Grade 7

Blackline Masters

Aboriginal Perspectives on Sustainability

Traditionally, Aboriginal people have exemplified the qualities of good stewardship in their interactions with the environment.

Aboriginal environmental knowledge developed over centuries of observing and understanding seasonal changes—changes that were taken into consideration as a natural part of daily life and decision making.

Decisions were made with regard for the environment, which ultimately met the needs of individuals, families, and communities.

As food gatherers, Aboriginal people moved to areas where the land was bountiful. Each of the four seasons had a special time to hunt and trap animals for food and clothing, a time to catch fish, to harvest fruit and berries, and to pick roots and prepare medicines.

In conducting these activities, Aboriginal people considered the growth, reproduction, and regeneration cycles of plants, animals, and birds. To interrupt these natural cycles and patterns was considered to be an act against the laws of nature. This knowledge and understanding of the natural environment reflected the importance of sustaining Mother Earth for seven generations to come.

It is necessary for all peoples to embrace the concept of survival of the seventh generation, which is truly the heart of sustainability.

We must make decisions that ensure an equitable quality of life for all for seven generations to come.

Embedded within the Aboriginal world view is the concept of collective responsibility for tending the land and using only that which is needed for sustenance. Important, as well, is the interconnectedness and interdependence of all life forms—humankind, flora and fauna, and all that exists on the Earth. The concept of sustainability is not new to Aboriginal people; they are very aware of the growing need for all humans to show greater respect for the environment—respect for Mother Earth—if we are to continue to coexist in this world.

Aboriginal people are rich in environmental knowledge and can provide important perspectives when considering the impact of economic decisions on the environment.

Aboriginal people are also a source of sustainability strategies that can contribute to our collective well-being. Through ongoing communication and an understanding of traditional and environmental knowledge, education for a sustainable future can be achieved.

Aboriginal Perspectives: Reproduced from *Education for a Sustainable Future: A Resource for Curriculum Developers, Teachers, and Administrators*. Winnipeg, MB: Manitoba Education and Training, 2000. pp. 49-50.

Photosynthesis and Cellular Respiration

Part A

Complete the statements below, using terms from the Word Bank provided. **Note:** Terms can be used more than once.

Word Bank

• water	• oxygen	• sugar
• photosynthesis	• carbon dioxide	• cellular respiration
• chlorophyll	• energy	• light energy

1. a. ____________________ is the process that green plants use to produce their own food.
   b. Plants must contain ____________________ to carry out this process.
   c. ________________+_______________+_______________ ➛ _______________+_______________
   d. The substance considered to be a by-product of this process is ____________________.
2. a. ______________ is the process that plants and animals use to change food into useable energy.
   b. _______________+_______________ ➛ _______________+_______________+_______________
   c. The substances considered to be by-products of this process are ____________________ and ____________________.

Part B

Answer the following questions:

3. What relationship do you see between the substances in the two word equations in 1.c. and 2.b.?
4. Why are green plants important to animals?
5. What do animals provide for plants?

Look for:

1. a. photosynthesis
   b. chlorophyll
   c. water, carbon dioxide, light energy, sugar, oxygen
   d. oxygen
2. a. cellular respiration
   b. sugar, oxygen, water, carbon dioxide, energy
   c. water, carbon dioxide
3. Products of one process are used in the other process.
4. Green plants give off oxygen, which animals require to live.
5. Animals give off carbon dioxide and water, which plants need to produce their own food.

Bean Seeds and Cellular Respiration

Proving That Germinating Bean Seeds Undergo Cellular Respiration

A scientist conducted four experiments to prove that bean seeds, as living things, undergo cellular respiration. The scientist summarized the experiments into four statements: the question, the hypothesis, the test, and the result. These statements were captured in an electronic format but a computer glitch caused the hypothesis statements, the test statements, and the result statements to become mixed up.

Using statements A to L from the Statement Bank below, fill in the blanks to match each of the following questions with its corresponding hypothesis statement, test statement, and result statement.

1. What substance provides the sugar portion of the cellular respiration equation?
   Hypothesis: ______ Test: ______ Result: ______
2. Is oxygen used in the germination of bean seeds?
   Hypothesis: ______ Test: ______ Result: ______
3. Do germinating bean seeds give off carbon dioxide?
   Hypothesis: ______ Test: ______ Result: ______
4. Are bean seeds able to transform stored chemical energy into usable energy?
   Hypothesis: ______ Test: ______ Result: ______

The following information may help you with this task:

- In order for something to burn, oxygen must be present.
- Limewater is a chemical indicator that becomes cloudy in the presence of carbon dioxide.
- When heated, Benedict's solution turns reddish-orange in the presence of sugar.

Statement Bank

A. Add water to bean seeds. Observe for several days.
B. Test for the presence of oxygen before and after the germination of bean seeds by observing the effect of the air in a flask on a flame (burning wood splint test).
C. Crush bean seeds. Add Benedict's solution and heat. Observe.
D. The bean itself provides the sugar.
E. When heated, Benedict's solution changed to reddish-orange.
F. The limewater turned cloudy.
G. Oxygen is used during the germination of bean seeds.
H. Germinating seeds give off carbon dioxide.
I. A burning wood splint flames longer in a flask of dry new beans than in a stoppered flask in which beans were allowed to germinate.
J. Seeds were seen to grow, beginning stems and first leaves.
K. Put germinating seeds in a covered container and have the air given off by the seeds come into contact with limewater.
L. Bean seeds use some of the transformed chemical energy to carry out the life processes of growth.

Look for:

1. D, C, E
2. G, B, I
3. H, K, F
4. L, A, J

The Compound Microscope

Purposes:

- Identify and describe the function of the parts of a compound microscope.
- Demonstrate proper care and use of the microscope (i.e., carrying the microscope, cleaning lenses, focusing carefully).
- Demonstrate the ability to prepare wet mounts, focus, calculate magnification, estimate specimen size, and sketch specimens as they appear under magnification using a compound microscope.

Procedure:

A. Handling the Microscope

1. Clean lenses as needed using lens paper only. Normal tissue is too coarse and may scratch lenses.
2. Microscopes are fragile and must be handled with care. Carry the microscope with one hand under the base and one hand grasping the arm. Make sure the electrical cord is secured to prevent accidents.
3. Put the lowest power objective lens in place and cover the microscope with the dust cover when finished.
4. Never use direct sunlight as a light source.

B. Adjusting Light

The diaphragm regulates the amount of light passing through a specimen. Too much light results in flare, causing a lack of contrast or lost detail when viewing the specimen.

C. Preparing a Wet Mount

1. Place a drop of water on the slide.
2. Place a very thinly sliced specimen in the water.
3. Hold the cover slip against the water at a 45-degree angle, and then release. This will reduce the number of air bubbles, which may obscure portions of the specimen or the entire specimen. Gently pressing on the coverslip with a pencil eraser can eliminate some air bubbles.

D. Focusing

1. Always begin with the lowest power objective lens in position. This gives the largest field of vision and the greatest depth of field. It also reduces the chance of the lens striking the slide.
2. To avoid breaking the slide during focusing, move the lowest power objective lens as close as possible to the slide while watching from the side of the microscope. Centre the specimen and focus by moving the objective lens away from the slide.
3. Turn the adjustment dials to sharpen the image.
4. Adjust the diaphragm for optimum contrast.
5. When going from a lower power objective lens to a higher power objective lens:
    - centre the specimen in the field of view
    - change to the next power objective lens
    - use the adjustment dials to sharpen the image and adjust the diaphragm for optimum contrast

(continued)

(continued)

E. Determining Total Magnification

Total magnification = ocular lens power x objective lens power (e.g., 5X x 4X = 20X)

Note: the units are times (X).

