hands-on science and Technology

An Inquiry Approach

Grade 6

Series Editor
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Portage & Main Press
Winnipeg • Manitoba • Canada

Portage & Main Press gratefully acknowledges the financial support of the Province of Manitoba through the Department of Sports, Culture, and Heritage and the Manitoba Book Publishing Tax Credit, and the Government of Canada through the Canada Book Fund (CBF), for our publishing activities.

Hands-On Science and Technology, Grade 6
An Inquiry Approach

ISBN: 978-1-55379-712-8
Printed and bound in Canada by Prolific Group

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www.portageandmainpress.com
Winnipeg, Manitoba
Treaty 1 Territory and homeland
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Contents

Introduction to *Hands-On Science and Technology, Grade 6*

Introduction to Hands-On Science and Technology

Program Introduction

Hands-On Science and Technology helps develop students' scientific and technological literacy through active inquiry, problem solving, and decision making. With each activity in the program, students are encouraged to explore, investigate, and ask questions as a means of heightening their own curiosity about the world around them. Students solve problems through firsthand experiences, and by observing and examining objects within their environment. In order for young students to develop scientific and technological literacy, concrete experience is of utmost importance—in fact, it is essential.

The Inquiry Approach to Science and Technology

As students explore science and technology concepts, they should be encouraged to ask questions to guide their own learning. The inquiry model is based on five components:

1. formulating questions
2. gathering and organizing information, evidence, or data
3. interpreting and analyzing information, evidence, or data
4. evaluating information, evidence, or data, and drawing conclusions
5. communicating findings

Using this model, the teacher becomes the facilitator of the learning process, and students initiate questions; gather, organize, interpret, and analyze information; evaluate findings and draw conclusions; and communicate their learning. As such, the process focuses on students' self-reflections as they ask questions, discover answers, and communicate their understanding.

Using an inquiry approach involves beginning with more structured inquiry, and moving to guided inquiry and, finally, open inquiry.

- In structured inquiry, the teacher may provide the initial question and structure the procedures to answer that question. Students follow the given procedures and draw conclusions to answer the given question.
- In guided inquiry, the teacher provides the research question, and students are involved in designing ways to answer the question and communicate their findings.
- In open inquiry, students formulate their own question(s), design and follow through with a developed procedure, and communicate their findings and results. According to Banchi and Bell (2008), "Open inquiry activities are only successful if students are motivated by intrinsic interests and if they are equipped with the skills to conduct their own research study."

In implementing an inquiry approach to science and technology, questions and ideas form the foundation of the teaching and learning process. The following excerpt from the Ontario Literacy and Numeracy Secretariat speaks clearly to this approach:

> While all students ask questions and express interests in world phenomena, it takes creative and responsive teaching to transform wonder into knowledge. To begin, inquiry works best in a classroom in which ideas are placed at the centre. Establishing a culture in which students are encouraged to express ideas but also to respectfully challenge and test one another's ideas is an important first step in the inquiry process. This spirit of inquiry is achieved by welcoming ideas and trusting that even the simplest questions can lead to something greater and not yet evident. Like any good growing system, these questions need time to germinate. Students' ideas can be expressed in many forms (questions, comments, diagrams, pictures, dance, etc.) and serve the important purpose of advancing student understanding of a topic. When the classroom culture is one that

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views ideas as improvable, students work hard to continuously improve the quality, coherence and utility of ideas—both individually and collectively (Scardamalia 2002).

21st Century Teaching and Learning

In this rapidly changing and globalized world, it is more important than ever to prepare students from many different backgrounds to lead fulfilling lives, be productive contributors, and thrive in our society. Educators are responding to this challenge through evolving practice that challenges students in engaging and meaningful ways that encompass diverse student perspectives. The **Hands-On Science and Technology** program responds to this challenge by ensuring it reflects best practices that focus on 21st Century Competencies. According to Michael Fullan (2013), these competencies are:

- **Critical thinking**—the ability to explore problems, weigh alternate solutions, and arrive at solutions. It also involves problem solving and making effective decisions, and applying them to real-world contexts.
- **Communication**—the ability to communicate effectively through reading, writing, speaking, listening, viewing, and representing. Communication also involves the ability to use a variety of information sources and digital tools.
- **Collaboration**—the ability to work in teams, learning from and contributing to the learning of others.
- **Creativity**—exploring new ideas, being innovative, and thinking outside the box. Being creative also means looking at novel ideas and finding ways to put ideas into action.
- **Citizenship**—thinking like both a local and a global citizen, considering the values and worldviews of others, and having a genuine interest in solving complex real-world problems that affect human and environmental sustainability.
- **Character**—showing traits such as perseverance, resilience, and being a life-long learner.

These competencies are the foundation of the inquiry-based approach used in **Hands-On Science and Technology**. As such, teachers take on a facilitation role as students use these skills to explore, investigate, research, design, create, and solve problems in the world around them. To provide a connection between science and technology activities and 21st Century Competencies, each lesson in ***Hands-On Science and Technology, Grade 6*** identifies one or more competencies teachers may focus on during the activity. This provides teachers with the opportunity to make ongoing links between the science and technology curriculum and 21st century classroom teaching and learning.

The Goals of the Science and Technology Program

Science and technology play fundamental roles in the lives of Canadians. In the introduction to *The Ontario Curriculum, Grades 1–8: Science and Technology* (2007), the Ministry of Education states:

> During the twentieth century, science and technology played an increasingly important role in the lives of all Canadians. Science and technology underpin much of what we take for granted, including clean water, the places in which we live and work, and the ways in which we communicate with others. The impact of science and technology on our lives will continue to grow. Consequently, scientific and technological literacy for all has become the overarching objective of science and technology education throughout the world.

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The Ontario Curriculum identifies three goals that form the foundation of the science and technology program. In keeping with this focus on scientific and technological literacy, these goals are the bases for the lessons in the **Hands-On Science and Technology** program:

Goal 1:
to relate science and technology to society and the environment

Goal 2:
to develop the skills, strategies, and habits of mind required for scientific inquiry and technological problem solving

Goal 3:
to understand the basic concepts of science and technology

Hands-On Science and Technology Strands and Expectations

For all grade levels, the Ontario science and technology curriculum is organized into four strands:

1. Understanding Life Systems
2. Understanding Structures and Mechanisms
3. Understanding Matter and Energy
4. Understanding Earth and Space Systems

Two sets of expectations are listed for each grade in each strand: (1) overall expectations, and (2) specific expectations.

The overall expectations describe, in general terms, the knowledge and skills students are expected to demonstrate by the end of each grade. There are three overall expectations for each strand in each grade in science and technology.

The specific expectations describe the expected knowledge and skills in greater detail.

NOTE: The overall and specific expectations must all be accounted for in instruction and assessment, but evaluation focuses on the three overall expectations (Ontario Ministry of Education 2010).

The overall and specific expectations for each strand are presented in chart format in the introduction to each unit. Alongside each specific expectation, corresponding lessons are identified.

Hands-On Science and Technology Fundamental Concepts and Big Ideas

Fundamental concepts are key ideas that provide a framework for the acquisition of all scientific and technological knowledge. These concepts also help students to integrate scientific and technological knowledge with knowledge in other subject areas, such as mathematics and social studies. The fundamental concepts addressed in the curriculum for science and technology are:

- matter
- energy
- systems and interactions
- structure and function
- sustainability and stewardship
- change and continuity

Big ideas are the enduring understandings students carry with them into the future. Big ideas are often transferable to other subjects and to real-life experiences.

For all grades, the fundamental concepts and big ideas for each strand can be found in a chart in the introduction to each unit of the **Hands-On Science and Technology** program.

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Hands-On Science and Technology Program Principles

- Effective science and technology programs involve hands-on inquiry, problem solving, and decision making.
- The development of students' skills, attitudes, knowledge, and understanding of Science, Technology, Society, and the Environment (STSE) issues form the foundation of the science and technology program.
- Children have a natural curiosity about science and the world around them. This curiosity must be maintained, fostered, and enhanced through active learning.
- Science and technology activities must be meaningful, worthwhile, and relate to real-life experiences.
- The teacher's role in science and technology education is to facilitate activities and encourage critical thinking and reflection. Children learn best by doing, rather than by just listening. Rather than simply telling, the teacher should instead focus on formulating and asking questions, setting the conditions so students ask their own questions, and helping students to make sense of the events and phenomena they have experienced.
- Science and technology should be taught in conjunction with other school subjects. Themes and topics of study should integrate ideas and skills from several core areas whenever possible.
- The science and technology program should encompass, and draw on, a wide range of educational resources, including literature, nonfiction material, audio-visual resources, and technology, as well as people and places in the local community.
- The science and technology program should be infused with knowledge and worldviews of Indigenous peoples, as well as other diverse multicultural perspectives.
- Assessment of student learning in science and technology should be designed to focus on performance and understanding, and should be conducted through meaningful assessment techniques carried out throughout each unit of study.

Infusing Indigenous Perspectives

Indigenous peoples are central to the Canadian context, and it is important to infuse Indigenous knowledge into the learning experiences of all students. The intentional integration of Indigenous knowledge in the **Hands-On Science and Technology** series helps to address the Calls to Action of the Truth and Reconciliation Commission of Canada (2015), particularly the call to "integrate Indigenous knowledge and teaching methods into classrooms" (clause 62) and the call for "building student capacity for intercultural understanding, empathy, and mutual respect" (clause 63).

Indigenous peoples of the past depended on the natural environment to survive. The environment shaped their way of life: geography, vegetation, climate, and natural resources of the land determined the ways they survived. By observing the land and its animal inhabitants, the environment also taught them how to survive. The traditional territories of the First Nations and Métis peoples cover Ontario, and many Inuit have moved to urban centres in the province. The worldviews of these peoples and their approaches and contributions to science and technology are now being acknowledged and incorporated into educational programs. It is also important to recognize the diversity of Ontario's Indigenous peoples and to focus on both the traditions and contemporary lives of the Indigenous communities in your area. Contact personnel in your school district—Indigenous consultants and/or those responsible for Indigenous education—to find out what

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resources (e.g., people, books, videos) are available to you and your students.

