping skills.

5. **Materials Needed:** Data sheets (see below), schoolyard maps, Poison Ivy illustration.

6. **Inquiry Plan**—Key questions, with teacher instructions in italics:
Begin by explaining to the class that you will be looking at Poison Ivy and that ***under no circumstances are they to touch or brush any part of their shoes or clothing against it.*** *Emphasize the danger of direct or indirect contact with this plant and how even individuals that are not sensitive to this plant can become so. Show the Poison Ivy illustration and note the key features of the plant. Tell them the "rule of thumb" for identifying Poison Ivy: "leaves of three, let it be." Begin a pre-trip discussion with your class by asking:*
How many have had a reaction to Poison Ivy?
Where was the Poison Ivy to which you were exposed?
What were your symptoms?
What are some ways you dealt with the rash?

When you are ready to go outdoors, bring the class to a representative Poison Ivy plant. On the data sheet, have them sketch the plant's leaf shape and arrangement. Reiterate the "leaves of three" rule.

What are the features of this plant?

How is it similar to the plants around it? How is it different from the plants around it?

What features would you look for to be sure that you would recognize this plant in the future?

Continue to walk around the schoolyard, looking for Poison Ivy plants. Have students use the data sheet to keep a tally of how many examples of shrub-like, vine-like, and ground cover-like Poison Ivy you find. Have the students note features of the habitats in which Poison Ivy plant is found. In addition, provide students with a schoolyard map (or have them make their own maps) and mark an ***X*** *each time a Poison Ivy plant is found. Back indoors, proceed with the following questions:*

Where was Poison Ivy found?

What are the features of the habitat where it was found?

Did all the Poison Ivy look the same?

What different forms did you observe?

Which form was most frequent? Where is it found?

How do you think mowing relates to the observed forms?

What characteristics should we look for to avoid contact with Poison Ivy in the future?

In what types of habitats are we most likely to find poison ivy?

What can you do if you realize you have accidentally come in contact with Poison Ivy, or suspect that you may have?

Discuss washing hands immediately and washing clothing before wearing again.

What projects could we do to help younger classes learn about Poison Ivy?

7. Closing Activity: Compile the mapping results into a larger map to display for the whole school. Have students illustrate the map with drawings showing the characteristic features of Poison Ivy.

Poison Ivy Observations

CAUTION: DO NOT TOUCH ANY PART OF THIS PLANT!

1. Sketches

Leaves:	Sketch
Shape of Leaf	
Leaf Arrange-ment	

2. Form and Habitat

Poison Ivy Form	One Check Mark for Each Plant Observed	Describe the Habitat	Total Number of Plants Observed
Shrub-like			
Vine-like			
Ground cover-like			

Sample Lesson 4: Paper Wasp Nests in Winter

(Related chapter/section: Roofs, Walls, and Eaves/Schoolyard Wasps)

1. Objectives: Students will examine and describe the structure of a wasps' nest, and describe how paper wasps use material similar to humans' paper to meet their need for shelter and a place to raise young.

2. Site Survey:

Content? Collect an old, abandoned, paper wasp nest from the eaves of a building. By mid-winter you can safely collect these nests. Old barns or hay sheds are other good places to collect nests. If you can, collect more than one nest to make it easier for students to examine a nest closely. Alternatively, locate a nest or nests on your school grounds; in this case, you can take your students on a short field trip to find the nests themselves.

Safety? Avoid getting close to a paper wasp nest until it has been exposed to *several hard freezes.*

Route? If you are taking students outdoors to discover a nest, identify and write here the particular route you will take at your school:

3. Lesson Format: Indoors, small groups examine the structure of a nest, compare the nest material to a newspaper, and discuss how the nest meets the insects' shelter needs.

4. Assessment Methods: Evaluate individual participation during activities and in discussions; check student data sheets for use of observation and record-keeping skills.

5. Materials Needed: hand lenses, newspaper, water.

6. Inquiry Plan—Key questions, with teacher instructions in italics:

Begin by encouraging students' own questions about wasps. Record student questions and keep for ideas for future lessons.

What do you know about wasps/wasps' nests?

What would you like to know?

How could you find out?

Now, either examine nests you have collected, or take students outside to find ones you have located. If you take the students out to find nests, encourage them to observe and think about where the nests are and how they are attached. In the classroom, place the students into small groups and allow them to examine nests closely using hand lenses. There's a good chance that the first question both you and your students will have is, "Are the wasps still in there?"! If students don't ask first, you might ask them to see if they find anything in the nests, and follow by asking them where the previous inhabitants are now *(in the winter). In autumn a nest's old queen, workers, and males die, leaving only females that are the young queens. The young queens leave the old nest and hibernate through the winter in buildings, logs, and other places. As the students examine the nests, guide their attention to the nest's internal structure (the cells), the attachment stalk, and the nest material.*

Describe the structure of this nest.

Why are there many individual "cells"? What happened in these cells last summer?

Do you know what a hornet's nest looks like? How is this nest different from a hornet's nest? How is it similar? *(Hornets' nests are large, paper-like ovals. The individual cells are inside the outer layers of "paper.")*

Describe the shape of the individual cells in this nest. Do all the cells have the same shape?

How do you think the wasp knows how to make cells of this shape?

How was the nest attached to the structure where it was built? What advantage does this give?

Have the students tear a small piece of material from the nest and look at it closely with a hand lens. At the same time, have them examine a small piece of newspaper. Encourage your students to consider weight, texture, color, absorption of water, and resistance to tearing. Have them record their observations on the following data sheet (next page).

How does the wasp nest material compare to the newspaper?

From what materials is the paper in your newspaper made?

What do you think is the source of materials for the paper wasp nest?

Which is the "better" paper? Imagine you are a salesperson and make a "pitch" for one paper over the other.

7. Closing Activities: Pose this question to your students: How do humans meet the same needs that a wasps' nest meets? Things that students could consider include shelter, child rearing, protection from danger, and use of building materials. Depending on the grade level you teach, your students might use role play, drawings, a chart, an essay, or other means to answer this question.

Comparing Paper Wasp Nest Material to Newspaper

Feature	Wasp Nest Material	Newspaper
Weight: Does one seem heavier? Weigh them if you can.		
Texture: How does it feel?		
Color		
Any **patterns** of color?		
Structure: Can the piece be split apart into any layers?		
Absorbing water: any differences?		
How easy to **tear**?		
Flexibility: How far could you bend the piece without its breaking?		

Sample Lesson 5: Trees, Temperature, and Evaporation

(Related chapter/section: Trees / Trees and Their Surroundings)

1. Objectives: Students will identify ways that trees' shade can affect other plants and animals, make measurements of the effect of trees' shade on surrounding temperatures and on evaporation, and use a graph appropriately to summarize results.

2. Site Survey:

Content? Identify large trees that cast substantial shade over the lawn. Avoid areas where some measurements would be on grass and others on pavement. Identify other areas, both sunny and shady, where students can test evaporation.

Safety? Survey the lawn for potential hazards, such as trash, holes, insect nests, and Poison Ivy. Identify the boundaries of the study area for students. Be sure each student knows how to identify Poison Ivy, especially the vine form found growing on trees. Caution them that, if they are in doubt about a plant, don't touch it, and caution them not to put *any* plant in their mouth. Also, remember that certain trees, such as Black Locust (discussed in the Fencerows chapter of this book), have thorns.

Route? Identify and write here the particular route you will take at your school:

3. Lesson Format: Indoors, the class discusses how trees can affect their surroundings, including other plants and animals. Students predict how a tree's shade affects the temperature of its surroundings, then they go outside to work in small groups to measure this. In a related activity, students measure evaporation from cups placed in various sunny/shady locations in the schoolyard. Students record their measurements on data sheets, then return indoors to discuss their findings and graph the results of the evaporation activity.

4. Assessment Methods: Evaluate individual participation during discussions and small-group activities; check student data sheets for evidence of measuring and record-keeping skills; check students' graphs for evidence of ability to use graphs to summarize results appropriately.

5. Materials Needed: Thermometers, meter sticks, plastic beakers for measuring water (or make your own: mark plastic cups to show either water volume or height of water in the cup).

6. Inquiry Plan—Key questions, with teacher instructions in italics:

Start by discussing indoors the effects of trees on their surroundings.

How can a tree affect its surroundings?

How can a tree affect the temperature around it?

Predict how far from the tree you will still be able to see some effect. What features of the tree would affect this?

Then, on a sunny day, have students measure the temperature at 1-meter intervals from the base of the tree by placing a thermometer face up on the surface of the ground. Have different groups do this along different directional lines from the tree, or from other trees. Provide them with the "Trees and Temperature" data sheet shown below. Back indoors, proceed with the following questions:

Describe the effect of the tree on temperatures around it.

How far away from the tree did you see any effect? How does this compare with your predictions?

Did the effect differ depending on the direction away from the tree?

How might the temperature variation you observed affect where plants and animals are likely to be found?

What happens to you when you run around on a hot sunny day? Why do you become thirsty?

Are other organisms affected by exposure to sun and heat in similar ways?

Can organisms simply go get a drink when they need water?

Predict some areas in your schoolyard where you think water would evaporate the fastest/slowest.

At this point, stop the lesson for the day, and let students know that you will test their predictions in another activity in your next lesson. When you are ready to continue, provide groups of students with plastic beakers (or marked plastic cups). Take the students outside and have them place the beakers at various locations in the schoolyard. Then add, or have them add, known quantities of water in cups. Have students measure the amount of water remaining at the end of the day or after 24 hours, and record the information in the "Evaporation" data sheet below. Then, have them follow the instructions on the data sheet to make bar graphs of their results.

Which locations showed the most evaporation? Which showed the least? How do the results compare to your predictions?

What affected the amount of evaporation?

How could the information you gathered help explain where you might find plants and animals in your schoolyard?

7. Closing Activity: Ask students to describe the features a plant or animal would need to live in a place where temperature and evaporation are high. To follow up further, have them research the adaptations of desert plants and animals.