1. Determine the total magnification for each combination of ocular and objective lenses found on your microscope. Complete the table below:

	Ocular Lens Power (X)	**Objective Lens Power (X)**	**Total Magnification (X)**
Low Power			
Medium Power			
High Power			

2. Prepare a wet mount slide of the following letter: e (lower case). Use an "e" from a newspaper or magazine or draw your own.
   a. In the space below, draw the letter as it appears with the unaided eye on the stage of the microscope. To the right of this diagram, draw the letter as it appears in the field of view under low power.
   b. Compare the two drawings and describe what you see. (In your description, answer the following questions: What is the consistency of the ink or pencil lead? Describe the texture of the paper. Is the position or orientation of the letter in the two drawings the same or different?)
   c. Describe the movement of the specimen in the field of view when you move the slide to the left. Describe the movement of the specimen in the field of view when you move the slide away from you.

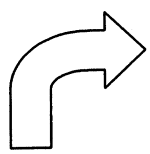
(continued)

(continued)

d. Make a general statement about the orientation and movement of objects viewed through a microscope.

e. What would you say to help a friend who is having trouble locating a specimen in the field of view?

f. The image below is drawn as viewed through the microscope. Draw what you would expect to see on the stage.



3. Prepare a wet mount slide of two overlapping hairs or thin threads.

a. Locate the hairs under low power. Is it possible to have both hairs in focus?

b. Locate the hairs under medium power. Is it possible to have both hairs in focus? Draw what you see. Indicate the total magnification.

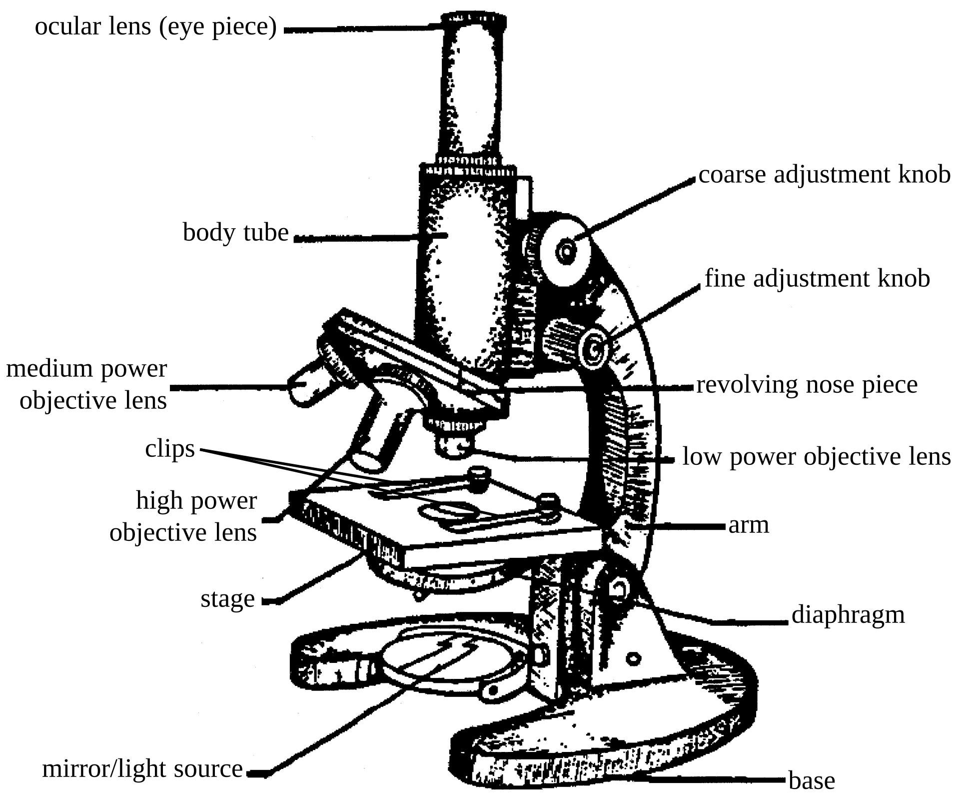
c. Locate the hairs under high power. Is it possible to have both hairs in focus?

d. What happens to the depth of field (i.e., the ability to focus on more than one object when the objects are at different depths on the slide) as magnification increases?

(continued)

(continued)

The Microscope



The Barbeque

A group of six friends get together on a hot July day for a barbeque and a game of baseball. Each person brings a different menu item. Sally brings potato salad (which contains mayonnaise made from eggs), Fred brings thick burger patties made from raw hamburger meat, Mary brings a tossed green salad and a bottle of oil and vinegar salad dressing to add later, Sam brings potato chips and frozen hot dogs in a cooler, Harry brings pop to drink and hamburger and hot dog buns, and Alice brings ketchup, mustard, and freshly washed strawberries. As Fred places his dinner contribution into Sam's cooler the group decides to play baseball.

After a 45-minute game the group begins to prepare supper. Fred is in charge of the barbeque and ensures that the hamburgers and hot dogs are well cooked. When the juices from the hamburgers are clear he places the meat on a clean plate. The table is set and the group finally sits down to eat, one hour and thirty minutes after they initially arrived at the site. Everyone has at least one hamburger and one hot dog except Sally, who has one hot dog only. Sally, Sam, Alice, Fred, and Mary eat the green salad. Alice does not eat the potato salad due to an allergy but she shares the strawberries she brought with Harry. Harry likes the potato salad so much he decides to have a second helping. After the meal the group cleans up and heads home.

The evening finds all the friends except Alice suffering from nausea and/or diarrhea. Sally also has a fever and Fred is suffering from stomach cramps. Harry is so ill he decides to go to the hospital.

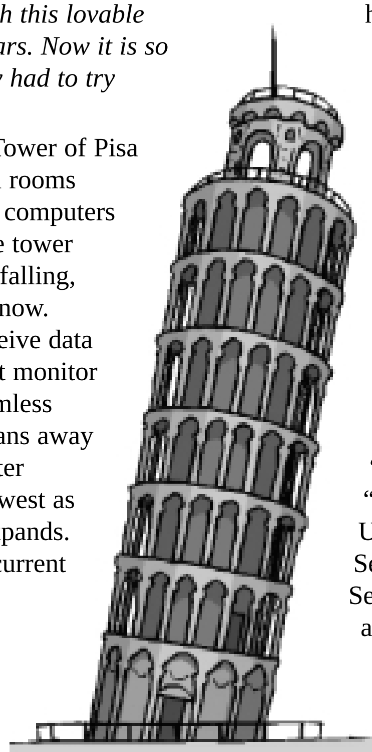
What's the Cause?

List all the food practices contained within the barbeque scenario and indicate whether they were safe. Use this information to identify and explain a possible cause for the illnesses, including an explanation of why Harry was extremely ill while Alice did not succumb to the illness her friends did.

Anti-gravity in Pisa

By Robert Kunzig

Engineers have been tinkering with this lovable leaning bell tower for hundreds of years. Now it is so close to actually falling over that they had to try something radical.