In incorporating Indigenous perspectives, it is important to value Traditional Ecological Knowledge (TEK) which is:

> …the knowledge base acquired by indigenous and local people over many hundreds of years through direct contact with the environment. It includes an intimate and detailed knowledge of plants, animals, and natural phenomena, the development and use of appropriate technologies for hunting, fishing, trapping, agriculture, and forestry and a holistic knowledge, or "worldview" which parallels the scientific disciplines of ecology (Inglis 1993).

Indigenous peoples developed technologies and survived on the land for millennia, in part, because they were good scientists. They used observation and experimentation to refine their technologies such as building canoes and tipis and discovering food-preservation techniques. As such, TEK serves as an invaluable resource for students and teachers of science and technology.

Throughout the **Hands-On Science and Technology** program, there are many opportunities to incorporate culturally appropriate teaching methodologies from Indigenous worldviews. First Peoples pedagogy indicates that making connections to the local community is central to learning (First Nations Education Steering Committee 2016). As one example, both Elders and Métis Senators offer a wealth of knowledge that can be shared with students. Consider inviting an Elder or a Métis Senator as a guest into the classroom during the study of specific topics. An Elder or a Métis Senator can guide a nature walk, share stories and experiences, share traditional technologies, and help students understand Indigenous peoples' perspectives of the natural world. Elders and Métis Senators can provide guidance for learners and opportunities to build bridges between the school and the community. Here are a few suggestions for working with Elders and Métis Senators:

- Some Indigenous keepers of knowledge are more comfortable being called "Knowledge Keepers" than "Elders" or "Métis Senators." Be sensitive to their preferences.
- It is important to properly acknowledge any visiting Elders or Métis Senators and their knowledge, as they have traditionally been and are recognized within Indigenous communities as highly esteemed individuals. There are certain protocols that should be followed when inviting an Elder or a Métis Senator into your classroom. The Lakehead District School Board has protocols available at: <https://www.lakeheadschools.ca/aboriginal-education/>.
- It is especially important to connect with Indigenous communities, Elders, and Métis Senators in your local area, and to study local issues related to Indigenous peoples in Ontario. Contact family memebers of students who have self-identified as First Nations, Métis, or Inuit for referrals, as well as Indigenous education consultants within your school district or the Ontario Ministry of Education. Also, consider contacting local Indigenous organizations for referrals to Elders, Métis Senators, and other Knowledge Keepers. Such organizations may also be able to offer resources and opportunities for field trips and land-based learning.

Finally, when incorporating Indigenous artifacts in the classroom, keep in mind that there is cultural significance to some objects made by Indigenous people that should only be shared by Indigenous people. For example, special ceremonies and protocol are performed when a tipi is erected or a drum is 'birthed,' or a feather is given. When a canoe is created, there are certain steps and traditions that the canoe builder follows. These are the teachings that an ▶

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Indigenous person can share when they create something with students. A non-Indigenous person could re-create a tipi or a wigwam, but they would not be able to share the ceremony that went with it, nor should they, because they are not part of the culture. Instead, they should invite an Indigenous person to share this knowledge and explain the significance to students. The Toronto District School Board's *Aboriginal Voices in the Curriculum: A Guide to Teaching Aboriginal Studies in K-8 Classrooms* says the following:

> Don't have students create dream catchers, masks, Seven Grandfather Teachings, Medicine Wheel, Totems, Wigwam, or Tipi, feathers/eagles, or other sacred cultural objects except in context, accompanied with discussion and provision of information on its historical and culutral significance and purpose, and preferably in the presence of an Elder or Aboriginal teacher.

Cultural Connections

To acknowledge and celebrate the cultural diversity represented in Canadian classrooms, it is important to infuse cultural connections into classroom learning experiences. It is essential for teachers to be aware of the cultural makeup of their class, and to celebrate these diverse cultures by making connections to curricular outcomes. In the same way, it is important to explore other cultures represented in the community and beyond, to encourage intercultural understanding and harmony.

Throughout the **Hands-On Science and Technology** program, suggestions are made for connecting science and technology topics to cultural explorations and activities.

Land-Based Learning

Land-based learning replaces the classroom walls with the natural land. For all students, land-based learning offers firsthand opportunities to observe, explore, and investigate the land, waters, and atmosphere of the natural world. Land-based learning promotes a healthy interplay between society and nature and helps students envision a world where there is meaningful appreciation and respect for our natural environment—an environment that sustains all life forms. Many lessons in ***Hands-On Science and Technology, Grade 6*** incorporate land-based learning activities, whether it be a casual walk around the neighbourhood to examine trees or a more involved exploration of local waterways. When land-based learning connections are made in ***Hands-On Science and Technology, Grade 6*** lessons, the following icon is used:

Technology

Digital learning, or learning with information and communication technology (LwICT), is an important component of any classroom. As such, technological supports available in schools—including digital cameras, computers/tablets, interactive whiteboards (IWB), projectors, document cameras, audio-recording devices, and even calculators—can be used with and by students to enhance their learning experiences. When technology connections are made in ***Hands-On Science and Technology, Grade 6*** lessons, the following icon is used:

Sustainability

The **Hands-On Science and Technology** program provides numerous opportunities for students to investigate issues related to sustainable development. Asking students the following question can often help to clarify for them what is meant by sustainability: "Is there enough for everyone, forever?" Exploring sustainability ▶

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also connects to Indigenous worldviews about respect and care for the Earth. The three pillars of sustainability are the environment, society, and the economy. When sustainability links are made in ***Hands-On Science and Technology, Grade 6*** lessons, any or all of the sustainability pillars may be the focus of this connection, and are identified by the following icon:

Program Implementation

Program Resources

Hands-On Science and Technology, Grade 6 is organized in a format that makes it easy for teachers to plan and implement. The book opens with this introduction (which includes assessment reproducibles) and is divided into four units that cover the selected topics of study for the grade level. The units relate directly to the strands, expectations, fundamental concepts, and big ideas outlined in *The Ontario Curriculum, Grades 1–8: Science and Technology* (2007).

Each unit also has its own introduction, which summarizes the general goals for the unit. This introduction provides background information for teachers, planning tips, and lists of vocabulary related to the unit, as well as other pertinent information such as how to embed Indigenous perspectives into the unit of study.

Additionally, the introduction to each unit includes a list of related resources (books, websites, and videos) suitable for students.

Each unit is organized into numbered lessons comprised of topics and activities based on the overall and specific expectations. Lessons are arranged in the following format:

Lesson title: The title of each lesson is posed as a guided inquiry question, which is related to the expectations being addressed.

Information for Teachers: Some lessons provide teachers with the basic scientific and technological knowledge they will need to present the activities. This information is offered in a clear, concise format, and focuses specifically on the topic of study.

21st Century Competencies: At the start of each lesson, the key competencies (critical thinking, communication, collaboration, creativity, citizenship, and character) focused on during the various activities are identified.

Materials: A complete list of materials required to conduct the main activities is provided. The quantity of materials required will depend on how you conduct activities. If students are working individually, you will need enough materials for each student. If students are working in groups, the materials required will be significantly reduced. Many of the identified items are for the teacher to use for display purposes, or for making charts for recording students' ideas. In some cases, visual materials (e.g., large pictures, sample charts, diagrams) have been included with the lesson to assist the teacher in presenting ideas and questions, and to encourage discussion. Some lessons include Image Banks. Black-and-white thumbnails of Image Bank visuals can be found in the Appendix, on page 435. Colour images of these thumbnails can be downloaded from the Portage & Main website. These images may be displayed or printed, depending on the availability of projectors, their use in specific activities, and the needs of students.

Activate: This activity is intended to activate prior knowledge, review previous lessons, and engage students in the lesson. The guided inquiry question for the lesson is also introduced

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The Hands-On Science and Technology Assessment Plan

The **Hands-On Science and Technology** program provides a variety of assessment tools that enable teachers to build a comprehensive and authentic daily assessment plan for students. Based on current research about the value of quality classroom assessment (Davies 2011), suggestions are provided for authentic assessment, which includes assessment *for* learning, assessment *as* learning, and assessment *of* learning.

Ontario's policy on assessment is outlined in the document *Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools* (see: <www.edu.gov.on.ca/eng/policyfunding/success.html>). The document outlines a fundamental shift in the roles of teachers and students in the learning process:

> In a traditional assessment paradigm, the teacher is perceived as the active agent in the process, determining goals and criteria for successful achievement, delivering instruction, and evaluating student achievement at the end of a period of learning. The use of assessment for the purpose of improving learning and helping students become independent learners requires a culture in which student and teacher learn together in a collaborative relationship, each playing an active role in setting learning goals, developing success criteria, giving and receiving feedback, monitoring progress, and adjusting learning strategies. The teacher acts as a "lead learner," providing support while gradually releasing more and more responsibility to the student, as the student develops the knowledge and skills needed to become an independent learner.