Trees and Temperature in the Schoolyard

Distance from Tree	Under Shade? (Mark Yes or No)	Temperature on Ground

Evaporation in the Schoolyard

Location	Water in Cup at Beginning of Experiment	Water in Cup at End of the Experiment	Difference (The Amount of Water That Evaporated)

Make a bar graph of your results. On the horizontal axis (side to side), put locations. On the vertical axis (up and down), put the amount of water that evaporated. On your graph, rank from 1 to 4 the locations that had the most to least evaporation (1 = most, 4 = least).

Sample Data Sheets

This section contains 10 data sheets designed for various topics in this book. These data sheets can be used directly with the related content material and lines of inquiry in this book, or they can provide a model for designing a data sheet to fit a lesson you develop. They may also help you come up with ideas for developing lessons.

List of Data Sheets

For studying *habitat features*:

1. Environments in the Schoolyard
2. Comparing Habitats

For studying *where plants grow*:

3. Finding a Certain Plant
4. Discovering Plant Variety

For studying *plant features*:

5. Getting to Know a Plant
6. Flower Development

For studying *where animals live*:

7. Discovering Animals in Their Habitats
8. Animal Homes on a Building

For studying *animal features*:

9. Insect Features
10. Animal Behavior

Environments in the Schoolyard

Use this data sheet to help you find different environmental features in the schoolyard. Try to find at least four sites with different features. Be sure to note the location of the site so that you could return to study it again. If you like, give each site a name that describes it.

Feature to observe	Site #1	Site #2	Site #3	Site #4
Location in the schoolyard (Tell how to get there)				
Sunlight (Sunny, shady, or shady for part of day?)				
Slope (Steep, flat, or gentle slope?)				
Ground Surface (Exposed or covered with plants? Loose soil or packed tightly? Rocky, sandy, clay, or a mixture?)				
Drainage (Good: rain water runs off or soaks in quickly; Poor: rainwater sits on the ground for a time)				
Any other special features?				
Your name for this site				

Note to teachers: This data sheet will help you compare two different schoolyard habitats. Some possible features to compare have been listed in the table, but spaces are left for you to add features of interest to you. Completing this table may take several schoolyard field trips and activities, and you may need to use other data sheets. If you have done other activities and kept data, use that information if you can. Students should work in groups and split up the measuring tasks; then the class can compile the data.

Comparing Habitats

Habitat types we are comparing: #1 ____________ #2______________

Your group number ___________

Your group's tasks ____

Feature to Observe	**Habitat #1**	**Habitat #2**
Temperature at ground level.	____°F ____°C	____°F ____°C
Number of plants with open flowers seen in one square meter		
Number of plants with seed heads seen in one square meter		
Number of different kinds of plants seen in one square meter		
Number of different kinds of insects seen or heard in 10 minutes		
Number of different kinds of birds seen or heard in 10 minutes		
Other:		
Other:		
Things you observed that might affect results (weather, traffic, mowing, or others)		

Note to teachers: Choose a type of plant that everyone in class can easily recognize. Also, choose four different areas or habitats (sites 1 2, 3, and 4) on your school grounds to investigate. Working in groups, students count the number of plants of this type that they observe in a square meter and record this information. Then the class compiles data from all groups into the class data table.

Finding a Certain Plant

Name of the plant________________
Draw the plant on the back of this sheet.

Your group number______ Your site number _____

Type of habitat your group is searching _________________________

How many of this certain plant did your group find? __________

Class Data Table

Group Number	Site Number	Habitat Type	Number of this plant found

Total Number of This Plant Found by Class	Date of Search	Weather on This Date	Things That Could Have Affected the Results

Note to teachers: Choose one or more different areas or habitats on your school grounds to investigate. Working in groups, students count the number of different kinds of plants that they observe in a square meter and record this information. Then the class compiles data from all groups into the class data table.

Discovering Plant Variety

Your group number __________

Type of habitat your group is searching: ____________________________

Predict how many different kinds of plants you will find: ______________

How many different kinds of plants did your group find? ______________

Class Data Table

Group Number	Habitat Type	Number of Different Plants Found

Total Number of Different Plants Found by Class	Date of Search	Weather on This Date	Things That Could Have Affected the Results

Getting to Know a Plant

Practice observing! Pick any plant, whether you know the name or not, and use the chart to help you learn about its features. While you are work ing, give the plant a name that helps you remember the plant. Use more than one chart if you want to compare two or more plants.

Your name for the plant________________________

Plant Part	Description	Sketch
Leaves Look at color, shape, and size. Are all the leaves the same? How are they arranged on the plant? Are they hairy or smooth? Are the edges jagged or straight?		
Stem Can you see a stem? What is its shape? Is there one stem or are there several? Are there branches? Where are leaves attached?		
Flowers Are flowers present? How many flowers are there? What color are they? What shape are the flowers? How many petals does each flower have?		
Record any other observations and sketches in this row		

If you learn the real name of the plant, write that here:____

Flower Development

Pick a type of flowering plant in the schoolyard. Watch it as it changes from flower bud to flower, then to a fruit with seeds. Find and collect these different stages of development. Tape the stages in order in the large spaces in the chart below. Be sure torecord the date that you found each stage. In the smaller boxes, name or describe the stages.

Name of the plant you are observing ____________________________

Stage:	Stage:	Stage:	Stage:	Stage
Date: Date found:	Date: Date found:	Date: Date found:	Date: Date found:	Date: Date found:

Here's another way to watch flowers:

Place a piece of tape around a flower, and mark the tape with your name. Then watch every day as the flower develops, using this chart to record the changes in drawings or words.

Note to teachers: Students can use this chart to record information about animals they find and where they find them. In the schoolyard, many of the animals your students find will be insects, but there will also be spiders, centipedes, millipedes, birds, small mammals, and others. You may also find signs of an animal--leaves that have been eaten, nests, shed skins or shells, and many other signs. Students can use this chart to record those finds, as well, even if they never see the animal.

Discovering Animals in Their Habitats

If you are looking for a particular animal,
write the name here: ______________________________

Habitat or **Plant** searched	**Name**, **Describe**, or **Sketch** the animal or animal sign.	**Where** on the plant or in the habitat did you find the animal or sign?

Animal Homes on a Building

Record information about animal homes—birds' nests, wasps' nest, spiders' webs, or others—that you find around or on a building. You will need to know the compass directions around your building.

Do not disturb any animal homes that you find!

Do not disturb any wasps or bees that you see!

Part of building where animal home was found	Is this part of the building facing east, west, north, or south?	Type of home (Is it a web? a nest? something else?)	Number of homes found

Insect Features

Insects are everywhere, so it's good to know one when you see one. This data sheet will help you tell whether a new animal is an insect or not. You can use it with up to three new animals.

Before you start, remember that insects have these key features:

- 3 body parts (not including legs and wings)
- 6 legs with joints
- 2 antennae
- Often, but not always, wings
- Usually, but not always, a hard outer skeleton

Feature	Animal 1	Animal 2	Animal 3
Number of legs			
Number of body parts (not legs or wings)			
Size			
Are wings present? How many?			
Color			
Other interesting features?			
Is this an insect? Why or why not?			
Name of this animal (if you know)			

Animal Behavior

Animals behave in certain ways, sometimes in **behavior patterns**. Choose a type of animal to watch, try to identify behaviors, and make a guess about the function of repeated behaviors. Birds and insects are good animals to watch.

Type of animal you are watching ____________________________

Behavior Seen (Name or describe it.)	**Time of Day** (Morning, afternoon, or evening?)	**How Long the Behavior Lasts** (Did it take seconds or minutes?)	**Function of the Behavior** (Your best guess.)

Chapter 8. *The MINTS Book* and the Virginia Science Standards of Learning

Science Standards of Learning for Virginia Public Schools was published by the Virginia Board of Education in June 1995. According to that document, the standards are designed to "set reasonable targets and expectations for what teachers need to teach and students need to learn." In developing the standards, the Board of Education involved four school divisions to lead the effort, and considered the ideas, advice, and comments of many Virginia parents, teachers, principals, school board members, and community leaders.

This first section identifies how *The MINTS Book* supports many of the goals and ideas of the Virginia science standards of learning (hereafter referred to as the "standards"). The second section identifies parts of the book that support specific standards.

The science standards document is available from the Virginia Department of Education at the following address and phone:

Virginia Department of Education
Office of Technology/Production
Monroe Building
101 N. 14th Street
Richmond, VA 23219
Phone (804) 225-2400.

The MINTS Book and the Overall Goals of the Science Standards

Following is the goals statement from the science standards document. The bold type indicates the goals that use of *The MINTS Book* particularly supports.

"The purposes of scientific investigation and discovery are to satisfy humankind's quest for knowledge and understanding and to preserve and enhance the quality of the human experience. Therefore, as a result of science instruction, students will be able to:

1. **Develop and use an experimental design in scientific inquiry;**
2. **Use the language of science to communicate understanding;**
3. Investigate phenomena using technology;
4. **Apply scientific concepts, skills, and processes to everyday experiences;**
5. **Experience the richness and excitement of scientific discovery of the natural world** through the historical and collaborative quest for knowledge and understanding;
6. Make informed decisions regarding contemporary issues taking into account the following:
   - public policy and legislation
   - economic costs/benefits
   - validation from scientific data and the use of scientific reasoning and logic
   - respect for living things
   - personal responsibility
   - history of scientific discovery;
7. **Develop scientific dispositions and habits of mind including:**
   - **curiosity**
   - **demand for verification**
   - **respect for logic and rational thinking**
   - consideration of premises and consequences
   - respect for historical contributions
   - **attention to accuracy and precision patience and persistence;**
8. Explore science-related careers and interests."

The MINTS Book and Standards for Individual Grades and Subjects

The table beginning on the next page lists abridged versions of the science standards that can be supported by one or more Lines of Inquiry in *The MINTS Book.* (The table omits any standards not supported by a Line of Inquiry.) Beside each standard, we have cited an example of a Line of Inquiry in this book that supports the given standard; the chapter and section where the Line of Inquiry is located are also identified. (For Lines of Inquiry in the Parking Lot chapter, no section is identified in the table, because only one section in that chapter has Lines of Inquiry.) By "supports the standard," we mean that the Line of Inquiry involves a topic or the practice of skills that are *relevant to* and *can assist* students' achievement of a particular standard or part of a standard. This is based on our judgement and a review of this table by several teachers.

