"How Did They Do That?"
Understanding Science through Ancient Technologies

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Technologies such as stone tool making, weaponry, cordage production, stone boiling, and pottery manufacture were crucial to ancient societies. These represent some of the very first scientific innovations, by people who understood and applied basic principles of physics, chemistry, and engineering in addition to a deep knowledge of the location and properties of essential natural resources. And they represent some of the most important "firsts" in the history of human technology, essential to the advancement of society itself.

Because prehistoric peoples left no written descriptions of how they made or used their tools, archaeologists must use other means to learn about ancient technologies. Experimental archaeology and the study of use-wear patterns are two such methods. Experiments provide possible hypotheses about how former tools were made and used. Experimental archaeology replicates artifacts and technologies in ways that may have been used by prehistoric peoples. By making artifacts and using them, archaeologists can address questions such as how long it took to make a projectile point, how far a spear might have been thrown, what chert was best for chipped stone tools, how far someone traveled to find good sources of raw materials, what plants were best for cordage, what rocks were best for stone boiling, and how long it took to heat liquids with hot rocks?

Experimental archaeology also studies how tools were used in the past by using them in ways that produce wear or damage patterns similar to that observed on artifacts. The results of these studies help produce hypotheses about how prehistoric people may have performed similar tasks.

The following provide a series of activities that relate to prehistoric technologies. They will allow you to gain an appreciation for how tools were created and used by prehistoric people, and how archaeologists make hypotheses about the manufacture and function of these artifacts. Keep in mind that in order to create successful technologies, prehistoric artisans had an inherent understanding of basic principles of science and math, a deep knowledge of the properties of natural resources, and the ability to discover and successfully extract such resources.

Vocabulary

Cordage: string; cordage technology is the ability to take plant or animal fibers and, through rolling or twisting, make string. These strings can be very thin and finely made, or coarse and thick. Thin strings can be combined through rolling into ever longer and thicker cords, eventually becoming rope.

Sinew: tendons connecting large muscles to bones or joints, or the outer covering of long muscles such as those running parallel to the animal's spine

Sherd: a piece of broken pottery

Temper: material like crushed granite, sand, or shell, added to the clay to prevent the pot from cracking during the drying and firing process

Ocher: pigment or paint made from hematite or limonite (iron oxides) mixed with animal fat or water, or used in dry form

Petroglyph: a design carved or pecked onto a rock surface

Pictograph: a design painted onto a surface

Replication: the act or process of recreating artifacts, structures, and use patterns

Potential energy: stored energy (the energy of a boulder at the top of a cliff)

Kinetic energy: the energy of motion (the energy of a falling boulder just before it strikes the ground)

Mussel: freshwater bivalve mollusk

Organic: living or once living

Making Cordage
(Don Wirth)

Materials: Cordage comes from two major sources: animal fiber and plant fiber. Longer animal hair such as bison or human is difficult to roll into cordage. It is much easier to braid hair, but the greater effort (braiding takes more time than rolling) results in a flat, fairly broad cord that is difficult to use. Long strips of rawhide can also be rolled into cordage, but it must be knotted rather than spliced to extend its length and loses its smoothness and suppleness, resulting in an inferior cord. Therefore, hair cordage and rawhide cordage will not be discussed here.

There is a great deal of knowledge about when and how to gather cordage fiber and how to process it in preparation to cordage production. Some cordage techniques require dry fiber (example, dogbane) while others, such as sinew or basswood, require dampened fibers.

Animal Fiber: In prehistoric and early historic times the animals of Iowa yielding fibers were bison, elk, and white-tailed deer. The fibers are derived from the dried sinews of these animals. During the butchering process, the long sinews are removed and the meat and fat is carefully scraped away. The sinews are then set aside to dry in the sun. Once dried, they can be stored indefinitely. Fibers are obtained by pounding the sinew between an anvil stone and a hammer stone and pulling the resulting fibers from the dried tendon. These long sinew fibers are set aside until the cordage is made.