The control room of the Leaning Tower of Pisa is not very impressive, as control rooms go—just a handful of technicians and computers in a construction-site trailer. But if the tower ever decides to stop leaning and start falling, those technicians will be the first to know. Every five minutes the computers receive data from 120 sensors inside the tower that monitor its inclinations. The tower has its harmless daily moods. In the late morning it leans away from the sun, like some giant antimatter sunflower, tilting imperceptibly northwest as its southeastern side warms up and expands. At night the tower settles back to its current southward tilt of around 5.3 degrees.

It is that persistent angle that is alarming. It is bigger than it sounds or than it looks on postcards. When you walk the streets of Pisa, and the tower pops into view for the first time, it is shocking—the visual equivalent of a prolonged screech of brakes. For a split second you wait for the crash. People have been waiting for centuries, of course, and so you might reassure yourself that the crash can't really happen. After all, it is hard to imagine 177 feet and 32 million pounds of marble simply falling, in an instant, after 800 years. But some people have no trouble imagining it. "It is pretty terrifying," says John Burland, a specialist in soil mechanics at Imperial College in London. "The tower is literally on the point of falling over. It is very, very close."

Not quite as close as it was last year, though: Lately the tower has been moving ever so slightly in the right direction. From his London office Burland is supervising a delicate operation in which dirt is being extracted through thin drill pipes—the geotechnical equivalent of laboratory pipettes—from under the north, upstream side of the tower foundations, allowing it to settle toward the upright direction. The rate of soil extraction amounts to just a few dozen shovelfuls a day; anything faster might jolt the tower over the brink. Its condition is considered so precarious that it has been closed to visitors for a decade: The top leans a full 15 feet out of plumb. Burland and his colleagues on an expert committee appointed by the Italian government are hoping to bring it back 20 inches by next summer.

There are 13 members of the committee, but Burland, for this crucial operation, is the "responsible officer." Every day he gets faxes from the control room in Pisa telling him how the tower is doing; every day he sends back instructions on where to remove dirt next. He takes care to sign his messages. "That's absolutely essential," he says. "Someone's got to take responsibility. Unless you do that, you get another Black September." Burland is referring to September 1995, when it seemed for a while as if the committee, which was charged with saving the tower, might manage to knock it down instead.

In 1902 the campanile collapsed in St. Mark's Square in Venice, and the Italian government appointed an expert committee, the third, to consider what to do about the Leaning Tower of Pisa. In 1989 another medieval bell tower collapsed in Pavia, south of Milan, killing four people, and the Italian government appointed its 16th (or 17th, depending on who's counting) expert committee to consider what to do about the leaning bell tower of Pisa. Burland had never been to Pisa and little knew how his life was about to change when he took a phone call early in 1990 from his friend Michele Jamiolkowski, a geotechnical engineer at the Polytechnic in Turin. Burland remembers the conversation this way:

Burland: Michele! How are you?

Jamiolkowski: I was fine until this morning. Then I opened my newspaper and read that Prime Minister Andreotti has set up a commission to stabilize Pisa, and I'm chairman.

Burland: Oh, Michele, I'm sorry. What a terrible job!

Jamiolkowski: Keep your sympathy. Your name is there as well.

(continued)

There followed a telex—it all seems so long ago, Burland says; he and Jamiolkowski both are gray-haired now—a summons to a meeting in Rome. Thus began a decade during which Burland devoted much of his energy to Pisa. He was known in his profession for another delicate excavation, in which he built a below-ground parking garage alongside the Houses of Parliament without toppling Big Ben; he is still working for the London Underground on the extension of the Jubilee Line. But he has spent more time in recent years analyzing various models of the Italian tower. One morning last spring, in his office at Imperial, he demonstrated the simplest one. Taking a cardboard box from his bookshelf, he extracted some cylindrical plastic blocks and a two-inch-thick piece of foam rubber. “The problem of Pisa,” Burland said, laying the foam on his worktable and stacking the blocks on it, “is that it’s not built on rock. It’s built on soft clay.”

Under the Tower of Pisa, under all of Pisa, 1,000 feet of sediments cover the bedrock. The sediments come both from the Arno River, which flows through the town on its way to the Mediterranean, about six miles to the west, and from the sea itself, because as recently as the Roman period the area around Pisa was still a coastal lagoon. The tower sits on 30 feet of fairly dense river silts, below which lies a 100-foot-thick layer of marine clay. Called the Pancone Clay, it is made of flat, jumbled, loosely packed particles, and it is thus especially compressible. The tower, bearing down on a foundation just 65 feet wide and 10 feet deep, has compressed it.

The first three stories—the tall ground story and the first two loggias, or open galleries—were built between 1173 and 1178. The next four loggias were added between 1272 and 1278; the belfry was finished in 1370. In other words, there were two construction delays of nearly a century—and that was lucky, because otherwise the clay would have failed right then under the growing load. “In both cases the masons stopped just in the nick of time,” says Burland. “Because they left it, the weight of the tower squeezed a lot of the water out of the clay, and the clay became stronger.”

It’s possible they stopped because they were worried about the lean; it’s certain, anyway, that the tower was leaning, right from the beginning. When the new generations of masons resumed work, at the fourth story and then again at the belfry, they tried to correct the lean by building substantial northward kinks into the tower, thus giving it a banana shape. They were trying to curve the center line of the tower back over the center of the foundations, Burland thinks, just as a child would when faced with a leaning stack of blocks. Any child who has stacked blocks on a soft carpet knows, though, that sooner or later you add one block too many. At Pisa, the belfry was one block too many.

The tower had already sunk 10 feet into the soil, according to Burland’s calculations, but the belfry caused it to sink another few inches, which quickly caused a big jump in its tilt, to about four degrees. The tower tilts south because one of the shallow silt layers happens to be more compressible on that side—it has some soft clay mixed into it. Today that shallow layer has become the seat of the tower’s problem, Burland believes. Analyzing data collected by previous committees, he has found that the tower as a whole, even as its tilt continued to increase, had stopped sinking in the 20th century, apparently because the Pancone Clay strengthened again. Instead, the tower is rotating: As the south side of the skimpy foundation digs deeper into that soft shallow layer, the north side is moving up toward the surface, ready to pop out like the roots of a storm-felled tree.

Every little nudge moves the tower closer to that fate. According to Burland, ever since the addition of the belfry, it has been “metastable,” like a ball on a flat table. Give it a nudge and it does not come back, as it would if it were truly stable, like a ball at the bottom of a bowl. It just rolls along toward the edge of the table—toward what a geotechnical engineer calls “leaning instability.”

In 1838 the tower received a big nudge: An architect named Gherardesca decided that people should be able to see the base of the tower—which had disappeared into the dirt—and so he excavated a walkway around it. The tower jumped half a degree south. In 1934 an engineer named Girometti decided to stabilize the foundations by drilling 361 holes into them and injecting 80 tons of grout; the tower jumped another 31 arc seconds. (There are 3,600 arc seconds in a degree.) More recently, the gradual increase in the tilt has been caused, Burland thinks, by groundwater rising up under the base of the tower during the annual rainy season. For some reason it pushes up on the north side of the tower more than on the south. “It starts in September, and it ends in February,” Burland says. “The tower ratchets in one direction, and it never comes back. It’s just moving inexorably toward falling over, and accelerating as it gets closer.”