The primary purpose of assessment is to improve student learning. Assessment *for* learning provides students with descriptive feedback and coaching for improvement. Assessment *as* learning helps students self-assess by developing their capacity to set their own goals, monitor their own progress, determine their next steps in learning, and reflect on their learning. Assessment *of* learning is summative in nature and is intended to identify student progress in relation to learning expectations. The challenge for educators is to integrate assessment seamlessly with other learning goals. The Ontario assessment model uses the following process:

- **Establish learning goals from curriculum expectations.** Lessons include learning goals in student-friendly language that have been developed from curriculum expectations. These learning goals are shared with students and used to guide instruction.
- **Develop success criteria.** These descriptors are written in student-friendly language to help students understand what successful learning looks like. Criteria can be established by the teacher, using assessment task exemplars of student work, or by using the Achievement Chart from *The Ontario Curriculum, Grades 1–8: Science and Technology* (2007). Success criteria can also be determined in collaboration with students.
- **Provide descriptive feedback.** In conversations with students, identify what criteria they have and have not met, and provide any needed instruction. At this stage, teachers work with students to identify next steps to determine how students may improve. This may include differentiating instruction.
- **Use information for peer and self-assessment.** Students assess their own work and the work of others to determine what still needs to be done.
- **Establish individual goals.** Students determine what they need to learn next and how to get there.

The **Hands-On Science and Technology** program provides assessment suggestions, rubrics, and templates for use during the

Portage & Main Press, 2018 · *Hands-On Science and Technology · Grade 6* · ISBN: 978-1-55379-712-8

teaching/learning process. These suggestions include tasks related to assessment *for* learning, assessment *as* learning, and assessment *of* learning.

Assessment *for* Learning

It is important for teachers to assess students' understanding before, during, and after a lesson. The information gathered helps teachers determine students' needs and then plan the next steps in instruction. Students may come into class with misconceptions about science and technology concepts. By identifying what they already know, teachers can help students make connections and address any challenging issues.

To assess students as they work, use the assessment *for* learning suggestions provided with many of the activities.

While observing and conversing with students, teachers may use the **Anecdotal Record** template and/or the **Individual Student Observations** template to record assessment *for* learning data.

- **Anecdotal Record:** To gain an authentic view of a student's progress, it is critical to record observations *during* lessons. The **Anecdotal Record** template, on page 27, provides the teacher with a format for recording individual or group observations.
- **Individual Student Observations:** When teachers wish to focus more on individual students for a longer period of time, consider using the **Individual Student Observations** template, on page 28. This template provides more space for comments and is especially useful during conferences, interviews, or individual student performance tasks.

Assessment *as* Learning

It is important for students to reflect on their own learning in relation to science and technology. For this purpose, teachers will find a **Student Self-Assessment** template, on page 32, as well as a **Student Reflections** template on page 33.

In addition, the **Science and Technology Journal**, on page 29, will encourage students to reflect on their own learning. Teachers can copy several sheets for each student, cut the sheets in half, add a cover, and bind the sheets together. Students can then create their own title pages for their journals. For variety, teachers may also have students use the blank reverse side of each page for other reflections, such as drawing or writing about:

- new science and technology challenges
- favourite science and technology activities
- real-life experiences with science and technology
- new terminology
- new places explored during investigations

Students may also journal in other ways, such as by adding notes to their portfolios, or by keeping online science and technology blogs or journals to record successes, challenges, and next steps relating to the learning goals.

NOTE: This Science and Technology Journal template is provided as a suggestion, but journals can also be made from simple notebooks or recycled paper.

Another component of assessment *as* learning involves opportunities for students to reflect on their use of 21st Century Competencies. During each lesson, teachers should spend time discussing and reflecting on the competencies being focused on. The intent here is to enhance students' understanding of how and when they use the competencies during the inquiry ▶

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process. For this purpose, teachers may project a copy of the **21st Century Competencies Reflection** template, on page 30, and complete it as a class, using words and pictures to communicate students' reflections. A completed **Sample 21st Century Competencies Reflection** is included on page 31.

NOTE: Since no lesson addresses all six competencies, teachers can focus specifically on those covered in a lesson. Students can then explore the meaning of those skills at a deeper level.

Another component of assessment *as* learning utilizes the **21st Century Competencies Student/Teacher Reflection** template, which is found on page 34. Students complete this at the end of the unit, to encourage them to reflect on how they have used the competencies. Students record their reflections in the rectangles on the template, and teachers provide descriptive feedback in the outer ovals.

NOTE: Depending on their literacy level, students may complete the assessment in various ways. For example, the sheets may be used as guides for oral conferences between teacher and student, or an adult may act as a scribe for the student, recording their responses. Alternatively, students may complete the sheets independently or with guidance and support as needed.

NOTE: This descriptive feedback from teachers may also be considered assessment *for* learning. Even though this feedback is provided at the end of the unit, students will consider the anecdotal comments as they continue to develop their 21st Century Competencies.

Students should also be encouraged to reflect on their cooperative group work skills, as these are directly related to 21st Century Competencies, as well as to the skills scientists use as they collaborate in team settings. For this purpose, a **Cooperative Skills Self-Assessment** template is on page 35.

Student reflections can also be done in many ways other than by using these templates. For example, students can:

- Interview one another to share their reflections on science and technology.
- Write an outline or brief script and make a video reflection.
- Create a slide show with an audio recording of their reflections.

Assessment *of* Learning (AOL)

Assessment *of* learning provides a summary of student progress related to the accomplishments of the learning goals at a particular point in time. It is important to gather a variety of assessment data to draw conclusions about what a student knows and can do. As such, consider collecting student products, observing processes, and having conversations with students. Teachers should also consider which student work is formative and which is summative. Only the most recent and consistent evidence should be used.

Assessment *of* learning suggestions are provided with the culminating lesson of each unit of the **Hands-On Science and Technology** program. Teachers may use the **Anecdotal Record** template, on page 27, the **Individual Student Observations** template, on page 28, and the **Rubric**, on page 37, to record student results.

Always assess a student's individual accomplishments, not group work. However, you may assess how an individual student works within a group. Such skill development includes the ability to listen to others respectfully, share ideas, and participate actively in the inquiry process. For this purpose, use the **Cooperative Skills Teacher Assessment** template on page 38.

Portage & Main Press, 2018 · *Hands-On Science and Technology · Grade 6* · ISBN: 978-1-55379-712-8

Performance Assessment

Both assessment *for* learning and assessment *of* learning include performance assessment. This is planned, systematic observation and assessment based on students actually doing a specific science and technology activity. Teacher- or teacher/student-created rubrics can be used to assess student performance.

A **Sample Rubric** and a **Rubric** template for teacher use are on pages 36 and 37. For any specific activity, before the work begins, the teacher and students should discuss together success criteria for completing the task. This will ensure that the success criteria relate to the lesson's learning goals. The teacher can then record these criteria on the rubric.

When conducting assessment *for* learning, the rubric can be reviewed with students to determine strengths, challenges, and next steps related to learning goals.

When conducting assessment *of* learning, the rubric can be used to determine summative data. For example, teachers can use the rubric criteria to assess student performance, and students can receive a check mark for each criterion accomplished to determine a rubric score from a total of four marks. These rubric scores can then be transferred to the **Rubric Class Record** template, on page 39.

When using the rubric for assessment *of* learning, consider using four levels of achievement to correlate with the Ontario Science and Technology Achievement Chart (see pages 26 and 27 of *The Ontario Curriculum*).

For example:

1. achievement that falls much below the provincial standard
2. achievement that approaches the provincial standard
3. achievement that meets the provincial standard
4. achievement that surpasses the provincial standard

The **Hands-On Science and Technology** program provides numerous opportunities for students to apply their skills. By considering the same levels of achievement throughout the year, teachers should be able to track student learning and determine when students have a thorough understanding and demonstrate in-depth application of concepts and skills.

Portfolios

A portfolio is a collection of work that shows evidence of a student's learning. There are many types of portfolios—the showcase portfolio and the progress portfolio are two popular formats. A showcase portfolio highlights the best of a student's work, with the student involved in the selection of pieces and justification for choices. A progress portfolio reflects a student's progress as their work improves and aims to demonstrate in-depth understanding of the materials over time.

Select, with student input, work to include in a science and technology portfolio or in a science and technology section of a multi-subject portfolio. Selections should include representative samples of student work in all types of science and technology activities. Templates are included to organize the portfolio (**Portfolio Table of Contents** is on page 40, and **Portfolio Entry Record** is on page 41).

Alternatively, the student and teacher may select completed work from a coming-to-know perspective that reflects participatory learning, and which is common in Indigenous learning culture. With this approach, the student reflects on their own understanding of the world around them and may gain a sense of negotiating other points of view.

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Evidence of Student Achievement Levels for Evaluation

At the end of each unit, teachers can determine achievement levels for each student. Assessment *of* learning information gathered throughout the unit can be used to identify these levels, according to the Ontario Science and Technology Achievement Chart.

The most recent and consistent assessment information should be used to determine levels of achievement. A reproducible, **Achievement Chart for Science & Technology**, on page 42 and 43, is included for teacher reference.

Important Note to Teachers

Throughout the **Hands-On Science and Technology** program, suggestions are provided for assessment *for* learning, assessment *as* learning, and assessment *of* learning. Keep in mind that these are merely suggestions. Teachers are encouraged to use the assessment strategies presented in a wide variety of ways, and to ensure they build an effective assessment plan using these assessment ideas, as well as their own valuable experiences as educators.

Teachers should be aware that some Indigenous students might feel apprehensive about a formal process of assessment; others may find Western achievement goals do not fit their own worldviews. Assessment within an Indigenous learning culture tends to be community-based, qualitative, and holistic, and includes input from all the people who influence an individual student's learning—parents, caregivers, Elders, Métis Senators, educators and other community members. An assessment that includes all these perspectives provides a balanced understanding of what represents success for Indigenous students and their families and community, with an understanding that strong partnership between parents/guardians, communities, and school improves student achievement.

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Unit 1

Biodiversity

Introduction

In this unit of ***Hands-On Science and Technology, Grade 6***, students explore the diversity of living things and the classification of species into kingdoms. The focus is on plants and animals, with additional lessons related to protists, bacteria, and fungi. Students will begin to understand how these kingdoms are organized according to structural characteristics of living things, with a focus on the phyla (branches) of the various kingdoms.