Keep in mind that the specific questions written in this book may not be exactly what you use with your students. The Lines of Inquiry provide an idea and a framework, but the details will depend on a teacher's particular situation.

The authors would appreciate knowing if you find that any Line of Inquiry *does not* work well for the standard(s) indicated, or if you find other Lines of Inquiry that *do* support a standard listed in the table. A blank column has been included for this purpose. In addition, at the end of the chapter, we have included a blank table for you to record any other matches you discover between *other* science standards and this book.

A Word About This Book and the Physical and Chemical Science Standards

The content of this book focuses on natural history, living systems, and ecology. That makes the book particularly suited to supporting the standards in biology and life science. But this book can also support study of the physical and chemical sciences, in the following ways:

- Some sections in the book, for example the Parking Lot chapter, discuss physical factors in the schoolyard, such as heat, temperature, and water relations;
- Many Lines of Inquiry involving living systems can be used to show physical science principles in action in the real world outside of the classroom;
- The inquiry processes promoted by this book—such as asking questions, making observations, summarizing data, and basing conclusions on evidence—are valuable in any science.

Natural History Lessons Can Support Math Standards, Too

Many Lines of Inquiry in this book ask students to quantify their observations of living things. In some cases, students are asked to make simple measurements, such as the length of a vine. In other cases, a Line of Inquiry asks for a more complicated measurement, such as estimating the number of leaves on a tree. Regardless of the specific task, however, measuring natural history objects and phenomena is a good way for students to practice, develop, and apply mathematics skills.

Lines of Inquiry That Support Specific Standards

Abbreviations in the table for standards of learning

K-6 = Kindergarten through Grade 6
LS = Life science
PS = Physical science
ES = Earth science
BIO = Biology
CH = Chemistry
PH = Physics
(Example: "K.1" means the first standard under Kindergarten.)

Abbreviations in the table for book chapters

PL = Parking Lot (Chapter 2)
LA = Lawn (Chapter 3)
FRO = Fencerows and Other Overgrown Areas (Chapter 4)
RWE = Roofs, Walls, and Eaves (Chapter 5)
TR = Trees (Chapter 6)

Virginia Science Standard (Summaries only. Most standards state that students are to "investigate and understand the topics listed inthe standards.	**Example of Lines(s) of Inquiry supporting this inquiry** (Explanatory notes in paren theses)	**Chapter and section of the MINTS book containing Line(s) of Inquiry**	**Use this space to add your own notes on using this inquiry or some other to help meet the standard**
K.1 Conducting investigations	Any[1]	All chapters	
K.2 Human senses and sensory descriptions	Any	All chapters	
K.4 Objects described in terms of physical properties	Any in the Tree Parts section	TR/Tree Parts	
K.5 Water has properties that can be observed and tested	Water Relations	PL[2]	
K.8 Simple earth patterns and cycles	Observing Leaf Growth and Development	TR/Tree Parts: Leaves	

[1] "Any" means that any Line of Inquiry in this book *may* support the given standard. In some cases, teachers may need to adapt the language of the suggested questions to fit their students' ages.
[2] All Lines of Inquiry in the Parking Lot chapter are in the section "Habitat Features and Natural History".

1.1 Planning and conducting investigations	Any	All chapters	
1.4 Plants' life needs, parts, and classification	Discovering the Variety of Plants in the Lawn	LA/ Introduction	
1.5 Animal life needs, characteristics, and classification	Insect Structures	FRO/Discovering Insects	
1.6 Relationships between earth and sun	Energy Absorption	PL	
1.7 Weather and seasonal effects	Leaf Colors	TR/Tree Parts: Leaves	
2.1 Planning and conducting investigations	Any	All chapters	
2.3 Properties of solids, liquids, and gases	Leaves and Water Loss	TR/Tree Parts: Leaves	
2.4 Plant and animal changes and cycles	Chickweed Flower Features	LA/Common Chickweed	
2.5 Living things are part of a system	Any	All chapters	
2.7 Weather and seasonal effects	Water Relations (for weathering and erosion)	PL	
2.8 Benefits from plants	Investigating Habitats & Food Provided by a Tree	TR/Trees and Their Surroundings	
3.1 Planning and conducting investigations	Any	All chapters	
3.4 Animals' behavioral and physical adaptations	Grasshopper Behavior	LA/Short-horned Grasshoppers	
3.5 Aquatic and terrestrial food chains	Plant Visitors 1, 2, and 3.	FRO/Goldenrods	
3.7 Soil origin, components, and importance	Earthworms in the Soil	LA/Earthworms	
3.8 Basic cycles in nature	Growth Habits and Life Cycle	FRO/Goldenrod	

4.1 Planning and conducting investigations	Any	All chapters	
4.4 Plant structures and processes	Any in the Tree Parts section	TR/Tree Parts	
4.5 Interactions within ecosystems	Clover and Pollinators	LA/Clovers	
4.8 Virginia's natural resources	Investigating the Structure of the School Building	RWE/Introduction	
5.1 Planning and conducting investigations	Any	All chapters	
5.7 Changes in earth's surface	Water Relations and Plant Succession	PL	
6.1 Planning and conducting investigations	Any	All chapters	
6.2 Demonstrating scientific reasoning and logic	Any	All chapters	
6.7 Changes in physical and chemical properties	Comparing Deciduous Leaf Litter to Coniferous Leaf Litter	TR/Trees and Their Surroundings	
6.8 Essential life processes	Exploring How Spittle is Made	FRO/Spittlebugs	
6.9 Interdependence of organisms and dependence on environment	Insect Home 1 and 2.	FRO/Black Cherry	
LS.1 Planning and conducting investigations	Any	All chapters	
LS.4 Basic plant and animal needs	Identifying Different Environmental Sites in the Lawn	LA/Introduction	
LS.5 Classification of organisms	Comparing Isopods to Insects	RWE/Terrestrial Isopods	

LS.6 Photosynthesis and its importance	Tree Leaf Math 3: Leaf Area	TR/Tree Parts: Leaves	
LS.7 Interdependence of organisms and dependence on environment	Using Violets to Investigate Flower Structures and Pollinators	LA/Common Blue Violet	
LS.8 Interactions within a population	Mud Dauber Wasp Nest Construction	RWE/School-yard Wasps	
LS.9 Interactions within a community	Competition Between a Tree and Other Plants	TR/Trees and Their Surroundings	
LS.11 Changes within organisms and ecosystems	The Features of Twigs and Buds	TR/Tree Parts: Twigs	
LS.12 Ecosystem dynamics and human activity	Lawn Plant Distribution	LA/Intro-duction	
LS. 13 Genetics	Investigating a Familiar Fruit	LA/Wild Strawberry	
PS. 1 Planning and conducting investigations (emphasizing physical properties)	Tree Leaf Math 2: Weight of Leaves	TR/Tree Parts: Leaves	
PS. 6 Energy states, forms, and changes	Energy Absorption	PL	
PS. 7 Temperature and heat transfer	Investigating the Building's Effect on Snowmelt	RWE/Intro-duction	
ES. 1 Planning and conducting investigations (emphasizing earth science)	Tree height methods (not a Line of Inquiry)	TR/How to to Determine Tree Height	
ES. 2 Demonstrating scientific reasoning and logic	Any	All chapters	
ES. 3 Maps, globes, models, charts, and imagery	Several Lines of Inquiry suggest mapping; see the Index (Map Activities)	LA, FRO, RWE and TR/various sections	
ES. 7 Renewable vs. non-renewable resources	General Surface Features —used with— The Importance of Trees	PL TR/Introduc-tion	

ES. 8 Geologic processes	No Line of Inquiry, but see the background information on limestone	PL	
ES. 9 Geologic/human influences on freshwater	Plant Succession, and Water Relations	PL	
ES. 10 Rocks and fossils in the study of earth's history and evolution	Ways to make leaf "fossils" (not a Line of Inquiry)	TR/Ways to Record Leaf Shape for Further Study	
BIO.3 Biochemical principles essential for life	Investigating the Broad, Flat Leaves of a Deciduous Tree (sites of photo-synthesis)	TR/Tree Parts: Leaves	
BIO.5 Life functions of different organism groups	Any involving observation of organisms	All chapters	
BIO.8 Population changes over time	Grasses and Mowing 1 and 2.	LA/Grasses	
BIO.9 Dynamics of ecosystems	Signs of Succession	FRO/Eastern Redcedar	
CH.6 Chemical principles in biochemistry, nuclear chemistry, and environmental chemistry	Insects and Humans	FRO/Discov-ering Insects	
PH.1 Planning and conducting investigations (emphasizing measurement of physical properties)	Tree Leaf Math 2: Weight of Leaves	TR/Tree Parts: Leaves	
PH.2 Analysis and interpretation of data	Many Lines of Inquiry could be used to collect data for analysis	All chapters	
PH.3 Demonstrating scientific reasoning and logic	Any	All chapters	
PH.4 Application of physics to the world	Measuring Wind Dispersal	TR/Tree Parts: Fruits and Seeds	

Record of Other Information or Lines of Inquiry That Support Other Standards of Learning

Virginia Science Standard	*MINTS Book* information or Line(s) of Inquiry supporting the standard	Chapter and section of *The MINTS Book* containing the information or Line(s) of Inquiry

Chapter 9. Additional Materials for Teachers

This chapter provides information on books, programs, and sources of inexpensive science tools. This information can help you develop your own supply of books and tools to assist you and your students in using, and in going beyond, this book.

Books

The following is an annotated list of some good books containing science information or activities. This is by no means a complete list of the many books available, but they are ones that we have used or examined and believe to be valuable for teachers or students of natural history or of inquiry-based science.

