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Invention through Form and Function Analogy

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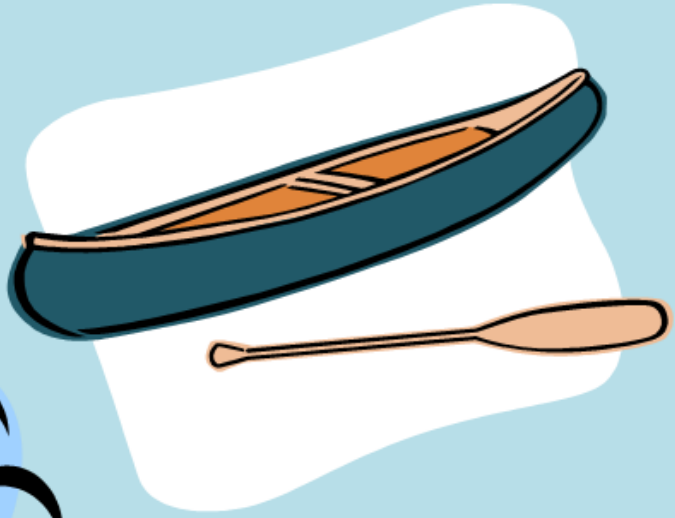

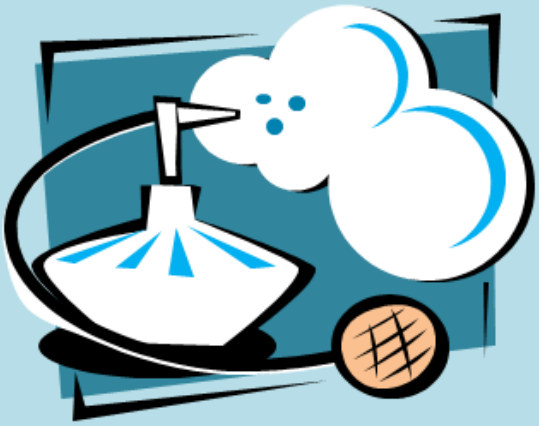

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Comments from Contributing Reviewers:

"[Third grade students] loved working together and the challenge of the card sets. I loved how they suddenly realized that so many inventions were extensions of the human body. One of my students said, "I can't believe I never realized how amazing my hands are!"

"Invention units such as this one force students to consider the fact that early, seemingly simple and rudimentary inventions, led the way for the more advanced inventions that we use today. My students are now thinking about the limitations of inventions that we currently use."

"My students and I have greatly enjoyed these lessons, I chose to do multiple levels [5th grade, 7th grade, and 8th grade] to experiment with how it would work, so far it is great in all three levels and I am planning on trying it with even younger students. I love this unit and will use it frequently!"

"Fifth grade students realized that it is because of our basic human needs plus our own human creativity and ingenuity that leads to every single invention in today's world. We even listed things like folklore, mythology, and religion as an invention to meet the basic human needs of acceptance, community, and a need for understanding of self and the world."

"The [fourth grade] students seemed to most enjoy putting the lesson 6 cards into order. "It is like a puzzle!" The storage of music cards were favorites because the students were very familiar with iPod, CD, sheet music, and even the magnetic tape. They seemed to gain the most learning from seeing the precursors of the inventions they were familiar with, and how the limitations of each stage were solved by a later stage of the invention. It was neat to ask them to consider what made it easier to determine order and what made it more difficult (metacognition). They very much enjoyed the hands-on nature of the cards and sharing their thoughts during discussions."

"Overall, it made me eager to do similar activities with other students. I think the book of suggested lessons takes a lot of the "How?" out of deciding to teach invention to elementary students by providing a strong set of activities that teachers can easily incorporate and link to other studies."

I truly enjoyed giving [students] this challenge. Once the first set was done, they were a little disappointed to know that we were spacing it out over a few days so we could talk about why the selections were made. They were very excited for the next day!!

Invention through Form and Function Analogy

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Introduction

The skills addressed by the exercises in this book are important. Talent, thinking skills, and innovation/inventiveness are necessary for a successful society with a high standard of living, especially in a rapidly changing global economy. "Commercially viable innovations are becoming the linchpin of success in global markets by helping to raise total productivity, and they account for a major portion of the growth in advanced and industrializing economies," (Yusuf, 2009, p. 1). Research has long ago shown that creativity and innovation skills can be taught (Torrance, 1963), but many schools are not addressing them, partly because of a lack of appropriate curriculum (Wagner, 2010). Advances in school curriculum are necessary to fill the demand for well-prepared workers with developed problem-solving skills. This book presents a curriculum for teaching about creativity and invention from the scientific form and function approach, combined with analogy and other creative skills.

Many 21st Century skill sets, designed for the new era of quickly-evolving technologies, jobs, and culture, focus on creativity, invention, and innovation. For example, the Partnership for 21st Century Skills (2011) published a *Framework for 21st Century Learning* that includes learning and innovation skills of critical thinking, communication, collaboration, and creativity. The Association for Supervision and Curriculum Development's position statement (2008) asks for teaching, learning, and leadership that adequately prepare students who can demonstrate creativity, innovation, and flexibility. The *Next Generation Science Standards*, based on the National Research Council's (2012) *A Framework for K-12 Science Education* include standards for engineering and invention. For instance, at the fourth grade level, students are asked to "Apply scientific ideas to design, test, and refine a device that converts energy from one form to another" (Standard 4-PS3-4; Achieve, Inc., 2013, p. 31). A handbook of curriculum for teaching about invention that includes hands-on materials and creative approaches will fill a need for many teachers, as well as leaders of scouting and youth organizations. The following section provides a literature review of teaching invention through analogy with a form and function approach.

Analogical Thinking in Science Learning and Invention

Fundamental cognitive operations for learning include determining similarities and differences between objects or events. Four key strategies for assisting students in using these fundamental operations (Marzano, Pickering, & Pollock, 2001) are (1) comparing similar characteristics and differences between the objects or events; (2) classifying items into categories based on attributes; (3) creating analogies that map relationships between pairs of concepts; and (4) creating metaphors that show similar patterns from different domains. A meta-analysis (Apthorp, Dean & Igel, 2012) of published studies that centered on using similarities and

differences, such as analogy with kindergarten through high school students, found that these approaches positively affected student learning.

Metaphors

Metaphors, figures of speech in which a word or phrase is applied to something in a non-literal way to suggest a comparison or resemblance, can assist students in understanding new experiences by connecting them to previous knowledge. Elementary students often spontaneously suggest metaphors as they engage in science observations of nature. Jakobson and Wickman (2007) noted that these comparisons of the observed natural phenomena to qualities of other things assisted students in maintaining attention and in remembering characteristics. These researchers also observed that students' spontaneous comparisons were springboards to constructing the final science concepts, rather than being endpoints in themselves.

At times, students' use of metaphors can restrict what they observe, preventing other important observations from being made. Teachers' interactions with the students through asking questions can assist students in noticing important phenomena and characteristics. Students may make comparisons to objects without indicating how they are specifically connected through shared qualities; again, teachers can assist by asking students which qualities make these objects similar to the natural phenomena they are exploring. Because understandings of metaphors are based on prior experiences, all comparisons will not be equally effective for all students. Sometimes students' metaphors contain negative aesthetic or value judgments that prevent students from exploring the phenomena further. Jakobson and Wickman (2007) suggested that teachers might make a game of students generating positive metaphors when the conversation is negative. Finally, a teacher might mediate metaphors that appeal mostly to one gender or culture by suggesting additional, more universal comparisons. The emotional or value judgment aspect of metaphors makes them useful in creative writing and poetry. Such creative writing activities may be motivating to students in studying science, as has been shown by Rule, Carnicelli, and Kane (2004), who used poetry-writing about minerals to motivate high school students in an earth science class.

Analogies

Analogies make a direct comparison between objects, concepts, or events to draw attention to the common relationships of their various features, avoiding emotional reactions and value judgments. Analogies assist student learning in many ways (Venville & Treagust, 1996): (1) transferring the structure from an unfamiliar domain to a familiar one, thereby aiding comprehension; (2) motivating students through recognition of familiar aspects and increasing their science self-efficacy; (3) easing a change in mindset of the learner from "matter" to

"processes"; and (4) supporting memory through recall of features and relationships of a concept. Further substantiation of the usefulness of analogical thinking in memory retrieval comes from research conducted by Gentner, Loewenstein, Thompson, and Forbus (2009). They found that, when analogical comparisons were used during learning, later retrieval of information was improved. They attributed this to student mental representation of the information in abstract comparison categories.

Analogies provide early mental models that connect prior knowledge to developing understandings. Unfortunately, analogical thinking can be misused and lead to misconceptions when a learner interprets unshared attributes as valid or when learners are not familiar with the analogy (Harrison & Treagust, 1993). To prevent these problems, teachers need to guide students in mapping the relevant features of the analogy and in identifying its limits (Adúriz-Bravo, Bonan, Galli, Chion, & Meinardi, 2005).

A teaching model that assists students in avoiding some of the problems associated with using analogies with complex concepts is the Teaching with Analogies Model (Glynn, 2007, 2004; Glynn, Duit, & Thiele, 1995). This model has six steps: (1) introduce the *target* concept, a new, unfamiliar idea; (2) present the familiar concept to which the target concept is compared and remind students of is features (called the *analog*); (3) recognize the most important features of both the target and analog concepts; (4) connect the identified ideas from the target and analog that have the same types of relationships by making a diagram or chart (called *mapping*); (5) identify areas in which the comparison breaks down (called the *limits of the analogy*); and (6) draw conclusions about the target concept, identifying new student understandings made through the analogy. For this teaching model to work well, both target and analog need to have several similar features; the more features shared by target and analog, the better the analogy. *Structural alignment* is the pairing of parts from the target and analog that have similar roles in each system. This task is accomplished through mapping on a diagram or chart that connects the paired features. The paired elements do not have to have similar visual or surface appearances; the important aspect of pairing is similar relationships to other components in their systems. The Teaching with Analogies Model will be used in the proposed project to ensure effective use of analogies.

Form and Function Analogies

Analogies can assist students in going beyond memorization of features to conceptualize relationships between structure and function within a complex system. Creating analogies exercises students' higher levels of thinking, actively engaging them in the process of making sense of a system (Marzano, et al., 2001). For example, middle school learners who created models of cells as baseball games, cities, restaurants, or homes (Grady & Jeanpierre, 2011) evidenced higher test scores compared to control groups, showing students' improved

comprehension of cell parts and functions. Nevertheless, the isolated use of analogies is not enough to develop deep understanding; students need opportunities to verbalize their understandings, to discuss ideas, and apply the new learning (Guerra-Ramos, 2011).

Form and function is a unifying concept of science identified in the National Science Education Standards (National Committee on Science Education Standards and Assessment and National Research Council, 1996). This concept is applicable to both the natural and designed world, thereby supporting analogies between these domains. *Form* is any physical attribute of an object such as shape, color, configuration, pattern of motion, texture, sound, smell, taste, and so forth. *Function* refers to the use, purpose, or task of a component. Forms support the functions of manufactured objects, animal body parts, plant parts, and other aspects of organisms. For example, the sharp, narrow (form) spines on a cactus conserve evaporation of water and prevent many browsers from eating the plant (functions). Several research studies have been conducted regarding the use of form and function analogies in science instruction. Rule and Furletti (2004) found that high school students who used form and function analogies to learn human body systems had greater gains with a large effect size than a control group. Similarly, Rule, Baldwin, and Schell (2008) showed that second graders learned animal adaptations better using form and function analogies compared to reading informational text about animal adaptations and researching the information via the Internet. These two studies utilized a unique instructional material called an "object box," which is described next.

An effective science teaching material that uses form and function analogies is called a form and function analogy object box. This teaching material consists of a set of small, familiar, manufactured items (the "objects"), each representing an analog, and a set of corresponding two-sided cards housed in a plastic shoebox (the "box"). The front of each card describes the form and function of an animal body part (second grade study on animal adaptations by Rule, Baldwin, & Schell, 2008) or a component of a human body system (high school study by Rule & Furletti, 2004). To begin, the student takes a card, reads about the form and function, and then searches through the given manufactured items to locate one with a similar form and function. Advantages of this object box activity include being hands-on and having concrete examples of the analogs for students to examine. The reverse side of each card provides the name of the correct analogous object and explains how its form and function corresponds to that of the target.

Form and Function Analogies in Problem-Solving and Innovation

Innovation is the process of creating new products or services, or enhancements to existing products or services. Organizational processes that significantly impact a person, group, organization, industry, or society are also types of innovations (Higgins, 1996). Analogies can be valuable in solving problems and developing innovations. A solver who recognizes the similarities

between two analogous problems and who can also recall the solution to the analog problem is likely to be able to apply this information to solving the new problem (Condell, Wade, Galway, McBride, Gormley, Brennan, & Somasundram, 2010). Practice in comparing two similar problems helps people develop a general schema that operates across domains. This skill allows problem solvers to be more able to consider the problem in broad terms and use analogous thinking to solve it.

The use of analogy assists scientists in making structured connections between different domains to better understand how they work and to exploit well-known relationships in one domain for innovations in another. Many scientists and inventors have used analogy to assist them in making conceptual breakthroughs. James Dyson, while looking for ways to make vacuum cleaners more effective, observed the whirling action of a sawmill cyclone sucking sawdust without becoming clogged. His first vacuum cleaner prototype was based on this analogy (Foreman & Drummond, 2008). Hans Krebs defined the citric acid cycle, later named the Krebs Cycle, by recognizing the similarities of parts of the chain to components in other cyclic processes (Lightman, 2005). Charles Darwin compared evolution to a tree, connecting budding twigs to existing species and older growth as the long succession of extinct organisms. He noticed that new growth overtops older branches, blocking the light from them in the same way that new species outcompete others in the struggle for resources. This analogy helped Darwin notice other aspects of evolution to investigate (Darwin, 1859; Marcelos & Nagem, 2012).

Form and function analogies have been combined successfully with the SCAMPER method to create new inventions or innovations of manufactured items (Rule, Baldwin, & Schell, 2009). This creative thinking technique's name, SCAMPER (Eberle, 1972), is an acronym for various operations that can produce changes for innovations: Substitute, Combine, Adapt, Modify-Minify-Maximize, Put-to-another-use, Eliminate, and Rearrange. These ideas were developed from Osborn's checklist (1963) of tactics for producing creative transformations. First, an item is identified to which innovation or invention will be applied. In work with second graders, Rule et al. (2009) used simple items such as an envelope, plastic spoon, or paper cup. A chart is used to implement this technique. The first column has the creative SCAMPER operations that will be applied to ideas; the second column is used to note a form and function relationship present in one or more organisms that will be applied to the item in conjunction with the SCAMPER operation to generate ideas for innovation. The combination of disparate ideas in this manner is called forced relationships, an effective strategy for producing novel ideas (Guilford, 1986). The last column shows ideas for innovation of the product.

Human Need and Invention

Maslow's hierarchy of needs shows the stages of human need starting with the foundational base of the pyramid that shows physiological needs (Hagerty, 1999). Needs farther up the pyramid become more complex and include safety needs, social needs, esteem needs, and, at the top, self-actualization. Humans everywhere create inventions to better satisfy their needs. These inventions include tools and social constructions such as family structures, religion, community organization, and government. Table 1 shows the five sets of needs, example specific requirements, and inventions that have addressed that need area. Humans have satisfied their needs throughout history by making more sophisticated inventions.

Table 1. Maslow's Hierarchy of Needs and How these Connect with Inventions

General Category of Need	Example Specific Needs	Examples of Inventions that Support that Area of Need
Self-Actualization	Achieving one's full potential	Research technology such as specialized equipment and computers, books on creativity
Esteem	Prestige and feeling of accomplishment	Awards, stickers, trophies; Facebook pages, plastic surgery
Belongingness and love	Intimate relationships, family, friends	Writing for communication; cell phone, photographs, scrapbooks
Safety	Security and safety	Pocket pepper spray, weapons, alarm systems, fences, locks, antibiotics
Physiological needs	Air, water, food, warmth, shelter, rest	Scuba equipment, gourmet food, food processor, microwave oven, bunk beds

Cultural Universals

Cultural universals are basic categories of human social experience that have existed in all cultures, past and present. These cultural universals include activities and inventions related to basic human needs of food, clothing, shelter, family structures, communication, government, transportation, religion, occupations, and recreation. Although these cultural universals can be found in all societies, they do not necessarily take the same form. They are heavily influenced by local climate, geographical features, natural resources, and available materials (Brophy & Alleman, 2006).

Lesson 1

Identifying Forms and Functions of Objects

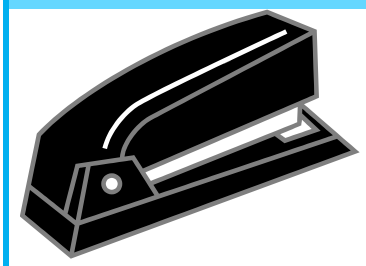
Objective: Students will be able to tell what is meant by the terms "form" and "function" and will be able to identify forms and functions of given objects.

Exploration: Ask students to write a definition for "form" and for "function" followed by examples of each. Discuss their ideas.

Explanation: One of the unifying concepts and processes in science is "form and function" (National Research Council, 1996, p. 104). A **"form"** is any physical characteristic of an object or organism such as shape, pattern, color, size, configuration, flexibility, toughness, jointing, motion, texture, or luster. ***"Function"*** refers to the purpose or use of the object or organism or one of its parts. Form and function combinations work together when body parts of organisms, like animal legs and teeth or cactus spines and woody tree trunks, or parts of manufactured or human-made items are shaped, colored, textured, or configured to be physically suited to their purpose or use.

Choose some objects from the classroom, such as a stapler, pencil, and someone's shoe. Practice having students identify the "forms" – any physical characteristic, including **shape, color, size, texture, composition, flexibility, smoothness, pattern, luster (gloss or sheen), movement such as snapping or vibrating, sounds made such as clicking,** etc. Then identify the *function* of the object. Discuss how the forms support the object's function. See Table 2 for ideas. In this unit of activities, and in most diagrams and card sets, **forms** will be underlined and ***functions*** will be italicized to help students better distinguish them.

Table 2. Forms and Functions of Three Common Objects

Object	Forms	*Functions*
 **Stapler**	Color: black Surface texture: smooth Configuration: hinged top part Configuration: top opens Composition: metal Sound: clicks Motion: snaps down	*Allows stapler to fit into any office décor's color scheme* *Pleasant to hold in the hand; easily wiped clean of dirty fingerprints* *Able to pivot to crunch down on paper* *Able to load staples inside* *Durable so it lasts a long time* *Indicates when stapling is complete* *Puts pressure on staple to bend it*
 **Pencil**	Shape: cylindrical and long Texture: smooth Soft graphite in center Pointed tip Flexible rubber eraser end	*Allows it to be comfortably gripped in hand* *Allows wood to be ground off as graphite is used. Soft graphite rubs off on paper to make a mark* *Allows sharp lines or writing to be drawn* *Allows graphite mistakes to be removed*
 **Running Shoe**	Holes with metal rims Rubbery plastic sole Colorful with patterns of different shapes and colors Textured sole	*Allow shoe to be laced to adjust fit; metal keeps holes from tearing* *Cushions foot; waterproof and durable* *Attractive and status-symbol* *Allows shoe to grip the surface for traction*

Expansion:

1st Activity: Ask students to work in small groups of 2, 3, or 4 persons. Each group should secretly choose a different object present in the room and identify its forms and functions. Groups present a form or function of their object to the class and ask class members to guess the object. After each guess, present another clue until the object has been correctly identified. Students may want to use the strategy of presenting a form that is present in many objects in the room to make the game more challenging.

2nd Activity: Students bring in two objects from home (or found in the classroom) that have the same function. Make a chart to analyze the forms present in the objects as a way of evaluating which object serves the function best. Discuss findings with the class.

Lesson 2

Forms and Functions of the Human Hand

Objective: Students will be able to name forms and functions of the hand and relate them to tools and inventions.