Plant Fiber: There are many plants in Iowa that yield fiber of varying quality and strength. These fibers can be derived from the stems of some plants such as dogbane (*Apocynum cannabinum*), or nettles (*Boeheria, Laportea, Urtica*). The inner bark of basswood (*Tilia americana*), willow (*Salix spp.*), red cedar (*Juniperus virginiana*), and cottonwood (*Populus deltoides*) can yield serviceable fiber for cordage. Dogbane and nettles can be cut when growing and dried for later use, or gathered in the late winter or early spring. Dogbane and nettle fibers are prepared when dry. Inner bark fibers are stripped from living tree limbs or suckers and prepared when damp.

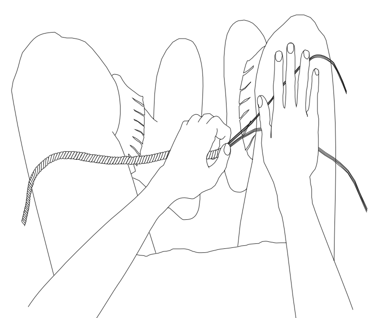
Cordage Production: Making serviceable cordage is a skill learned through practice. A good way to practice the technique is from fibers derived from recycled baling twine in approximately 20-inch lengths. There are four major steps to making cordage: (1) preparing the fibers, (2) starting a 2-ply cord, (3) rolling the cord, and (4) splicing. Basswood makes a superior cord and is easily obtained. Therefore, this technique will be explained in detail. Since basswood cordage production is a "damp" technique, the procedure is nearly the same for sinew cordage. To make serviceable cordage, both hands are required to perform fine motor skills. A right-handed method will be described, but it can be easily transposed to left-handed if necessary.

Procedure:

1. *Preparing the fibers:* Collecting bark fibers is easiest when the tree is actively growing (spring, summer, and early fall). The basswood tree has two inner bark layers. The most inner layer (adjacent to the wood) is thin and white and makes the best fiber. This layer can be obtained by stripping off a section of inner and outer bark about one half to one inch wide. This bark strip should be as long as possible. Some of the desired fibers will adhere to the wood. With your thumbnail, peel off the fiber in long sections. Some of the fibers will adhere to the inner layer of the previously stripped bark. Obtaining these fibers requires a sharp tool (knife or chert flake) and is less reliable than pulling the fibers from the wood. The optimal working length is about 18-20 inches and about one-eighth of an inch wide. Any fibers shorter than 8 inches are not worth using. Some strands of fibers will have small wood or bark fragments adhering to them. Scrape off these imperfections by drawing a sharp chert flake across the fiber. When you have gathered 20-30 fibers, dampen them by balling the fibers into a loose wad and placing the wad into your mouth. Saliva is a good lubricant because it is viscous and not too wet. An alternate method is to dry the fibers for later use. Dried fibers must be soaked in clean water for several hours prior to cordage production.
2. *Starting a 2-ply cord:* Select one of the longest of the prepared fibers to begin the cord. Pinch the left end of the fiber between your left thumb and index finger. Place the fiber across your right thigh (reverse position if left-handed). (A bare, shaved thigh works best, but snug blue jeans are serviceable.) With the flat of your right palm, roll the fiber on your thigh away from your body toward your knee until it becomes taut. It is very important that the rolling direction be *away* from your body only.

   At the completion of the roll, pinch the fiber between your right thumb and index finger to prevent the strand from unraveling. Transfer the pinched spot to your left hand and repeat the process of rolling the strand away from you until it becomes taut. When you reach near the end of the fiber strand, take a second, long fiber strand and overlap the loose right end of the previously rolled strand to extend the foundation strand's length. Repeat the process until you have a single-ply rolled strand about 24 inches in length that is tightly rolled. At this point your left thumb and index finger should be holding the left end and your right thumb and index finger should be holding a tightly rolled single-ply strand.