Burland and his colleagues have developed a computer model that reproduces the tower’s tilt history

(continued)

from the 12th century on. The one thing it can't quite reproduce is the tilt of 5.5 degrees, the angle it had reached before soil extraction. At any angle above 5.44 degrees, the computer tower refuses to remain standing—which suggests how close to the edge the real one has been. On the worktable in his office, Burland slowly adds blocks to his plastic tower. It teeters as it presses into the foam foundation. At block number seven it topples.

When Jamiolkowski's committee convened for the first time in 1990, the tower was increasing its tilt by around six arc seconds a year. An equally pressing danger, though, was that its masonry wall would fail first, causing the tower to collapse on itself, as the Pavia tower had. The wall is not solid; it consists of external and internal facings of marble encasing an infill of rubble and lime mortar. The stress exerted by the weight of the building is concentrated in these foot-thick facings—and the tilt has concentrated it dangerously at one point in particular: on the south side, at the bottom of the first loggia. That also happens to be where the wall suddenly shrinks from 13 feet to nine feet in thickness, and where it is hollowed by the internal stairway, which spirals around the tower inside the wall and arrives at the first loggia on the south side. In 1990 the external facing there was already badly cracked.

The tower was threatened with a hernia—and the first solution, says Jamiolkowski, was "like a belt for your belly." In 1992 the committee ordered the installation of 18 plastic-sheathed steel tendons around the first loggia and the ground story, pulled tight to hold it together. Early this year workers finally finished the rest of the committee's wall-strengthening program, which included injecting grout into the wall to fill air pockets in the infill and inserting stainless steel bars between the inner and outer facings to tie them together.

The committee also decided that they had to take some simple, temporary measures to stabilize the lean, to give themselves time to develop a long-range solution. If the north side of the foundation was rising, as Burland had found, there was an obvious option: Add a counterweight to stop it. In 1993, 600 tons of lead ingots were stacked on the north quarter of the tower, atop a concrete ring cast around the base. "For the first time in the history of the tower the tilt was stopped," says site engineer Paolo Heiniger. By the summer of 1994 the tower had moved some 50 arc seconds north, around two thirds of an inch.

The counterweight worked, but it was also very ugly. Six years later the ground floor of the tower remains obscured on the north side by that 15-foot pile of lead and concrete. The committee, which includes art restoration experts alongside its engineers, started to worry about this ugliness soon after creating it. In an effort to remove the pile, they came close to bringing the tower down.

By 1995 Burland had done much of the research to develop a permanent solution: soil extraction. It was not a new idea, having been suggested as early as 1962 by an engineer named Fernando Terracina. At Imperial, Helen Edmunds, a student of Burland's, had built a simple scale model of the tower on a bed of sand and sucked sand from under the model with a syringe. She found that, as long as she kept the point of the needle north of a certain line, there was no danger of the tower being inadvertently tipped into oblivion.

But a large-scale field test still needed to be done, and then a test on the tower itself, and it was all taking a long time. The committee had endured funding troubles and ministerial turf squabbles and periodic lapses in its mandate; the Italian parliament had never gotten around to ratifying the decree that had created the committee in the first place. Some members began to fear that the committee would go out of business, with the lead blight still in place as their one legacy to Pisa.

An idea for a new, temporary solution popped up: Why not replace the lead weights with 10 anchors buried 180 feet underground, in the firmer sand below the Pancone Clay? The anchors would hang from cables attached to yet another reinforced-concrete ring, this one hugging the foundations underneath Gherardesca's sunken walkway. To install it would require digging under the walkway and under the shallow water table. The committee knew that digging the walkway had caused the tower to lurch back in 1838, but they figured it would be safe to excavate their own trench in short sections. To avoid a groundwater escape that would flood the trench and possibly cause the tower to lurch again, they decided to freeze the ground first by injecting it with liquid nitrogen. The procedure worked on the north side of the tower. In September 1995, at the beginning of the rainy season, when the tower is at its most mobile, freezing started on the south side.

"The operation," says Heiniger, "had unexpected effects. The tower showed a tendency to move south, a tendency that developed quite suddenly." South was the wrong direction for the tower to be going.

(continued)

"It was hair-raising, really," says Burland, who rushed out of a conference in Paris to fly to Pisa. "As soon as they switched the freezing off, the tower began to move southwards at a rate of four to five arc seconds a day, which is the normal rate for a year. For three weeks we were watching the tower day and night." Burland suspects that by freezing the groundwater under the walkway on the south side, he and his colleagues had compressed the soil underneath—water expands when it freezes—creating a gap for the tower to settle into once the freezing stopped. Ultimately, though, another 300 tons of hastily added lead halted the southward excursion, and the tower shifted only seven arc seconds.

The committee now faced loud criticism. Piero Pierotti, an architectural historian at the University of Pisa, told *The Guardian*, a leading British newspaper, that Burland had done "incalculable damage" to the tower. "I just hope for the sake of the good people of Britain," he added, "that he doesn't do to your Big Ben what he has managed to do to the Leaning Tower." James Beck, a professor of art history at Columbia University, compared the Pisa committee to the Keystone Kops—and also to Mussolini, for the committee's supposedly authoritarian disregard of outside criticism.

Meanwhile, Jamiolkowski was finding he had plenty of internal dissension to deal with. The government disbanded the committee for most of 1996, and when it was finally reconstituted with many new members, there was heated debate on how best to proceed. "To keep together a large group of university professors is quite a difficult task, especially when these university professors must make important decisions," says Jamiolkowski. "I believe after this experience I will come to New York and open a psychoanalytic practice."

For the moment, the argument seems to be over; what the committee is doing now is working. In 1998 they added one more ugly prophylactic to the tower, intended to catch it should anything go drastically wrong while soil is being extracted. Two steel cables looped round the second loggia were attached to giant anchors partially concealed behind a neighboring building. The final underexcavation program began in February. "There are no more polemics at the moment," Pierotti says. "People have accepted this solution."

Forty-one drill pipes are now arrayed around the north quadrant of the tower. They enter the soil at different points along an arc about 40 feet from the tower and at an angle of 30 degrees; their tips lie about 12 feet under the north edge of the foundation. Inside each eight-inch-diameter pipe is an augur, a corkscrewlike bit that traps soil between its blades and channels it to the surface. The tower then settles into the resulting yard-long cavities. Burland steers the tower, and tries to keep it on an even northward course, by deciding how much soil to remove through each pipe on any given day. As of late May, Heiniger's crew had removed more than 10 tons of soil. The tower had rotated 513 arc seconds north, and the crew was one third of the way to its goal. There had been no ominous lurches.

Every day now the workers wind the tower's tilt clock back by months or even as much as a year. By next summer the committee hopes to restore the tower to five degrees, an angle it last saw early in the 19th century. That should buy the tower roughly two centuries of stability. Visitors are not likely to notice a half-degree decrease in tilt. The mayor of Pisa hopes to reopen the tower next year on June 17, the feast of San Ranieri, the city's patron saint.

But they are not there yet, the tower-savers. Jamiolkowski is looking forward to closing the work site, disbanding his fractious committee, enjoying life—but he balks superstitiously when you mention how well things seem to be going. Heiniger points out that the greatest threats to the tower have always come from people trying to give it a friendly nudge. "I hope it won't happen this time," he says. Burland, in the driver's seat, has perhaps the most reason to carry a rabbit's foot. Everywhere he goes these days the faxes from the control room follow him—two a day telling him how the tower has responded to the latest gentle suctioning underneath it. Every night Burland sends back the next day's instructions, signed.