Exploration: List parts of the human hand, such as thumb, fingers, knuckles, wrist, fingernails, palm. Have students tell the **forms** of the fingers. Possible responses include: long and thin, have joints to bend, attached to palm of hand, work together, thumb can meet fingers for pinching, fingers can curl around an object to grasp, skin-covered, and with nails for protection, scratching, digging.

Have students tell the ***functions*** of the hands ("Name things that you can do with your hands"). If a student names a very specific task, the teacher should generalize it. For example, if a student says, "You can make biscuits with hands," the teacher can generalize that as holding items like rolling pins and pushing/pinching things like dough. Other generalized functions might be: grasp items, pull things toward person, push things away, dig, pat things, scratch a surface, rub things, roll things between fingers, pick up items, support body when crawling, signal other people, smooth a surface, pick small things out of a tangle or mass, and attract attention, among others.

Explanation: Make the connection as to why the hand can do these things. What forms ("What physical characteristics?") of the hand help it scratch? The fingernails are tough and sharp; the hand can move to reach different areas; the fingers can bend and move to scratch. What forms of the hand allow signaling? The broad flat palm and fingers and the wrist joint allows motion.

Name activities that people can do somewhat with their hands, but might like to find a way to do better such as reach into pot of hot water, hold water for a drink, dig a hole in the garden, or draw with paints – finger-paint.

What do people do about these problems? (They invent tools/ other items). Name some tools that extend the actions of the hands. Name things that you wear on the hand or hold with the hand, such as shovel, trowel, spoon, cup, ladle, clothespin, flag, jewelry, or false fingernails).

Use Card Set 1, found in the Appendix. This set contains 14 sets of 4 cards each and header cards. Print the card set in color and mount it on cardboard. Cut apart into individual cards. Give each small group of students a set of the cards that have been mixed so they are not

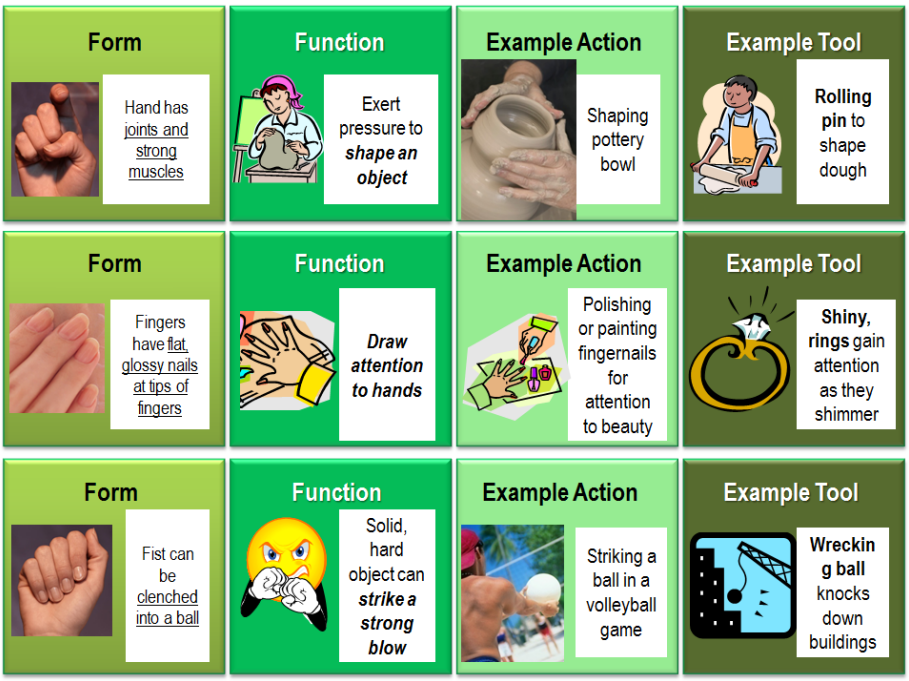
in the correct order. Ask them to make an arrangement of rows and columns – a large chart. Each row should show a form, function, example action and example tool that all go together.

Figure 1. Card Set 1, Forms and Functions of the Hand with Analogous Manufactured Tools, Correctly Arranged as a Chart

Figure 1 (Continued). Card Set 1, Forms and Functions of the Hand with Analogous Manufactured Tools, Correctly Arranged as a Chart

Form	Function	Example Action	Example Tool
 Hand has jointed fingers that bend	 Fingers curl around object ***to hold it***	 Holding a phone	 **Straps** on backpack
 Fingers have tough, sharp pointed nails at tips	 ***Scratch a surface*** with nails	 Scratching someone's back	 **Scrub brush** for scratching off dirt
 Thumb can move to meet fingertips	 Pincer grip for ***grasping objects***	 Holding a pen	 **Binder clip** grips papers
 Index finger can be extended while other fingers are curled	 Small surface area for ***touching objects***	 Pressing a mouse button	 **Stylus** for touching items on a computer screen
 Index finger can be extended while other fingers are curled	 ***Draw attention*** to a small area; point or gesture	 Pointing to an item of interest	 **Laser Pointer** for presentations
 Palm, fingers and thumb can form cup-shape	 ***Holding*** liquids, loose items, cradling object	 Holding water	 **Cup** for holding pencils and other items

Figure 1 (Continued). Card Set 1, Forms and Functions of the Hand with Analogous Manufactured Tools, Correctly Arranged as a Chart



Expansion: Create a class chart of student ideas concerning form and function of the hand and tools that extend these functions. Table 3 shows ideas that the teacher might suggest if student thinking becomes stalled. Use the same column headings.

Table 3. Suggestions for Forms and Functions of the Human Hand

Form	Function	Example Action	Example Tool or Extension
Hand can be planar when stretched with flat palm and fingers held together	Broad surface for visibility	Waving, signaling "Stop"	Foam hand used as sports games; day-glow police officer's glove for traffic signaling
	Broad surface to spread impact	Slapping a person when under attack; smoothing a surface while folding laundry; pushing against water while swimming; fanning air to cool off	Paper fan for circulating air; rolling pin to flatten dough; swim fins for swimming; leather baseball glove for catching balls
	Broad surface to produce maximum noise	Clapping hands for applause or attention; playing a bongo drum	Cymbals to clang together
	Flat surface to reach in a crevice	Feeling beside couch cushion to retrieve lost object.	Narrow attachment on vacuum cleaner for reaching crevices
	Edge of flat surface strikes with large force in a linear area	Karate chop; hand motion to cut through dough	Knife for cutting

Table 3 (Continued). Suggestions for Forms and Functions of the Human Hand

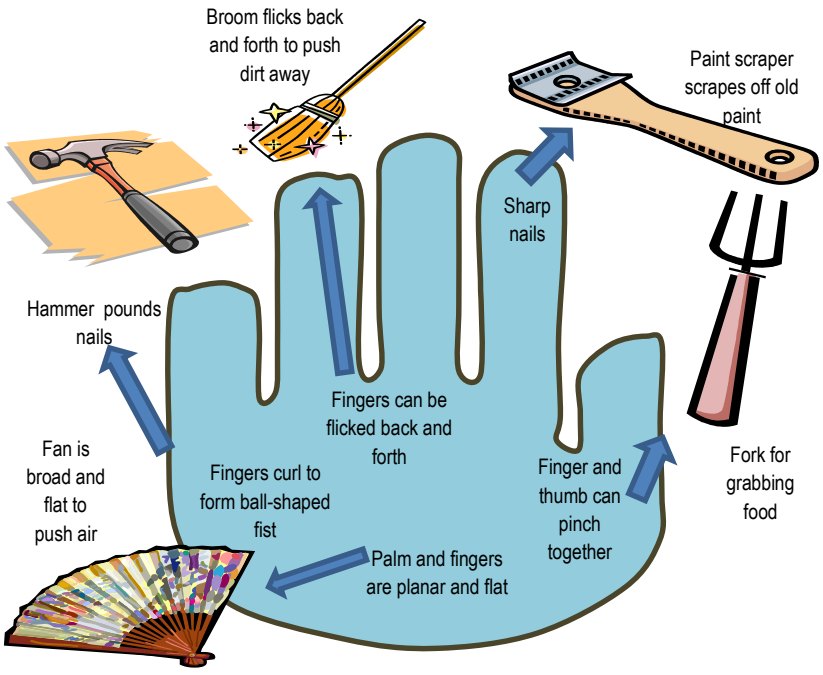
Form	Function	Example Action	Example Tool or Extension
Hand has joints and muscles to change configuration	Change shape to press differently into a surface or mold a surface	Working with dough or clay or finger paint	Sculpting tools, thicker paints
Fingers are jointed and work together	Fingers can curl around an object	Holding the handle of a suitcase or umbrella; holding cup or mug handle	Straps for attaching purse, backpack; gripper handle on apparatus that picks up objects from floor or shelves
Fingers have tough and pointed nails at the tips	Protect the fingertips	Fingernails protect the fingertips from damage when pinched or stepped-on.	Touch gloves to protect fingers; finger guards on items such as paper cutters
	Scratch into a surface	People pick off dirt with their fingernails	Scrubber pads for cleaning pots and pans or scrubber sponge for floors
	Attract visual attention	People buff, trim, and groom fingernails to gain attention and look attractive	False or press-on nails, colored polish, decals, glitter
Thumb can move to meet fingers	Pincer grip for grasping objects	Holding a book or pencil; picking up small items	Clasp, paper clip, binder clip for set of papers; clothespins
One or more fingers can be raised	Signaling; symbolizing	Pointing with index finger; making the peace sign, a “V” for victory; Spock’s Vulcan sign	Pins, medallions, tee-shirts, signs with symbols and messages
Move fingers independently	Operate mechanical devices or musical instruments	Keyboarding and typing; playing piano or musical instruments	Voice recognition software for translating speech into typing; music CD’s
Grasp and move fingers at same time	Hold onto item while doing an operation	Knitting, crocheting	Automatic knitting/weaving machines - looms
Palm, fingers, and thumb can form cup-shape	Holding liquid or loose grains	Cupping hand to drink water from a bowl or stream	Drinking cups, mugs, glasses; scoops, ladles
Fingers and thumb can be curled into a fist	Concentrate mass of the hand into a ball	Pounding a drum, pounding fist on surface for attention; punching an opponent; striking a large ball in sports	Drumsticks; gavel for judge or chair of a committee; punching glove, brass knuckles; sports racket
Skin of hand is elastic and covers hand completely	Protects hand from abrasion, sun’s rays	Protects against bumps and minor scratches	Protective work or gardening gloves
Fingers can be firmly held apart with fingers slightly curved	Sifting or combing	Combing through tangled hair; sifting pebbles from sand	A strainer used to sieve berries or a comb to comb hair
Skin of hands is soft	When hand rubs face or body it does not scratch	Washing face; giving backrub; brushing dirt or insects off body	Washcloth, towel; backrub/massage tools; sponges

Table 3 (Continued). Suggestions for Forms and Functions of the Human Hand

Form	Function	Example Action	Example Tool or Extension
Fingers have ridges in skin, or fingerprints	Gripping a surface	Gripping a jar as it is opened	Textured rubber pad for opening jars
Skin of hand darkens with sun exposure	Protects from sunburn	Hands of people who work outside are dark to prevent sunburn	Sunscreen; gloves
Index finger can be extended	Concentrate pressure/attention at one point	Pressing a button; pointing to an item of interest	Pointer, lever

As a culmination of the work in this lesson, ask students to trace around a hand on a piece of paper or provide a clipart hand printed on paper or in a file. Close to or on top of the sketch of the hand, label its forms. Then draw 5 tools/items around the hand that extend the forms and functions of the hand. Tell the function of each tool and connect it to one of the forms of the hand. See Figure 2.

Figure 2. Drawing of Hand with Forms, Functions, and Tools that Extend these Actions



Lesson 3

Forms and Functions of the Body Extended with Tools

Objective: Students will be able to name forms and function of the body that were extended by early inventions of humans.

Exploration: Remind students that many tools that are extensions of the form and function of the hand have been recently discussed. What other tools have people invented that extend other body parts?

Explanation: Ask students to share the ideas they generated. List parts of the human body (hands, arms, feet, legs, trunk, head, eyes, etc.) The Latin root of many words (manicure, manacles, or manual) is *manus* meaning hands. Humans can use their hands better than most other animals. Humans make tools to extend the functions of their hands (although a few animals also make tools – crows and chimps for example). Humans use their brains – their intelligence and imagination – to think of new ideas to make their lives easier. Besides extending the functions of the hand, some tools extended the functions of other body parts.

Name some tools that early humans invented (stone knives, spearheads, digging sticks, fire, and clothing). Pass around stone tools if possible or show images of them. Tell the function of each item and tell how it is an extension of a human body part (knives- cutting like teeth or fingernails; spearhead puncture like teeth or fingernails; digging stick to dig like fingers; fire and clothing to keep warm like hair and skin). Name other tools or items early humans invented to make their lives easier (pottery, different home styles such as skin tents, bags or pouches for carrying items, baskets, rugs).

Use Card Set 2 of the Appendix, Early Artifacts and Tools as Extensions of Forms of the Human Body, available in the Appendix. This card set contains 14 sets of 3 cards each that should be arranged to form a large chart of 14 rows and 3 columns. Figure 3 shows the cards correctly arranged into a chart; the order of the rows does not matter.

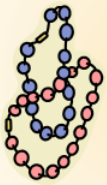
Figure 3. Card Set 2, Early Artifacts and Tools as Extensions of Forms and Functions of the Human Body

Artifact and Form	Function of the Tool	Human Body Part Extended
Artifact and Form  A **drum** has a broad top surface that resonates and makes a loud sound when slapped.	Function of the Tool This tool is used to ***make percussion rhythms and music***.	Human Body Part Extended Slapping one's **thighs** with flattened palms to make a rhythmic noise. 
Artifact and Form  Blowing into a hollow **reed flute** causes the reed to vibrate.	Function of the Tool This tool has holes at different positions along the length that ***produce different pitches of sound*** as it is played.	Human Body Part Extended Blowing through **mouth** and vibrating the **lips** to produce whistles. 
 Artifact and Form A heavy stone **axe head** is block-shaped with a sharp tapered edge and a groove around all or most of the block.	Function of the Tool The heavy weight of the stone and sharp edge allow it to be used to ***chop objects such as wood or to be used as a weapon***. The groove allows it to be attached to a handle.	Human Body Part Extended **Fists** (for pounding); **teeth** (cutting and breaking apart). 
 Artifact and Form A stone **knife** has a fairly flat top and bottom surface, but a sharp serrated edge all around.	Function of the Tool The sharp edge all around this tool and its fairly large palm-size allow it to be ***held in the hand and used for cutting*** plants, hides, meat, and other items.	Human Body Part Extended **Teeth** cutting into something to break off a part. 
 Artifact and Form A stone **scraper** has broad sharp edges.	Function of the Tool The broad sharp edge is perfect for dragging across a hide to ***scrape off*** the layer of fat and for ***scraping*** dirt or skins from carrots or potatoes.	Human Body Part Extended **Fingernails** (for scratching and scraping); **teeth** (scraping). 

Figure 3 (Continued). Card Set 2, Early Artifacts and Tools as Extensions of Forms and Functions of the Human Body

Artifact and Form	Function of the Tool	Human Body Part Extended
 An **arrowhead** is triangular in shape with a point at the tip and sharp edges. Arrowheads often have notches at the base.	The pointy end and sharp edges make it penetrate an animal's or enemy's body ***to injure or kill it.*** The notches allow the tool to be *attached to a shaft.*	**Fists** (for punching); teeth for cutting. 
 A strong stone **hoe** has a large, flat tapering wedge-shaped rectangular shape with sharp edges.	The strong wedge can be ***pushed into the ground to dig*** a hole for planting or remove weeds.	**Hands** (for pushing into the ground). 
 A leather or woven **pouch or bag** is lightweight flexible, and made of readily-available materials. It can expand to hold more items.	This tool functions as ***a container to hold items.*** It can expand or contract a bit to hold more or less.	**Hands** (holding items). 
 An **basket** is made of strips of wood or plant stems woven together. It is lightweight and hollow. It may have a lid or cover.	The hollow nature of this item allows it to ***hold or contain items*** like seeds, berries, and other foods or personal items.	**Hands** (holding items). 
 A **blanket** is a broad flat layer made of soft skins or woven fabric. It is flexible and can be wrapped or arranged in many shapes.	The fibrous layer is used ***to trap body heat*** or to insulate/protect a person from dampness or cold.	Like having a thicker **skin** or more **hair.** 
 A stone **drill** is a fairly small tool with a long, sharp pointed end.	This tool is turned or twisted on a surface ***to bore a hole*** in that surface.	**Fingernails** scratching a hole in something. 

Figure 3 (Continued). Card Set 2, Early Artifacts and Tools as Extensions of Forms and Functions of the Human Body

Artifact and Form	Function of the Tool	Human Body Part Extended
 A **visor** or **hat with a brim** is made of woven basketry, leather, or fabric. It extends above the forehead.	This lightweight item extends out from the head ***to shade or shelter*** the eyes from sun and rain.	**Hand** shading the face. 
 A **strand of beads** is a colorful, attractive set of small items that are held together by string or a leather thong.	The colorful items ***attract attention,*** are considered beautiful or a ***symbol of wealth and status***.	Colorful, shiny, and interesting like **eyes, lips, and teeth**. 
 A **pair of sandals** is woven of grasses or leather with a tough bottom.	This item ***protects the soles of the feet from injury***.	**Skin** - a layer of hard, tough skin on the bottom of feet. 

Expansion:

1st Activity: Ask students to develop a chart that lists early artifacts or tools used by people, their functions, and the human body part that is extended. Table 4 shows suggested ideas.

Table 4. Early Artifacts, their Functions and the Human Body Part Extended by the Tools

Artifact	Function	Human Body Part Extended
Stone arrowhead	Shooting and killing animals for food	Teeth (biting) or fingernails (scratching) or fist (punching)
Stone scraper chipped tool	Cleaning animal hides to make blankets, clothing, tents	Fingernails (scraping), teeth (scraping and biting)
Stone knife chipped tool	Cutting food, cutting branches, cutting animal skins	Teeth (cutting), fingers (tearing and ripping)
Stone hoe or digging stick	Planting seeds or removing weeds	Fingers (probing and scratching ground)
Woven blanket, animal hides	Trapping heat to keep body warm; protecting body from hard surfaces	Like having a thicker skin or more hair

Table 4 (Continued). Early Artifacts, their Functions and the Human Body Part Extended by the Tools

Artifact	Function	Human Body Part Extended
Pottery bowl	Storing, cooking, carrying items	Like an extra hand to hold things
Fabric or leather pouch or bag	Storing, carrying items	Like an extra hand to hold things
Hat with brim or visor	Keep sun or rain out of eyes	Like holding hand over eyes
Sandals	Protect the feet from cuts, injury	Like having thicker skin
Stick	Drawing in dirt or sand	Finger
Woven basket	Storing, carrying items	Like an extra hand to hold things
Wooden staff	Steady a person while walking on uneven ground	Like having an extra leg for stability
Rope	Pulling an item or suspending an item from a height	The arms
Flat grinding stones	Grinding grains to make breads	Teeth (grinding)
Bullroarer	Sending warnings or other signals	Voice used in calling
Strand of beads	Attract attention, mark status	Like having attractive and shiny eyes, teeth, and lips

2nd Activity: Bring in two items used by early humans that served similar purposes or functions. Perhaps one might bring a pottery jar/bowl and a basket as the two objects that were used for storage. Ask students to evaluate the two objects for the stated function, using forms of the object to support their ideas.

Lesson 4

Extending the Body to Serve Basic Human Needs

Objective: Students will be able to tell how various inventions/tools satisfy basic human needs.
Exploration: Ask students to name basic human needs. How do inventions help to satisfy human needs?
Explanation: Basic human needs are things all people need to survive, thrive, and reach their potentials: food, water, shelter, clothing, spirituality, entertainment. How do inventions help to satisfy human needs? What inventions help people grow, obtain, or process food? Possible responses are: tractor, plow, trucks, blender, and stove. What did early humans or groups of people with primitive technology do to satisfy these human needs? What modern inventions take the place of these earlier inventions? Make a chart similar to that shown in Table 3.