   Next, determine the approximate middle of the single-ply and gently hold that point between your front teeth. While still holding the ends in your hands and the middle in your teeth, move your hands together until your thumbs touch, all the while maintaining tension on the single-ply. Release the cord from your teeth. The single-ply will automatically twist upon itself, creating a short 2-ply cord with single-ply cords attached to which you will add more fiber. This should look like a Y.

3. *Rolling the cord:* Place the started 2-ply cord (Y) on your right thigh with the leg of the Y pointing

to the left and the opened fork to the right. With your left hand pinch the intersection of the single-plies. With your right flat palm roll *both* single-plies in tandem away from your body. This is done by a hard downward press and roll. It is important to keep the single-plies spread wide enough to keep from becoming entangled with each other. (Sometimes one single-ply will roll more easily than the other. When this occurs, roll the uncooperative single-ply between your right thumb and index finger until a uniform tension is achieved.) When both single-plies are rolled with sufficient tension, roll the 2-ply at the Y intersection with your left thumb and index finger. Continue the left hand roll out to the end of the 2-ply. This maintains a uniform twist on the completed 2-ply cord.

4. *Splicing:* Splicing adds length to your cordage. When adding fiber, stagger the locations of the splices on the single-plys to achieve a stronger cord. Continue as in step 3 with the placement of the cordage and hands. Splicing works best when the ends of the single-plies are frayed. Shred or split the end of the single-ply if necessary. Place a new, saliva-dampened fiber strand on the end of the single-ply and overlap about 3 inches. With your right thumb and index finger, roll the new strand and single-ply away from your body until it becomes integrated with the single-ply. Revert back to Step 3 and roll both single-plies in tandem to create an ever-lengthening 2-ply cord.

Hints:

Always roll the single-ply or 2-ply cords *away* from your body.

To make a stout 4-ply cord, simply extend the 2-ply to a length approximately 3 times the length of the finished product. For example, a 4-ply bowstring 3 feet in length, would require about 9 feet of 2-ply cordage. To accomplish this, the rolling process must be reversed. Tighten the twist by rolling the 2-ply cord *toward* your body, keeping the left end fastened to prevent unrolling. Since a very long length of 2-ply cord is needed, tie the left end to a stationary object or have the end held by an assistant. Find the center of the 2-ply cord as done in Step 2. This process can be repeated (with an additional corresponding direction change) to make an 8 or 16-ply cord. Remember, every time you double the ply, you will need to at least triple the original length.

Some fiber ends will not be completely rolled into the cord. To create smooth finished product, these stray fibers can be trimmed off with a sharp tool or singed off over a low flame. Stray fiber ends of a sinew cord can be moistened with saliva and will adhere to the finished cord when the cord is again rolled on your thigh.

The procedures outlined here can be modified by experimentation to meet the skills and experience of the cordage maker.

Questions:

1. Where would prehistoric people have found basswood in Iowa?
2. How would prehistoric people have determined the relative strength of different plants for cordage?
3. If it takes 10 minutes to make 25 centimeters of cordage, how long would it take to make 10 meters of cordage? 100 meters?
4. It takes approximately 2 meters of cordage to make a snare to catch a small animal. How long would it take to make the cordage for the snare if you can make 25 centimeters in 10 minutes?
5. Cordage is usually made of plant material that in most archaeological sites would biodegrade. How do archaeologists know that prehistoric people in Iowa made cordage? (Clue: think about another prehistoric technology, ceramics.)

Making Mussel Shell Temper for Pottery

(Adapted from Schermer 1992:18)

Materials: freshwater mussel shells collected from creek or river, bed of heated charcoals, hammerstone or pestle, and large flat rock.

Procedure:

1. Place shells directly in a bed of coals for an hour or more.
2. When cool, crush the shells against the large flat rock with a large hammerstone or pestle. Try crushing unburned shells to see how much harder it is when the shell is unburned.