"It's kind of taxing," he said recently, scanning the first fax of the day as he rode the elevator up to his office at Imperial. "It's like trying to ride a bicycle by fax. It's such a dangerous structure, and so many people have come unstuck on it. But yesterday was very good. We got the biggest north movement yet: four arc seconds in a single day."

How We Worked Together

Name: ___________________________________

Date: ___________________________________

Task: ___________________________________

Group Members:

____

____

____

	Yes	Sometimes	No
Everyone participated.			
We listened to each other.			
We encouraged each other.			
We took turns sharing ideas.			
The group stayed together.			
We accomplished our task.			

How We Worked Together: Reproduced from *Grades 5 to 8 Mathematics: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education and Training, 1997. Appendix.

Using a Rock Classification Key

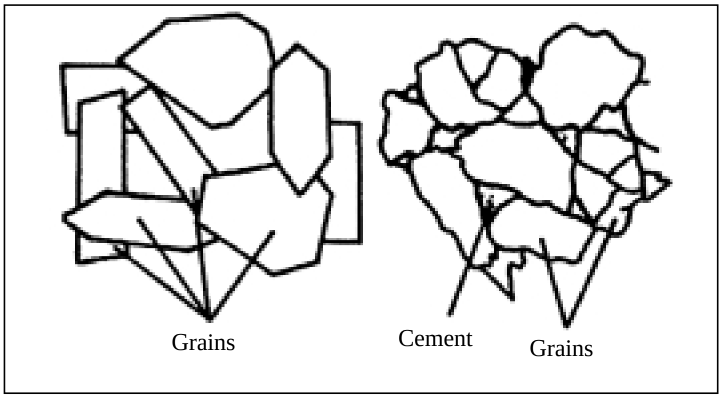
To use the key, start with #1 and move through the key until you have identified the rock type: igneous, sedimentary, or metamorphic.

1a. The rock is made up of distinguishable minerals. If so, go to 2a.

1b. The rock is not made up of distinguishable minerals. Go to 5a.

2a. The rock is made up of minerals that are interlocking. If so, go to 3a.

2b. The rock is made up of minerals that are non-interlocking. Go to 6a.



Interlocking and non-interlocking minerals

3a. The minerals in the sample are of the same kind. The rock is *metamorphic*.

3b. The minerals in the sample are of two or more different types. Go to 4a.

4a. The minerals in the sample are distributed in a random pattern. The rock is *igneous*.

4b. The minerals in the sample are not distributed randomly but show a preferred arrangement, or banding. The rock is *metamorphic*.

5a. The rock is either glassy or frothy (has small holes). The rock is *igneous*.

5b. The rock is made up of strong, flat sheets that look as though they will split off into sheet-like pieces. The rock is *metamorphic*.

6a. The rock is made of silt, sand, or pebbles cemented together. It may have fossils. The rock is *sedimentary*.

6b. The rock is not made of silt, sand, or pebbles but contains a substance that fazes when dilute HCl (hydrochloric acid) is poured on it. The rock is *sedimentary*.

The Rock Cycle

Igneous Rock

Rock begins as a molten mass of magma in the mantle of the Earth. Magma can ooze into already formed rock in the Earth's crust and cool to create *intrusive igneous rock*. If there is enough pressure, or if there are cracks in the crust, the magma itself comes to the surface of the Earth. Now known as lava, it flows out of volcanoes both on land and under the sea, creating *extrusive igneous rock* as it cools and hardens.

There are several things that could happen to igneous rock:

- It could be worn away in the process called weathering. Weathering breaks down the igneous rock, and sediment is created. This sediment may be transported elsewhere or it may collect layer upon layer (sedimentation). As the layers build up, their combined weight compresses the sediments, and sedimentary rock is formed. In many forms of sedimentary rock, layers may be seen, particles may be separated easily, or fossils (shells or bones of long-dead organisms) may be preserved.
- Besides being worn down and changed into sedimentary rock, igneous rock can be pushed lower and closer to the hotter mantle region of the Earth. Pressure and high heat can change igneous rock into metamorphic rock. Metamorphic rock can find its way back to the surface of the Earth by the movement of lower or neighbouring rock or by the weathering of the rock above. If igneous rock is pushed so low that it joins the hot mantle, it will become magma and eventually create new igneous rock.

Sedimentary Rock

Sedimentary rock can result from the wearing away of igneous rock. Sediment that forms sedimentary rock can also come from the breaking down of pre-existing sedimentary or metamorphic rock. Just as weathering can occur in igneous rock, so wind, water, ice, gravity, other rocks, and animals can break down sedimentary and metamorphic rock.

Sedimentary rock, in turn, could become metamorphic rock if enough heat and pressure were applied to it. It could even find itself turning back into igneous rock if it were forced back toward the Earth's mantle and allowed to melt. It may eventually return closer to the Earth's crust and become igneous rock.

Metamorphic Rock

Metamorphic rock could weather and provide sediment to create sedimentary rock or, if enough force were applied, metamorphic rock could be transformed into magma in the Earth's mantle.

Summary

All rock starts off as magma and hardens into igneous rock. Sedimentary rock is made as a result of the weathering of igneous and metamorphic rock. High heat and pressure applied to sedimentary or igneous rock can change them into metamorphic rock. These three types of rock continue to change from one form to another and back again. This process of change is called the *rock cycle*.

Create and Label Diagrams

Draw and label three diagrams to illustrate changes that can happen to igneous rock, sedimentary rock, and metamorphic rock.

Word Splash: The Rock Cycle

lava

weathering

hotter

magma

layer upon layer

process of change

pressure and heat

sedimentary

mantle

volcanoes

igneous

metamorphic

breaks down

sedimentation

extrusive

compresses

fossils

Soils in Manitoba

Like water, soil is a valuable resource for many forms of life. Green plants derive their energy from sunlight. Water, gases, and mineral nutrients are absorbed by plant organs and are incorporated into plant bodies. Plants that are consumed by animals or humans are eventually converted into animal tissue. Decomposition of plant and animal bodies and their waste products in soil allows matter to be used again and again by living organisms. In this way, soil serves as an important link between the living and non-living worlds.

Soils are made up of different compounds. Rocks are eroded by rain or wind and are broken down by physical or chemical processes to form tiny mineral particles. The sizes of the mineral particles are important in determining the characteristics and classifications of soils.

- *Clays* have the finest particles, the largest total air space, and the ability to soak up and hold much water.
- *Sands* and gravels have the largest particles and large pores, but less total air space. They hold little water and allow water to pass through easily.
- *Loams* have particles of intermediate size and space. They have the ability to hold water more easily than sands and gravels.

Irregular spaces between the mineral particles allow *atmospheric gases*, water, and water vapour to enter the soils. Atmospheric gases include oxygen, carbon dioxide, and nitrogen.

The decaying *organic matter* within the soil is added over many thousands of years. This organic matter provides many nutrients for plants and is responsible for aerating and loosening soil and helping with water absorption.

Also present in "dirt" are millions of *living organisms*. Bacteria, fungi, protozoans, and larger organisms are instrumental in determining the characteristics of soils.

Soil Zones

A *soil zone* is an area of relatively uniform soil colour and composition. In Manitoba, provincial soil maps generally identify from three to five soil zones. The soil zones shown on the Soil Zones of Manitoba map on the following page include

- bog and subarctic
- peat and podzolic
- lime-rich forest (grey)
- grey brown
- black soils

Brown soil zones are found in warmer and drier regions that may experience drought. Lack of moisture is usually the main factor limiting crop production. This short grass prairie soil zone has less organic matter than black soils. It has lower than average provincial yields and a higher chance of crop failure.