Table 5. Example Inventions of Early Humans and Modern People that Satisfy Basic Human Needs for Use with Lesson 4

Basic Human Need	Inventions of Early Humans	Inventions of Modern Humans
Food: Items for gathering seeds or plant materials	Baskets, hollow gourds, pottery bowls, jars	Plastic, glass and ceramic containers/dishes; tractors for harvesting
Food: Items for capturing wild game animals	Fish nets, hooks; spears, bows, arrows; pit traps	Guns, fishing rods
Food: items for processing grains and seeds	Mano and metate (flat grinding stone and grinding implement); stone knives	Blender, food processor, steel knives
Food: items for cooking	Campfire to heat stones put into pot to boil food	Electric or gas stove and metal pots; microwave oven, toaster
Clothing	Bone needle and animal sinew for sewing	Synthetic fibers such as nylon; sewing machines

Table 3 (Continued). Example Inventions of Early Humans and Modern People that Satisfy Basic Human Needs for Use with Lesson 4

Basic Human Need	Inventions of Early Humans	Inventions of Modern Humans
Food: utensils for eating	spoons, scoops, pottery bowls, gourds, shells	steel utensils, plastic picnic ware; bowls; fine china
Shelter: Warmth	campfire; hide or fur blankets, woven rugs; simple clothing	heated homes, space heater, elaborate clothing, parkas, boots, down comforters
Shelter: Safety from weather exposure	Caves, bark, hide or thatch-covered homes	Insulated brick or frame homes with windows; waterproof metal or shingled roofs
Shelter: Safety from animal/ human enemy attack	Homes, spears, groups of warriors	Fences, durable modern homes, security systems, lighting systems; police force, militia
Food: preservation for time of shortage	Salting or drying foods	Freezers
Safety: Fighting enemies or wild animals	Club made of bone or wood	Fences, door locks, security systems
Entertainment/ Spirituality: Music	Rattles from shell, gourds, turtle shells; flutes from hollow bones, reeds, shell; drums from hide stretched over a hollow log or similar	Modern musical instruments; recorded music on CD's ; radio; iPods
Self Esteem: Personal Adornment	Clay and iron minerals (hematite, limonite) for face paint; Carved bone or wooden combs; sharpened clam shell for shaving; necklaces of shells, seeds, beads	Modern make-up and cosmetics; soaps; modern razors, plastic costume jewelry; Metallic or sequined fabrics
Hygiene: Disposal of human waste	Digging a simple pit toilet	Modern flush toilets with seats
Communication	Smoke signals or drumming	Cell phones
Communication: Dances and Performances	Dance costumes with feathered headdresses, decorated capes, a fire for lighting	Dance costumes of synthetic materials; loudspeakers, stage lighting; printed programs
Communication: Historical records	Cave drawings; drawings on rock (petroglyphs and pictographs) drawings on skins, knotted ropes, designs on pottery wood	Books, ledgers, computer files, public records in public buildings, libraries, film and digital photographs, movies

Expansion:

1st Activity: Use Card Set 3. This set contains 20 sets of 3 cards each plus heading cards for the three columns. Print the card set in color and mount on cardboard. Cut apart into individual cards. Give each small group of students a set of the cards. Ask them to make an arrangement of rows and columns – a large chart. The chart rows should look like the chart in Figure 4.

Figure 4. Card Set 3, Early and Modern Inventions that Serve Basic Human Needs

Figure 4 (Continued). Card Set 3, Early and Modern Inventions that Serve Basic Human Needs

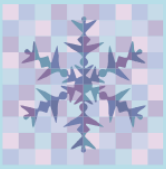
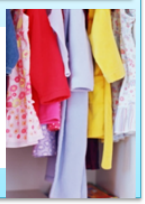
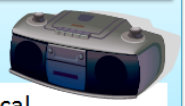
Basic Human Need	Early Invention	Modern Invention
Shelter: Heat source to *protect self from cold weather* 	Campfire 	Furnace, space heater 
Basic Human Need	**Early Invention**	**Modern Invention**
Clothing: Insulating body coverings for *warmth or protection from weather* 	Hide or fur blankets, woven cloth clothing/ robes 	Machine-woven blankets, fitted clothing, synthetic fabrics 
Basic Human Need	**Early Invention**	**Modern Invention**
Shelter: Insulating structure to *protect from rain and weather extremes* 	Caves and skin, bark, or thatch-covered homes 	Insulated brick or frame homes 
Basic Human Need	**Early Invention**	**Modern Invention**
Food: Dishes and utensils for serving and eating 	Spoons, scoops, pottery bowls, gourds, shells 	Steel utensils, plastic picnic ware; bowls; fine china 
Basic Human Need	**Early Invention**	**Modern Invention**
Communication: Sounds, rhythms and music to *communicate mood* 	Rattles from shell, gourds, turtle shells; flutes from hollow bones, reeds 	 Modern musical instructments; recorded music on CD's ; radio; iPods
Basic Human Need	**Early Invention**	**Modern Invention**
Communication through Clothing: Elaborate, symbolic costumes for ceremonies 	Costumes with feathers, flowers, shells, wooden decorations 	Costumes with glittery fabrics, synthetic beads 

Figure 4 (Continued). Card Set 3, Early and Modern Inventions that Serve Basic Human Needs

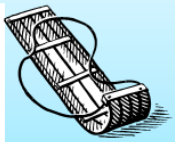
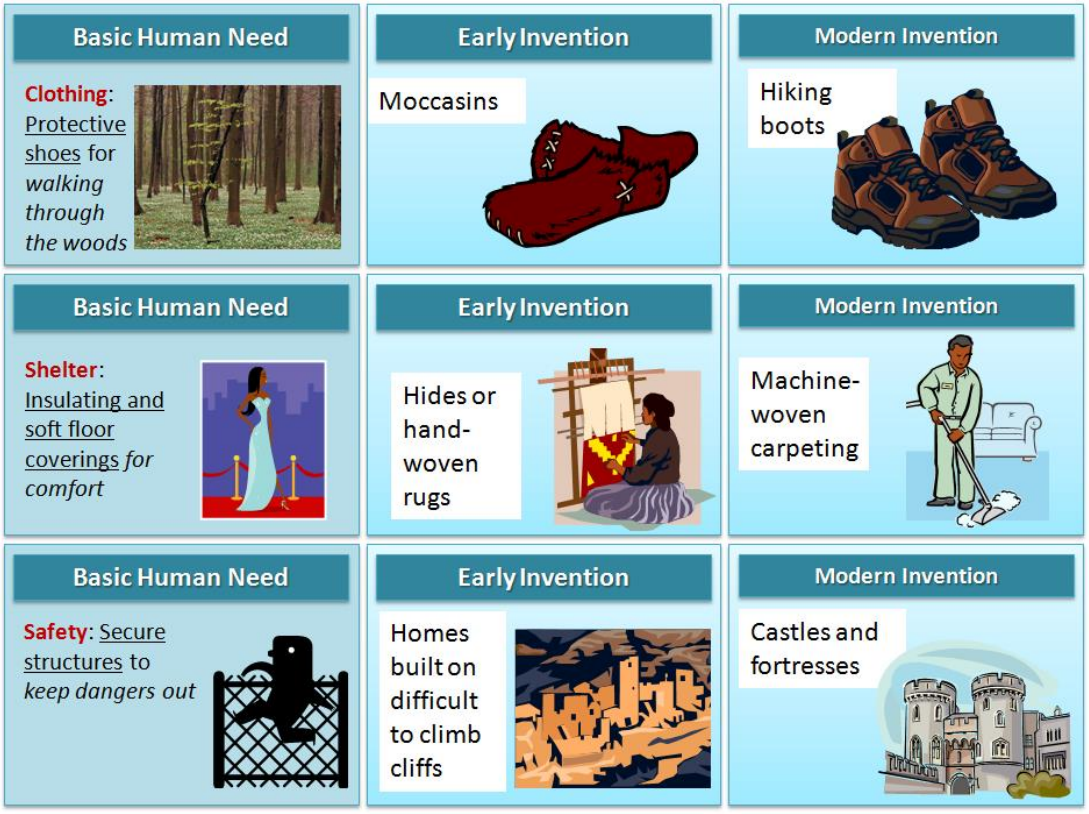
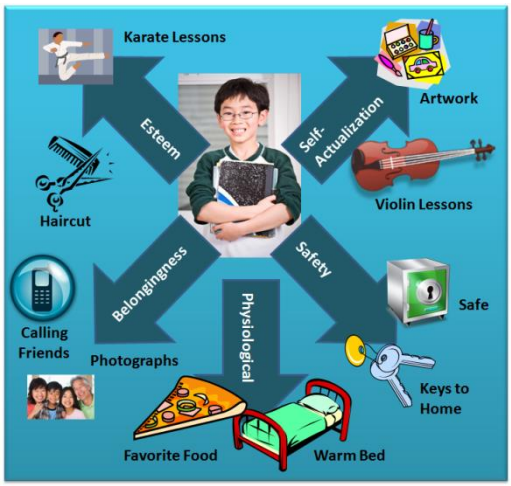
Basic Human Need	Early Invention	Modern Invention
Safety: Armed humans for *protection from animal/ enemy attack* 	Warriors with spears 	Police with guns, army personnel 
Basic Human Need	**Early Invention**	**Modern Invention**
Self Esteem and Communication: Colorful paints applied to the face to *communicate mood, status or improve appearance* 	Paint made of ground hematite or ochre mixed with oil and applied to face 	Modern cosmetics in many colors 
Basic Human Need	**Early Invention**	**Modern Invention**
Communication: Lasting records of events to *communicate group history* 	Petroglyphs, pictographs, drawings on leather, carved records 	Books, ledgers, computer files, films 
Basic Human Need	**Early Invention**	**Modern Invention**
Transportation: Vehicles that can carry people and supplies for *travel through snow* 	Wooden sled pulled behind the person 	Motorized snowmobiles 
Basic Human Need	**Early Invention**	**Modern Invention**
Transportation: Vehicles that can carry people and supplies *for travel through water* 	Canoes made of hollow trees or birch bark 	Motor boats 
Basic Human Need	**Early Invention**	**Modern Invention**
Transportation: Apparatus or vehicle for *transporting young children* 	Papoose or cradleboard for carrying child on back 	Baby carriages 

Figure 4 (Continued). Card Set 3, Early and Modern Inventions that Serve Basic Human Needs



2nd Activity: Ask students to create a collage with the individual student at the center surrounded by basic human needs. The student should find clip art, magazine photos, or take photographs to illustrate an invention that he or she uses to serve teach basic need.

Figure 5. Example Collage Featuring Human Needs of Student and Corresponding Inventions



Lesson 5

Tools Related to Forms and Functions of the Mouth

Objective: Students will be able to name ways the functions of the mouth are extended by tools and inventions.

Exploration: Ask students to list tools that they think are extensions of the mouth.

Explanation: List parts of the mouth (lips, tongue, teeth). Tell the forms of these parts and their functions. Teeth are hard, durable, fitting together and have grinding action to chew food. Tongue is very flexible and muscular to push food and clean teeth. Lips are elastic, can purse and change shape to make speech, whistle, and noises, to communicate, to suck up liquid. Create a chart with the following columns: form, function, example action, and example gadget from a catalog that is an extension of the form and function of the mouth.

Table 6. Forms and Functions of the Human Mouth with Gadgets that Extend Them

Form	Function	Example Action	Example Gadget or Tool
Front teeth are sharp and chisel-like	*Biting into and piercing; tearing*	Biting a chunk off an apple; tearing a piece of cloth or opening a sealed plastic bag of chips	Knives
Back teeth have hard, tough, broad surfaces	*Crushing and grinding*	Chew peanuts into a smooth paste for swallowing	Mortar and pestle
Mandibular joint of jaw allows up and down and sideways motions	*Crushing and grinding*	Chewing grapes to extract juice and grind skins	Juicer or food processor
Tongue is strong and flexible	*Push food around the mouth; clean teeth*	Push peanut butter off roof of mouth, push seeds from between teeth	Toothpicks, toothbrush

Table 6 (Continued). Forms and Functions of the Human Mouth with Gadgets that Extend Them

Form	Function	Example Action	Example Gadget or Tool
Tongue is long enough to extend outside the mouth	*Licking, cleaning*	Lick face area around mouth clean; lick popsicle	Washcloth; individual wipes in sealed pouches
Tongue changes shape and presses against different parts of mouth	*Different sounds are produced*	Speaking	Cell phone; loudspeaker; party horns; harmonica; flute
Lips are elastic and can open and close tightly	*Closing the mouth*	Keep bugs out of mouth	Hat with net that extends over face
Teeth are sharp and jaws can move to shear teeth against each other	*Tearing and shredding*	Biting and shredding foods	Paper shredder
Mouth is hollow and lips can close the opening	*Hide a secret item in the mouth*	Hiding gum, candy, or a coin	Fanny pack, pocket, or wallet
Lips change shape	*Produce sounds*	Whistling; making "raspberry" sounds when joking	Whoopee cushion
Upper throat has large opening	*Air passageway*	Allows breath to be expelled from lungs for blowing up a balloon	Balloon pump

Expansion:

1st Activity: Provide many gadget catalogs (travel gadget catalogs from airplanes are great) for students to cut apart. Ask students to find and cut out items that extend the functions of the hand or mouth or feet (choose one of these). Draw the body part in the middle of your paper. Paste the gadgets, tools, or items around it. On a line connecting the item to the body part, tell the form and function that makes this item an extension of the body part.

2nd Activity: Ask students to create their own invention that is an extension of the mouth. First, they should determine a need that they want to satisfy with the invention. Provide a box of recycled items and craft materials such as paper, aluminum foil, chenille sticks, and Popsicle sticks. Allow students to make their own version of an invention available as a manufactured item. For example, students may want to create a flute, whistle, or a nutcracker.

Lesson 6

Historical Perspectives of Inventions

Objective: Students will be able to place inventions related to the same concept in chronological order and to tell advantages and limitations.

Exploration: Ask students to name some inventions that have been improved over the years and to list limitations, advantages, and improvements.

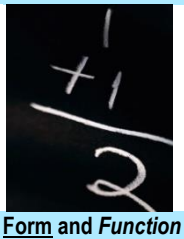
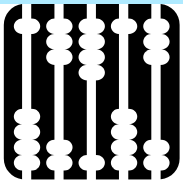
Explanation: Begin by discussing how things change overtime. Ask if anyone has videotaped movies at home. Many movies at theaters are still projected from film. Ask what other form movies take now – often on DVD's. More recently, movies are digital files sent over the web. So, movies started as films, then tapes, then DVD's and now digital files. Each time the way movies are stored changed and improvements were made. Films are large and bulky and often break. One needs a large projector to show them. Video tapes were an improvement because they are smaller and utilized less expensive equipment. DVD's were an improvement over videotapes because the tapes could not break and they were small disks that were easier to store. Having a digital file on your computer makes storage and playing even easier.

Define terms: a limitation is a restriction, weakness, or drawback; an advantage: a favorable characteristic that contributes to success of the product; an improvement is a change that brings an advancement in excellence.

Implement the sets of materials of Card Set 4. Each group receives a packet of pictures of related inventions with their forms and functions to be placed in time order from earliest (from a long time ago) to most recent (now). Figure 5 shows the answers in correct order. Then students place cards that tell the advantages and limitations, matching them to the correct inventions. This allows students to recognize the driving force behind new innovations to improve the product and get rid of limitations. This also shows how we should appreciate those who came before us to create these wonderful inventions. After a group has explored one set of materials, mix and rotate the materials so everyone gets to experience inventions in the sets.

Figure 6. Card Set 4, Technological Changes to a Product through Time

Addition Tools

Counting on fingers	Notches on a stick or knots on a rope	Base ten numerals written on surface	Abacus	Mechanical adding machine or slide rule	Electronic calculator
					
Form and ***Function*** Fingers move and are raised to *keep track by counting all.*	**Form** and ***Function*** Notches or knots *represent numbers for counting.*	**Form** and ***Function*** Numerals *serve as mnemonics* during mental addition.	**Form** and ***Function*** Beads on a frame are moved *to calculate sums.*	**Form** and ***Function*** Mechanical parts that slide or gears that turn *calculate a sum.*	**Form** and ***Function*** Computer chip electronically *calculate the sum.*
Advantages: Attached to body, so readily available. **Limitations:** Only have 10 fingers. No way to preserve final sum.	**Advantages:** Permanent record of counts; more than ten can be represented. **Limitations:** Very large numbers must be counted and recounted to keep track.	**Advantages:** One can make calculations by writing on the paper or bark. **Limitations**: Must do a lot of mental calculation.	**Advantages:** Can quickly calculate large sums. Beads aid memory. **Limitations:** May make errors.	**Advantages:** No errors if operated properly. Fast and can handle large numbers. **Limitations:** Human operated. Limited number size.	**Advantages:** High speed; high accuracy; can handle very large numbers. **Limitations:** Data input by hand.

Writing Pens

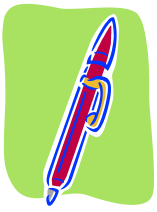
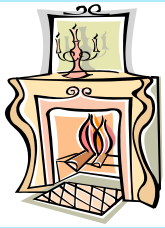
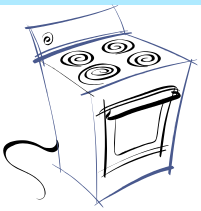
Duck or goose quill and ink well	Metal pen tip that fit into a pen holder	Fountain pen with nib and refillable ink cartridge	Ball-point pen	Felt-tip and soft-tip pens	Rollerball pens
					
Form and ***Function*** Tough, hollow tube that *can be shaped to form a pen point and dipped in ink.*	**Form** and ***Function*** Strong, durable metal pen tip *used with ink for writing.*	**Form** and ***Function*** Hollow plastic cylinder contains inner cartridge of ink *to supply tip.*	**Form** and ***Function*** Ball-shaped writing tip turns in a socket *to roll and write*; thick ink is used *to prevent leakage.*	**Form** and ***Function*** A felt or porous plastic tip *allows ink to flow from reservoir to allow easy writing.*	**Form** and ***Function*** A ball-shaped tip *writes smoothly*; a wick draws the ink from a reservoir *to prevent leakage.*
Advantages: A natural material readily available. Hollow tube holds ink to write a couple of words. **Limitations:** Tip wears out in a week and must be re-shaped.	**Advantage**: can be machine-pressed to a specific shape. Lasts longer than a quill tip. **Limitations:** Must continually dip pen into ink.	**Advantage**: No need to constantly dip pen tip in ink **Limitations:** Leaks occasionally, reservoir must be re-filled.	**Form: Advantage**: Less leaks. **Limitations:** skips and globs sometimes. Ink is thick- must use pressure to write.	**Advantage**: Ink is thin and allows easy writing. **Limitations:** Felt tips become deformed – plastic tips are better.	**Advantage**: Very easy pressure-free writing because ink is thin. **Limitations:** more expensive than other common types.

Figure 6 (Continued). Card Set 4, Technological Changes to a Product through Time

Cooking

Campfire in rock circle	Fireplace with iron tools	Pot-bellied or cast-iron stove	Gas stove with burners	Electric stove with elements	Microwave oven
					
Form and ***Function*** Smoky, burning wood fire contained by rock circle for *heat and cooking.*	**Form** and ***Function*** Wood-burning fire in a stone or brick arched area *for containment* with a chimney *for smoke.*	**Form** and ***Function*** Cast-iron container *to radiate heat* with a flat top *for cooking* attached to a chimney or stove pipe *for smoke.*	**Form** and ***Function*** Metal stove attached to gas line or gas cylinder for *fuel.* Burners on top *direct fire to bottom of pots or pans.*	**Form** and ***Function*** Stove with electric wiring; *for smokeless and flameless fuel*; coiled elements *deliver heat without flame.*	**Form** and ***Function*** A box-like oven *protects people from microwaves*; Microwaves excite water molecules *to produce heat.*
Advantage: Simple to construct from natural materials. **Limitations:** Smoky and difficult to control – may send out sparks.	**Advantage**: Part of a house – provides heat to home. Contained on three sides and use screen to stop sparks. **Limitations:** Smoky at times.	**Advantage**: Fire is contained, much less smoke; top surface for cooking; heats home. **Limitations:** Must start fire and load with wood.	**Advantage**: Can light with a match. Easy to turn on and off. No need to gather fuel. No smoke. **Limitations:** Hot surfaces; can burn food easily, may start a fire.	**Advantage**: Can easily start and stop; less danger of fire. **Limitations:** Fire danger if elements are left on.	**Advantage**: Food cooks much faster; cold food can be easily re-heated. Timer system shuts microwaves off so less fire danger. **Limitations:** Cannot use metal containers.