Field Guides and Natural History Books

Benyus, Janine M. *The Field Guide to Wildlife Habitats of the Eastern United States.* Simon & Schuster, New York, 1989.

This text approaches wildlife from the standpoint of their associated habitats. It will not direct you to finding a specific animal, but rather it will assist you in identifying habitat types and give you information on common species you may encounter in those types. Illustrated "Wildlife Indicator Charts" assist you in matching your observations to potential wildlife in the area.

Borror, Donald J. and Richard E. White. *A Field Guide to the Insects.* (Peterson Field Guide Series) Houghton Mifflin Company, Boston, 1970.

This guide includes the major insect families in the United States and Canada. Detailed information is given on body form and physical appearance, including tips for easy identification. The book contains illustrations for representative members of most North American families of insects.

Comstock, Anna B. *Handbook of Nature Study.* Cornell University Press, Ithaca, 1986 (originally published in 1911).

This is a classic text that aims to encourage scientific investigation. Extensive coverage is given to all kinds of plant and animal systems and their interrelationships. Each chapter has background information supplemented with questions to help guide inquiry-based lessons into the topic of the chapter.

Harlow, William M. *Trees of the Eastern and Central United States and Canada.* Dover Publications Inc., New York, 1957.

This field guide is for those who are looking for detailed information about tree identification presented in a non-technical manner. It has an extensive key to distinguishing between tree species. For each species there is information on habitat, distribution, leaves, flowers, twigs, bark, flowers, fruits, and common uses of the wood. Black and white photographs accompany the text.

Imes, Richard. *The Practical Entomologist.* Simon & Schuster, Inc., New York, 1992.

With beautiful color photographs throughout, this book covers the basics of entomology (the study of insects) and how to collect and document insects. It

also has detailed information and identification keys for the major insect groups. It is useful with all grade levels.

Kricher, John C. *A Field Guide to Ecology of Eastern Forests* (Peterson Field Guide Series). Houghton Mifflin Company, New York, 1988.

This field guide focuses more on interpretation than identification. It covers forest communities and the interactions among plants, animals, and their physical environment. There are several color plates of habitats and of animals in their associated plant habitats.

Martin, Alexander C. *Weeds* (Golden Guide Series). Golden Press, New York, 1987.

This small book is for people with a basic interest in weed identification. There are color illustrations of each plant, non-technical information listing the benefits and drawbacks of each plant, and a map of each plant's distribution across the United States.

Miller, Orson K. and Hope H. Miller. *Mushrooms In Color.* E. P. Dutton Publishing Company, New York, 1980.

This is a beginner's guide to mushrooms, both the most common edible mushroom species and poisonous species that are to be avoided. It includes basic scientific information, color photographs of each species, and keys to locating the most common varieties.

Murie, Olaus J. *A Field Guide to Animal Tracks, Second Edition* (Peterson Field Guide Series). Houghton Mifflin Company, Boston, 1974.

This guide covers all the North American mammals, as well as many birds, reptiles, amphibians, and insects. The focus of the guide is on tracks, but it also includes information on other signs of wildlife. The text includes a "What Has Happened Here?" chapter that will help you get started in identifying and interpreting animal signs you may encounter.

Peterson, Roger T. *A Field Guide to the Birds East of the Rockies* (Peterson Field Guide Series). Houghton Mifflin Company, Boston, 1980.

This is perhaps the most popular of bird guides. The text includes physical descriptions, contrasts between similar species, and detailed range maps. Color drawings of each species point out distinguishing features, making identification easier.

Peterson, Roger T. and Margaret McKenney. *A Field Guide to Wildflowers of Northeastern and North-central North America* (Peterson Field Guide Series). Houghton Mifflin Company, Boston, 1968.

The southern Virginia border is the southern boundary of this guide's coverage. While the guide gives technical information for each species, it stresses visual clues for identification. The text is arranged by flower color and includes detailed drawings of each flower.

Stokes, Donald W. *A Guide to Nature in Winter* (Stokes Nature Guides Series). Little, Brown, & Company, Boston, 1976.

This field guide is actually a collection of several smaller field guides on winter occurrences and the characteristics of many organisms one can find during the cold season. Topics included in the guide are weeds, trees, birds, mushrooms, evidence of insects, and snow. Each chapter has identification keys, some general information, and natural history of the subject. The many black and white illustrations are helpful in field identification.

Stokes, Donald W. *A Guide to Observing Insect Lives* (Stokes Nature Guides Series). Little, Brown & Company, Boston, 1983.

While this guide offers general physical descriptions of common insects, its focus is on identification by observing behavior patterns you are likely to encounter. The book tells you where to look and what to look for when observing insects. This valuable guide is very accessible to readers with little scientific background and is conveniently arranged by season.

Stokes, Donald W. and Lillian Q. Stokes. *A Guide to Enjoying Wildflowers* (Stokes Nature Guide Series). Little, Brown & Company, Boston, 1985.

This is an attractive, general guide to the most common wildflowers of North America. The guide provides you with tips for easy identification. The brief text focuses on the life history and common uses of each plant, rather than on technical information. A color illustration of each species is included.

Virginia Cooperative Extension. *Insect Fact Sheets.* To request individual fact sheets or a list of all available fact sheets, contact your nearest Virginia Cooperative Extension office (listed in your local phone book's government pages).

These are 2-page flyers on a number of common insects that may be pests in lawn, garden, or farm plants. Subjects include aphids (#444-220), scale insects (#444-224), Locust Leaf Miners (#444-242), and many others.

Wright, Amy B. *Caterpillars: a simplified field guide to the caterpillars of common butterflies and moths of North America* (Peterson First Guide Series). Houghton Mifflin Company, Boston, 1993.

This is a very basic field guide to identifying caterpillars and the butterflies and moths they become. The text covers over 120 of the most common caterpillars, with information on their habitats, feeding habits, pupal stages, and likely places to find them. The book includes color drawings of each caterpillar and of most of the adult butterflies and moths.

Natural Science Activity Books

Braus, J. *Nature Scope.* National Wildlife Federation, 1400 Sixteenth Street NW, Washington, D.C. 20036-2266.

This is the Ranger Rick series of soft-cover books, covering a wide range of science and environmental topics. Titles include "Amazing Mammals, Part I" (Vol. 2, No. 3. 1986), "Incredible Insects" (Vol. 1, No. 1. 1986), "Birds, Birds, Birds!" (Vol. 1, No. 4. 1988), "Trees are Terrific!" (Vol. 2, No. 1. 1988), and many others. The series, designed for classroom use in kindergarten through grade 7, contains extensive background information, indoor and outdoor activities, and "copycat" activity worksheets.

Cornell, Joseph. *Sharing the Joy of Nature.* Dawn Publications, Nevada City, CA, 1989.

This book gives many valuable insights into getting children of all ages excited about being outdoors. The majority of the book is devoted to simple nature activities that can be done just about anywhere.

Hogan, Kathleen. *Eco-Inquiry: A Guide to Ecological Learning Experiences for the Upper Elementary/Middle Grades.* Kendall Hunt Publishing Co., Dubuque, IA, 1994.

This is a teachers' guide to leading inquiry-based investigations into ecological relationships. Organized into three modules of increasing complexity, the text can be used with students in upper elementary school through middle school. The activities can be conducted in many environments.

Ingram, Mrill. *Bottle Biology: an idea book for exploring the world through soda bottles and other recyclable materials.* Kendall/Hunt Publishing Co., Dubuque, IA, 1993.

This creative book has over 20 activities that utilize plastic soda bottles in scientific investigations. While the book's main focus is on ecology, many of the lessons include principles in a range of scientific fields. The book has many illustrations and easy-to-follow instructions. Activities useful for students from kindergarten through the college level can be found.

Lawrence Hall of Science. *Outdoor Biological Instructional Strategies (OBIS).* Delta Education Inc., Hudson, NH, 1991.

This is a series of challenging outdoor investigations for 10- to 15-year-olds. There are 97 activities in the series, covering a range of scientific and environmental topics. Each activity is presented in a separate pamphlet.

Lingelbach, Jenepher (editor). *Hands-On Nature: Information and Activities for Exploring the Environment with Children.* Vermont Institute of Natural Science, Woodstock, VT, 1986.

This book features interdisciplinary natural science activities for students in kindergarten through sixth grade. The text covers such topics as habitat, adaptation, and natural patterns. Included in the book are teacher background information and references, follow-up activities, and a list of suggested outside readings for students.

Russell, Helen R. *Ten-Minute Field Trips: A Teacher's Guide to Using the Schoolgrounds for Environmental Studies (Second Edition).* National Science Teachers Association, Washington, D. C., 1990.

This is a K-12 teachers' guide to using the school grounds for environmental studies. These easy excursions take students through animals, weather, seasonal changes, building materials, rocks and soil formation, water and its effects, and recycling and natural decomposition.

The World of Insects: Insect Biology for the Elementary Level. The Imaginarium, 725 West 5th Avenue, Anchorage, AK 99501.

This book contains 13 complete lesson plans on insects, with instructions for both students and teachers. Each lesson has activity pages that can be reprinted for use in the classroom.

Educational Reform Books

Rutherford, James F. and Andrew Ahlgren. *Science for All Americans.* Oxford University Press, New York, 1990.

and

Rutherford, James F. *Benchmarks for Science Literacy.* Oxford University Press, New York, 1993.

These books are products of the American Association for the Advancement of Science's "Project 2061." *Science for All Americans* is intended to be a "view of the scientific community on what constitutes literacy in science, mathematics, and technology." *Benchmarks for Science Literacy* recommends "what all students should know or be able to do in science," listed as goals for students to complete by the end of grades 2, 5, 8, and 12. These are important references for designing or reevaluating science curricula.

First Aid/Safety Books

The American Red Cross. *First Aid Fast.* Mosby Lifeline, St. Louis, 1995.

This is a pocket-sized, quick-check guide to standard first aid procedures. A simple first aid guide, such as this one, as well as a first aid kit, should be readily accessible when conducting any outdoor activity. This guide can be purchased from your nearest American Red Cross chapter, listed in your local phone book. Other first aid books and kits can be found in drug and department stores. Although first aid books can be helpful, they are no substitute for formal first aid training. In any serious emergency, call your local emergency service quickly!