There has been great debate among scientists regarding how best to classify living things into distinguishable kingdoms. Before the invention of the microscope, organisms were classified only as plant or animal. With the discovery of microscopic forms of life, it became apparent that many of these microorganisms (e.g., fungi, bacteria, algae, viruses, single-cell organisms like the paramecium and amoeba) held both animal and plant characteristics and could not be simply classified into either kingdom.

The debate on this issue continues, and no single agreed-upon classification system for living things exists. With the study of taxonomy, several different possible kingdoms and domains become evident.

One of the most popular systems today is Linnaean taxonomy, the five-kingdom classification of living organisms conceived by Swedish scientist Carolus Linnaeus: animal, plant, fungus, protist, and monera (viruses have yet to be identified within this classification system).

Remember that this controversy persists, and it should not be a surprise to find reference materials with contradictory information. Teachers are encouraged to discuss this classification debate with their students. This can provide a venue for understanding that science is an ever-evolving field of study and does not always provide black-and-white answers. New information about DNA continues to influence our understanding of how to classify organisms.

Indigenous peoples also have systems for classifying living things. Though Indigenous classification systems use different criteria than western science, they nevertheless contribute to a deep understanding of symbiotic relationships, ecological conservation, and sustainability. The Haudenosaunee and Iroquois creation story of Sky Woman clearly delineates the four main classifications for life within their cultures: land walkers, water dwellers or divers, winged creatures, and flora or plant life. The Anishinaabe creation story of Turtle Island also clearly delineates these four categories for life on Earth. The story of the Three Sisters is an example from the Six Nations and Ojibwe cultures that demonstrates another understanding of plant classification through the lens of symbiotic relationships and the dangers of monoculture.

Classifying objects is an important part of a scientist's work. They do this to better understand the classes, both as individual species and how they compare and contrast with other organisms. When teaching the content found in this unit, it is important to keep in mind that classifying is very much a scientific-process skill. Since the classification systems used to organize living things are quite complex, educators are encouraged to give students repeated opportunities to explore and extend their thinking. Encourage them to compare and contrast animals, plants, and even nonliving things; this will help students develop critical-thinking skills. This unit also provides a variety of suggestions for graphic organizers and strategies to aid students in their study.

Planning Tips for Teachers

- Collect a wide variety of pictures of living things from magazines and old calendars before beginning the unit.

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- Teachers are encouraged to have on hand at least one good-quality, high-powered microscope. Also, consider accessing other related materials, such as prepared slides or Microslide Viewers.
- Develop a classroom Makerspace centre, where students can learn together and collaborate on do-it-yourself projects. Students have opportunity to work with a variety of age-appropriate tools at the centre, as well as everyday, arts-and-craft, and recycled materials.

  For this unit, the Makerspace centre should encourage informal learning about biodiversity. Collect and include a variety of supplies and materials that reflect the challenges students might take on at the centre. Include general materials, such as those listed in the Introduction to ***Hands-On Science and Technology, Grade 6*** (page 19), as well as unit-specific materials. For example, include a variety of living-thing artifacts (e.g., shells, seeds, leaves, fresh fruit, vegetables, grains, unique examples like a bird's nest, a starfish, a shark's tooth, a bear claw, fur). Encourage students to collect artifacts as well and bring them to school for the centre (with parental permission; teachers should screen anything students bring in for the centre). Also, provide specimens in jars (e.g., insects, worms), field guides, identification keys, photos of organisms, preserved plants, microscopes and relevant prepared slides, micro-viewers and appropriate slide strips. For creating terrariums, provide clear containers, rocks, pebbles, activated charcoal (activated carbon), moss, figurines, sticks or decorative items (optional), various small plants, with appropriate potting soil, scoops, spoons or shovels, scissors, and gloves. Art supplies are also encouraged, as well as access to digital cameras and computers/tablets.

SAFETY NOTE: Take all necessary precautions with regards to any food included at the Makerspace (e.g., fresh fruit, vegetables, grains). Review any student allergies in the class and ensure that no known allergens are included at the Makerspace. Also, keep track of the condition of food that will not last long without refrigeration (teachers might consider keeping food products in labelled bags in a staff refrigerator, and bringing it out only on days when students will have opportunity to visit the Makerspace).

Students' Makerspace projects may be anything related to the concepts within this unit. Some examples are:

- building a terrarium
- creating an environment in which two species could live together
- creating a wildlife habitat modelled after the National Wildlife Federation Certified Wildlife Habitat, which means it contains all essential elements required for wildlife living there to survive

NOTE: For the preceding activity, the suggestion is to model rather than create an actual National Wildlife Federation Certified Wildlife Habitat, which also means paying a fee. See: <https://www.nwf.org/Garden-For-Wildlife/Certify.aspx>.

- creating a model of a plant that could exist in more than one ecosystem and explaining its features (e.g., How could wheat grow in a climate with less water than the prairies?)
- creating and visually representing (e.g., with Padlet) a new classification system to replace Linnaeus's system
- creating a new type of product packaging that reduces waste
- creating a new system for transporting merchandise after purchase
- creating a model community that fosters, encourages, and assists people in recycling (e.g., with community composts, fix-up shops, give and take shops)

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- creating a model of a future home or community and explaining how it incorporates renewable energy sources and more sustainable living
- creating a 3D model of a future home or business, using a 3D computer-aided design (CAD) tool (e.g., Tinkercad) or other similar software

Books that might inspire Makerspace projects with literacy connections:

- *The Great Kapok Tree: A Tale of the Amazon Rain Forest* by Lynne Cherry
- *A Drop Around the World* by Barbara McKinney
- *A River* by Marc Martin
- *Diary of a Worm* by Doreen Cronin
- *Finding Wild* by Megan Wagner Lloyd
- *Pass the Energy, Please!* by Barbara Shaw McKinney
- *The Tree in the Ancient Forest* by Carol Reed-Jones
- *The Forever Forest: Kids Save a Tropical Treasure* by Kristin Joy Pratt-Serafini

The inquiry questions posed with each lesson will inspire other do-it-yourself projects related to the unit. Students may determine solutions to these questions through the creating they do at the Makerspace centre. Remember not to direct the learning here; simply create conditions for learning to happen.

Indigenous Worldviews

Teachers are encouraged to enhance students' science and technology education by infusing, as often as possible, Indigenous perspectives into the lessons of ***Hands-On Science and Technology, Grade 6***.

Through oral stories and accounts, Indigenous peoples pass down their knowledge and observations of the natural world to new generations. As mentioned in the Introduction, the Haudenosaunee, Iroquois, and Anishinaabek have creation stories that classify life forms into four categories: land walkers, water dwellers or divers, winged creatures, and flora or plant life. The Six Nations and Ojibwe peoples used the story of the Three Sisters to share understandings of plant classifications, symbiotic relationships, and the dangers of monoculture.

A common Indigenous understanding is that all life—plant, animal, and human—are equal, and all living things are interdependent for survival. Traditionally, Indigenous peoples lived off the land and hence are keenly aware of their surroundings—including the breadth of plants and animals found in their ecosystem. This close relationship to the land helps foster Indigenous worldviews of connection to all living things. It is also believed that an animal gives up its spirit to provide humans with what we need for survival. Therefore, out of respect, no portion of a hunted animal should go to waste, with every part being used for food, clothing, tools, or shelter.

Animals are viewed as teachers, guides, and companions, in addition to being integral to physical survival—Indigenous peoples' existence depended on animals and plants for everything from transportation to signalling seasonal changes to assisting with agricultural pursuits.

Science and Technology Vocabulary

Throughout this unit, teachers should use, and encourage students to use, vocabulary related to living things, such as:

- *animal, arthropod, bacteria, biodiversity, classification key, classification system, endoskeleton, exoskeleton, fungus, interrelationship, invasive species, invertebrate, kingdom, mould, native species, naturalist, organism, plants, protist, species, structure, vertebrate*

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In lesson 1, students begin a Science and Technology Glossary in which they record new vocabulary introduced throughout the unit. Also, in lesson 1, teachers create a word wall for the unit, which can be created on a bulletin board or simply on a piece of poster paper, so as not to take up too much space. On the bulletin board or poster paper, record new vocabulary as it is introduced throughout the unit. Ensure the word wall is placed in a location where all students can easily see and access the words. Refer frequently to new vocabulary and encourage students to use it in both their writing and conversation.

Throughout the unit teachers should also use, and encourage students to use, vocabulary related to scientific inquiry skills. This vocabulary can be displayed in the classroom throughout the year, as the terms relate to all science and technology units. Teachers and students can then brainstorm which skills they are being asked to use as they conduct particular activities. They can also discuss what that skill looks and sounds like as they explore and investigate.

Vocabulary related to scientific inquiry skills includes:

- *access, ask, brainstorm, collect, compare, connect, consider, construct, cooperate, create, describe, develop, estimate, explain, explore, find, follow, graph, identify, improve, investigate, measure, observe, order, plan, predict, recognize, record, repeat, research, respond, select, sequence, test*

Promoting Scientific Inquiry

Throughout the inquiry process, it is essential for both teachers and students to generate thoughtful questions about the scientific information and issues presented. There are many questioning systems that can be implemented; the point is to apply them to the material within the unit. Often simply changing a question can turn the intent from a focus on knowledge and understanding to an emphasis on scientific inquiry, which can then lead to use of technological problem solving.

The chart below shows how questions related to topics of study in this unit, and which address specific curriculum outcomes, can focus either on knowledge and understanding (as in column two) or can encourage more in-depth inquiry and higher-level thinking (as in column three) and then lead to technological problem solving (column four).

Both teachers and students can use a questioning system such as this to reach beyond factual content toward rich, inquiry-based investigations.