Bathing

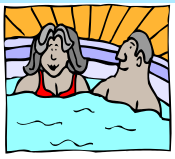
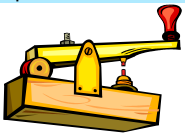
Wash self in stream	Use pottery basin and pitcher and take a sponge bath	Hand-pump water to sink for washing; heat water on stove for metal/wood tub.	Bathtub filled with running water; must still heat water on stove.	Bathtub filled with warm or hot water from hot water heater.	Built-in whirlpool bath or hot tub
					
Form and ***Function*** Natural outdoor stream with cold rushing current so that *water washes away dirt.*	**Form** and ***Function*** Cold water from pitcher poured in basin *for washing indoors in privacy.*	**Form** and ***Function*** Cold water from pitcher poured in basin *for washing indoors in privacy.*	**Form** and ***Function*** Cold water flows from tap. Extra water must be heated on stove *to adjust the temperature.*	**Form** and ***Function*** Both cold and hot (from hot water heater) flow from tap for *hot baths.*	**Form** and ***Function*** Warm water and whirlpool action *clean the body and sooth sore muscles.*
Advantage: Stream water is often readily available without preparation. **Limitations:** Little privacy, no soap, water is cold.	**Advantage**: Washing can be done in privacy. **Limitations:** Must fill and empty pitcher and basin. Generally the water is cold.	**Advantage**: Water heated on the stove makes the bath warmer. **Limitations:** Must fill and empty heavy tub of water.	**Advantage**: Cold running water requires little effort to fill and drain tub. **Limitations:** Warm water must still be heated on the stove.	**Advantage**: Both hot and cold running water and easy to drain tub. **Limitations:** No way to create wave action.	**Advantage**: Warm wave action soothes and cleanses the body. **Limitations:** Uses a lot of water and energy.

Figure 6 (Continued). Card Set 4, Technological Changes to a Product through Time

Storage of Music

Sheet Music	Mechanical Music Box	Phonograph Records	Magnetic Tape	Compact Disk	iPod
					
Form and ***Function*** Symbols on parchment or paper *interpreted* and *played by musicians using musical instruments.*	**Form** and ***Function*** A cylindrical rotating drum with small metal nubs *play a repeating melody on larger mucial prongs.*	**Form** and ***Function*** A plastic disk with a long spiralling groove *that vibrates a needle riding along the groove to produce music.*	**Form** and ***Function*** A long plastic, iron-coated tape passes by an electromagnet and *is altered by a field caused by sound waves vibrating a wire coil on the magnet.*	**Form** and ***Function*** A thin disk of polycarbonate plastic impressed with bumps on a long spiral track is *read by a laser and the data is converted to music.*	**Form** and ***Function*** Music is stored as information on a computer chip and *converted to music through a player.*
Advantage: Can obtain a wide variety; easy to store. **Limitations:** Must know how to read music and play an instrument. Must have an instrument available.	**Advantage**: Anyone can play and replay. **Limitations:** The music is always played by one type of musical instrument.	**Advantage**: Plays all varieties of music. Can change records to hear different tunes. **Limitations:** Must have a studio to record. Player cannot be moved while playing.	**Advantage**: Highly portable instant recording/ playback and erasing. **Limitations:** Wears out and breaks easily, especially if exposed to heat.	**Advantage**: High-quality recordings last a long time. **Limitations:** A large collection takes up a lot of space.	**Advantage**: Thousands of recordings stored in small space. **Limitations:** Listening to loud music through ear buds may damage hearing.

Weather Forecasting

Observe Cloud Patterns	Kites used to Obtain Information	Weather Balloons	Telegraph Information from Upwind Areas	Weather Satellites	Computer Modeling of Data
					
Form and ***Function*** People watch cloud patterns and *recall the weather than usually follows.*	**Form** and ***Function*** A kite floats to the upper atmosphere *to collect information to help predict the weather.*	**Form** and ***Function*** A weather balloon floats to the upper atmosphere *to collect information to help predict the weather.*	**Form** and ***Function*** A telegraph brings information from upwind areas *to help people see what is coming.*	**Form** and ***Function*** Satelites take wide-range photographs and collect temperature information *to help predict the weather.*	**Form** and ***Function*** Cumputer programs *synthesize data to make statistically valid predictions.*
Advantage: Can perform without equipment. **Limitations:** Relies on memory; Not very accurate.	**Advantage**: Can sample air from higher levels. **Limitations:** Dangerous during storms; hard to control.	**Advantage**: Can go quite high and carry equipment for measurements. **Limitations:** Only samples air in one locality.	**Advantage**: Can determine the weather that is moving toward an area. **Limitations:** Harder to predict long-range weather.	**Advantage**: Photographs and temperature maps of large areas produced. **Limitations:** Expensive.	**Advantage**: Information is integrated and more accurate. **Limitations:** Weather is complex and difficult to model.

Expansion:

1st Activity: Students name modern items that had less-sophisticated predecessors. Encourage students to think not only of gadgets and appliances, but of furnishings, businesses, and processes. Tell the advantages of the new items. Tell any disadvantages or limitations. Predecessor: something that came before and is now replaced by something else.

Figure 7. Card Set 5, Common Items, Businesses, or Processes and their Predecessors

Figure 7 (Continued). Card Set 5, Common Items, Businesses, or Processes and their Predecessors

2nd Activity: Students should choose an invention that has a long history of changes and research these. Students should prepare a chart similar to one of the sets of Figure 6. They should determine the advantages and limitations of each stage in the history of the invention.

Lesson 7

Animal Form and Function Analogies

Lesson 4. Form and function of animal body parts or animal-made homes and relationship to human manufactured items

Explore form and function analogy object boxes related to different animals. The available sets of materials (available in the Appendix) include:

- Alligator form and function analogy cards;
- Beaver form and function analogy cards;
- Bluebird form and function analogy cards;
- Owl form and function analogy cards;
- Whale form and function analogy cards; and
- Wolf form and function analogy cards.

Lesson 7 Activity 1 Matching Animal Forms and Function to Manufactured Items

Objective: Students will be able to identify the forms and functions of animal body parts or animal-made homes to identify human tools that have similar forms and functions.

Procedure: Card Set 6 contains sets of cards for six different animals. Students work with the cards for one animal at a time. They take out the one-sided manufactured object cards with an orange background color and place them face up on the work surface. These are the human-manufactured items that can be related through form and function analogies to the animal body parts or animal made homes. Students should then turn the 12 two-sided animal form and function cards to the side that shows an image of the animal or the animal home. Choose one of these cards. Read the animal form and function on the front of the card. Attempt to find a human manufactured item with the same form and function. Place that object card with the form and function card. Do not turn the form and function cards over until all cards have been paired with their corresponding objects. Then turn the cards over and check your work with the explanations on the backs.

Lesson 7 Activity 2. Mapping an Analogy

Objective: Students will be able to map the similarities and differences between animal body parts form and function and corresponding human tools.

Procedure: Take one animal form and function card from the card set. Map the similarities of the analogy and limits of the analogy for this one card. Example Figures and Tables follow that show one card from each set. (See Figures 7 through Figure 12 and Table 7 through Table 12).

Figure 8. Example Front (left) and Back of a Card (right) from the Alligator Set

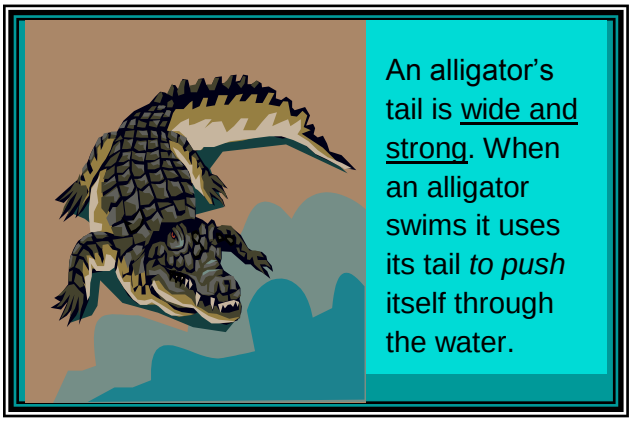


Table 7. Mapping One of the Analogies for Alligator

Similarities = Mapping the Analogy **Alligator Tail**	**Category**	**Boat Oar**
Tan-brown	Form: color	Tan-brown
Moves side to side in water	Form: motion	Pushes sideways in the water
Broad, flat	Form: shape	Broad, flat
Water repellant	Form: surface characteristics	Water repellant
Propel through water	Function	Propel through water
Steer in water	Function	Steer in water
Differences = Limits of the Analogy **Alligator Tail**	**Category**	**Boat Oar**
Always a natural alligator skin color of browns or greens	Form: color	May be a natural wood color or may be painted or even made of plastic
Alligator hide and flesh	Form: composition	wood, plastic, fiberglass
Stays in the water during swimming	Form: position and motion	Is moved in and out of the water
Alligator flesh heals naturally	Repair	May be glued or taped
Weighs many pounds	Form: weight	Lightweight

Figure 9. Example Front (on the left) and Back of a Card (on the right) for Beaver Set

Table 8. Mapping One of the Analogies for Beaver

Similarities = Mapping the Analogy		
Beaver Teeth	**Category**	**Hand Saw**
Sharp, chisel-shaped teeth	Form: angularity	Sharp teeth along saw blade
Strong, hard material	Form: strength	Strong, hard material
Several teeth used	Form: number	Several teeth used
Cut wood	Function	Cut wood
Produces chips and sawdust	Form: products	Produces chips and sawdust
Differences = Limits of the Analogy		
Beaver Teeth	**Category**	**Hand Saw**
Orange- have natural iron oxide coating that strengthens teeth	Form: color	Silvery saw blade
Enamel	Form: composition	Steel
Prying, chipping motion	Form: motion	Back and forth saw motion
Teeth constantly growing	Repair	Blade can be sharpened or replaced
Grow naturally in beaver's mouth	Origin	Purchased at hardware store

Figure 10. Example Front (left) and Back of a Card (right) from the Bluebird Set

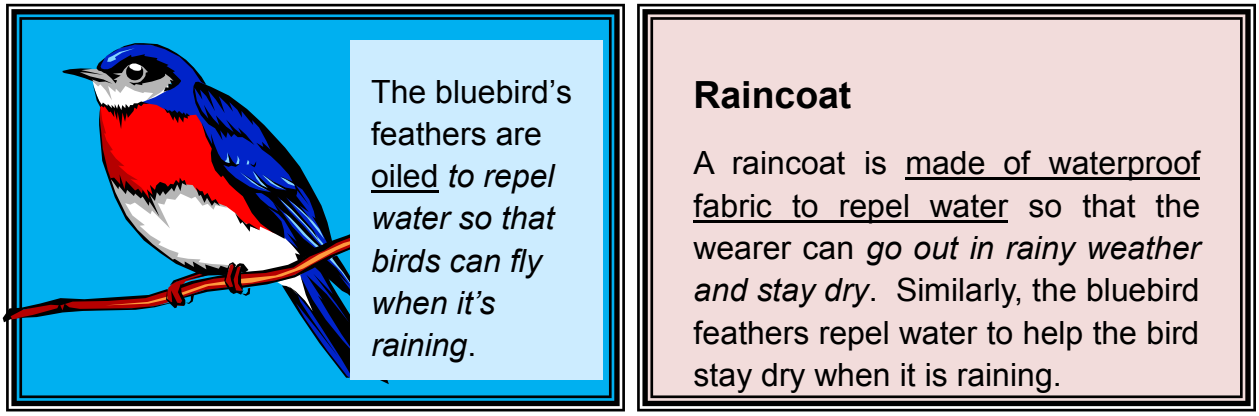


Table 9. Mapping One of the Analogies for Bluebird

Similarities = Mapping the Analogy		
Bluebird Feathers	**Category**	**Raincoat**
Bright blue and red colors	Form: color	May be bright colors
Feathers insulate the bird's body	Form: insulating	Fibers are woven and insulate the wearer
Oily coating repels water	Form: water repellant	Slick surface repels water
Protect bird from inclement weather	Function	Protect wearer from inclement weather
Feathers cover body shape	Form: fits body shape	Cloth fits body shape
Differences = Limits of the Analogy		
Bluebird Feathers	**Category**	**Raincoat**
Always blue and sometimes other colors	Form: color	May be any color
Feathers	Form: composition	Fabric or plastic
Individual feathers can be ruffled	Form: surface texture	Smooth surfaces
Bird grows more feathers	Repair	Holes can be patched
Feathers are molted but never completely	Form: removability	Can be completely removed from body

Figure 11. Example Front (left) and Back of a Card (right) from the Owl Set

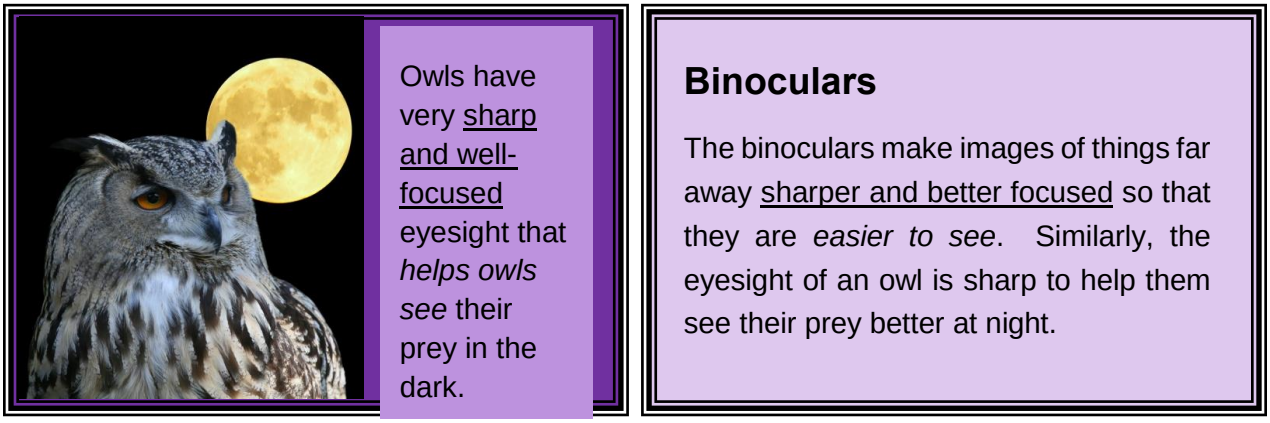


Table 10. Mapping One of the Analogies for Owl

Similarities = Mapping the Analogy		
Owl Eyes	**Category**	**Binoculars**
Both eyes see same object for depth perception	Form: binocular vision	Both eyes see same object for depth perception
Muscles in eyes allow eyes to focus	Form: able to focus	Dial allows viewer to focus binoculars
Keen eyesight for distances	Form: able to see distant objects	Lenses allow viewer to see at distance
Watch small animals	Function	Watch small animals
Two eyes	Form: two "eyes"	Two lenses
Differences = Limits of the Analogy		
Owl Eyes	**Category**	**Binoculars**
Colored iris is often yellow	Form: color	Housing of binoculars is often black
Made of living tissue	Form: composition	Made of plastic and glass
Part of bird 's body	Form: origin	Manufactured tool
Hunting prey for survival	Function	Watching birds and animals for enjoyment
Not able to remove	Form: removability	Can be stored in car or closet

Figure 12. Example Front (left) and Back of a Card (right) from the Whale Set

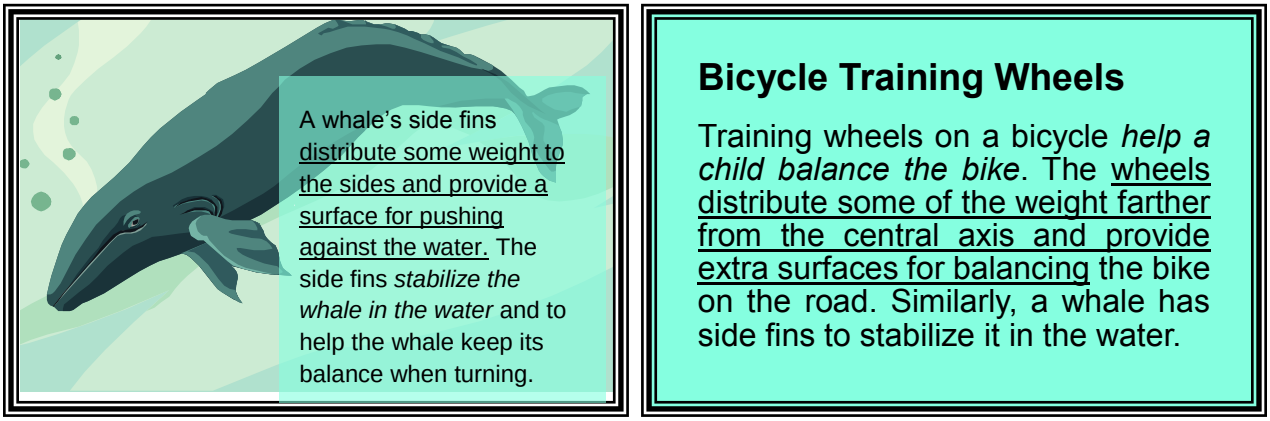


Table 11. Mapping One of the Analogies for Whale

Similarities = Mapping the Analogy		
Whale Side Fins	**Category**	**Bicycle Training Wheels**
Symmetrical placement of fins	Form: symmetry	Symmetrical placement of training wheels
Balancing and stability	Function	Balancing and stability
Two fins	Form: number	Two wheels
Near bottom of whale	Form: placement	Near bottom of bike
Push against water	Function: pushing	Push against road surface
Differences = Limits of the Analogy		
Whale Side Fins	**Category**	**Bicycle Training Wheels**
Living tissue	Composition	Metal and rubber
Paddling	Motion	Rolling
Near front of whale	Form: Placement	Near rear of bike
Natural part of whale	Origin	Manufactured item
For whales throughout life	Function	For novice bike riders

Figure 13. Example Front (left) and Back of a Card (right) from the Wolf Set

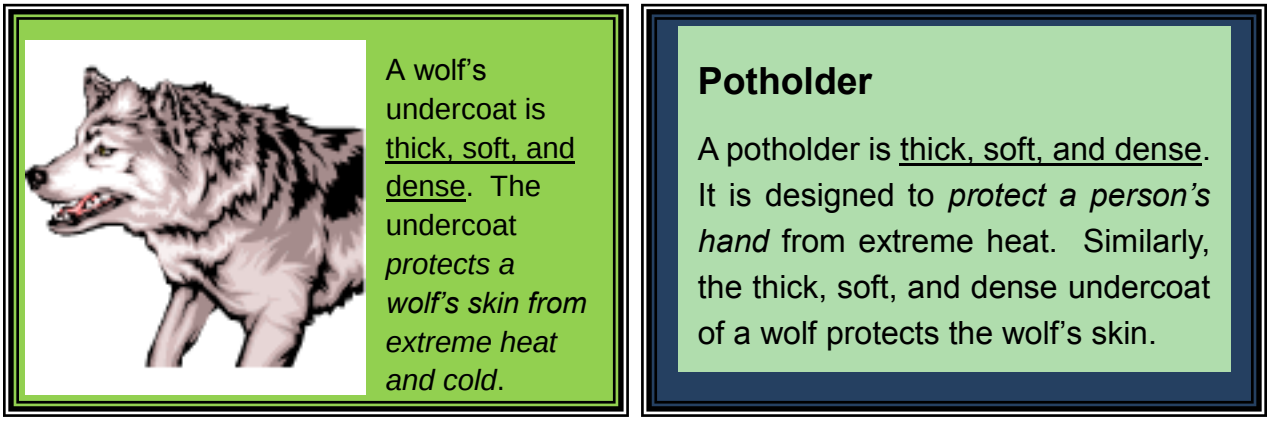


Table 12. Mapping One of the Analogies for Wolf

Similarities = Mapping the Analogy		
Wolf's Undercoat	**Category**	**Potholder**
Hair fibers	Form: fibrous nature	Cotton or polyester fibers
Hair protects wolf from temperature extremes	Function: insulator	Potholder pad protects from temperature extremes
Less than a couple of inches thick	Form: thickness	Less than a couple of inches thick
Undercoat is usually white hair	Form: color	Cotton fibers are white
Protect wolf from temperature extremes	Function: protection	Protect user from temperature extremes
Differences = Limits of the Analogy		
Wolf's Undercoat	**Category**	**Potholder**
Mostly for cold weather, but insulates from heat somewhat	Function	Mostly protects from heat but can be used for handling cold items
Covers most of body-irregular shape	Form: shape	Usually square
Wolf hair	Composition	Cotton or synthetic fibers
Wolf licks clean	Cleaning	Put in washing machine
Wolf grows more hair	Repair	Patch or replace with a new one

Lesson 7 Activity 3. Ask students to choose one of the form and function analogy cards. Try to generate five other items that could be used as an analogy instead of the suggested object. Tell advantages and disadvantages of using each proposed item. See examples in Table 13 through Table 18.