Other Hands-on Science Programs

Project WILD and Aquatic Project WILD. Sponsored in Virginia by the Virginia Department of Game and Inland Fisheries and by the Virginia Division of the Izaak Walton League of America. For information, contact the Department of Game and Inland Fisheries, P. O. Box 11104, Richmond, VA 23230-1104, phone (804) 367-0188.

The two Project WILD's are interdisciplinary, environmental- and conservation-education programs that emphasize wildlife. The programs offer activity guides and teacher workshops.

Project Learning Tree. Sponsored in Virginia by the Virginia Department of Education, the Virginia Department of Forestry, and the Virginia Forestry Association. For more information, contact Lou Southard at the Virginia Department of Forestry, P. O. Box 3758, Charlottesville, VA 22903; phone (804) 977-6555.

Project Learning Tree is a forestry-based program with activity guides and teacher workshops. Topics include trees, sensory awareness, forest habitats, forest uses, and resource management.

Project WET. Sponsored by the Virginia Department of Environmental Quality, P. O. Box 10009, Richmond, VA 23240-0009; phone (804) 698-4442.

Project WET is a water-education program for children in kindergarten through grade 12. It includes activities and information on many water-related topics.

Save Our Streams (SOS). Sponsored nationally by the Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878-2983; phone (800) 284-4952; the Virginia Museum of Natural History at Virginia Tech is a regional SOS coordinator for southwestern Virginia.

The Save Our Streams (SOS) program is a hands-on river protection and restoration program. SOS teaches volunteers how to monitor streams through simple hands-on techniques that can be done by people of all ages. *Hands On Save Our Streams*, an interdisciplinary, environmental-education curriculum guide for grades 1-12, is one of several publications available through the program.

Inexpensive Science Tools

Many Lines of Inquiry and sample lessons in *The MINTS Book* call for students to use simple, inexpensive science tools, such as hand lenses. If your school lacks a supply of such tools, the information in this section can help you develop a supply.

The table below is based on a kit developed by the Virginia Museum of Natural History at Virginia Tech for doing science investigations like those described in this book. The inventory of the kit, which is available on loan from the Museum, gives you a framework for developing kits for your school. The number of each item in the table is what we estimate for an average class (say, 20-30 students); the costs are the total for this number of items. The costs are those we found in September 1996. Sales tax and shipping charges (where applicable) have not been included.

At the end of the list are the addresses and phone numbers of the suppliers listed in the table. Listing of a supplier here is not meant to convey an endorsement by the Museum of that supplier's products over some other supplier. Many suppliers carry the same equipment, so it is wise to shop around, both locally and through catalogs.

ITEM	USE	#	COST	SUPPLIER
Beakers (plastic, 100 ml)	measuring liquids	20	$9.30	Science Kit
Bug boxes (small)	observing insects	12	$4.80	Museum Products
Bug boxes (large)	observing insects	5	$7.50	Museum Products
Compasses (15 mm diam.)	finding direction	12	$9.95	Science Kit
Dropper bottles (2 oz.)	measuring small amounts of liquid	8	$5.25	Delta Education
Flags (bright yellow, five-inch wire stake)	marking areas	50	$4.50	Forestry Suppl.
Graduated cylinders (100 ml)	measuring liquids	10	$47.50	Forestry Suppl.
Hand lenses (3x and 6x)	close observation	30	$29.95	Delta Education
Measuring tapes (1m)	measuring length	4	$3.95	Delta Education
Measuring wheels	measuring distance	1	$25.00	Delta Education
Meter sticks (flexible)	measuring length	10	$18.50	Delta Education
OBIS Terrestrial Hi-Lo Hunt activity folder	templates for light meters and wind gauges	1	$2.75	Delta Education
Petri dishes (100 x 15 mm)	containing samples	40	$9.20	Science Kit
pH paper	measuring pH	2 rolls	$7.50	Science Kit
Plastic bags (gallon size)	storing samples	20	$2.09	grocery stores
Plastic bags (sandwich)	storing samples	30	$1.59	grocery stores
Plastic tub (18 gallon)	storing kit items	1	$5.00	variety stores
Rulers (30 cm/12 in.)	measuring lengths	30	$10.95	Delta Education
Shoe boxes (plastic)	storing samples	3	$3.00	variety stores
Thermometers (plastic, F and C scales)	taking temperatures	36	$29.85	Delta Education
Trowels	sampling soil or plants	6	$12.00	hardware stores
Tweezers (green plastic)	holding small objects	20	$13.80	Science Kit

Addresses and Phone Numbers of Science Tools Suppliers Listed in the Table

Delta Education
P. O. Box 3000
Nashua, NH 03061
phone (800) 442-5444

Forestry Suppliers
P. O. Box 8397
Jackson, MS 39284-8397
phone (800) 647-5368

Museum Products
84 Route 27
Mystic, CT 06355
phone (800) 395-5400
fax (860) 572-9589

Science Kit and Boreal Laboratories
777 East Park Drive
Tonawanda, N.Y. 14150-6782
phone (800) 828-7777
fax (716) 874-9572
(Note: individuals must pre-pay.)

Seasonal Guide for Topics in *The MINTS Book*

If you are interested in a specific *topic*, and want to know the possible seasons for doing activities related to that topic, check the left-hand column for the topic of interest (the topics are listed in the order in which they appear in the book). If, on the other hand, you are thinking of a particular *season*, and want to know what topics are good for doing activities during that season, scan the right-hand column of the chart for the symbol of the season of interest.

The seasonal notation in this chart refers to the topics as a whole, not necessarily to all aspects of the topic. For example, the American Robin section is given a year-round notation because Robins can be found year-round in Virginia; however, some aspects of Robins' natural history—such as nesting—can be studied only in certain seasons.

Topic/Activity	Possible Season(s)
Chapter 2. The Parking Lot	
Habitat Features and Natural History	Year-round
Chapter 3. The Lawn	
Introduction	Spring, Summer, Fall
Grasses	Spring, Summer, Fall
Clovers	Spring
Dandelion	Spring
Hawkweeds	Spring
Plantains	Spring, Summer, Fall
Common Chickweed	Spring
Common Cinquefoil	Spring
Wild Strawberry	Spring
Buttercups	Spring
Common Blue Violet	Spring
Speedwells	Spring
Ground Ivy	Spring
Puffballs	Spring, Fall
Short-horned grasshoppers	Fall
Leafhoppers	Spring, Summer, Fall
Grass Spiders	Spring, Summer, Fall
Earthworms	Spring, Summer, Fall
American Robin	Year-round
Chapter 4. Fencerows and Other Overgrown Areas	
Vines	Spring, Summer, Fall
Queen Anne's Lace	Spring, Summer, Fall
Common Burdock	Fall, Winter
Thistles	Fall
Chicory	Spring, Summer, Fall

Yarrow	Spring, Summer, Fall
Goldenrods	Fall
Spittlebugs	Spring
Tortoise Beetles	Spring, Summer, Fall
Meadow Vole	Spring, Summer, Fall
Eastern Redcedar	Year-round
Black Cherry	Spring, Summer, Fall
Black Locust	Spring, Summer, Fall
Discovering Insects	Spring, Summer, Fall
Collecting Insects	Spring, Summer, Fall
Chapter 5. Roofs, Walls, and Eaves	
Introduction	Year-round
Common Mallow	Spring, Summer, Fall
Yellow Wood Sorrel	Spring, Summer, Fall
Terrestrial Isopods	Spring, Summer, Fall
Harvestmen	Spring, Summer, Fall
Spiders	Spring, Summer, Fall
Schoolyard Wasps	Spring, Summer, Fall (close-up nest observations in Winter only)
Centipedes and Millipedes	Spring, Summer, Fall
House Mouse	Year-round
House Sparrow	Spring, Summer, Fall
Chapter 6. Trees	
Introduction	Year-round
Trees and Their Surroundings	Year-round
Tree Shapes	Year-round
Tree Parts:	
Trunks	Year-round
Bark	Year-round
Leaves	Deciduous: Spring, Summer, Fall Evergreen: Year-round
Twigs	Year-round, but best observed in Spring and Winter
Flowers	Spring (most trees)
Fruits and Seeds	Spring, Fall
White Pine	Year-round
How to Determine Tree Height	Year-round
Ways to Record Leaf Features for Further Study	Deciduous: Spring, Summer, Fall Evergreen: Year-round

What's a Family, What's a Genus? The Basics of Classifying Living Things

Classification is a formal way of grouping organisms based on shared characteristics. **Taxonomy** is the science of naming and classifying organisms. Scientists classify, or group, living things in order to organize and understand a diverse world and to help trace evolutionary pathways. Organisms that are classified together are believed to have a common ancestry, and so are often referred to as being "related." The actual grouping of organisms is based on similarities and differences in organisms' physical features, reproductive methods and structures, and other characteristics.

At the lowest (most specific) level of classification, **species** are made up of individuals who are so closely related that their features are extremely similar. Members of a species can reproduce one with another and produce fertile offspring.

Species that are similar to one another are grouped together in a **genus** (plural, **genera**). Species tend to form clusters, that is, groups of species that appear similar to one another. A genus represents such a cluster of species. For example, all goldenrods (genus *Solidago*) are recognizable by their flower color and structure. The goldenrod species cluster, or genus, is distinguished from other genera by relatively distinct, measurable characteristics.

Genera that appear similar and are thought to be of the same ancestry are grouped together into **families**. Plants, especially, are commonly referred to as being in a particular family. This is because plants are relatively easy to identify to family, and knowing a plant's family gives you some idea of the general characteristics of the plant (if you know the family characteristics, or if you know other members of the family). Plant families are mentioned frequently in this book.

Families of supposed common ancestry are clumped together into **orders**. Insects are relatively easy to identify to order, so insects are often referred to by their order name. For example, the bees represent an order of insects called Hymenoptera. Insect orders are also mentioned frequently in this book.