Unit Topic	**Knowledge and Understanding** (content questions that range in complexity)	**Scientific Inquiry** (testable questions by students or by scientists)	**Technological Problem Solving** (prototype questions designed or critiqued by students)
Classification and identification	What are the branches of the Animal Kingdom?	What similarities and differences can you observe between plants and animals?	What are the limitations of a compound light microscope (found in high-school labs) in observing bacteria?
Invertebrates and vertebrates	Is there an advantage to having a backbone?	What diversity of invertebrates can be found in a rotting log?	What conditions are necessary to keep a terrarium healthy?

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Unit Overview

Fundamental Concepts	Big Ideas
Systems and Interactions	■ Biodiversity includes diversity of individuals, species, and ecosystems.
Sustainability and Stewardship	■ Classification of the components within a diverse system is a beginning point for understanding the interrelationships among the components. ■ Because all living things are connected, maintaining diversity is critical to the health of the planet. ■ Humans make choices that can have an impact on biodiversity.

Overall Expectations

By the end of Grade 6, students will:

1. Assess human impacts on biodiversity, and identify ways of preserving biodiversity.
2. Investigate the characteristics of living things, and classify diverse organisms according to specific characteristics.
3. Demonstrate an understanding of biodiversity, its contributions to the stability of natural systems, and its benefits to humans.

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Curriculum Correlation

Specific Expectations	Lesson											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Relating Science and Technology to Society and the Environment												
1.1 Analyze a local issue related to biodiversity, taking different points of view into consideration, propose action that can be taken to preserve biodiversity, and act on the proposal.											√	
1.2 Assess the benefits that human societies derive from biodiversity and the problems that occur when biodiversity is diminished.									√	√	√	
2. Developing Investigation and Communication Skills												
2.1 Follow established safety procedures for outdoor activities and fieldwork.	√	√	√	√	√	√	√	√	√	√	√	√
2.2 Investigate the organisms found in a specific habitat, and classify them according to a classification system.		√	√	√	√	√	√	√	√	√	√	√
2.3 Use scientific inquiry/research skills to compare the characteristics of organisms within the plant or animal kingdoms.		√	√	√	√	√	√	√	√	√	√	√
2.4 Use appropriate science and technology vocabulary, including *classification*, *biodiversity*, *natural community*, *interrelationships*, *vertebrate*, *invertebrate*, *stability*, *characteristics*, *and organism*, in oral and written communication.	√	√	√	√	√	√	√	√	√	√	√	√
2.5 Use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes.	√	√	√	√	√	√	√	√	√	√	√	√
3. Understanding Basic Concepts												
3.1 Identify and describe the distinguishing characteristics of different groups of plants and animals, and use these characteristics to further classify various kinds of plants and animals.	√	√	√	√	√	√		√	√	√	√	√
3.2 Demonstrate an understanding of biodiversity as the variety of life on earth, including variety within each species of plant and animal, among species of plants and animals in communities, and among communities and the physical landscapes that support them.	√		√	√	√	√	√	√	√	√	√	√
3.3 Describe ways in which biodiversity within species is important for maintaining the resilience of those species.				√	√	√	√	√	√	√	√	
3.4 Describe ways in which biodiversity within and among communities is important for maintaining the resilience of these communities.				√	√	√	√	√	√	√	√	
3.5 Describe interrelationships within species, between species, and between species and their environment, and explain how these interrelationships sustain biodiversity.				√	√	√	√	√	√		√	
3.6 Identify everyday products that come from a diversity of organisms.									√		√	
3.7 Explain how invasive species reduce biodiversity in local environments.						√					√	

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Curriculum Correlation

Specific Expectations	Lesson									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1. Relating Science and Technology to Society and the Environment										
1.1 Assess the benefits and costs of aviation technology for society and the environment, taking different social and economic perspectives into account.										√
2. Developing Investigation and Communication Skills										
2.1 Follow established safety procedures for using tools and materials and operating flying devices.	√	√	√	√	√	√	√	√	√	√
2.2 Use scientific inquiry/experimentation skills to investigate the properties of air.		√	√	√						
2.3 Investigate characteristics and adaptations that enable living things to fly.	√			√		√	√			
2.4 Use technological problem-solving skills to design, build, and test a flying device.					√	√	√	√	√	
2.5 Use appropriate science and technology vocabulary, including *aerodynamics*, *compress*, *flight*, *glide*, *propel*, *drag*, *thrust*, *and lift*, in oral and written communication.	√	√	√	√	√	√	√	√	√	√
2.6 Use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes.	√	√	√	√	√	√	√	√	√	√
3. Understanding Basic Concepts										
3.1 Identify the properties of air that make flight possible.	√	√	√	√	√					
3.2 Identify common applications of the properties of air, such as its compressibility and insulating qualities.		√	√	√				√		
3.3 Identify and describe the four forces of flight: *lift*, *weight*, *drag*, and *thrust*.				√	√	√	√	√		
3.4 Describe, in qualitative terms, the relationships between the forces of lift, weight, thrust, and drag that are required for flight.					√	√	√	√		
3.5 Describe ways in which flying devices or living things use unbalanced forces to control their flight.					√		√			
3.6 Describe ways in which the four forces of flight can be altered.					√	√	√	√		

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Curriculum Correlation

Specific Expectation	Lesson													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Relating Science and Technology to Society and the Environment														
1.1 Assess the short- and long-term environmental effects of the different ways in which electricity is generated in Canada, including the effect of each method on natural resources and living things in the environment.												√	√	√
1.2 Assess opportunities for reducing electricity consumption at home or at school that could affect the use of non-renewable resources in a positive way or reduce the impact of electricity generation on the environment.												√	√	√
2. Developing Investigation and Communication Skills														
2.1 Follow established safety procedures for working with electricity.	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2.2 Design and build series and parallel circuits, draw labelled diagrams identifying the components used in each, and describe the role of each component in the circuit.								√						√
2.3 Use scientific inquiry/experimentation skills to investigate the characteristics of static electricity.		√												√
2.4 Design, build, and test a device that produces electricity.									√		√			√
2.5 Use technological problem-solving skills to design, build, and test a device that transforms electrical energy into another form of energy in order to perform a function.							√	√	√	√	√			√
2.6 Use appropriate science and technology vocabulary in oral and written communication.	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2.7 Use a variety of forms to communicate with different audiences and for a variety of purposes.	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3. Understanding Basic Concepts														
3.1 Distinguish between current and static electricity.	√	√	√											√
3.2 Use the principles of static electricity to explain common electrostatic phenomena.		√												√
3.3 Identify materials that are good conductors of electricity and good insulators.						√								√
3.4 Describe how various forms of energy can be transformed into electrical energy.				√							√			√
3.5 Identify ways in which electrical energy is transformed into other forms of energy.			√							√	√			√
3.6 Explain the functions of the components of a simple electrical circuit.					√									√
3.7 Describe series circuits (components connected in a daisy chain) and parallel circuits (components connected side by side like the rungs of a ladder), and identify where each is used.					√			√						√
3.8 Describe ways in which the use of electricity by society, including the amount of electrical energy used, has changed over time.	√											√	√	√

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Curriculum Correlation

Specific Expectations	Lesson																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Relating Science and Technology to Society and the Environment																	
1.1 Assess the contributions of various Canadians to the exploration and scientific understanding of space.													√				√
1.2 Evaluate the social and environmental costs and benefits of space exploration, taking different points of view into account.												√		√	√		√
2. Developing Investigation and Communication Skills																	
2.1 Follow established safety procedures for handling tools and materials and observing the Sun.	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2.2 Use technological problem-solving skills to design, build, and test devices for investigating the motions of different bodies in the solar system.							√				√						√
2.3 Use scientific inquiry/research skills to investigate scientific and technological advances that allow humans to adapt to life in space.									√			√		√			√
2.4 Use appropriate science and technology vocabulary, including *axis*, *tilt*, *rotation*, *revolution*, *planets*, *moons*, *comets*, and *asteroids*, in oral and written communication	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2.5 Use a variety of forms to communicate with different audiences and for a variety of purposes.	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3. Understanding Basic Concepts																	
3.1 Identify components of the solar system, including the Sun, the Earth, and other planets, natural satellites, comets, asteroids, and meteoroids, and describe their physical characteristics in qualitative terms.	√	√	√	√				√		√						√	√
3.2 Identify the bodies in space that emit light and those that reflect light.				√				√		√						√	√
3.3 Explain how humans meet their basic biological needs in space.									√			√		√			√
3.4 Identify the technological tools and devices needed for space exploration.												√		√	√		√
3.5 Describe the effects of the relative positions and motions of the Earth, moon, and Sun.					√		√			√	√						√

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3 How Is the Animal Kingdom Organized?

Information for Teachers

There is no one agreed-upon way of classifying organisms among scientists. One of the more common classification systems for living things includes five kingdoms: monera (helpful and harmful bacteria), protists (small, single-celled organisms, only visible under microscope), fungi (mushrooms and moulds), plants (from moss to trees), and animals. Within the latter, we often place organisms into one of two groupings: *vertebrates* (animals with backbones) and *invertebrates* (animals without backbones).

Key to classifying organisms are their physical characteristics, which allow us to break down the kingdoms into multiple levels, each level more specialized than the one above it. This has been true for the past 300 years, but DNA classification is becoming much more important, and sometimes differs from morphological classification. Categories often used to classify living things include *kingdom*, *phylum/phyla*, *class*, *order*, *family*, *genus*, and *species*. In higher grades, students will study these levels of taxonomy in more detail.