Figure 14. Example Card with Soda Can Opener used as Analogy for Alligator Teeth

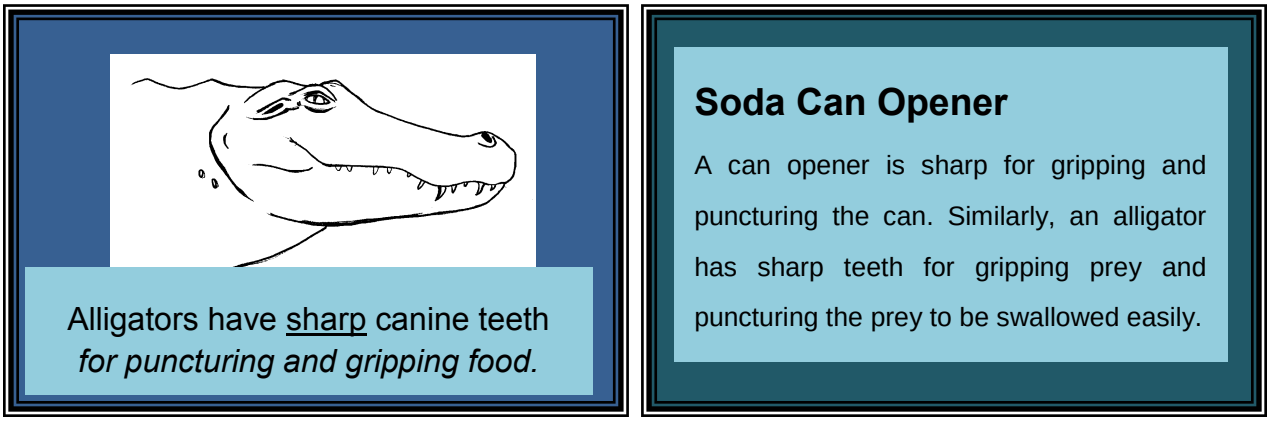


Table 13. Other Objects that Could Be Used as Analogies for Sharp Alligator Canine Teeth

Other Analogous Object	Advantages and Disadvantages
Chipped stone spear head	Sharp and shaped in a similar way, but no jaw action
Steel pocket knife	Very sharp but no jaw action
Steel trap	sharp teeth and jaw snaps shut
Paper punch	sharp edge of punch die and jaw action, but "tooth" is cylindrical
Stapler	Sharp and has jaw action, but leaves tooth in victim

Figure 15. Example Card with Shovel Being Used as an Analogy for Webbed Beaver Feet

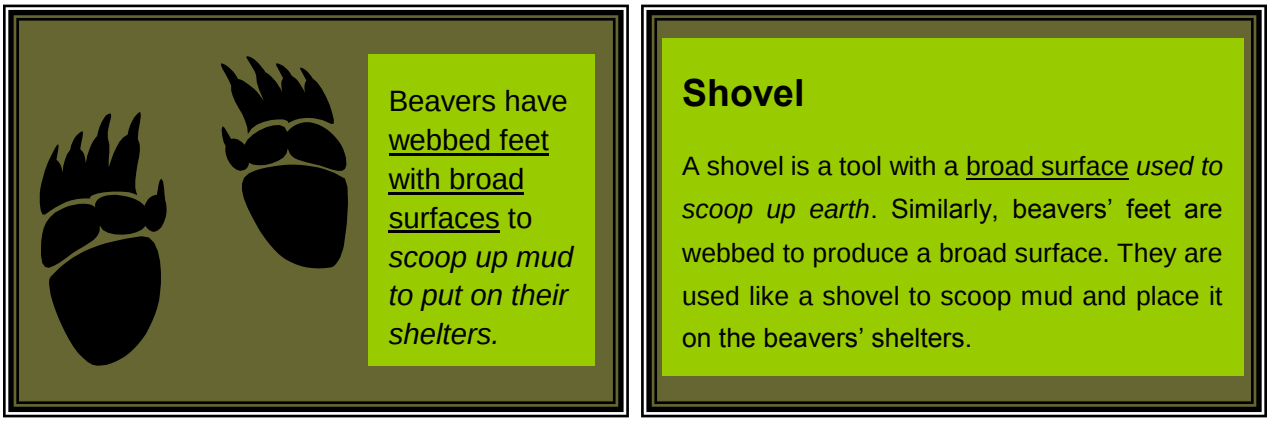


Table 14. Other objects that Could Be Used as Analogies for Webbed Beaver Feet with Broad Surfaces for Scooping Mud

Other Analogous Object	Advantages and Disadvantages
Cement trowel	Closer in size to beaver feet and can scoop mud
Spoon	Similar in size to beaver feet but lacking claws
Dustpan	Larger than beaver feet, but able to scoop mud; no claws
Ice cream scoop	Cup-shaped and so simulate beaver's ability to hold mud; no claws
Fork	Has sharp "claws"; a large fork can scoop a lot of mud

Figure 16. Example Card with an Aluminum Tube Bicycle Frame Being Used as an Analogy for Bird Bones

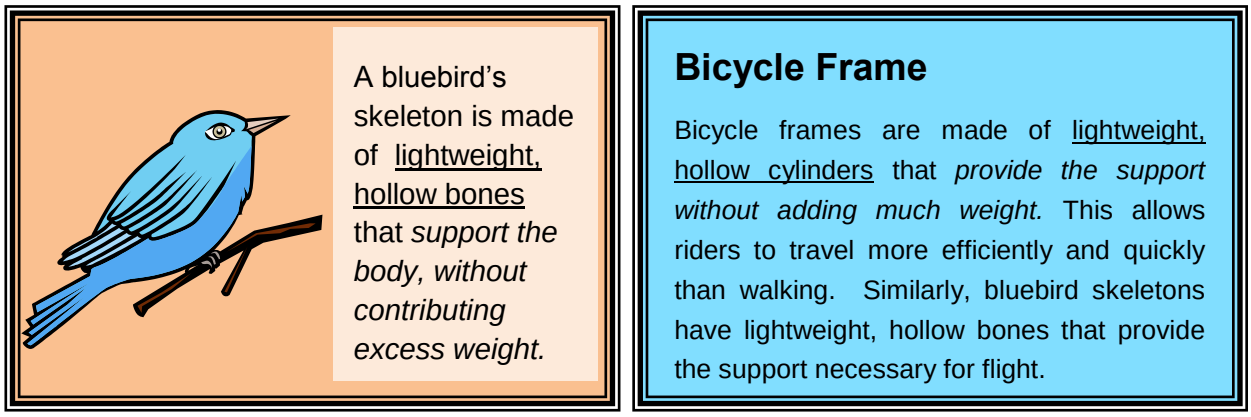


Table 15. Other Objects that Could Be Used as Analogies for Lightweight Hollow Bird Bones

Other Analogous Object	Advantages and Disadvantages
Corrugated cardboard	This has "tube-shaped" empty spaces on the inside; cardboard is lightweight and used in shipping containers because of its strength
Bamboo scaffolding	This is another natural material that is rigid and lightweight
Hollow plastic tent poles	These are lightweight, yet strong and good for backpacking
Aluminum frame for lawn chairs	These are strong and lightweight for carrying to the beach
Golf club shaft	These are hollow and made to be lightweight

Figure 17. Example Card with an Oscillating Fan being used as an Analogy for an Owl's Swiveling Neck Joint

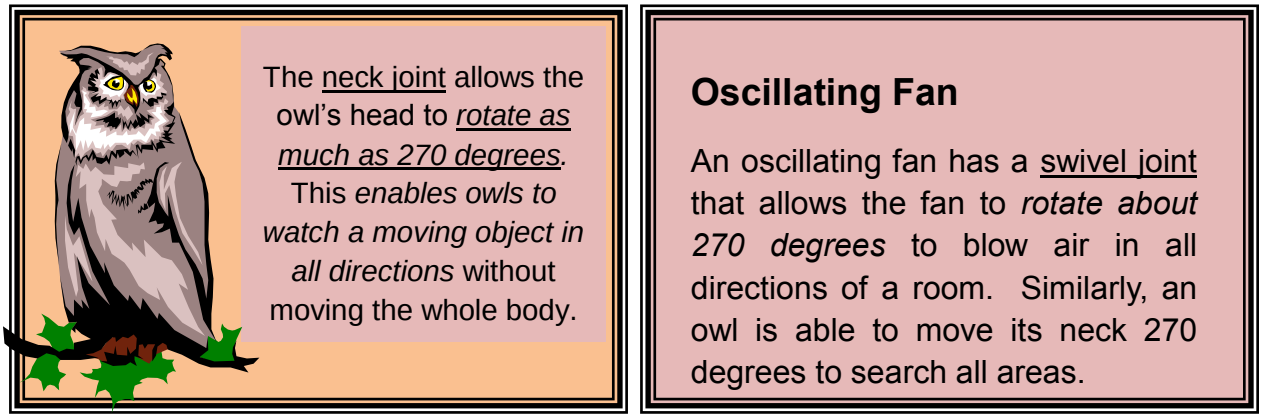


Table 16. Other Objects that Could Be Used as Analogies for an Owl's Swiveling Neck Joint that Gives it a Greater Range of Visual Operation

Other Analogous Object	Advantages and Disadvantages
Lazy Susan turntable	This item can swivel to any angle and has a range of serving anyone around the perimeter.
Playground roundabout	This equipment can swivel to any angle and allows riders to view the entire playground.
Gooseneck lamp	This lamp can be twisted to a large range of angles and can "see" or throw light on a variety of objects.
Gun turrets on battleships	These can turn about 270 degrees to "see" and hit targets.
Periscope	This can turn to different angles for a wide range of vision

Figure 18. Example Card with a Cage Being Used as an Analogy for Baleen which Allows Liquid to Escape, but Holds Food Trapped

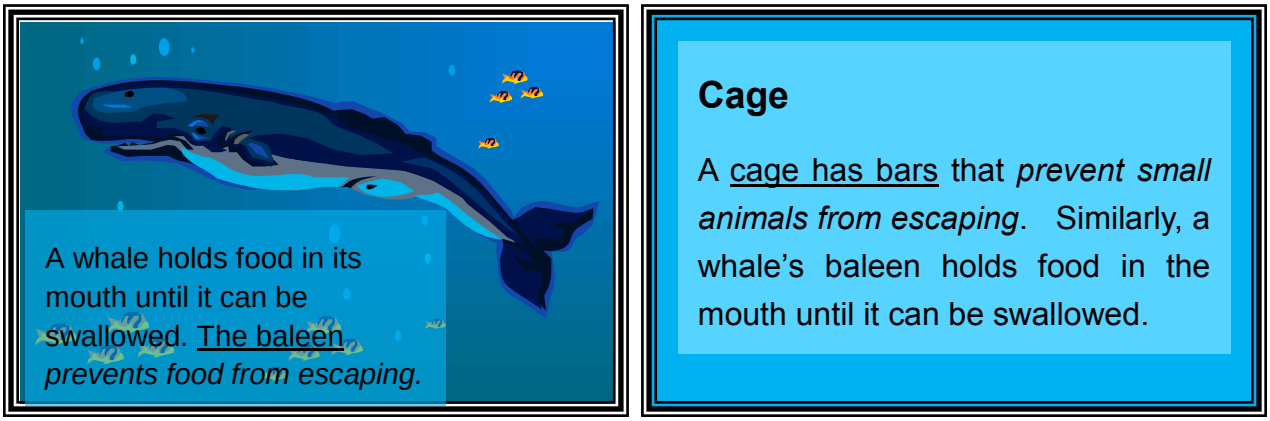


Table 17. Other Objects that Could Be Used as Analogies for Whale Baleen that Holds Food Trapped but Allows Liquid to Escape

Other Analogous Object	Advantages and Disadvantages
Coffee filter	The best part in this case, though, is the coffee liquid, rather than the coffee grounds
Food strainer	The strainer retains foods like berries that are being washed
Window screen	Allows air to flow through while keeping insects out (sort of opposite of baleen)
Playpen	Has bars or netting to keep baby in – but baby is not "food"
Fishnet	Catches and hold fish and lets water drip out

Figure 19. Example Card with a Police "Do Not Cross this line" Ribbon Being Used as an Analogy for a Wolf's Tail that can be Positioned to Communicate to Others

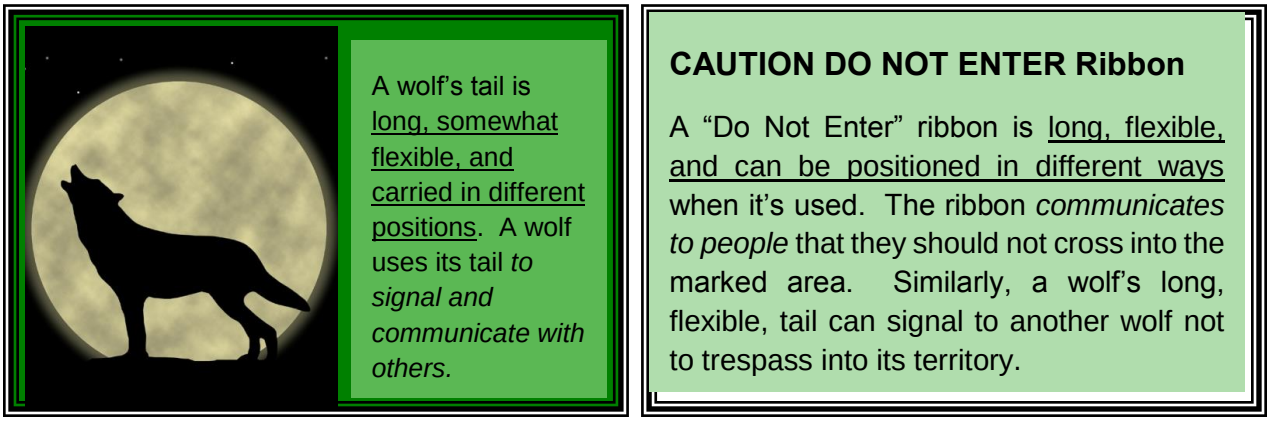


Table 18. Other Objects that could be Used as Analogies for a Wolf's Tail that can be Positioned in Different Ways to Communicate Messages

Other Analogous Object	Advantages and Disadvantages
Semaphore flags	These flags are held in different positions to signal different messages.
Arrows on signs	Arrows can be positioned to indicate different messages
Railroad barrier signals	These barriers move up and down to signal whether one can cross the tracks.
Sign language	People position their hands in different ways to send different messages
Secret spy messages	Spies have secret ways of positioning objects to communicate messages such as raising or lowering window shades

Lesson 8

Inventors Inspired by Form and Function

Objectives: Students will be able to match an inventor's interest, inspiration, the form and function of the invention, and the new product. Students will be able to discuss how form and function analogies helped many inventors develop new products. Students will be able to research an inventor of interest and make a poster that communicates information to other class members.

Exploration: Ask students to name a product that was inspired by an analogy to the form and function of something else.

Explanation: Pass out a set of the Lesson 8 cards to each small group of students. Their job is to create a large chart with the cards. Each row should focus on the invention of one inventor. Place the inventors to form the first column. The next column should show the corresponding inspirational idea. Column 3 should show the form and function. The last column should show the new invention. After students have completed the charts, discuss the inventions and how form and function was used to help the inventors.

Figure 20. Card Set 7, Form and Function Inspirational Ideas for New Products

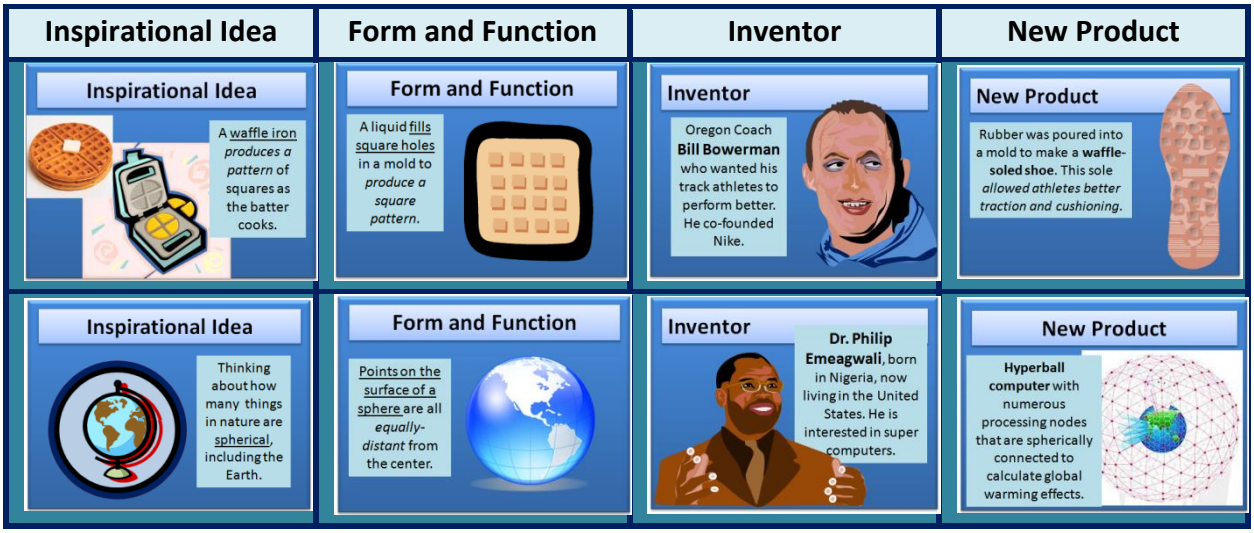


Figure 20 (Continued). Card Set 7, Form and Function Inspirational Ideas for New Products