Questions:

1. Why would shell have been used as temper?
2. How would native peoples have created slow burning fires for heating the shell?
3. What is shell made of chemically?
4. What happens if acid is applied to lime or limestone? If prehistoric pottery is encased in an acidic soil for centuries, what might happen to the shell?

Making Pots

(Adapted from Schermer 1992:18–19)

Materials: potter's clay or clay collected from a natural source such as creek bank, temper (sand, finely crushed rock, burned and crushed freshwater mussel shell), large wooden board (like a cutting board), twine or cordage, piece of burlap, wooden paddle wrapped with cordage, small and smooth hammerstone, popsicle stick, rounded ended stick, sharply pointed stick or pencil, unburned mussel shell.

Procedure:

1. If using natural clay collected from a stream bank, sample the material by taking a handful and mashing it together. If it holds together without crumbling, it probably has a high clay content. If the

clay is taken from just above the water level it may be moist enough to work without further processing. It will stay workable for some time if sealed in a plastic bag or plastic container. If the clay is too dry to work, it must be dried out completely, broken up, and reconstituted with water until the right consistency is reached.
2. Take a handful of clay, roll in temper, and knead. Continue until the clay is workable.
3. Slam the clay onto the board to remove air bubbles.
4. Shape into a ball and tap on hard surface to form a cube.
5. Holding clay in hands, use thumbs to push center down and out and use fingers to pull clay up and in, thus forming a pot.
6. If small cracks develop while shaping the pot, dip finger lightly in water and rub into cracks (use sparingly). Use finger and thumb to mend cracks.
7. Paddle the exterior of the pot with the cord-wrapped paddle while supporting the interior wall with a small, smooth hammerstone. Keep cord marks on the surface as a decorative feature or smooth away the cord marks with a smooth stone or edge of a popsicle stick.
8. Try different decorative techniques:
   a. Impress a single woven cord into the clay while it is still wet or wrap the pot with woven fabric like burlap and press gently into the clay.
   b. Push small punctates into the rim using a round-ended stick or your fingers.
   c. Allow the pot to air dry for about 10 minutes, then shave and shape the walls using an unburned mussel shell. Scrape out the bumps.
   d. Use a sharply pointed stick or pencil to scribe geometric designs into the rim, neck, and shoulder of the pot.
   e. Make separate small clay figures of animals (effigies) and attach as a handle to the pot.

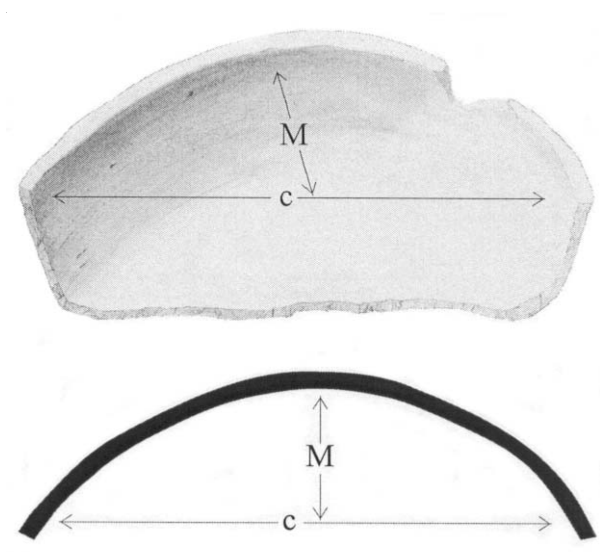
Questions:
1. What minerals are found in clay?
2. How could you determine if a pot was handmade or wheel made?
3. Prehistoric pottery in Iowa was fired in open type settings at relatively low temperatures. What effect could this low firing have had on pottery?

Measuring Pots: Calculating Their Size from Sherds

(Adapted from *Intrigue of the Past*: pp. 70-72)

Materials: “broken pots,” or sherds from broken clay flowerpots, paper, pencil.