Orders are grouped together in a relatively few **classes** that have a few broad characteristics. Classes, in turn, are grouped into **divisions** for plants and **phyla** for animals. Finally, the divisions and phyla are grouped into the plant and animal **kingdoms**, respectively.

Classification of organisms—such as fungi—that are neither plant nor animal follows a similar scheme, although the particular names of classification levels may be somewhat different.

References

About the Information Sources

You might very well ask, "Where did all the information in this book come from, and how do I know it's correct?" During the preparation of the book, several reputable, published sources were consulted. The main sources used during this process are listed below. The background information in the habitat chapters (chapters 2-6) was reviewed in 1995 for scientific accuracy by several currently practicing scientists (as noted in the Acknowledgments); this final version includes corrections based on those reviews. We have attempted to eliminate any questionable statements that could not be verified by readily available references. We welcome being told about any errors that readers discover.

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Glossary

The following definitions are meant to assist users of this book in clarifying potentially unfamiliar terms. The aim here is not to be overwhelmingly technical, but rather to provide accurate working definitions for certain key terms used in this book. In order to stress concepts rather than terms, many of the definitions have been lumped into single entries; in these cases, the defined terms are **bolded**, matching the bolding of the main entry. The primary sources consulted in writing these definitions were *Webster's Ninth New Collegiate Dictionary* (1990) and the *McGraw-Hill Dictionary of the Life Sciences* (1976).

abdomen — The rear body part of an insect, spider, or crustacean.

aerial root — An exposed root that some plants (such as vines) use to attach themselves to another structure.

algae — Microscopic, single-celled plants that grow in water or in moist areas. Some kinds of algae form colonies in visible strands or filaments.

annual — A plant that completes its life cycle in one year.

biennial — A plant that completes its life cycle in two years. Vegetative growth occurs in the first year, while seed development occurs in the second.

blossom — A flowering plant's flower-bearing structure. A blossom can be made up of many individual flowers, as in clovers and Dandelion.

bracts — Any of several possible modified leaf structures found on various plants.

brood — The young of a bird that hatch at one time.

bud — An undeveloped stem, flower, or leaf. A **terminal bud** is at the end of a twig; **lateral buds** are on the sides of twigs.

caste — See **social insects**.

climax community — See **succession**.

community — The interacting plant and animal populations in a given common location.

compound leaf — See **leaf**.

cone — See **conifer**.

conifer — Any cone-bearing tree, most of which are evergreens. Pines and cedars are examples of conifers. Conifers produce seeds but have neither flowers nor fruits. **Cones,** rather than flowers, are the reproductive structures in conifers. **Seed cones** are mature, seed-bearing, female cones.

cross pollination — See **pollination**.

crustacean — An organism with an **exoskeleton**, one pair of jointed appendages on each body segment, generally two pair of antennae, and gills for breathing. Common crustaceans are crabs, lobsters, and crayfish.

deciduous — Possessing the trait of losing leaves in the autumn (as in many tree species).

decomposer — An organism that gains its nutrients from dead organic matter in the process of breaking down or "decomposing" the matter. Many microorganisms, for example, are decomposers, but so are many larger organisms, such as earthworms.

dichotomous key — A system for identifying organisms by choosing between a series of opposing characteristics. Many field guides to natural history subjects include some version of a dichotomous key.

distribution — The location of organisms within a given area, especially referring to any pattern of location. Plant distribution is discussed frequently in this book. In **random** plant distribution, individual plants of a given species are located in no specific pattern. In a **clumped** distribution, plants of a given species would be found in groups, rather than individuals; the groups themselves would typically not be arranged in a specific pattern. In a **uniform** distribution, plants of a given species would be found in a regular pattern. Environmental factors play an important role in determining distribution both of plants and animals.

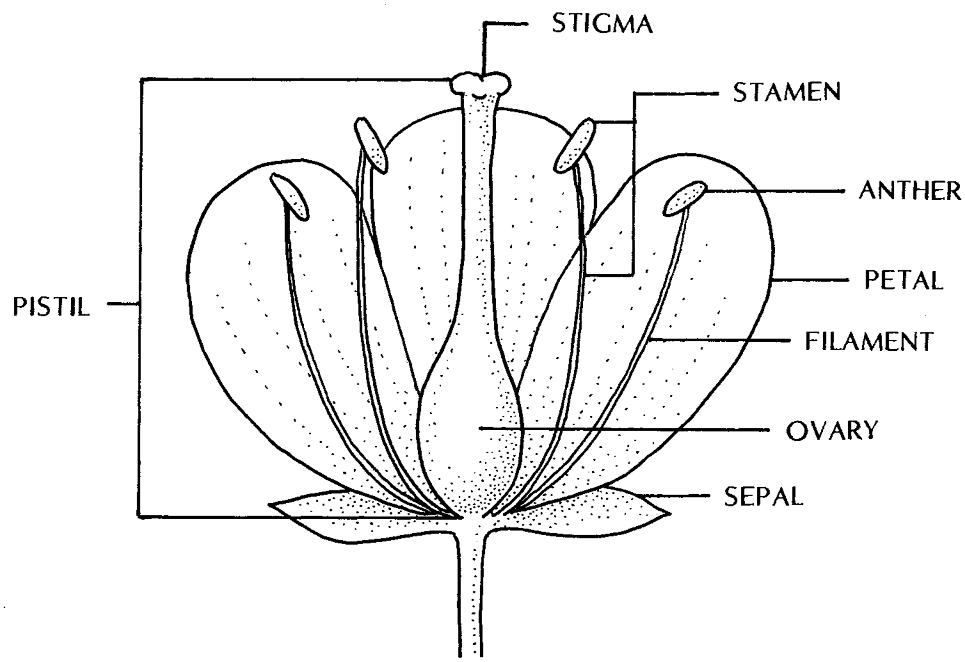
dolomite — A calcium-based sedimentary rock, specifically a type of limestone, high in magnesium content.

drone — See **social insects**.

embryo — A developing organism, produced by the fertilization of an egg by a sperm cell in organisms that undergo sexual reproduction.

exoskeleton — An external shell of many organisms, serving as the main support and protection system of the body. Insects, spiders, and crustaceans are common organisms with exoskeletons.

flower — The often-decorative reproductive structure of most seed plants. The male structure, known as the **stamen**, is composed of the **anther** (which bears the **pollen**, the male reproductive cells) and the **filament**. The female structure is known as the **pistil**, the



Basic Flower Parts

top of which is the **stigma**, where pollen enters the pistil. At the base of the pistil lies the **ovary**, where eggs (the female reproductive cells) are contained. A **fruit** is a seed-bearing ovary. **Sepals**, a type of bract, are sometimes found inserted on the plant stem directly below the **petals** that often surround the pistil and stamen. Some plants' flowers contain only female or male structures, while others contain both.

fruit — See **flower**.

fungus (plural **fungi**) — Any of a group of organisms that resemble plants, but lack chlorophyll and gain nutrients either from decaying organic matter or from another living organism. Mushrooms are a widely known type of fungi.

gall — Swollen plant tissue that arises from a parasite or fungus invasion.

gamete — A reproductive cell that must fuse with a gamete of the opposite sex in order to complete fertilization, as part of sexual reproduction.

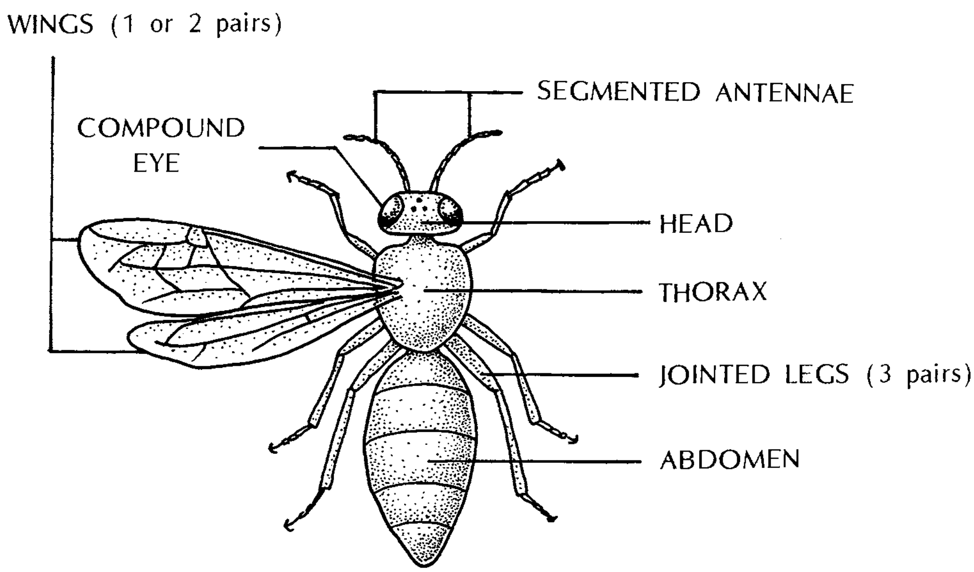
herbaceous — Possessing non-woody plant tissue.

herbicide — An agent (most often chemical) used to destroy or deter the growth of plants.

herbivorous — Having a diet of plants. An herbivorous organism is known as an **herbivore.**

hyphae — Small filaments that make up the vegetative body of a fungus. In a mushroom-producing fungus, the above-ground mushroom is the reproductive structure, while the hyphae are found underground.

insect — An invertebrate animal with an exoskeleton, a segmented body, three pairs of legs, one pair of antennae, and one or two pair of wings (as an adult).