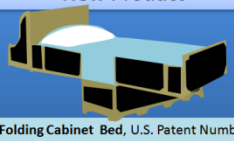
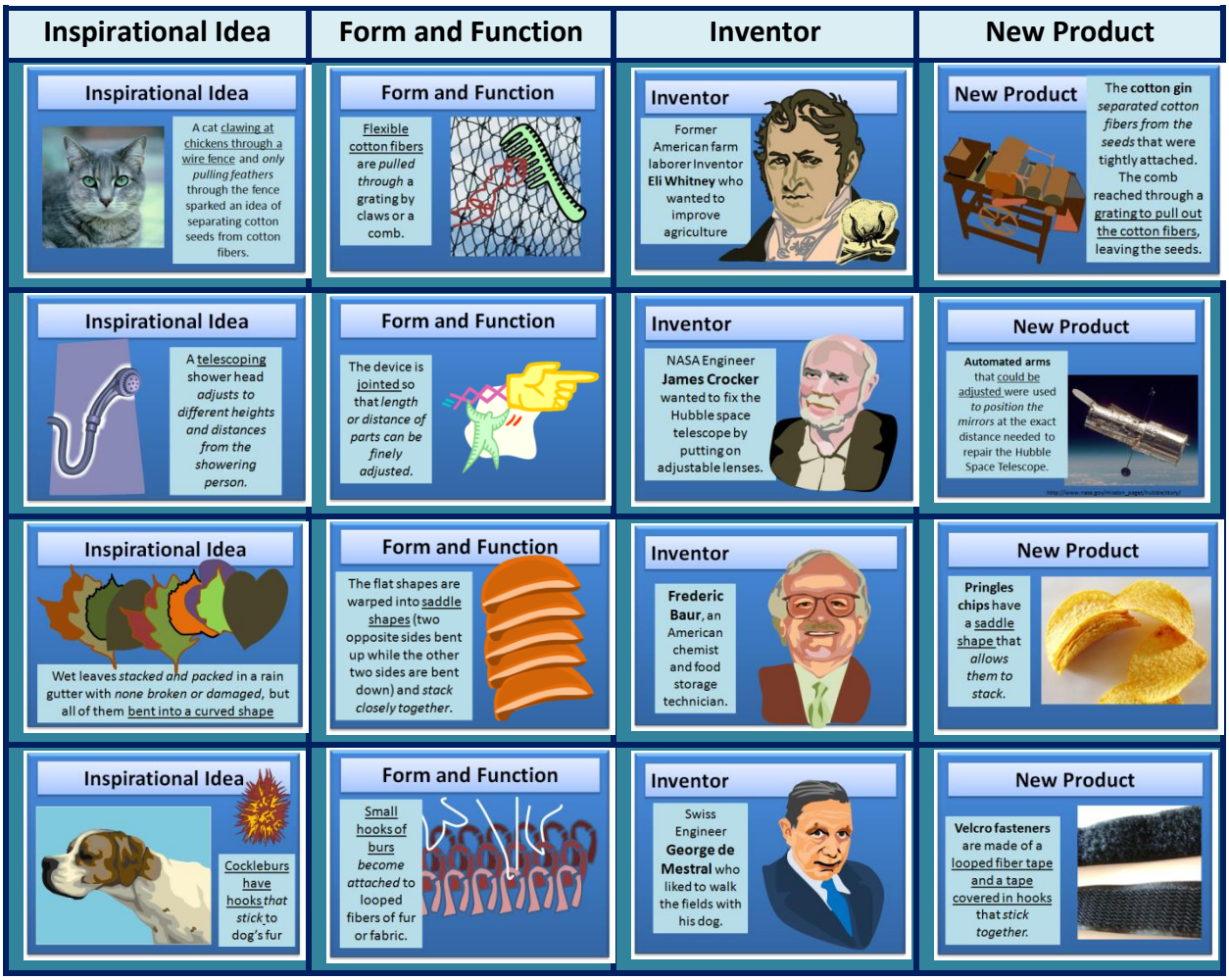
Inspirational Idea	Form and Function	Inventor	New Product
Inspirational Idea  *Images and letters on coins* were made by pressing a die (metal stamper) into the metal. Could this idea be applied to making letters on paper?	**Form and Function** *The shape of a die (a metal stamper) is produced* on a flat surface by stamping. 	**Inventor** German printer **Johannes Gutenberg** was interested in printing papers and books more quickly. 	**New Product**  The **printing press** had metal letters that could be arranged to form words. These were inked and *pressed onto the paper to make many copies.*
Inspirational Idea  People in small apartments in New York City need compact furniture *to make the best use of the space.*	**Form and Function** Hinges in the furniture *allow* a bed *to be folded* into a writing desk *to make the best use of limited space.* 	**Inventor** **Sarah E. Goode** was a former slave and the first African-American woman to hold a U.S. patent. 	**New Product**  **Folding Cabinet Bed**, U.S. Patent Number 322,177; issued July 14, 1885
Inspirational Idea  As steam builds inside the pot, the lid *vibrates with the pressure.*	**Form and Function** Steam produced by hot liquid takes up more space and *produces pressure.* 	**Inventor** Scottish Mechanical Engineer **James Watt** was fascinated with steam. 	**New Product**  **Steam engines** *were powered* by steam pressure.
Inspirational Idea A customer complained that the French fries were too thick. As a joke, Chef Crum cut the potatoes *so thin they could not be eaten with a fork.* 	**Form and Function**  The thin, crispy potato chips *crunched in a pleasing manner.* Customers loved them.	**Inventor** **George Crum** was a Native American/ African-American chef at a restaurant in Saratoga Springs, NY in 1853. 	**New Product** **Potato chips** were thin and crispy to *delight customers with a new snack.* 
Inspirational Idea  A coiled loop of a flexible garden reminded the inventor of a *wheel.*	**Form and Function** A long fluid-filled cylinder made of flexible material can be bent into a circle and used to *cushion impacts.* 	**Inventor** Scottish Inventor **John Dunlop** with a young son who liked to ride a tricycle. 	**New Product**  The first **air-filled tire** was made for the inventor's son's tricycle. The inventor wound an air-filled piece of a garden hose around the wheel and covered it with a rubber tread. The tire now *absorbed shocks.*
Inspirational Idea  Soaring birds twist their wings to *retain balance while flying.*	**Form and Function** Curved surface *deflects air giving lift and stability to vehicles.* 	**Inventors** The **Wright Brothers** wanted to build and fly planes. 	**New Product** **Warped wings** on **aircraft** for *lift and stability.* 

Figure 20 (Continued). Card Set 7, Form and Function Inspirational Ideas for New Products



Expansion: Students should read about an inventor and his/her work. Each student should make a presentation to the rest of the class, perhaps making a poster of information about the inventor. Student posters should include the following:

- A picture of the inventor
- A picture of the product
- A description of the inventor's background
- A description of how the inventor obtained creative ideas
- Forms and function of the product (including how it works)
- Five other interesting facts about the inventor or invention

Lesson 9

Combining SCAMPER with Form and Function to Spur Invention

Lesson 9. Use SCAMPER method combined with form and function analogies to make product innovations or inventions.

Lesson 9 Activity 1.

Objective: Students will be able to apply the forms and functions of animal body parts to products to produce innovations.

Use an empty SCAMPER chart similar to the one in Table 19 . Note that the word SCAMPER is an acronym for the key words Substitute, Combine, Adapt, Modify-Minify-Maximize, Put to another use, Eliminate, and Reverse-rearrange-reorder. First, have students recall adaptations from one of the animals studied through form and function. Write these ideas in the middle column of the chart. At first, place them on any line, with the idea that their positions might be changed later. After the middle column has been filled, begin playing with these ideas to produce product innovations. For example, start with the first SCAMPER idea, "Substitute." Ask students how the animal adaptation might lead to some sort of substitution (in an aspect) regarding the product. Perhaps it is a substitution of materials, or a new part for an old part, or a substituted use of the product. Write the resulting ideas in the last column. Then proceed to the next line and explore those ideas. Sometimes, one can see that the animal adaptation fits better with a different SCAMPER idea. In that case, move the animal adaptations to different lines of the chart. More than one idea may be written on the chart for each line. Example charts for different animals and different products follow as Tables 20 to 25.

Table 19. Blank Scamper Chart

Scamper Operation		Animal Adaptation Idea	Applying idea to improve :_____
S	Substitute		
C	Combine		
A	Adapt		
M	Modify, Minify, Maximize		
P	Put to another use		
E	Eliminate		
R	Reverse, reorganize		

Table 20. Example Scamper Chart Related to "Alligator" Used to Improve a Chair

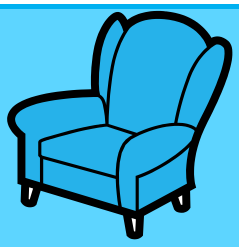
			
Scamper Operation		**Animal Adaptation Idea**	**Applying idea to improve a chair**
S	Substitute	Alligators have movable flaps on their ears that close to prevent water intrusion	The chair might have a seat cushion and back cushion that are inflated to different amounts of cushioning and firmness rather than cushions stuffed with foam or batting or no cushion
C	Combine	An alligator bellows or growls to communicate with others	Combine the chair with a silent electronic communication system so that a waiter or servant or friend can receive a message and bring the sitter a drink or snack
A	Adapt	Alligators have a tan-green body covering that is camouflaged in the environment	Change the chair fabric so that is paintable so it can be spray-painted to match its surroundings and blend in. This might be nice for garden parties with lots of guests. This way, the chairs won't detract from the flower garden but blend in
M	Modify, Minify, Maximize	An alligator has strong jaws that snap shut to hold onto things	Modify the back of the chair so that it has a giant clip that holds reading material out of sight
P	Put to another use	Alligators have wide nostrils on their snouts so they can breathe while submerged	Instead of a typical indoor house furnishing chair, make the chair be for the bottom of a 3 to 4 foot deep pool so that a person can stay submerged to cool off and avoid sunburn; there would be a snorkel mask attached so that the person can breathe while relaxing under the water
E	Eliminate	An alligator has a glottis flap in its throat that opens to allow food through	Eliminate the idea of a permanent back to the chair; allow the back to flip to different positions
R	Reverse, reorganize	Alligators have smooth skin on their bellies	Substitute smooth plastic for all the areas of the chair so that it can potentially be flipped over and sat in three different ways with their being a continuous sculpture rather than a chair with legs

Table 21. Example Scamper Chart Related to "Beaver" Used to Improve a Pair of Gloves.

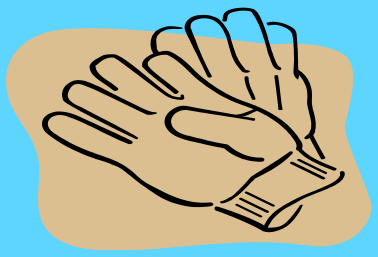
			
Scamper Operation		**Animal Adaptation Idea**	**Applying idea to improve a pair of gloves**
S	Substitute	Beavers cover their lodge floors with wood chips to absorb water and keep the floor from being muddy	Substitute tough, woody, sisal fibers for the outer coating of the gloves to make them tough and to protect the hands
C	Combine	Beaver lodges are surrounded by water for protection	Put an absorbent liner inside the gloves and squirt lotion on it to surround the hands with healing liquid that protects the skin
A	Adapt	Beavers have large flat tails for slapping the water to indicate danger	Put flat metal plates into the palms so that people can make more noise when clapping at a performance; call these "opera gloves"
M	Modify, Minify, Maximize	Beaver lodges are covered with a thick layer of mud and twigs for insulation	Make the gloves insulated; have some gloves with twig-like supports in the fingers to support the fingers when carrying loads in the hands
P	Put to another use	Beavers have webbed feet to push against the water or pick up and pack mud	Make the fingers of the glove webbed. Use these gloves for playing volleyball or other ball sports in which more hand contact with the ball is desired
E	Eliminate	Beavers have two underwater passages for accessing their lodges	Have gloves with a wrist entrance and another hole cut in the palm near the roots of the fingers; the gloves can be worn over the palm with the fingers free if needed
R	Reverse, reorganize	Beaver teeth never stop growing	Put some pleats in the gloves so that they will fit a variety of hand sizes

Table 22. Example Scamper Chart Related to "Bluebird" Used to Improve a Hair Style

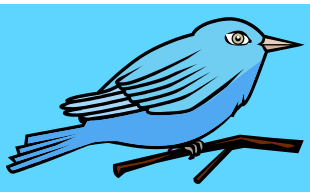
			
Scamper Operation		**Animal Adaptation Idea**	**Applying idea to improve a hair style**
S	Substitute	Bluebird beaks are made of two parts that pinch together to hold onto objects	Substitute a variety of clips for rubber bands. Divide the hair into two sections; twist these around each other For a short haircut, divide the hair into two sections; use mousse to make them into two peaks
C	Combine	Female bluebirds have white rings around the eyes to signify their sex	Combine decorations with the hair by placing white rings around braids or bunches of hair to decorate the hair Add barrettes in the hair that say "Girl" or the person's name
A	Adapt	Bluebird wings spread out to form broad, flat surfaces for flight	Gather the hair into a ponytail on top of the head and then use mousse to flatten it out into a draped covering of the head
M	Modify, Minify, Maximize	A bluebird's feathers are oiled to repel water	Use oily Vaseline to sculpt a new hair arrangement
P	Put to another use	Bluebirds have hollow bones for lightweight in flying	Roll the hair on fancy decorated hollow rollers that stay in the hair Make the hair into ringlets that are pulled back by a headband and "fly" around the face
E	Eliminate	Bluebirds are able to hover to find insects	Eliminate curls and bouncy hair that "hovers" by covering with a netted cap Place beautiful butterfly and other insect pins in the hair for decoration
R	Reverse, reorganize	A bluebird's nest is woven together into a cup shape	Start by sectioning the hair into braids and then weave the braids together to form a network Weave ribbons or interesting twigs into the hair

Table 23. Example Scamper Chart Related to "Owl" Used to Improve a Window

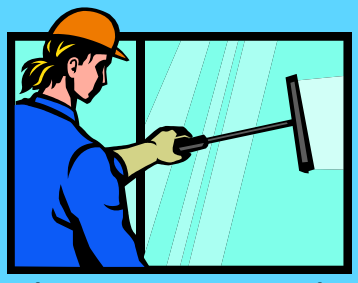
			
Scamper Operation		**Animal Adaptation Idea**	**Applying idea to improve a window**
S	Substitute	Owls are active at night	Most people look out the windows during the day; make a special night-gazing window in the ceiling for watching the stars and moon
C	Combine	Owls have ear tufts that are positioned to show moods	Have a series of partial shutters and screens for the window that can be arranged to let in more or less light for different moods
A	Adapt	Owls have sharp-focused eyesight	Have a line of special lenses built into the window so you can look out through them and see a great distance
M	Modify, Minify, Maximize	Owl neck joints rotate as much as 270 degrees	Modify the window frame so that it can swivel to open the window
P	Put to another use	Owls have sharp, curved talons for catching prey	Have a row of sharp clips above the window for attaching a variety of curtains made of flat sheets of fabric that are gathered by the clips. Change these as your mood changes
E	Eliminate	Owls have soft feathers that muffle sounds	Have several screens made of soft baffles that muffle sounds from an open window.
R	Reverse, reorganize	Owls are camouflaged to become unnoticed in their surroundings	Change the window to become the focal point of the room and use bold colors in its framing and curtains to draw attention

Table 24. Example Scamper Chart Related to "Whale" Used to Improve a Rug

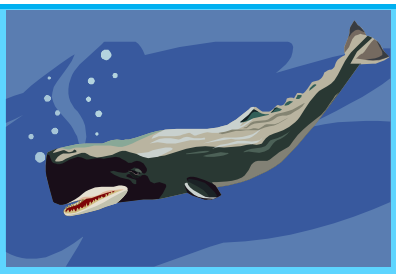
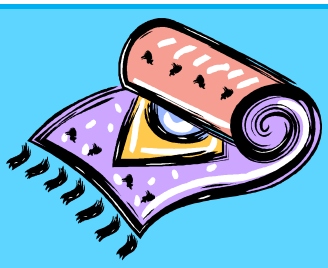
			
Scamper Operation		**Animal Adaptation Idea**	**Applying idea to improve a rug**
S	Substitute	Barnacles often attach to whales	Rugs often acquire stains; substitute a rug fabric dye for the stains; allow people to "paint" their rugs with attractive colors to hide stains
C	Combine	Whales travel in pods for socializing and safety	Have a basic-colored base rug with a lot of highly-decorated smaller rugs on top that are then securely attached
A	Adapt	Whales have long fibrous baleen that sifts food	Have fibrous rugs at the entrance that sift dirt from shoes and empty it into a pan underneath
M	Modify, Minify, Maximize	Whales have side fins that help it balance and remain stable in the water	Have some extensions from the rug that slide behind baseboards to stabilize the rug's position
P	Put to another use	Whales make whistles, buzzes and cries to communicate	Put a sensor under the rug at the entranceway that makes a sound when someone enters the room to alert others
E	Eliminate	Whales have fat layers for insulation	Eliminate chills from the floor with a highly-insulating rug
R	Reverse, reorganize	Whales have blowholes through which they breathe	Have porous areas of the rug that overlay vents and allow cold air to return to the furnace unnoticed

Table 25. Example Scamper Chart Related to Wolf Used to Improve a Shoe

			
Scamper Operation		**Animal Adaptation Idea**	**Applying idea to improve a shoe**
S	Substitute	A wolf's nose has a keen sense of smell	Substitute a porous fabric for leather so that the shoe is airy and doesn't smell bad
C	Combine	Wolves live in groups called packs and work together	Shoes could be sold as packs that include socks and extra shoe laces
A	Adapt	Wolves have long, curved, sharp toenails	Shoes can have an open toe area for someone with nails that stick out so that nails don't press against the shoe; this area can be screened over to keep out pebbles
M	Modify, Minify, Maximize	A wolf has a thick, soft, dense undercoat to insulate	Pad the sole with a thick spongy layer to cushion impacts and insulate from hot tar surfaces
P	Put to another use	Wolves have cupped ears to gather sound waves	Place GPS units in kids' shoes so that the travels can be tracked by parents on a computer
E	Eliminate	A wolf has a smooth topcoat to repel rain	Eliminate the need for waterproofing by making the entire shoe submersible and having holes on the sides and in the sole for water drainage
R	Reverse, reorganize	Wolves have sharp incisor teeth to rip and tear	Have repair kits sold with the shoes to stop rips and tears

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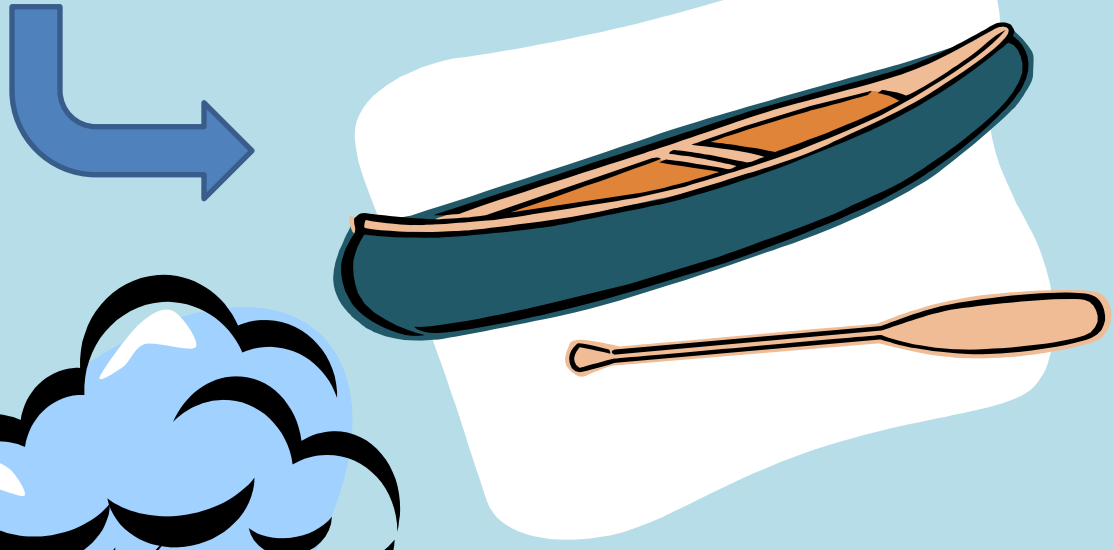
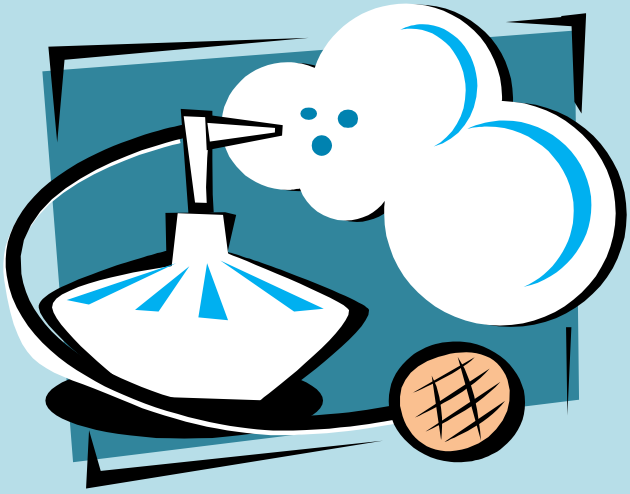
Appendix for Invention through Form and Function Analogy





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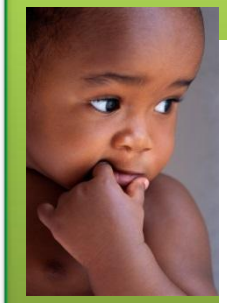
Card Set # 1

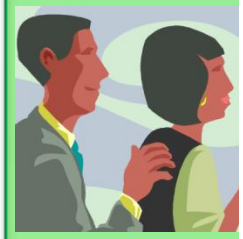
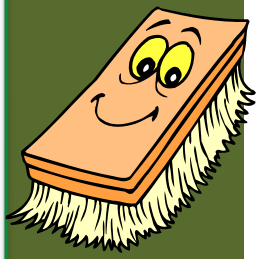
<u>Forms</u> and *Functions* of the Hand with Analogous Manufactured Tools

Preparation: These are one-sided cards that should be cut apart and mixed before being given to the student. The first page shows heading cards that should be used at the top of each column. A small group of students should be given this complete set or half of it. Therefore, depending upon class size, several sets will need to be made.