Black soil zones are much more favourable to good crop production. They are found in areas with slightly cooler temperatures and more effective moisture levels. This tall grass and parkland prairie soil zone has more organic matter than brown or grey soil zones.

(continued)

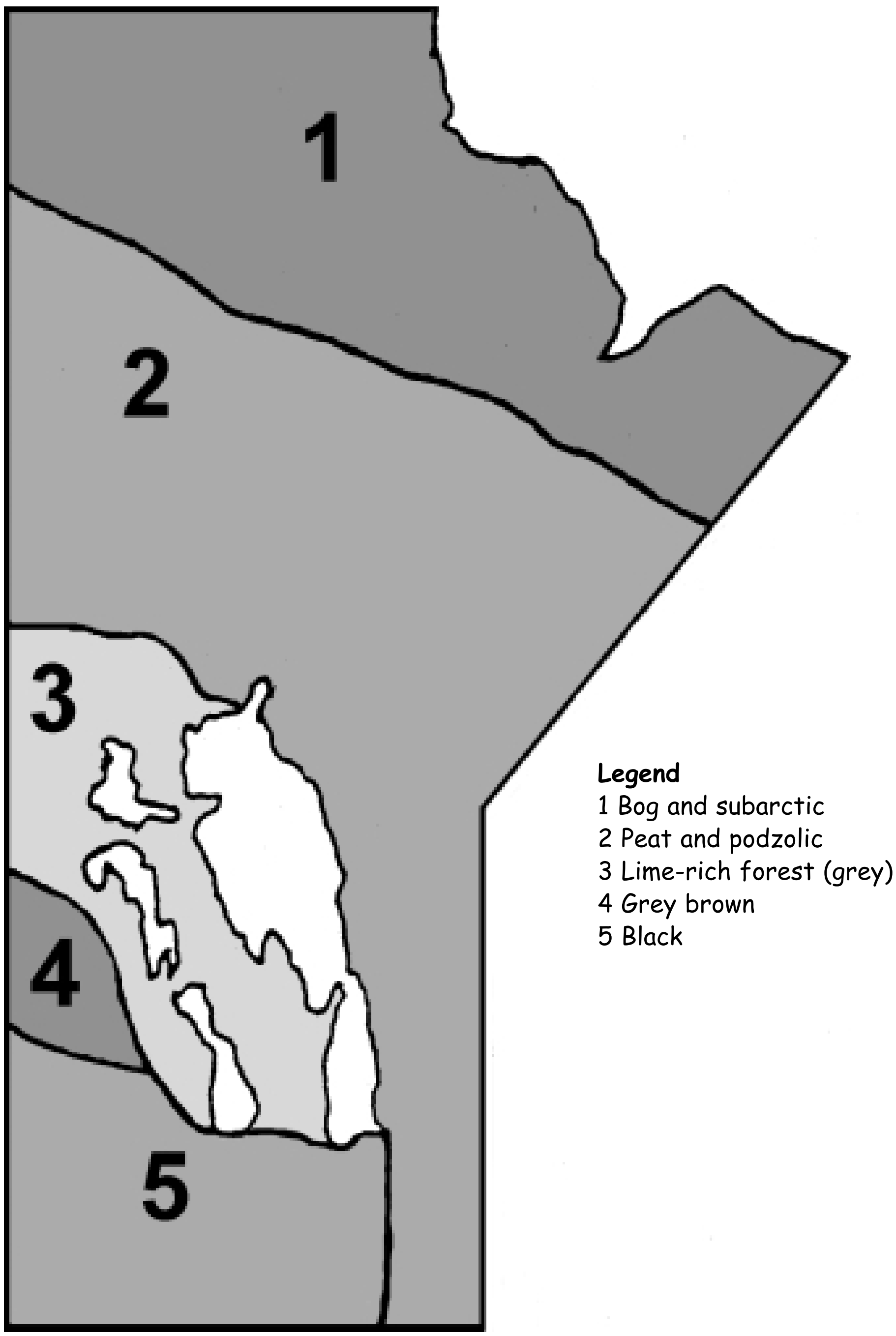
Soils in Manitoba: Reproduced from *Senior 3 Agriculture: A Full Course for Distance Education Delivery, Field Validation Version*. Winnipeg, MB: Manitoba Education and Training, 1999. pp. 17, 86-90.

(continued)

Grey soil zones experience less decomposition of plant matter. This soil type is located farther north, where cooler temperatures result in increased soil moisture. These higher moisture levels leach minerals and nutrients out of the upper layers at a faster rate. As a result, the grey topsoils tend to be more shallow and less fertile than black or brown soils.

Climate and vegetation play major roles in soil formation. The boundaries of the soil zones are similar to the boundaries for climatic and vegetation belts. All have significant effects on the farming operations of their areas. About 12 percent of Manitoba's land area is considered to have soils suitable for agriculture. Compare the following three maps: Soil Zones of Manitoba, Climatic Regions in Manitoba, and Natural Vegetation in Manitoba. Notice the similarities.