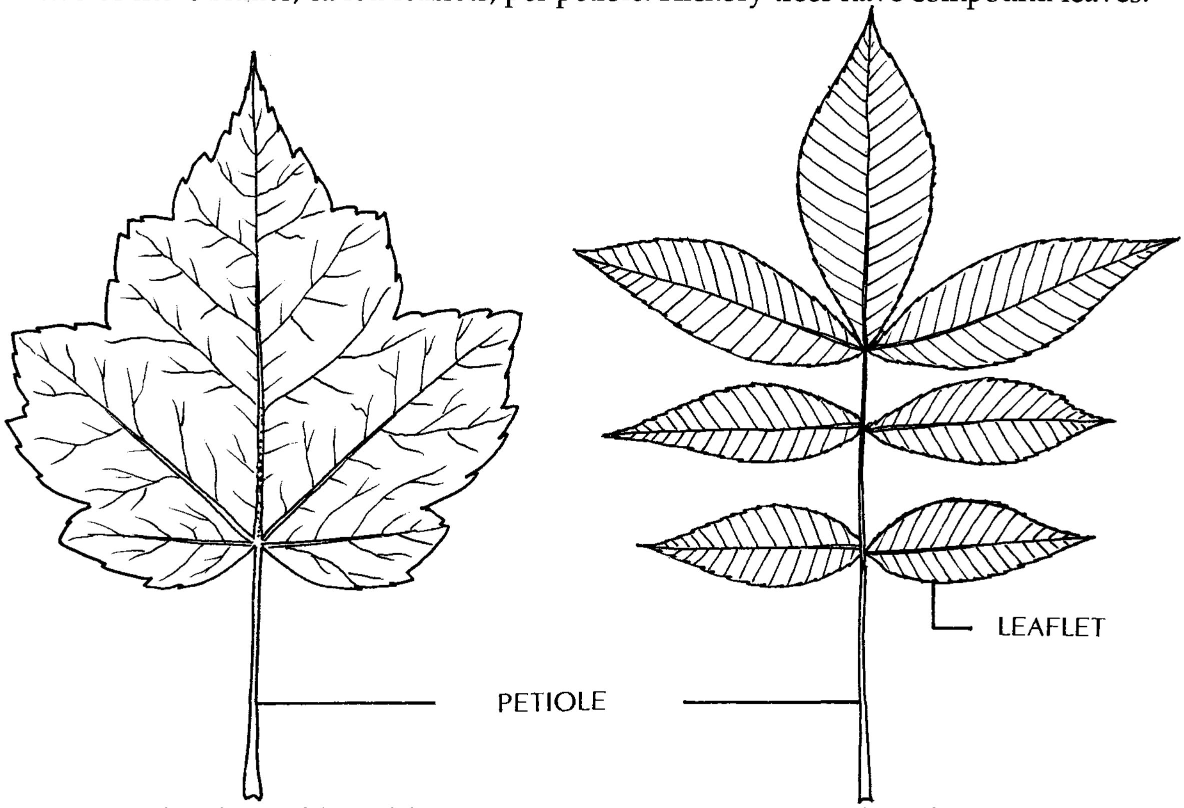


Basic Insect Structures

invertebrate — An animal without a spinal column or backbone. Common invertebrates are insects, spiders, and worms. **Vertebrates,** in contrast, have a backbone (spinal column). Fish, amphibians, reptiles, birds, and mammals are all vertebrates.

larva — See **metamorphosis.**

leaf — The structure of a plant where photosynthesis primarily occurs. Leaves are attached to the main stem of a plant by a modified stem called a **petiole.** A **simple leaf** has one blade per petiole. Maple trees, for example, have simple leaves. A **compound leaf** has two or more blades, called **leaflets,** per petiole. Hickory trees have compound leaves.



Simple Leaf (Maple) **Compound Leaf (Hickory)**

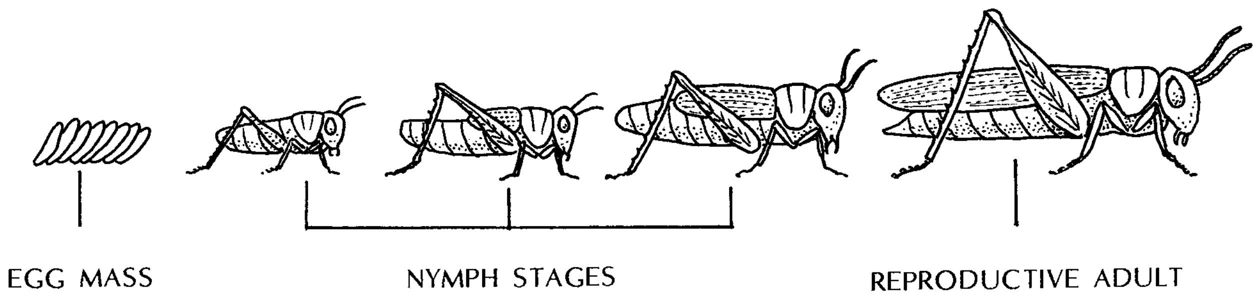
leaflet — See **leaf.**

lichen — An organism consisting of an alga (singular of algae) and a fungus growing together. Certain types of lichens colonize bare rock.

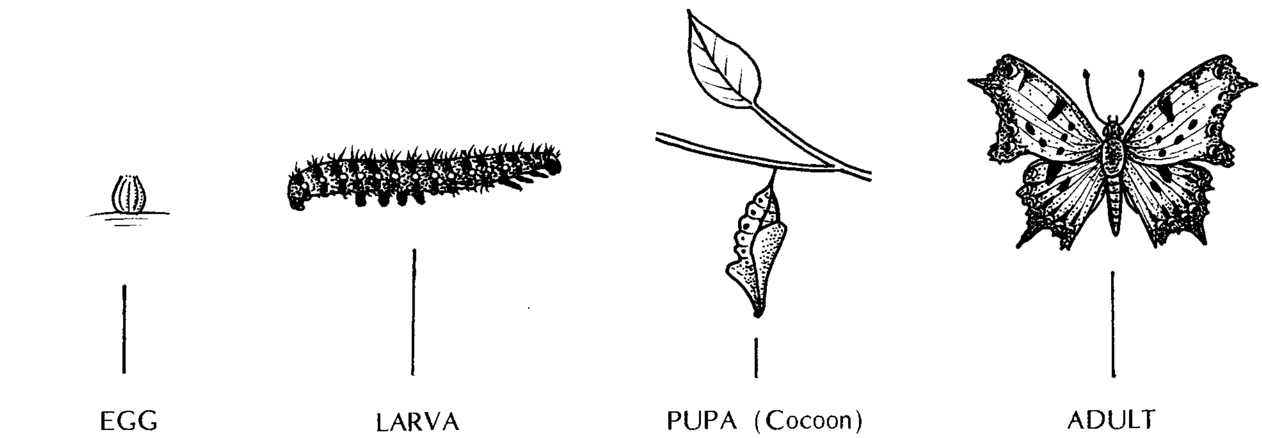
litter layer — A layer of leaves and other organic material, especially in a forest, that has not been completely decomposed.

metamorphosis — The process by which an immature insect transforms into an adult form. During **complete metamorphosis,** a fertilized egg hatches into a **larva,** a worm-like life form. (A caterpillar is an example of a larva.) After the larva develops for some time it begins **pupation,** where the **pupa** transforms itself into its adult form inside a case (or "cocoon" in some insects). During **incomplete metamorphosis,** the egg hatches into a **nymph,** which closely resembles the adult form but lacks developed wings. (An immature grasshopper is an example of a nymph.) When the wings fully develop, the insect has reached the adult stage. In both types of metamorphosis, only the adult form has the ability to reproduce.

Two Basic Types of Insect Metamorphosis



Incomplete Metamorphosis (Grasshopper)



Complete Metamorphosis (Butterfly)

microclimate — The highly localized climate of a small area or habitat. For example, a Tent Caterpillar's "tent" creates a microclimate: The temperature inside the tent is consistently higher than its surroundings, because the tent traps warm air inside its walls.

molt — To shed the outer layer (exoskeleton, feathers, hair, etc.) of an animal. Molting occurs commonly among insects, birds, and snakes.

nymph — See **metamorphosis**.

organism — Any living (or very recently living) thing.

ovary — See **flower**.

overwinter — To live through the cold season.

parasite — An organism that lives in or on another—its **host**—and gains its nutrients from that organism to the detriment of the host organism.

perennial — A plant that does not complete its life cycle in just one year. Perennials die after a variable amount of time. Trees, shrubs, and Poison Ivy are all perennials.

petiole — See **leaf.**

pH — Scale used to determine whether a solution is an **acid**, a **base**, or neutral. The pH scale goes from 0 to 14. Any value less than 7 indicates an acidic solution, with 0 being the most acidic. Any value greater than 7 indicates a basic solution, with 14 being the most basic. A solution with a pH of 7 is said to be neutral. Levels of pH indicate relative strength to each other by factors of ten, so an acid with a pH of 3 would be ten times as strong as an acid with a pH of 4, and a base with a pH of 13 would be ten times as strong as a base with a pH of 12. Vinegar, a common acid, has a pH of 2.5. Ammonia, a common base, has a pH of 12. Both strong acids and strong bases can be caustic and/or corrosive.

photosynthesis — The process by which chlorophyll-containing plants convert light energy, carbon dioxide, and water into chemical energy (in the form of carbohydrates, or sugars) and oxygen.

pistil — See **flower.**

pollen — See **flower** and **pollination.**

pollination — The process by which pollen, containing male reproductive cells, in seed plants is transferred to structures housing the plant's egg cells (the female reproductive cells). When this occurs on a single plant, it is known as **self-pollination**. When this occurs between different plants, it is known as **cross-pollination**.

predator — An animal that survives by hunting, killing, and feeding on other animals. The animals on which a predator feeds are known as **prey.**

primary succession — See **succession.**

pupa — See **metamorphosis.**

queen — See **social insects.**

rhizomes — See **stem.**

scavenger — An organism that primarily feeds on dead animals or other discarded sources of food.

secondary succession — See **succession.**

seed cones — See **conifer.**

self pollination — See **pollination.**

sepal — See **flower.**

simple leaf — See **leaf.**

social insects — Insects that live in communities divided according to specific tasks. These task-divisions are known as **castes**. In general these communities include **queens**, fully developed females that lay eggs; **males** that fertilize the queen's eggs (called **drones** in Honey Bee colonies); and **workers**, sterile females that provide labor and protection.

spinneret — The organ spiders use to silk secretions into fibers for web-making and other purposes.