Procedure:
1. Calculate the interior circumference of a pot represented by a sherd in the example or from a real sherd. If you are using real sherds, lay a rim sherd finished side down on a sheet of paper and trace around its inner edge. Use either the rim tracing or the sherd in the example below, and measure a straight line between two points on the curve. Measure the length of that line (*C*, chord length), calculate its midpoint, and then measure the distance from the midpoint to the curve edge (*M*, middle ordinate).



2. The formula to calculate the radius (*r*) of a circle from a portion of it is:
   $r = C^2/8M$.
3. The formula to calculate the circumference (*c*) is:
   $c = 2\pi r$
   where
   $\pi = 3.14$
4. Example
   $C = 7.8$ cm $r = 7.8^2/8(1)$ $c = 2\ (3.14)(7.6)$
   $M = 1$ cm $r = 7.6$cm $c = 47.8$
5. Calculate the circumference of the pots presented by a series of rim sherds from broken clay flowerpots.

Questions:
1. Why would archaeologists want to get some idea of the circumference of pots?
2. What could the presence of pots of different capacity at a site mean?
3. Can you think of ways that the function of different pots might be hypothesized by the archaeologist (clue, what might pots have contained)?

Rock Art: Making Pigments

(Lynn M. Alex)

Materials: charcoal pieces salvaged from a campfire or fireplace, hematite or limonite from the creek, hammerstone or pestle, large flat rock or mortar, lard or Crisco, popsickle sticks, water, brown butcher paper, small paintbrush, small paper cups.

Procedure:
1. Salvage pieces of charcoal from a campfire or fireplace

2. Gather pieces of the minerals hematite (red) and limonite (yellow) from creek gravels. Clue, these often occur as concretions. To identify these materials as suitable for pigments, rub them against a sidewalk or tile to see if they streak red or yellow.
3. Separately crush up the charcoal, hematite, and limonite with the hammerstone or pestle against a large flat stone or in a mortar.
4. Mix the crushed or powdered pigment with enough lard to form a paste suitable to use as paint or with the water to form paint.
5. Paint designs on the brown butcher paper using your fingers or a brush dipped in the two types of paint. Use your fingers to apply face paint.

Questions:

1. To what class of minerals do limonite and hematite belong? What is a mineral? What is a rock?
2. Limonite and hematite may occur as concretions in creek beds. What is a concretion?
3. What was the proportion of pigment to either fat or water that you needed to prepare a workable paint?
4. Although limonite and hematite are non-organic, other materials used in pigments like charcoal and lard are composed of materials that were organic or once living. Radiocarbon or C14 dating can be used to determine the age of organic materials. How does radiocarbon dating work?

Stone Boiling
(Lynn M Alex)

Materials: large metal container, ceramic crock or crockpot (unplugged) filled with water, second pot or pan filled with clean water, fist-sized rocks (not limestone nor chert), campfire or grill with active fire or hot charcoal, water, tongs (wooden or metal), oven mitts or pot holders, safety goggles, vegetables or pieces of meat to cook.

Procedure:

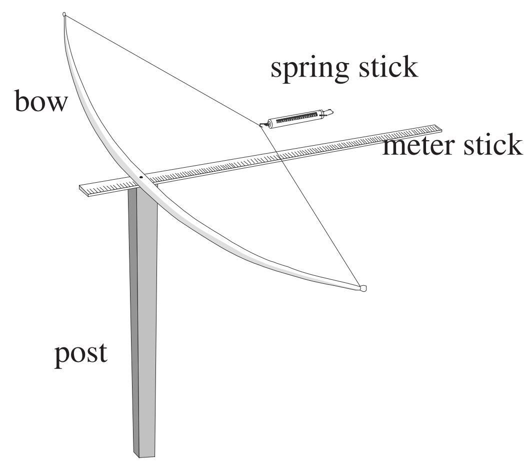
1. Prepare campfire or charcoal grill fire.
2. Put rocks in the fire or coals.
3. Have metal container or crock filled with water sufficient for cooking.
4. Remove hot rocks, one at a time with metal or wooden tongs from fire, briefly rinse in clean water, place in large metal container, crock or crock pot until water is heated to boiling.
5. Add meat or vegetables to simmer or boil. (you may need to take out some of the rocks to make room for the food).
6. Add more hot rocks as water cools until food is sufficiently cooked.
7. Remove and discard rocks, remove food.
8. Further experiment: try different rock types to see if some conduct heat more efficiently.