Animals with backbones are called *vertebrates* and belong to the phylum *chordata*. This includes the following classes:

- **Amphibians**: cold-blooded animals that begin life with gills to breathe in water, then develop lungs to breathe air (e.g., frog, toad, newt, salamander)
- **Birds**: warm-blooded animals with wings and feathers (e.g., penguin, hummingbird, flamingo, sparrow)
- **Fish**: cold-blooded animals with gills to breathe in water (e.g., shark, goldfish, tuna).
- **Mammals**: warm-blooded animals with hair or fur that nurse their young (e.g., cat, bat, human, whale)
- **Reptiles**: cold-blooded animals with scales (e.g., snake, lizard, turtle, alligator, crocodile)

Animals without backbones are called *invertebrates*. These include the following phyla:

- **Sponges**: animals with large pores that live in water (e.g., calcareous sponge, glass sponge, homoscleromorpha, demosponge)
- **Coelenterates**: water animals with stinging tentacles (e.g., jellyfish, man-of-war, coral)
- **Flatworms**: animals that are flat, and not really worms that we recognize (e.g., turbellaria, trematoda, monogenea, cestoda)
- **Nematodes**: thread-like animals found in soil and as parasites in other animals (e.g., roundworm, pinworm, threadworm)
- **Mollusks**: soft-bodied animals often protected by an outer shell (e.g., snails, oysters, clams, squid, octopuses)
- **Annelids**: segmented worms (e.g., earthworms, ragworms, leeches)
- **Arthropods**: animals with jointed legs and segmented bodies (e.g., centipedes [two legs per body section], millipedes [four legs per body section], spiders [eight legs and two body parts], insects [six legs and three body parts], and crustaceans [e.g., crabs, lobster, shrimp]). Eighty percent of all animals on Earth are arthropods
- **Echinoderms**: spiny animals (e.g., starfish, sea urchins, sand dollars, sea cucumbers)

The term *species* is used to identify specific animals within each branch of the kingdom.

NOTE: A diagram of the Animal Kingdom (1.3.1) is included in this lesson. Teachers are encouraged to display the diagram throughout this unit by copying it, enlarged, onto chart paper or projecting it. This will help students become familiar with this method of classifying living things.

21st Century Competencies

Critical Thinking and **Communication**: Students will classify animals according to their own sorting rule, and will learn how the Linnaean

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3

system of classification works. They will then classify different animals on an Animal Kingdom classification chart.

Materials

- large collection of animal pictures (include as many phyla and classes as possible: see Information for Teachers)
- chart paper
- markers
- Diagram: The Animal Kingdom (1.3.1) (also see Appendix, page 459)
- projection device (optional)
- student dictionaries
- mural paper (optional)
- tape (optional)
- scissors
- computers/tablets with Internet access (optional)
- poster paper
- art supplies
- glue sticks
- string or thread (optional)
- reference materials about the Animal Kingdom
- Activity Sheet A: Invertebrates and Vertebrates of the Animal Kingdom (1.3.2)
- Activity Sheet B: Cubing Sheet: Animal Research (1.3.3)
- Learning-Centre Task Card: Illustrating an Animal Group (1.3.4)
- List: Animal Groups (1.3.5)
- sticky notes
- KWHL chart (from lesson 1)
- Science and Technology Glossary (1.1.1)

Activate

As a class, review the meaning of a classification system. Ask:

- What does the term *classify* mean?
- How do you classify objects?
- What is a *classification system*?
- What are some ways you can classify living things?
- How are plants and animals different?
- What are some ways you can classify animals?

Together with students, brainstorm a list of ways to classify animals. Record these on chart paper.

NOTE: Students may be familiar with animal classification from earlier grades (mammals, amphibians, reptiles, birds, fish, insects). Discuss these in addition to other ways of classifying (e.g., by number of legs, size, body covering, behaviour, specific features like beaks and claws).

Organize the class into working groups and distribute an assortment of animal pictures to each group. Have students classify their pictures based on one of the creation stories explored in lesson 2. Then, have students re-sort the pictures according to their own criteria.

Have each group present its classification system to the class. As groups present, discuss the rules or criteria students used. Add any new rules or criteria to the list recorded on chart paper earlier. Ask students:

- Which sorting system do you find easiest to use?
- Which system would be most helpful to a hunter?
- Which system would be the most useful to a scientist studying birds (but not other winged creatures, like bats or butterflies)?
- Which system would be the most useful for studying flight?

Introduce the guided inquiry question: **How is the Animal Kingdom organized?**

Action: Part One

Display the Diagram: The Animal Kingdom (1.3.1). Discuss the diagram, focusing on how animals

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3

are classified according to structural features (e.g., backbones, jointed legs, lungs, gills).

On chart paper, record the term *species*. Ask students to share their understanding of the term and record their ideas on chart paper. Have students check dictionaries and co-construct a class definition for the term.

During the discussion, encourage students to provide examples of animals that could be included on each branch. Have them observe and describe structural features of animals they can see on the diagram—for instance, discuss the characteristics of the centipede. Clarify that some structural features cannot be easily seen from the outside or in a picture (e.g. number of chambers in the heart). Ask students:

- Which species would fit into the insect branch?
- What do all insects have in common?
- How are insects different from spiders?
- What are examples of species of fish?
- What do all fish have in common?
- Are whales (or dolphins/porpoises) fish? Why not? (They are warm-blooded, have lungs, and nurse their young, so they are mammals.)
- What are some examples of species of amphibians (or reptiles/birds/mammals)?

Now, have the same groups of students from Activate sort their animal pictures according to the diagram of the Animal Kingdom. Have students determine how many "branches" are represented in their collection of pictures and which "branches" are missing.

Next, provide students with copies of Activity Sheet A: Invertebrates and Vertebrates of the Animal Kingdom (1.3.2), along with a variety of reference materials (e.g., books, encyclopedias, magazines, bookmarked websites) about animals. Have students work together in their groups to gather information about some branches of the Animal Kingdom.

NOTE: Not all branches of the Animal Kingdom are featured on the activity sheet. This activity is meant to give students background knowledge on how animals are classified by structural features.

Activity Sheet A

Directions to students:

Record your research about various animals of the Animal Kingdom on the chart (1.3.2).

NOTE: This is a two-page activity sheet.

Action: Part Two

Have each student select one animal species for more detailed research (encourage students to select species from a variety of branches). Distribute scissors, glue sticks, Activity Sheet B: Cubing Sheet: Animal Research (1.3.3), and reference materials about animals. Have students create information cubes on their selected species.

Once students have completed their cubes, gather the class together to sort the cubes according to the branches of the Animal Kingdom represented. Students may wish to draw a large tree on mural paper and use tape and string to hang the cubes from the appropriate branches to replicate the diagram of the Animal Kingdom.

Activity Sheet B

Directions to students:

Record researched information about your selected animal on the individual sections of the cube. Cut out the cube outline, fold it, and glue it to form a cube (1.3.3).

Assessment for Learning

Observe students as they conduct individual research for their cube. Focus specifically on each student's ability to gather information, organize ideas, and present findings on the cubing sheet. Record results on the Individual Student Observations sheet, on page 29.

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Learning Centre

At the learning centre, provide art supplies, poster paper, a copy of the Learning-Centre Task Card: Illustrating an Animal Group (1.3.4), and a copy of List: Animal Groups (1.3.5), which presents some of the colourful nouns used in the English language to describe groups of the same animal (e.g., bed of snakes, murder of crows).

Have students select one animal, record its name and the group name on a sheet of poster paper, and illustrate the description (e.g., a *crash* of rhinoceros, an *army* of frogs).

Consolidate and Debrief

- Revisit the guided inquiry question: **How is the Animal Kingdom organized?** Have students share their knowledge, provide examples, and ask further inquiry questions.
- Have students add to the KWHL chart as they learn new concepts, answer some of their own inquiry questions, and ask new inquiry questions.
- Add new vocabulary and corresponding illustrations to the word wall. Include the words in languages other than English, as appropriate.
- Have students add new vocabulary, illustrations, and sentences to their Science and Technology Glossaries (1.1.1). When possible, encourage students to add the words in languages other than English, including Indigenous languages, reflective of the classroom community.

Enhance

- Have students research to determine if the animal they chose for the cube activity is abundant, endangered, at risk, or extinct.
- Have students research the life of Carolus Linnaeus and his contributions to the classification of living things.
- Explain to students that the Animal Kingdom diagram used in this lesson (1.3.1) is just one type of graphic organizer used to classify animals. As a class, reconstruct the Animal Kingdom using a concept web format, as shown in the Diagram: The Animal Kingdom (1.3.7).
- At the beginning of the day or following a break, give each student a picture of an animal as they enter the classroom. Ask students to find the branch of the first Animal Kingdom diagram used in the lesson (1.3.1) on which their animal belongs.

NOTE: If the pictures are small enough, use tape or sticky tack to affix each one to the diagram once it has been correctly placed on the tree by a student.

- Give students an opportunity to experiment with using classification keys. Provide a variety of pictures of birds or butterflies, along with field guides that have classification keys. Challenge students to use the keys to classify the animals.
- Plan a bird-watching expedition in your community to identify birds in their natural habitat, using classification keys. Have students research local birding venues to determine a good location for the field trip. Consider inviting a local birder to speak to the class prior to the expedition, to share background knowledge and best practices.
- Display a collection of seashells (craft and dollar stores often sell them), which are from mollusks. Also include a guidebook on shells and mollusks. Have students examine, identify, and classify the shells. Have them construct their own charts to record their findings.
- Have students continue working on their do-it-yourself projects at the Makerspace centre.