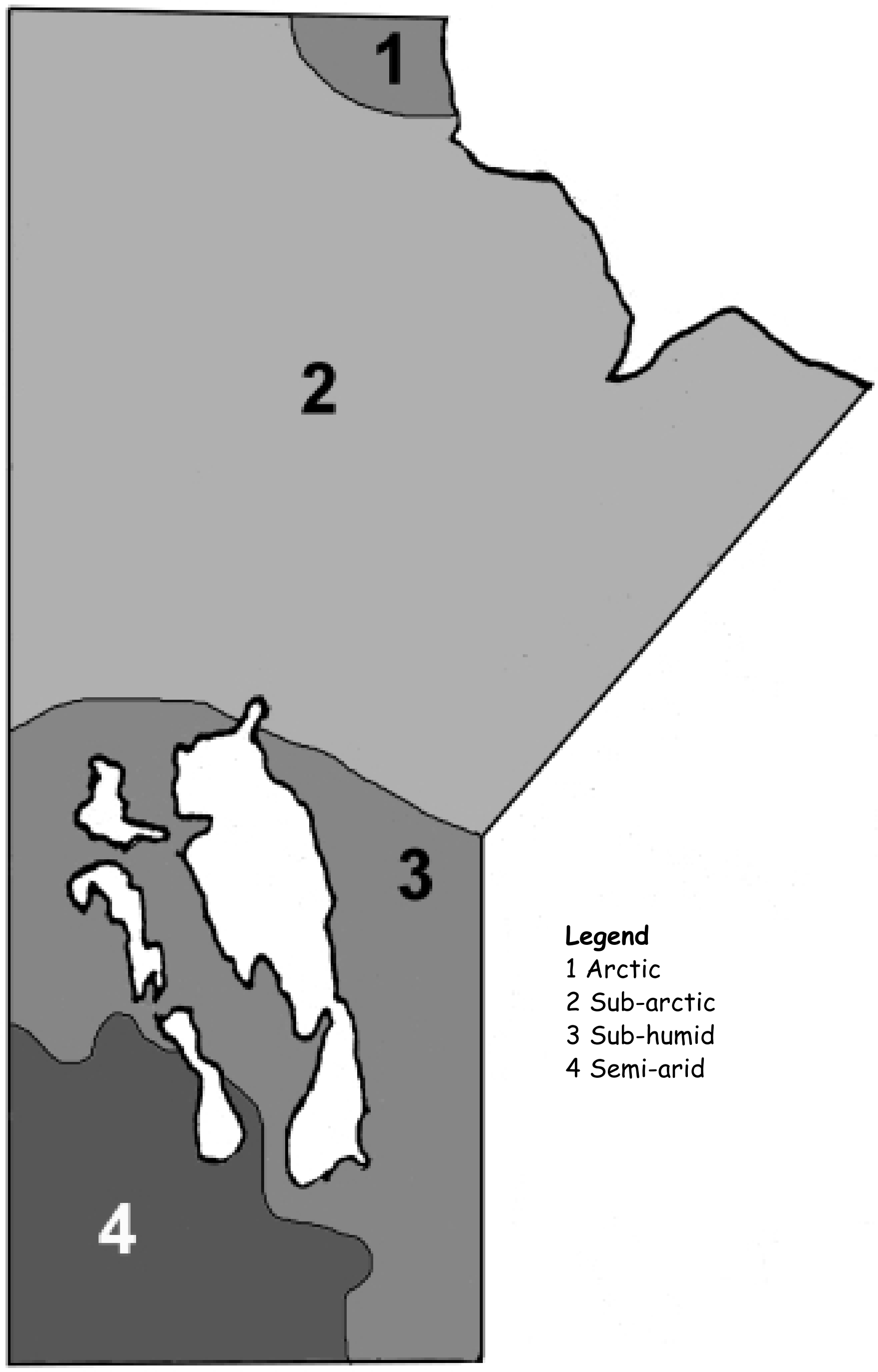
Soil Zones of Manitoba



(continued)

(continued)

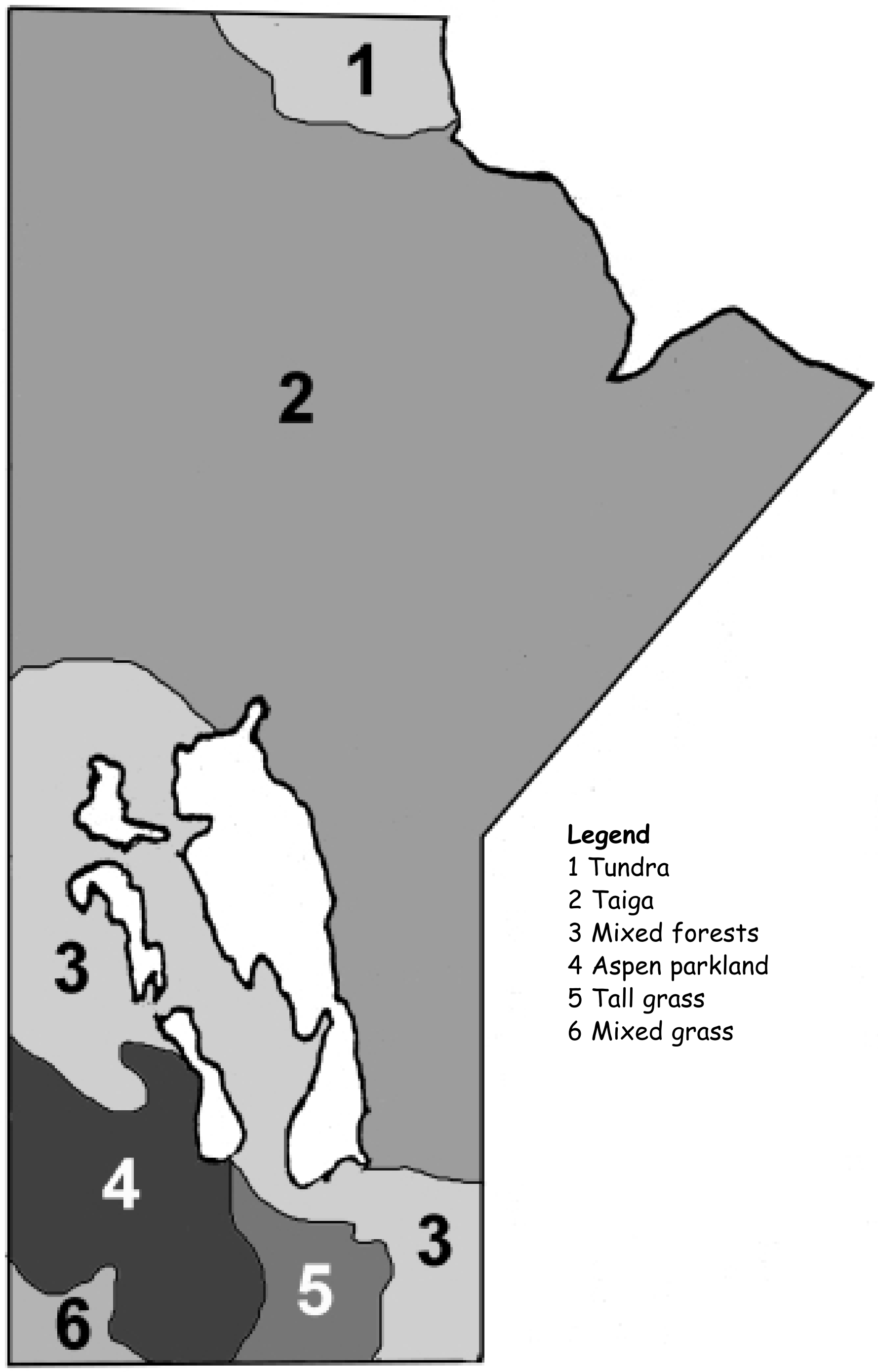
Climatic Regions in Manitoba



(continued)

(continued)

Natural Vegetation in Manitoba



Soil Erosion

Erosion is a naturally occurring process that can be either escalated or diminished by agricultural practices. With the disappearance of natural grass cover and the reduction of anchoring material in cultivated topsoil, erosion occurs. Drought conditions and an overextension or expansion of cultivation into regions of light soils resulted in tremendous losses of topsoil to winds in the 1930s.

The loss of mineral particles and organic matter to *wind erosion* continues today. Dry, windy conditions are common to many areas at spring seeding time and clouds of dust can still be seen in certain areas. Treatments to replace topsoil include the use of fertilizer, manure, and irrigation. Some Alberta studies have shown improved yields through these practices. However, those yields were still not as good as those in test plots where natural topsoil remained.

Water erosion occurs frequently. On sloping land, rill erosion of *tiny channels* that are several centimetres deep can eventually lead to gulley erosion characterized by *deep-cut channels* that can be measured in metres.

On bottomlands, especially along rivers, *sheet erosion* can take place in times of high water. When water covers large areas of relatively flat land, it will dissolve matter from the upper soil layers and carry it away when the land finally drains.

Solving Soil Problems

Problems created by water erosion and wind erosion can be reduced by specific soil management techniques that are in keeping with the principles of sustainable development.