Questions:

1. Why would some rocks be more suitable for stone boiling than other types?
2. Why would limestone or chert not be a good choice (what can happen when they are heated)?
3. What is the temperature at which a liquid boils? How long did it take for the liquid to reach this temperature? Do you think some rocks might conduct heat more efficiently than others? Experiment with this by measuring the time it takes for the same quantity of water to boil using the same weight of different kinds of rocks.
4. What other kinds of containers might prehistoric people have used in which to stone boil?
5. Which type of container seemed to more efficiently maintain and hold the heat?

Potential Energy Analysis of a Bow
(Adapted from Southworth 1990
by Stephen Lensink)

The potential energy of a bow is transferred to the arrow as kinetic energy when the bowstring is released and the arrow is shot. The more potential energy a bow can store, the more kinetic energy the arrow will have at the time of release. The kinetic energy of the arrow along with its mass determines the arrow's velocity and hence affects its flight distance and force of impact.

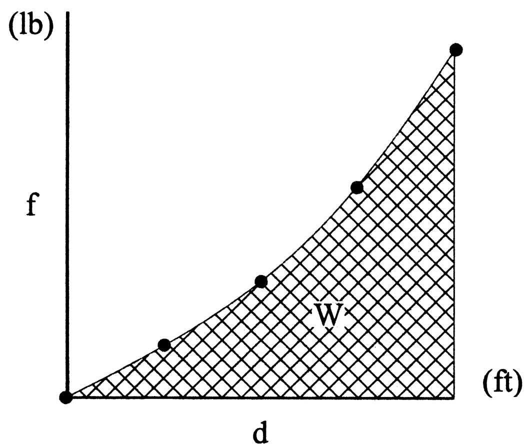


Materials: strung flat bow, 100-pound spring scale, meter stick, rope.

Procedure:

1. Tightly secure the center of a bow to a post with rope.
2. Secure a meter tape or measuring stick (scale in feet and inches) horizontally from the post behind the bow. A numerical increment on the tape representing zero should be just below the center of the bowstring.
4. Attach the spring scale to the center of the bowstring.

5. Pull horizontally on the spring scale and record the force (in pounds) and the displacement (in feet) for a series of displacements.
6. On a sheet of graph paper, plot force (*f*) as a function of displacement (*d*).
7. Work (*W*) or potential energy (in foot-pounds) is the area under the curve of your graph (between the curve and the displacement axis).



Questions:
1. What happens to *W* as the *f* increases?
2. What does this suggest about the draw of the bow?
3. Could different materials in the bow and bow string affect its strength and potential energy?
4. Would you expect to get different plots with bows made of different materials?

References

Schermer, Shirley J.
1992 *Discovering Archaeology: An Activity Guide for Educators*. Special Publication. Office of the State Archaeologist, University of Iowa, Iowa City.

Smith, Shelley J., Jeanne M. Moe, Kelly A. Letts, and Danielle M. Paterson
1996 *Intrigue of the Past: A Teacher's Activity Guide for Fourth through Seventh Grade*. Bureau of Land Management, United States Department of the Interior, Washington D.C.

Southworth, Tom
1990 Potential Energy Analysis of a Bow. *Physics Teacher*, January 1990:42-43.

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