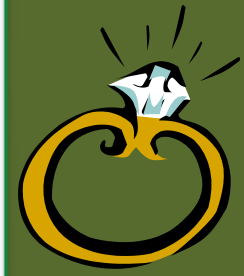
Directions for Student Work: Students should work in pairs or small groups of no more than four members. Students' task is to form a chart-like layout with the cards in each row arranged as shown in the sets here. The order of the rows is not important. Students should use the heading cards to form the columns of the layout.

Form of the Hand	Function of the Hand	Example Hand Action	Example Manufactured Tool
Form  Fingers can <u>bend around the edge of an object in the palm</u>	**Function**  ***keeps object from falling out of palm***	**Example Action**  Loosely holding a hot dog sandwich	**Example Tool** A **tray** is has raised edges to loosely hold cups in place 
Form  <u>Closed fist</u> can be <u>pressed against</u> something	**Function**  ***Supporting the weight to steady the object***	**Example Action**  Relaxing neck muscles while thinking	**Example Tool**  A **pillow** to supports the head, allowing rest

Form	Function	Example Action	Example Tool
 Hand is planar with flat palm and fingers fanned out	 Broad surface for ***visibility***	 Waving and signaling	 **Flag** that is waved to signal
 Hand is planar with flat palm and fingers held together	 Broad surface ***to produce noise***	 Clapping to show approval or gain attention	 **Cymbals** to clang together
 Two fingers can be raised while others are curled	 Symbolizing; ***sending message***	 Signifying victory to others	 **Badge** to symbolize ideas

Form	Function	Example Action	Example Tool
 Hand has jointed fingers that bend	 Fingers curl around object ***to hold it***	 Holding a phone	 **Straps** on backpack
Form	**Function**	**Example Action**	**Example Tool**
 Fingers have tough, sharp pointed nails at tips	 ***Scratch a surface*** with nails	 Scratching someone's back	 **Scrub brush** for scratching off dirt
Form	**Function**	**Example Action**	**Example Tool**
 Thumb can move to meet fingertips	 Pincer grip for ***grasping objects***	 Holding a pen	 **Binder clip** grips papers

Form	Function	Example Action	Example Tool
 Index finger <u>can be extended while other fingers are curled</u>	 Small surface area for ***touching objects***	 Pressing a mouse button	 **Stylus** for touching items on a computer screen
Form	**Function**	**Example Action**	**Example Tool**
 Index finger <u>can be extended while other fingers are curled</u>	 ***Draw attention*** to a small area; point or gesture	 Pointing to an item of interest	 **Laser Pointer** for presentations
Form	**Function**	**Example Action**	**Example Tool**
 Palm, fingers and thumb can form <u>cup-shape</u>	 ***Holding*** liquids, loose items, cradling object	 Holding water	 **Cup** for holding pencils and other items

Form	Function	Example Action	Example Tool
 Hand has <u>joints and strong muscles</u>	 Exert pressure to ***shape an object***	 Shaping pottery bowl	 **Rolling pin** to shape dough
Form	**Function**	**Example Action**	**Example Tool**
 Fingers have <u>flat, glossy nails at tips of fingers</u>	 ***Draw attention to hands***	 Polishing or painting fingernails for attention to beauty	 **Shiny, rings** gain attention as they shimmer
Form	**Function**	**Example Action**	**Example Tool**
 Fist can be <u>clenched into a ball</u>	 Solid, hard object can ***strike a strong blow***	 Striking a ball in a volleyball game	 **Wrecking ball** knocks down buildings

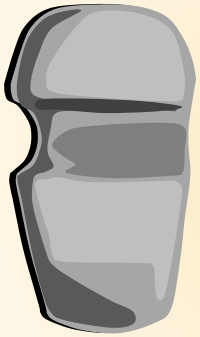
Card Set # 2

Early Artifacts and Tools as Extensions of Forms and *Functions* of the Human Body

Preparation: These are one-sided cards that should be cut apart and mixed before being given to the student. The first page shows heading cards that should be used at the top of each column. A small group of students should be given this complete set or half of it. Therefore, depending upon class size, several sets will need to be made. Providing real examples of the tools that can be matched to each row of the chart will make the work easier to understand and more engaging.

Directions for Student Work: Students should work in pairs or small groups of no more than four members. Students' task is to form a chart-like layout with the cards in each row arranged as shown in the sets here. The order of the rows is not important. Students should use the heading cards to form the columns of the layout.

Artifact and Form	Function of the Tool	Human Body Part Extended
Artifact and Form  A **drum** has a broad top surface that resonates and makes a loud sound when slapped.	Function of the Tool This tool is used to ***make percussion rhythms and music***.	Human Body Part Extended Slapping one's **thighs** with flattened palms to make a rhythmic noise. 
Artifact and Form  Blowing into a hollow **reed flute** causes the reed to vibrate.	Function of the Tool This tool has holes at different positions along the length that ***produce different pitches of sound*** as it is played.	Human Body Part Extended Blowing through **mouth** and vibrating the **lips** to produce whistles. 



Artifact and Form

A heavy stone **axe head** is block-shaped with a sharp tapered edge and a groove around all or most of the block.

Function of the Tool

The heavy weight of the stone and sharp edge allow it to be used to ***chop objects such as wood or to be used as a weapon***. The groove allows it to be attached to a handle.

Human Body Part Extended

Fists (for pounding); **teeth** (cutting and breaking apart).

Artifact and Form

A stone **knife** has a fairly flat top and bottom surface, but a sharp serrated edge all around.

Function of the Tool

The sharp edge all around this tool and its fairly large palm-size allow it to be ***held in the hand and used for cutting*** plants, hides, meat, and other items.

Human Body Part Extended

Teeth cutting into something to break off a part.

Artifact and Form

A stone **scraper** has broad sharp edges.

Function of the Tool

The broad sharp edge is perfect for dragging across a hide to ***scrape off*** the layer of fat and for ***scraping*** dirt or skins from carrots or potatoes.

Human Body Part Extended

Fingernails (for scratching and scraping); **teeth** (scraping).

Artifact and Form

An **arrowhead** is triangular in shape with a point at the tip and sharp edges. Arrowheads often have notches at the base.

Function of the Tool

The pointy end and sharp edges make it penetrate an animal's or enemy's body ***to injure or kill it.*** The notches allow the tool to be *attached to a shaft*.

Human Body Part Extended

Fists (for punching); teeth for cutting.

Artifact and Form

A strong stone **hoe** has a large, flat tapering wedge-shaped rectangular shape with sharp edges.

Function of the Tool

The strong wedge can be ***pushed into the ground to dig*** a hole for planting or remove weeds.

Human Body Part Extended

Hands (for pushing into the ground).

Artifact and Form

A leather or woven **pouch or bag** is lightweight flexible, and made of readily-available materials. It can expand to hold more items.

Function of the Tool

This tool functions as ***a container to hold items.*** It can expand or contract a bit to hold more or less.

Human Body Part Extended

Hands (holding items).

Artifact and Form

An **basket** is made of strips of wood or plant stems woven together. It is lightweight and hollow. It may have a lid or cover.

Function of the Tool

The hollow nature of this item allows it to ***hold or contain items*** /ike seeds, berries, and other foods or personal items.

Human Body Part Extended

Hands (holding items).

Artifact and Form

A **blanket** is a broad flat layer made of soft skins or woven fabric. It is flexible and can be wrapped or arranged in many shapes.

Function of the Tool

The fibrous layer is used ***to trap body heat*** or to insulate/protect a person from dampness or cold.

Human Body Part Extended

Like having a thicker **skin** or more **hair.**

Artifact and Form

A stone **drill** is a fairly small tool with a long, sharp pointed end.

Function of the Tool

This tool is turned or twisted on a surface ***to bore a hole*** in that surface.

Human Body Part Extended

Fingernails scratching a hole in something.

Artifact and Form

A **visor** or **hat with a brim** is made of woven basketry, leather, or fabric. It extends above the forehead.

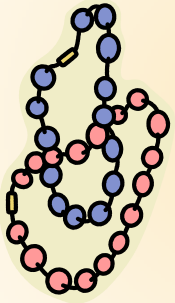
Function of the Tool

This lightweight item extends out from the head ***to shade or shelter*** the eyes from sun and rain.

Human Body Part Extended

Hand shading the face.

Artifact and Form



A **strand of beads** is a colorful, attractive set of small items that are held together by string or a leather thong.

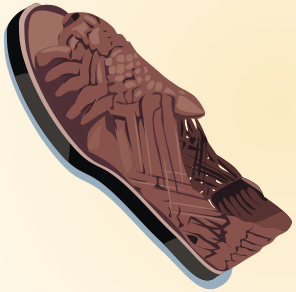
Function of the Tool

The colorful items ***attract attention,*** are considered beautiful or a ***symbol of wealth and status.***

Human Body Part Extended

Colorful, shiny, and interesting like **eyes, lips, and teeth**.

Artifact and Form



A **pair of sandals** is woven of grasses or leather with a tough bottom.

Function of the Tool

This item ***protects the soles of the feet from injury***.

Human Body Part Extended

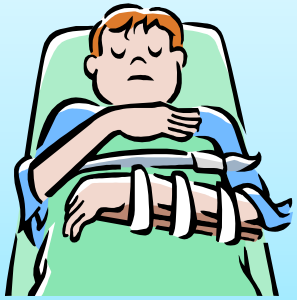
Skin - a layer of hard, tough skin on the bottom of feet.

Card Set # 3

Early and Modern Inventions in Response to Basic Human Needs

Preparation: These are one-sided cards that should be cut apart and mixed before being given to the student. The first page shows heading cards that should be used at the top of each column. A small group of students should be given this complete set or half of it. Therefore, depending upon class size, several sets will need to be made.

Directions for Student Work: Students should work in pairs or small groups of no more than four members. Students' task is to form a chart-like layout with the cards in each row arranged as shown in the sets here. The order of the rows is not important. Students should use the heading cards to form the columns of the layout.

Basic Human Need	Early Inventions	Modern Inventions
Communication: Instruments that produce loud musical tones for *alerting others* 	Musical instruments made of wood, shell, horn, or metal 	Electronically produced sirens 
Safety: Health procedures for *helping a person recover from a broken bone* 	Making a splint to hold the bone in place 	X-rays to examine the bone; medical doctors to set it 

Basic Human Need

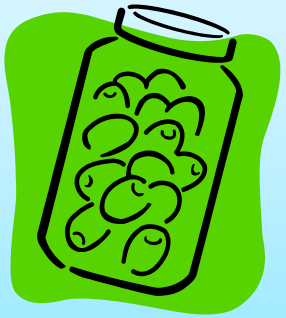
Food: Hollow containers for *gathering and storing* seeds or food materials

Early Invention

Baskets, hollow gourds, pottery bowls

Modern Invention

Plastic, glass and ceramic containers / dishes

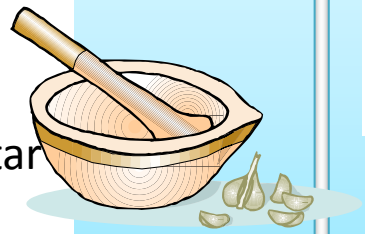


Basic Human Need

Food: Tools with grinding or cutting surfaces for *processing* grains, seeds, foods

Early Invention

Mano and metate (grinding stones); mortar & pestle

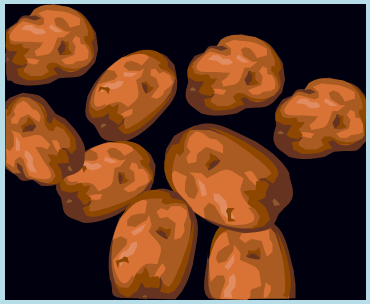


Modern Invention

Blender, food processor

Basic Human Need

Food: Hot heat sources for *cooking* food

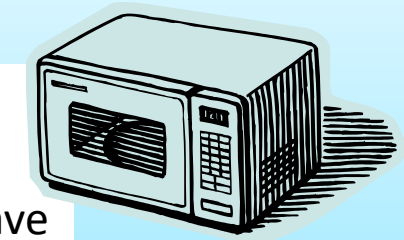


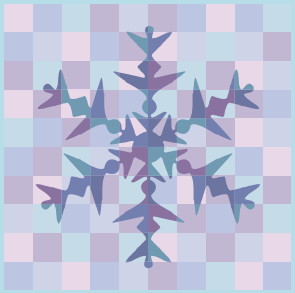
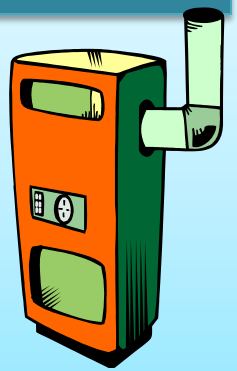
Early Invention

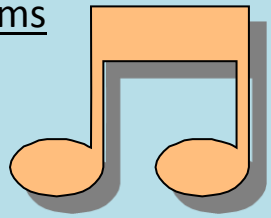
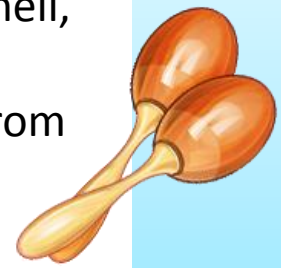
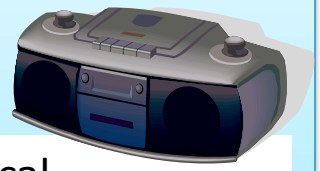
Open camp fire; heated stones

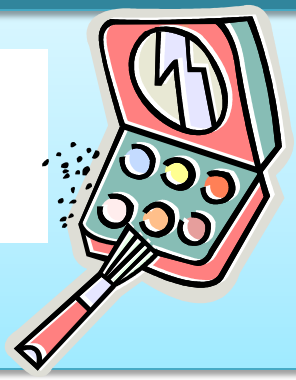
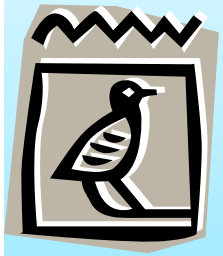
Modern Invention

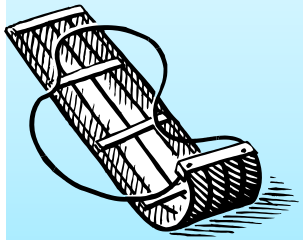
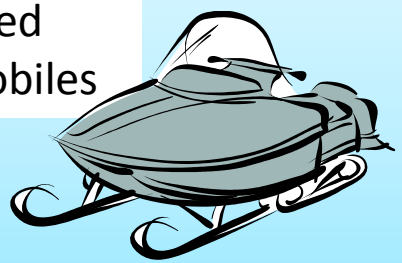
Stove, toaster, microwave oven

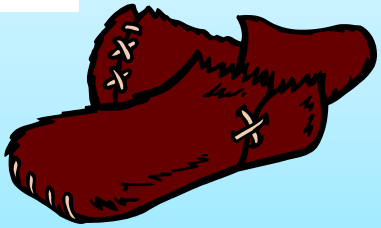
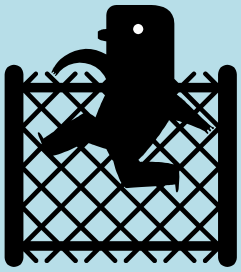
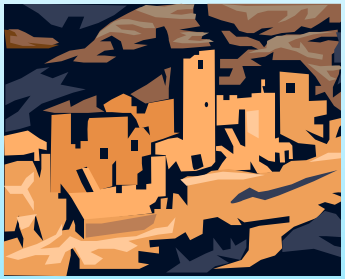


Basic Human Need	Early Invention	Modern Invention
Shelter: <u>Heat source</u> to *protect self from cold weather* 	Campfire 	Furnace, space heater 
Basic Human Need	**Early Invention**	**Modern Invention**
Clothing: <u>Insulating body coverings</u> for *warmth or protection from weather* 	Hide or fur blankets, woven cloth clothing/ robes 	Machine-woven blankets, fitted clothing, synthetic fabrics 
Basic Human Need	**Early Invention**	**Modern Invention**
Shelter: <u>Insulating structure</u> to *protect from rain and weather extremes* 	Caves and skin, bark, or thatch-covered homes 	Insulated brick or frame homes 

Basic Human Need	Early Invention	Modern Invention
Food: Dishes and utensils for serving and eating 	Spoons, scoops, pottery bowls, gourds, shells 	Steel utensils, plastic picnic ware; bowls; fine china 
Basic Human Need	**Early Invention**	**Modern Invention**
Communication: <u>Sounds, rhythms and music</u> to *communicate mood* 	Rattles from shell, gourds, turtle shells; flutes from hollow bones, reeds 	 Modern musical instruments; recorded music on CD's ; radio; iPods
Basic Human Need	**Early Invention**	**Modern Invention**
Communication through Clothing: Elaborate, symbolic costumes for ceremonies 	Costumes with feathers, flowers, shells, wooden decorations 	Costumes with glittery fabrics, synthetic beads 

Basic Human Need	Early Invention	Modern Invention
Safety: Armed humans for *protection from animal/ enemy attack* 	Warriors with spears 	Police with guns, army personnel 
Basic Human Need	**Early Invention**	**Modern Invention**
Self Esteem and Communication: Colorful paints applied to the face to *communicate mood, status or improve appearance* 	Paint made of ground hematite or ochre mixed with oil and applied to face 	Modern cosmetics in many colors 
Basic Human Need	**Early Invention**	**Modern Invention**
Communication: Lasting records of events to *communicate group history* 	Petroglyphs, pictographs, drawings on leather, carved records 	Books, ledgers, computer files, films 

Basic Human Need	Early Invention	Modern Invention
Transportation: Vehicles that can carry people and supplies for *travel through snow* 	Wooden sled pulled behind the person 	Motorized snowmobiles 
Basic Human Need	**Early Invention**	**Modern Invention**
Transportation: Vehicles that can carry people and supplies *for travel through water* 	Canoes made of hollow trees or birch bark 	Motor boats 
Basic Human Need	**Early Invention**	**Modern Invention**
Transportation: Apparatus or vehicle for *transporting young children* 	Papoose or cradleboard for carrying child on back 	Baby carriages 

Basic Human Need	Early Invention	Modern Invention
Clothing: Protective shoes for *walking through the woods* 	Moccasins 	Hiking boots 
Basic Human Need	**Early Invention**	**Modern Invention**
Shelter: Insulating and soft floor coverings *for comfort* 	Hides or hand-woven rugs 	Machine-woven carpeting 
Basic Human Need	**Early Invention**	**Modern Invention**
Safety: Secure structures to *keep dangers out* 	Homes built on difficult to climb cliffs 	Castles and fortresses 

Card Set # 4

Historical Perspective of Inventions

Preparation: This set contains six separate subsets of one-sided cards that should be used as separate packs of cards for work.
Print the cards in color and cut apart each of the sets of cards and place in labeled envelope.

Directions: Each small group of students first arranges the pictorial cards into a timeline. Then they place the cards that describe advantages and limitations below the corresponding cards.