Water erosion has been reduced by

- hillsides or slopes that are *contour-cultivated* or worked across the slope to create furrows, ridges, or plant strips that oppose the downward movement of water
- *gullies* or pathways for water movement that have been shaped and seeded to grasses or grass-legume mixtures
- areas of frequently submerged lowlands that have been *grass-seeded* to prevent *sheet erosion*
- crops (such as rye or winter wheat) seeded in the fall as crop cover to prevent spring water erosion

Wind erosion has been reduced by

- *shelter belts* around farmyards, around fields, or along roadsides that reduce wind speed
- tillage and seeding equipment *(cultivators)* that leaves straw stubble upright to hold soil in place
- maintaining a *trash cover* on the soil surface to keep the soil moist for a longer period, reducing the amount of loose, dry soil available to the wind
- *swathing* so that alternate strips are at different heights
- planting fall cover crops (winter wheat or rye) in areas of light, sandy soil that are prone to wind erosion
- planting perennial grass or legumes (for animal forage or grazing lands)

(continued)

Soil Erosion: Reproduced from *Senior 3 Agriculture: A Full Course for Distance Education Delivery, Field Validation Version*. Winnipeg, MB: Manitoba Education and Training, 1999. pp. 17, 60, 64, 65, 73.

(continued)

Organic Matter: Did You Know?
It is estimated that it has taken anywhere from 200 to 1 000 years for organic matter to form. This is why the loss of several centimetres of topsoil to wind or water erosion is considered serious.

Trends in Sustainable Agriculture

Some soil management practices that have been in use for many years are still being used today. Others are being modified, and still others are being abandoned. Decisions to adapt to new methods are influenced by the following factors:

- costs of new method
- availability of specialized equipment
- time involved
- availability of information
- size of farming operation
- type of farming operation
- values and beliefs

Conclusion

Producing, purchasing, and eating foods are all actions that directly relate to agriculture and ultimately relate to soils. Therefore, either directly or indirectly, your actions have effects on soil management. In the past, not much attention was paid to the way soil was handled as a resource. Land deterioration often went unnoticed because the process was slow and fairly widespread. Problems that were recognized received minimal attention. Even though most management practices that led to soil degradation were directly carried out by agricultural producers, the responsibility for good soil conservation techniques lies with us all—from the home gardener to the crop producer. Sustainable agriculture is more frequently becoming standard practice, and is supported by increased research, knowledge, and public awareness.

Constructing a Prototype: Observation Checklist

Date: ________________________________ Problem/Challenge: _______________________________

A group of students can be selected as a focus for observation on a given day, and/or one or more of the observational areas can be selected as a focus. The emphasis should be on gathering cumulative information over a period of time.

Names	Has Safe Work Habits (ensures personal safety and safety of others)	Works with Group Members to Carry Out Plan	Participates in Analysis and Modification of Prototype	Shows Evidence of Perseverance and/or Confidence	Comments
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					

(continued)

Constructing a Prototype: Observation Checklist *(continued)*

Names	Has Safe Work Habits (ensures personal safety and safety of others)	Works with Group Members to Carry Out Plan	Participates in Analysis and Modification of Prototype	Shows Evidence of Perseverance and/or Confidence	Comments
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					
32.					
33.					

Notes:

Design Project Report

Name: ___________________________________ Date: ___________________________________

Problem/Design Challenge:

Criteria:

Brainstorming (What are all the different ways . . .):

Planning:

Steps to Follow:

Materials:

Safety Considerations:

(continued)

Design Project Report *(continued)*

Testing:

Criteria	Test Used

Test Results: Attach Data Summary

Evaluating and Improving:

- Justification of changes to original design:

- Strengths and weaknesses of final design:

- Comment/Reflection (Next time . . . , A New Problem . . . .):

(continued)

Design Project Report *(continued)*

Prototype Sketch 1 (Plan):

Prototype Sketch 2 (Final):

Design Project Report: Assessment

Prototype: ______________________________ Date: ______________________________

Team Members: ____

Criteria	Possible Points*	Self-Assessment	Teacher Assessment
Identifying the Practical Problem and Criteria for Success • the problem is clearly stated • class and/or group criteria are identified • criteria address all or some of the following: function, aesthetics, environmental considerations, cost, efficiency			
Planning • all steps are included and clearly described in a logical sequence • all required materials/tools are identified • safety considerations are addressed • a three-dimensional sketch of the prototype is included (Sketch 1)			
Testing the Prototype • tests are described and align with criteria (e.g., each criterion has been tested) • test results are presented in an appropriate format (data sheet is attached)			
Evaluating and Improving the Design • a final sketch of the prototype is included (Sketch 2) • changes to the original plan are justified • strengths and weaknesses of the final prototype are presented • suggestions for “next time” are included and/or “new problems” are identified			
Total Points			

Comments:

*__Note:__ The teacher and/or the class assigns possible points to reflect the particular emphasis/es of the project.

Conducting a Fair Test: Observation Checklist

Date: ___________________________________ Experiment: _________________________________

A group of students can be selected as a focus for observation on a given day, and/or one or more of the observational areas can be selected as a focus. The emphasis should be on gathering cumulative information over a period of time.

Names	Has Safe Work Habits (workspace, handling equipment, goggles, disposal)	Ensures Accuracy/ Reliability (e.g., repeats measurements/ experiments)	Works with Group Members to Carry Out Plan	Shows Evidence of Perseverance and/or Confidence	Comments
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					

(continued)

Conducting a Fair Test: Observation Checklist) *(continued)*

Names	Has Safe Work Habits (workspace, handling equipment, goggles, disposal)	Ensures Accuracy/ Reliability (e.g., repeats measurements/ experiments)	Works with Group Members to Carry Out Plan	Shows Evidence of Perseverance and/or Confidence	Comments
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					
32.					
33.					

Notes:

Experiment Report

Name: ______________________________ Date: ______________________________

Experiment: ____

Testable Question:

Independent Variable:

Dependent Variable:

Prediction/Hypothesis: (Identify a cause and effect relationship between independent and dependent variables.)

Planning for a Fair Test

- **Apparatus/Materials:**

- **Variables to Control:**

- **Method:** (Include steps to follow, safety considerations, and plan for disposal of wastes.)

(continued)

Experiment Report *(continued)*

Observation: (Include data tables/charts on a separate sheet, if required.)

Analysis of Data: (Identify patterns and discrepancies.)

Note: Attach graph on a separate page, if required.

(continued)

Experiment Report *(continued)*

Strengths and Weaknesses of Approach/Potential Sources of Error:

Conclusion: (Support or reject prediction/hypothesis; pose new question(s).)

Applications/Implications: (Link to daily life or area of study.)

Experiment Report: Assessment

Experiment Title: ________________________________ Date ______________________________

Team Members: ____

Criteria	Possible Points*	Self-Assessment	Teacher Assessment
Creating a Testable Question • the question is testable and focused (includes a cause and effect relationship)			
Making a Prediction/Hypothesis • independent and dependent variables are identified • the prediction/hypothesis clearly identifies a cause and effect relationship between independent and dependent variables			
Planning for a Fair Test • required apparatus/materials are identified • major variables to be controlled are identified • steps to be followed are included and clearly described • safety considerations are addressed • a plan for disposing of wastes is included			
Conducting a Fair Test/Making and Recording Observations • evidence of repeated trials is provided • detailed data are recorded, appropriate units are used • data are recorded in a clear/well-structured/appropriate format			
Analyzing and Interpreting • graphs are included (where appropriate) • patterns/trends/discrepancies are identified • strengths and weaknesses of approach and potential sources of error are identified • changes to the original plan are identified and justified			
Drawing a Conclusion • cause and effect relationship between dependent and independent variables are explained • alternative explanations are identified • prediction/hypothesis is supported or rejected			
Making Connections • potential applications to or implications for daily life are identified and/or links to area of study are made			
Total Points			

***Note:** The teacher and/or the class assigns possible points to reflect the particular emphasis/es of the project.