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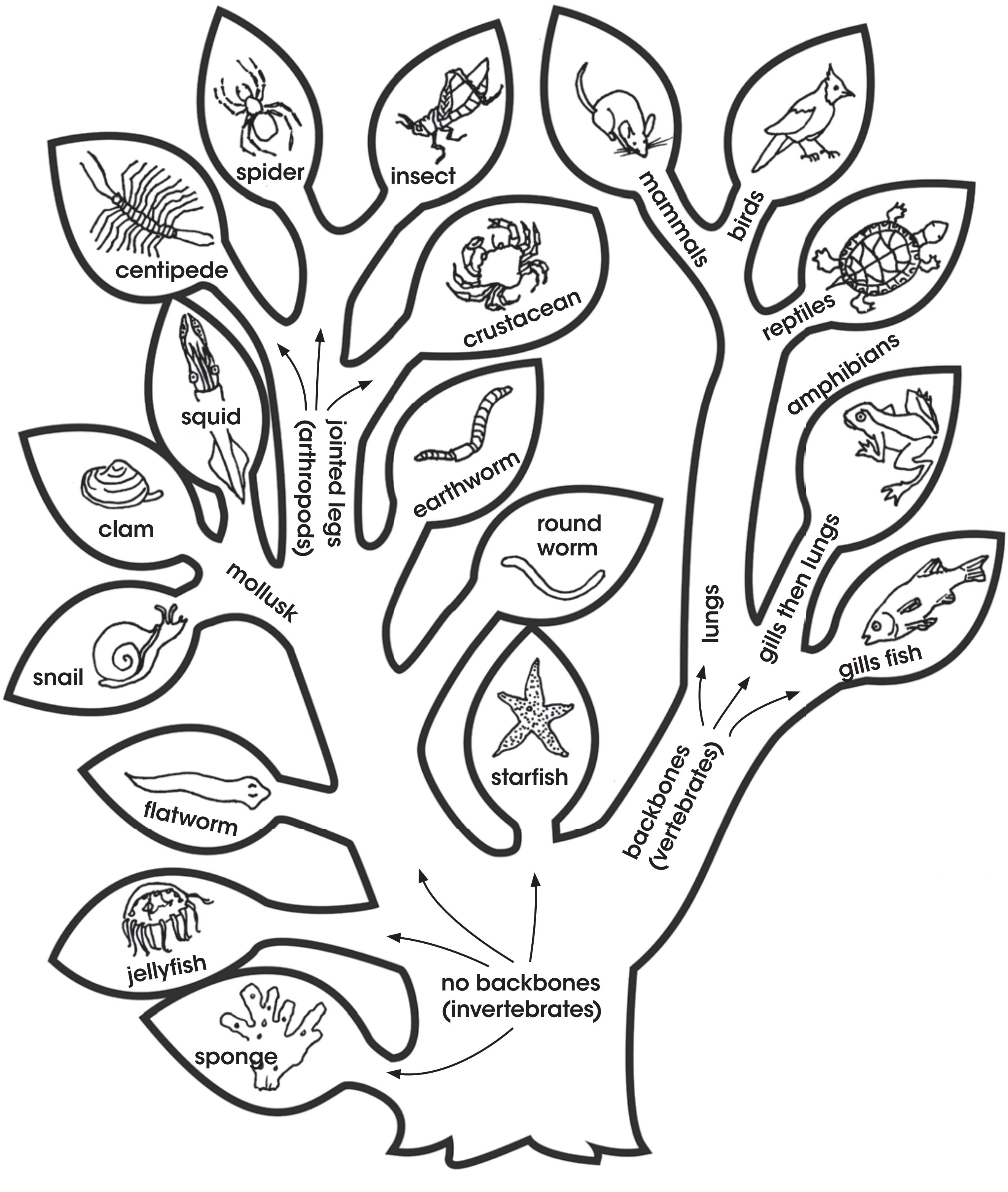
The Animal Kingdom



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Date: ____________________ **Name:** ______________________________

Invertebrates and Vertebrates of the Animal Kingdom

Invertebrates of the Animal Kingdom

Branches	Characteristics	Examples
mollusks		
crustaceans		
earthworms		
centipedes		

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Date: ____________________ **Name:** ______________________________

Invertebrates and Vertebrates of the Animal Kingdom (continued)

Vertebrates of the Animal Kingdom

Branches	Characteristics	Examples
fish		
amphibians		
reptiles		
birds		
mammals		

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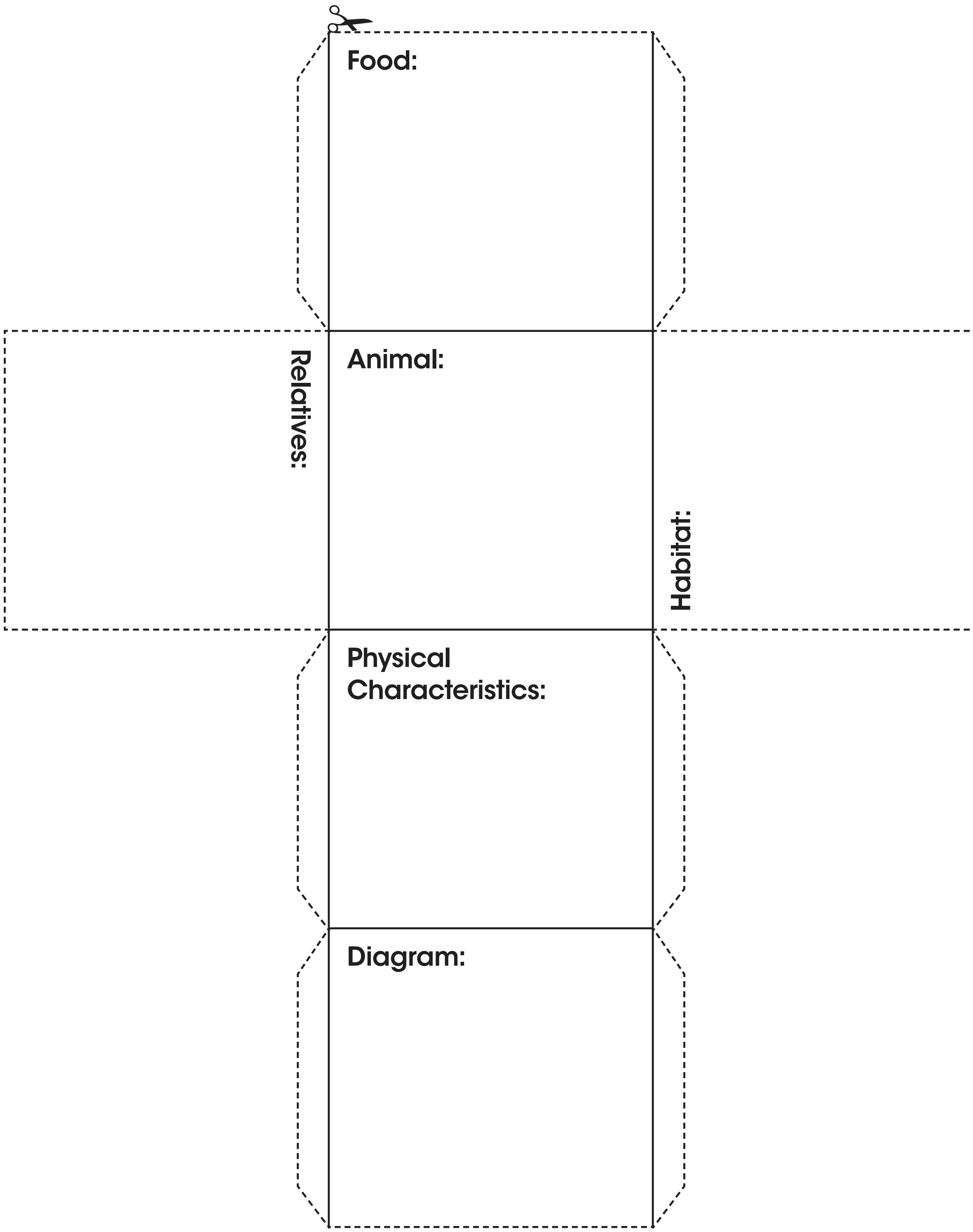
Cubing Sheet: Animal Research



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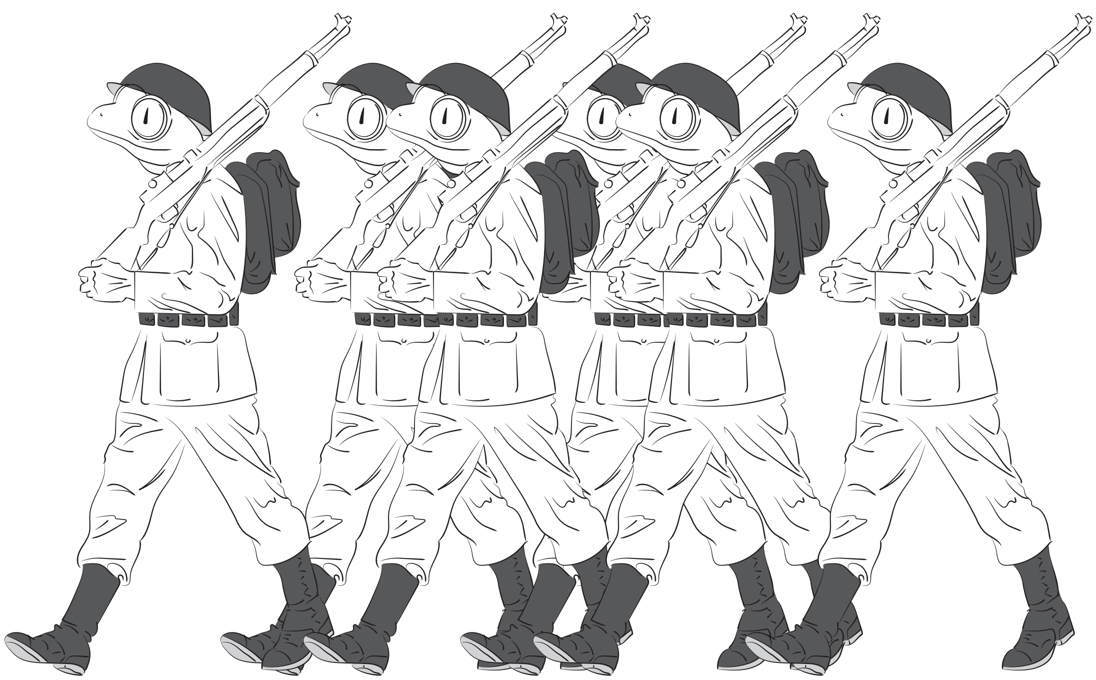
Illustrating an Animal Group

The English language is rich with colourful nouns that describe groups of the same animal.