stamen — See **flower.**

stem — The support structure of a plant that gives rise to roots and leaves. A **stolon** is a stem that runs along the ground, and a **rhizome** is an underground stem.

stigma — See **flower.**

stolon — See **stem.**

succession — A gradual, generally predictable pattern of changes in a natural community. Succession generally proceeds until a stable **climax community** is reached; in much of the eastern United States, including most of southwestern Virginia, a deciduous forest is the typical climax community. **Primary succession** occurs when an area that previously had no natural community, such as bare rock, undergoes succession. **Secondary succession** occurs after a disturbance--either a natural disturbance, such as a lightning fire, or a human disturbance, such as logging--alters an existing community.

tendrils — A modified leaf or stem, which can wrap around an object for support.

thorax — The middle part of an insect's body, between the head and the abdomen.

tracheal tubes — Small tubes that distribute air throughout the bodies of most insects.

transect — An imaginary straight line, often marked in some manner, over which observations are taken at regular intervals.

transpiration — In plants, the loss of water through openings in leaf surfaces.

veins (leaf) — The tubes that carry water and nutrients through a leaf.

worker — See **social insects.**

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⚠ **CAUTION is advised when studying plants or animals indicated by this symbol.**

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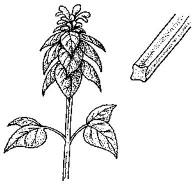
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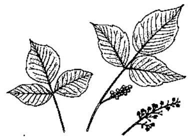
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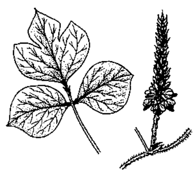
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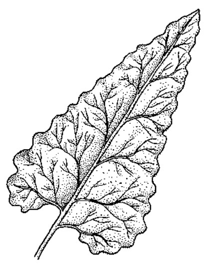
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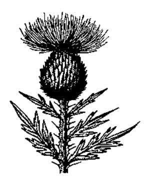
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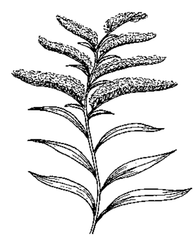
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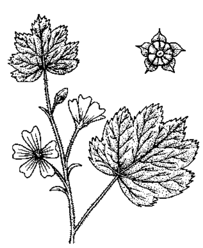
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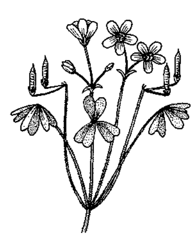
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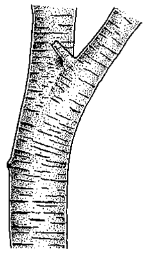

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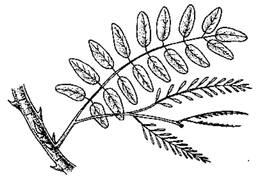

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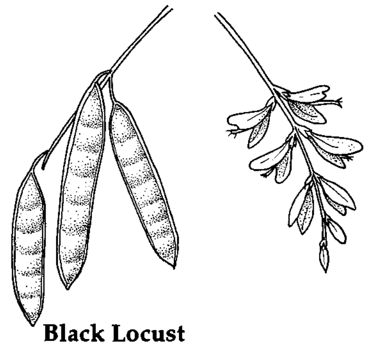

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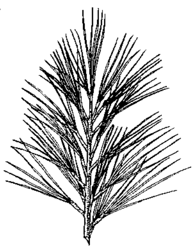

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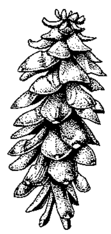

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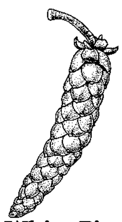

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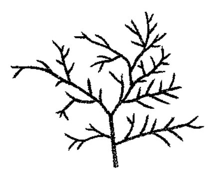

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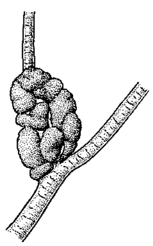

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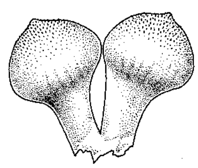

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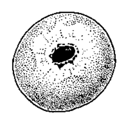

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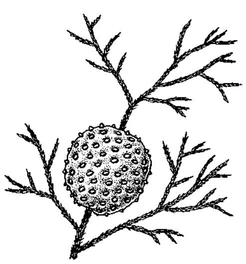

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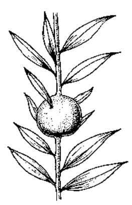

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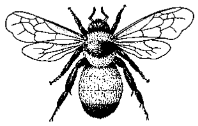

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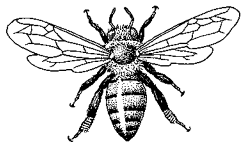

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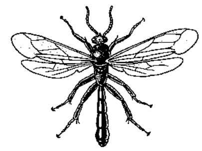

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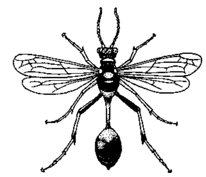

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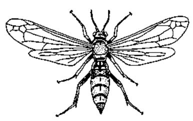

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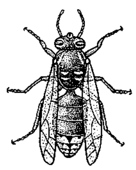

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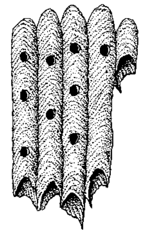

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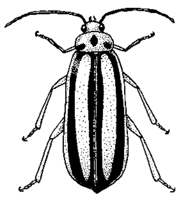

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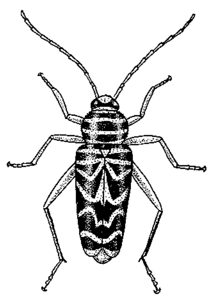

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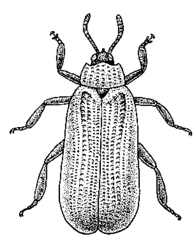

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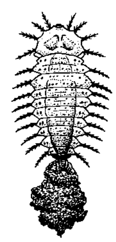

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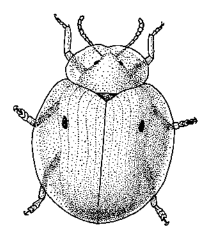

Tortoise Beetle adult
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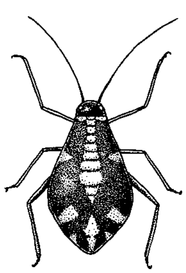
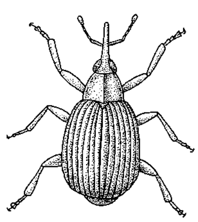
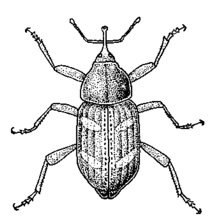


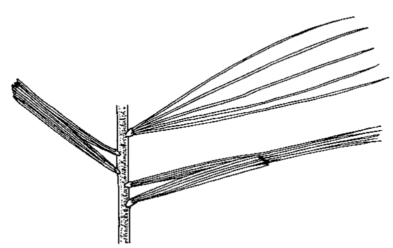
White Pine Aphid
page 203



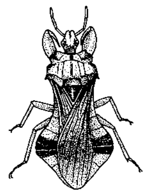
Snout Beetle
page 38

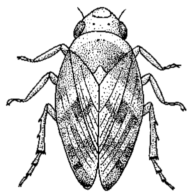


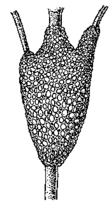
White Pine Weevil
page 203

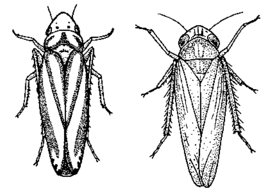


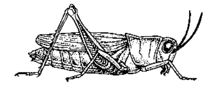
Pine Tube Moth, tube of
page 204

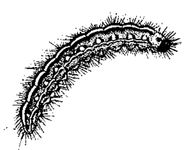


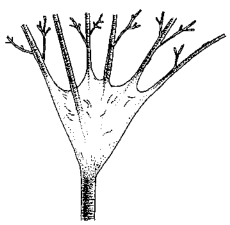


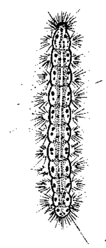


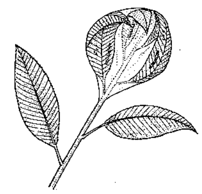


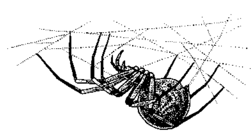


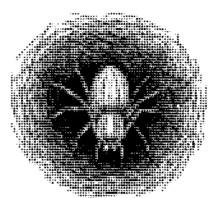


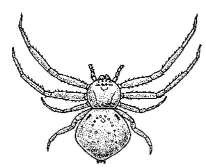


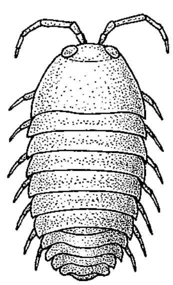


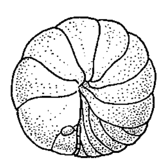


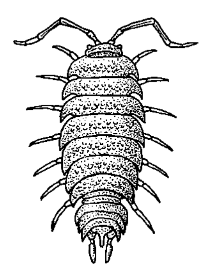




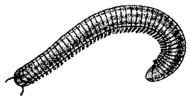




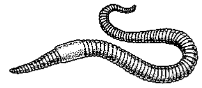




Centipede
page 168



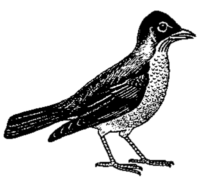
Millipede
page 168



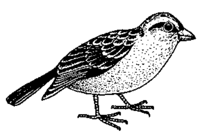
Earthworm
page 69

Meadow Vole
page 116

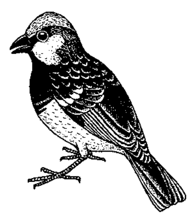
House Mouse
page 171



American Robin
page 71



House Sparrow
female
page 174



House Sparrow
male
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For further information please contact:

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