1. **Review the Animal Groups list.**
2. **Select one animal, and record the animal name and group name.**
3. **On poster paper, create a drawing or cartoon to fit the description**
4. **On the backside of the poster paper, write a paragraph describing the features of this animal, and explain how you would classify this animal within the Animal Kingdom.**



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Animal Groups

Animal Name	Group Name
ants	colony
bears	sloth or sleuth
beavers	colony
butterflies	flight or flutter
caterpillars	army
cats	clowder, clutter, cluster (tame), kindle, or litter (young)
chickens	brood, peep
crows	murder
dogs	kennel, litter (young)
ducks	brace, flock, or paddling (swimming), raft or team (in flight)
eagles	convocation
elk	gang
ferrets	business
fish	school
frogs	army
geese	gaggle (standing), skein (flying)
gorillas	band
grasshoppers	cluster
herons	siege
jackrabbits	husk

Animal Name	Group Name
jays	band
jellyfish	smack
kangaroos	troop
leopards	leap
lions	pride
locusts	plague
martens	richness
mice	nest
moles	labour
owls	parliament
parrots	company
ponies	string
prairie dogs	coterie
rabbits	warren
ravens	unkindness
rhinoceroses	crash
salmon	run
sandpipers	murmuration
snakes	bed
squirrels	drag (dray)
swans	wedge or flight
toads	knot
turtles	bale or nest
whales	gam or pod, herd (sperm)
woodpeckers	descent

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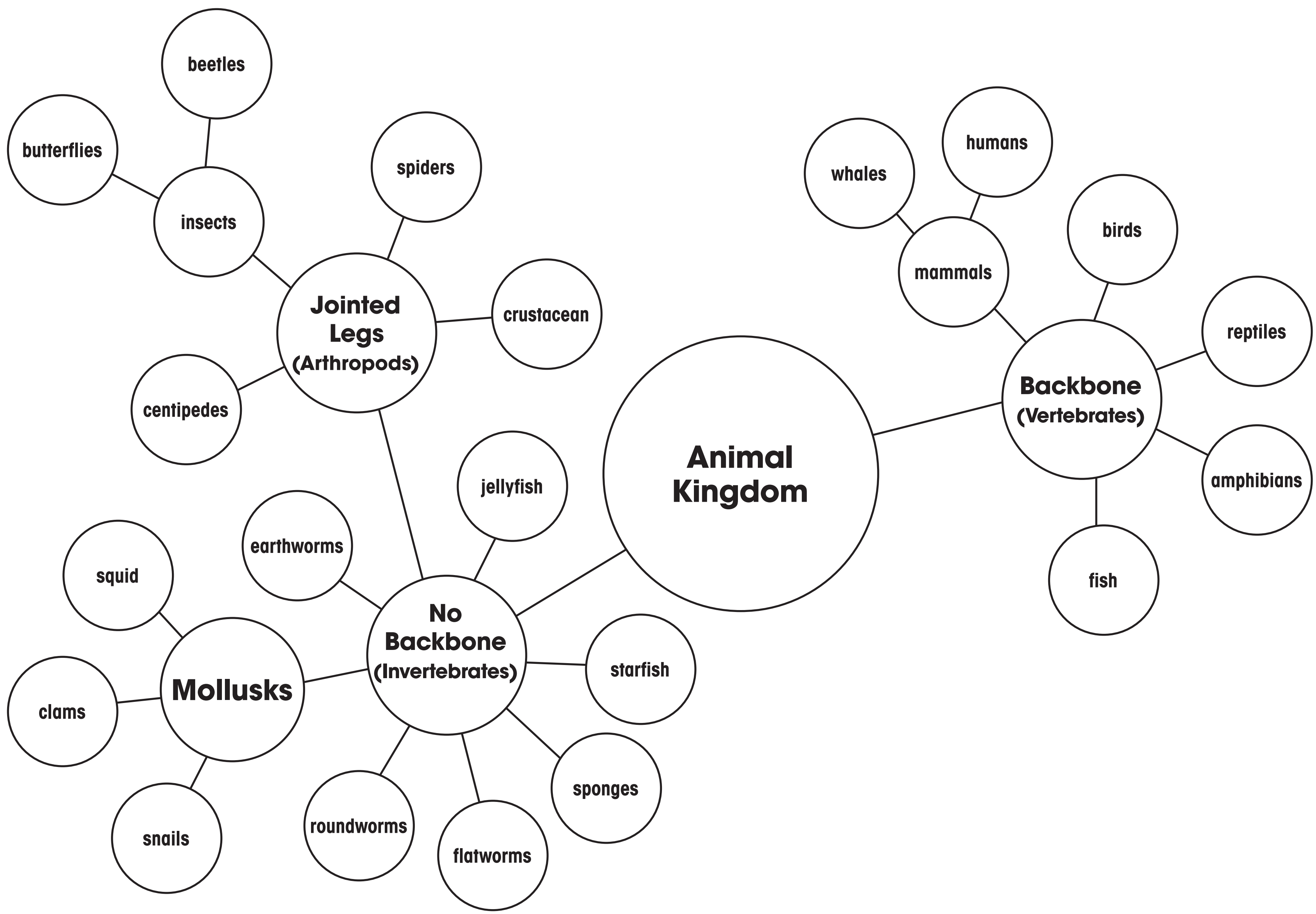
The Animal Kingdom



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Appendix

Images in this appendix are for the Image Banks referenced in the lessons. Also available in this appendix are diagrams and other reproducibles that are projected for activities. Corresponding full-page, high-resolution images can be printed or projected for the related lessons, and are found on the Portage & Main Press website.

Lesson 1: What Do We Know About the Diversity of Living Things?

Indigenous Plants and Animals of Ontario


1. Eastern Cottontail Rabbit


2. Elk


3. White-tailed Deer


4. Bull Moose


5. River Otter


6. Beaver


7. Raccoons


8. Black Squirrel


9. Muskrat


10. Fox


11. Timberwolves


12. Black Bear

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13. Lynx

14. Mallard Ducks

15. Blue Jay

16. Canada Geese

17. Ptarmigan

18. Wild Turkeys

19. Spruce Grouse

20. Cardinal

21. Great Horned Owl

22. Rainbow Trout Yearling

23. Muskellunge

24. Juvenile Northern Pike

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25. Gooseberry Plant


26. Sumac Tree


27. Bittercress


28. Wild Tobacco


29. Wood Sorrel


30. Aspen Trees


31. Shumard Oak Tree


32. Maple Trees


33. Pine Trees


34. White Trout Lily


35. Horsemint


36. Wild Strawberry

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37. Early Meadow Rue

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2 – Roosevelt elk, wildlife-2.jpg by Forest Service. Used under Public Domain Mark 1.0 licence.

3 – Deer by Noël Zia Lee. Used under CC BY 2.0 licence.

4 – Bull Moose by Denali National Park and Preserve. Used under CC BY 2.0 licence.

5 – river otter, babcock webb by Russ. Used under CC BY 2.0 licence.

6 – Beaver by USFWSmidwest. Used under CC BY 2.0 licence.

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18 – LBL_wild_turkey by Between the Lakes KY/TN. Used under CC BY-SA 2.0 licence.

19 – Spruce Grouse by U.S. Fish and Wildlife Service Northeast Region. Used under Public Domain Mark 1.0 licence.

20 – Cardinal by John Flannery. Used under CC BY-SA 2.0.

21 – Great Horned Owl 4-22-16 by Larry Smith. Used under CC BY 2.0 licence.

22 – Rainbow trout yearling (Oncorhynchus mykiss) by Robert Pos. Used under CC BY 2.0 licence.

23 – Muskiie attempting jump over dam 04-12-2015 098 by Richard Hurd. Used under CC BY 2.0 licence.

24 – Juvenile Northern Pike (esox lucius) by California Department of Fish and Wildlife. Used under CC BY 2.0 licence.

25 – Gooseberry by Jason Hollinger. Used under CC BY 2.0 licence.

26 – staghorn sumac berries by Wendell Smith. Used under CC BY 2.0 licence.

27 – Bittercress by Katja Schulz. Used under CC BY 2.0.

28 – Lobelia inflata_10Jul11 (1)ed by Cathie Bird. Used under CC BY-SA 2.0 licence.

29 – Oxalis pes-caprae habit1 by Harry Rose. Used under CC BY 2.0 licence.

30 – Aspen by Ben Mason. Used under CC BY 2.0 licence.

31 – Shumard Oak Tree by F.D. Richards. Used under CC BY-SA 2.0 licence.

32 – Swan song of cacophany by Angelo Juan Ramos. Used under CC BY 2.0 licence.

33 – Pine Trees by russellstreet. Used under CC BY-SA 2.0 licence.

34 – White trout lilies are some of the first spring wildflowers. They grow in colonies on the forest floor- so be on the lookout for their mottled leaves. by Danielle Brigida. Used under CC BY 2.0 licence.

35 – Horsemint by goldenecho. Used under CC BY 2.0 licence.

36 – Wild and Red by Scott Robinson. Used under CC BY 2.0 licence.

37 – Early Meadow Rue (Thalictrum dioicum) by Joshua Mayer. Used under CC BY-SA 2.0 licence.

Lesson 3: How Is the Animal Kingdom Organized?

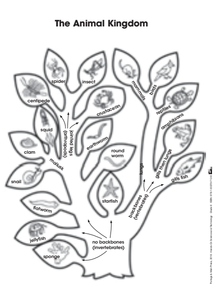

Diagram: The Animal Kingdom (1.3.1)

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