Counting on fingers

Form and ***Function*** Fingers move and are raised to *keep track by counting all.*

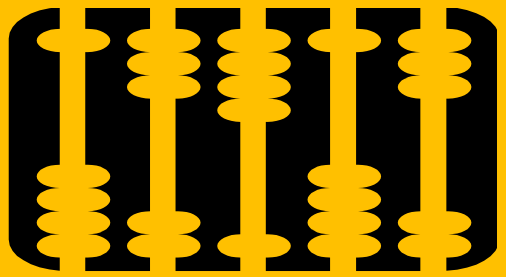
Notches on a stick or knots on a rope

Form and ***Function*** Notches or knots *represent numbers for counting.*

Numerals written on surface

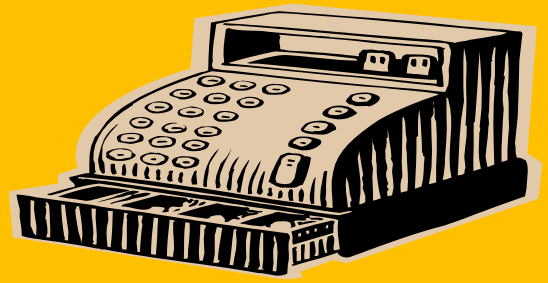
Form and ***Function*** Numerals *serve as mnemonics* during mental addition.

Abacus



Form and ***Function*** Beads on a frame are moved *to calculate sums.*

Adding machine or slide rule



Form and ***Function*** Mechanical parts *calculate a sum.*

Electronic calculator

Form and ***Function*** Computer chip electronically *calculates the sum.*

Addition Tool

Advantage: Attached to body, so readily available.

Limitation: Only have 10 fingers. No way to preserve final sum.

Addition Tool

Advantage: Permanent record of counts; more than ten can be represented.

Limitation: Very large numbers must be counted and recounted to keep track.

Addition Tool

Advantage: One can make calculations by writing on the paper or bark.

Limitation: Must do a lot of mental calculation.

Addition Tool

Advantage: Can quickly calculate large sums. Beads aid memory.

Limitation: May make errors.

Addition Tool

Advantage: No errors if operated properly. Fast and can handle large numbers.

Limitation: Human operated. Limited size of numbers.

Addition Tool

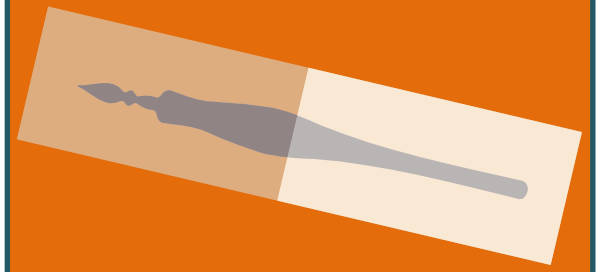
Advantage: High speed; high accuracy; can handle very large numbers.

Limitation: Data input by hand.

Duck or goose quill and ink well

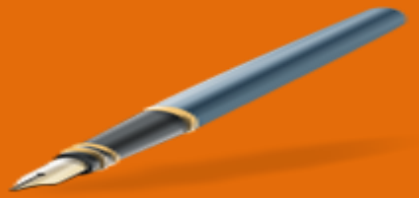
Form and ***Function***
Tough, hollow tube that *can be shaped to form a pen point and dipped in ink.*

Metal pen tip fitting into a pen holder



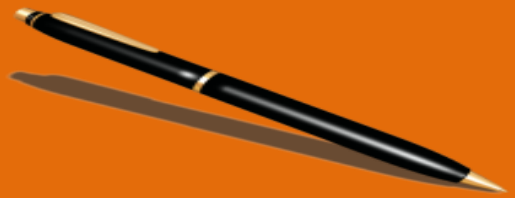
Form and ***Function*** Strong, durable metal pen tip *used with ink for writing.*

Fountain pen with ink cartridge



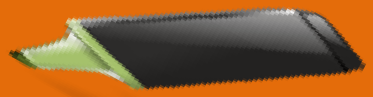
Form and ***Function*** Hollow plastic cylinder contains inner cartridge of ink *to supply tip.*

Ball-point pen



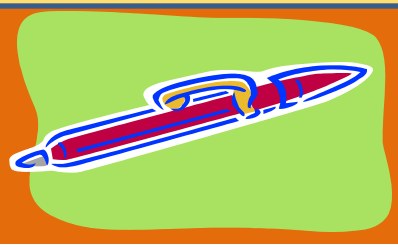
Form and ***Function*** Ball-shaped writing tip turns in a socket *to roll and write*; thick ink used *to prevent leakage*.

Felt-tip and soft-tip pens



Form and ***Function*** A felt or porous plastic tip *allows ink to flow from reservoir to allow easy writing.*

Rollerball pens



Form and ***Function*** A ball-shaped tip *writes smoothly*; a wick draws the ink from reservoir *to prevent leakage.*

Writing Pens

Advantage: A natural material readily available. Hollow tube holds ink to write a couple of words.

Limitation: Tip wears out in a week and must be re-shaped.

Writing Pens

Advantage: Can be machine-pressed to a specific shape. Lasts longer than a quill tip.

Limitation: Must continually dip pen into ink.

Writing Pens

Advantage: No need to constantly dip pen tip in ink.

Limitation: Leaks occasionally, reservoir must be re-filled.

Writing Pens

Advantage: Less leaks.

Limitation: Skips and globs sometimes. Ink is thick- must use pressure to write.

Writing Pens

Advantage: Ink is thin and allows easy writing.

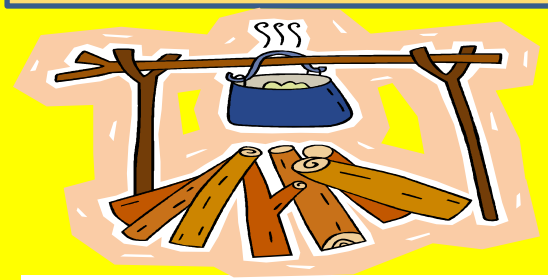
Limitation: Felt tips become deformed – plastic tips are better.

Writing Pens

Advantage: Very easy pressure-free writing because ink is thin.

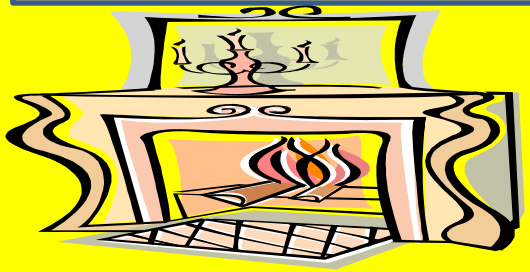
Limitation: More expensive than other common types.

Campfire in rock circle



Form and ***Function***
Smoky, burning wood fire contained by rock circle for *heat and cooking.*

Fireplace with iron tools



Form and ***Function*** Wood-burning fire in a stone or brick arched area *for containment* with a chimney *for smoke*.

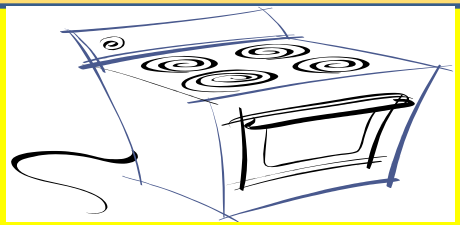
Pot-bellied or cast-iron stove

Form and ***Function*** Cast-iron container *to radiate heat* with a flat top *for cooking* attached to chimney or stove pipe *for smoke.*

Gas stove with burners

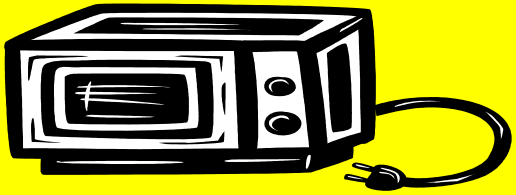
Form and ***Function*** Metal stove attached to gas line or gas cylinder for *fuel*. Burners on top *direct fire to bottom of pans.*

Electric stove with elements



Form and ***Function*** Stove with electric wiring; *for smokeless and flameless fuel*; coiled elements *deliver heat without flame.*

Microwave oven



Form and ***Function***
A box-like oven *protects people from microwaves*; Microwaves excite water molecules *to produce heat.*

Cooking

Advantage: Simple to construct from natural materials.

Limitation: Smoky and difficult to control – may send out sparks.

Cooking

Advantage: Part of a house – provides heat to home. Contained on three sides and use screen to stop sparks.

Limitation: Smoky at times.

Cooking

Advantage: Fire is contained, much less smoke; top surface for cooking; heats home.

Limitation: Must start fire and load with wood.

Cooking

Advantage: can light with a match. Easy to turn on and off. No need to gather fuel. No smoke.

Limitation: Hot surfaces; can burn food easily, may start a fire.

Cooking

Advantage: can easily start and stop; less danger of fire.

Limitation: Fire danger if elements are left on.

Cooking

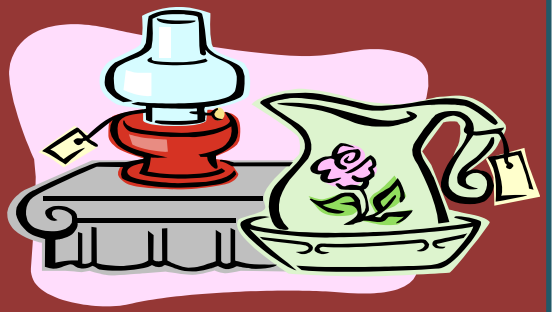
Advantage: Food cooks much faster; cold food can be easily re-heated. Timer system shuts heat source off so less fire danger.

Limitation: Cannot use metal food containers.

Wash soil in stream

Form and ***Function***
Natural outdoor stream with cold rushing current so that *water washes away dirt.*

Sponge bath using pottery basin



Form and ***Function*** Cold water from pitcher poured in basin *for washing indoors in privacy.*

Hand-pump water to sink for washing

Form and ***Function*** Water pumped from well by hand, heated on stove and used in bathtub *for warm washing*.

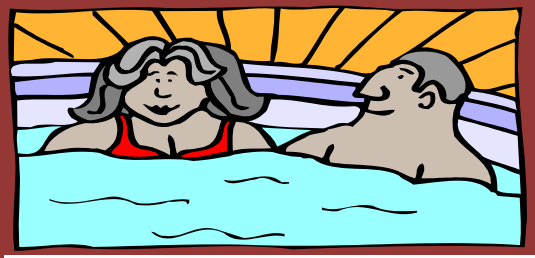
Bathtub filled with cold running water

Form and ***Function*** Cold water flows from tap. Extra water must be heated on stove *to adjust the temperature.*

Bathtub filled from hot water heater.

Form and ***Function*** Both cold and hot (from hot water heater) flow from tap for *hot baths.*

Built-in whirlpool bath or hot tub



Form and ***Function***
Warm water and whirlpool action *clean the body and sooth sore muscles.*

Bathing

Advantage: Stream water is often readily available without preparation.

Limitation Little privacy, no soap, water is cold.

Bathing

Advantage: Washing can be done in privacy.

Limitation: Must fill and empty pitcher and basin. Generally the water is cold.

Bathing

Advantage: Water heated on the stove makes the bath warmer.

Limitation: Must fill and empty heavy tub of water.

Bathing

Advantage: : Cold running water requires little effort to fill and drain tub.

Limitation: Warm water must still be heated on the stove.

Bathing

Advantage: Both hot and cold running water and easy to drain tub.

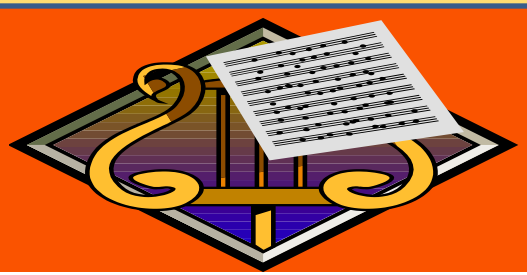
Limitation: No way to create wave action.

Bathing

Advantage: Warm wave action soothes and cleanses the body.

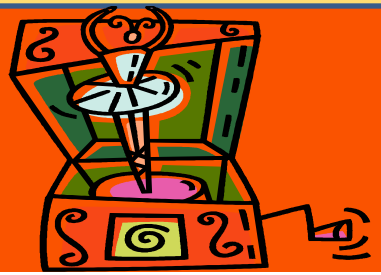
Limitation: Uses a lot of water and energy.

Sheet music



Form and ***Function*** Symbols on parchment or paper *interpreted* and *played using musical instruments.*

Mechanical music box

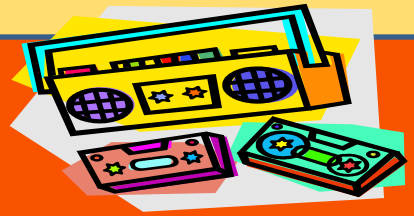


Form and ***Function*** A cylindrical rotating drum with small metal nubs *play a repeating melody on larger musical prongs.*

Phonograph records

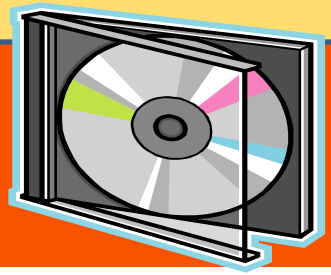
Form and ***Function*** A plastic disk with a long spiraling groove *that vibrates a needle riding along the groove to produce music.*

Magnetic tape



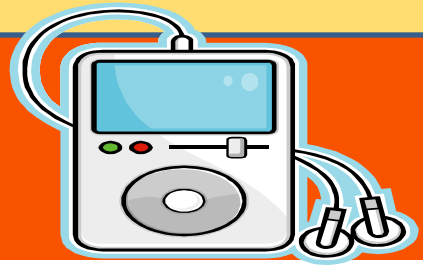
Form and ***Function*** A long plastic, iron-coated tape passes by an electromagnet and *is altered by a field caused by sound waves vibrating a wire coil on the magnet.*

Compact disk



Form and ***Function*** A thin disk of polycarbonate plastic impressed with bumps on a long spiral track is *read by a laser and converted to music.*

iPod



Form and ***Function*** Music is stored as information on a computer chip and *converted to music through a player.*

Storage of Music

Advantage: Can obtain a wide variety; easy to store.

Limitation: Must know how to read music and play an instrument. Must have an instrument available.

Storage of Music

Advantage: Anyone can play and replay.

Limitation: The music is always played by one type of musical instrument.

Storage of Music

Advantage: Plays all varieties of music. Can change records to hear different tunes.

Limitation: Must have a studio to record. Player cannot be moved while playing.

Storage of Music

Advantage: Highly portable instant recording/ playback and erasing.

Limitation: Wears out and breaks easily, especially if exposed to heat.

Storage of Music

Advantage: High-quality recordings last a long time.

Limitation: A large collection takes up a lot of space.

Storage of Music

Advantage: Thousands of recordings stored in small space.

Limitation: Listening to loud music through ear buds may damage hearing.

Observe cloud patterns

Form and ***Function***
People watch cloud patterns and *recall the weather than usually follows.*

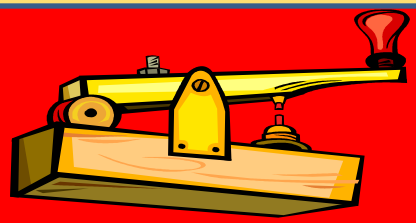
Kites used to obtain information

Form and ***Function*** A kite floats to the upper atmosphere *to collect information to help predict the weather.*

Weather balloons

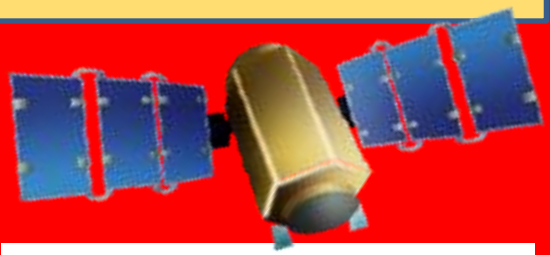
Form and ***Function*** A weather balloon floats to the upper atmosphere *to collect information to predict weather.*

Telegraph info from upwind areas



Form and ***Function*** A telegraph brings information from upwind areas *to help people see what is coming.*

Weather satellites



Form and ***Function*** Satellites take wide-range photographs and collect temperature information *to help predict the weather.*

Computer modeling of weather data

Form and ***Function***
Computer programs *synthesize data to make statistically valid predictions.*

Weather Forecasting

Advantage: Can perform without equipment.

Limitation: Relies on memory; not very accurate.

Weather Forecasting

Advantage: Can sample air from higher levels.

Limitation: Dangerous during storms; hard to control.

Weather Forecasting

Advantage: Can go quite high and carry equipment for measurements.

Limitation: Only samples air in one locality.

Weather Forecasting

Advantage: Can determine the weather that is moving toward an area.

Limitation: Harder to predict long-range weather.

Weather Forecasting

Advantage: Photographs and temperature maps of large areas produced.

Limitation: Expensive.

Weather Forecasting

Advantage: Information is integrated and more accurate.

Limitation: Weather is complex and difficult to model.

Card Set # 5

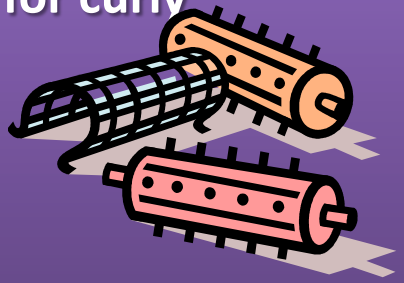
Predecessors of Innovations

Preparation: These are one-sided cards that should be cut apart and mixed before being given to the student. The first page shows heading cards that should be used at the top of each column. A small group of students should be given this complete set or half of it. Therefore, depending upon class size, several sets will need to be made.

Directions for Student Work: Students should work in pairs or small groups of no more than four members. Students' task is to form a chart-like layout with the cards in each row arranged as shown in the sets here. The order of the rows is not important. Students should use the heading cards to form the columns of the layout.

Predecessor	New Innovation	Improvements
Sweeping the rug clean with a broom 	Shampooing the rug with a rug cleaner 	Dissolves dried-on dirt Vacuums and sucks dirt away Removes odors No dust left
Heating home with fireplace 	Heating home with furnace 	Cleaner, no ash, smoke Less work No need to gather wood Can easily adjust temperature

Using hair rollers for curly hair



Using a curling iron for curly hair

Faster
Easier
Can re-curl parts that are not curly enough

Candles for lighting

Electric fluorescent lighting

Instant on and off
More light
Cool
Little fire danger

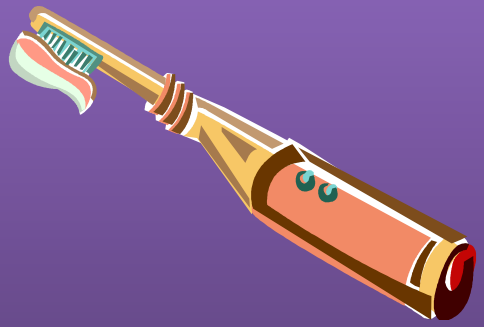
Wild Strawberries

Huge Strawberries selectively bred

Much larger
Firm when ripe
Sweet-tasting
Last longer without rotting

Simple manual toothbrush

Electric Toothbrush



More brush strokes
Variable angle
Easier to use because hand does not tire

Home Remedy for Illness

Prescription Medicine

Powerful antibiotics kill germs
Designed to target specific ailments

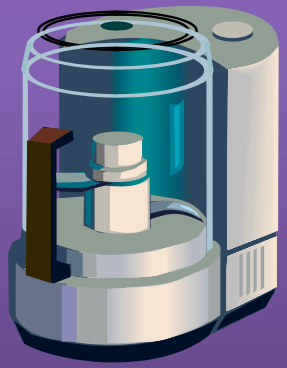
Paper Grocery Bag

Re-usable Fabric Bag

Does not require cutting trees
Reusable
Stronger and more durable
Has carrying handles
More colorful
Washable

Metal grater for food shredding

Electric Food Processor



Less work for cook
Can chop to desired sizes
All food bits are contained none falling elsewhere
Less risk of cutting fingers

Mixing with a spoon

Electric Mixer

Faster
Easier
Mixes smoother
Whips in more air

Sending trash to a landfill

Recycling plastics, metal, paper

Less wasteful
Saves energy
Does not take up land space
Less pollution of groundwater

Card Set # 6

Two-sided Animal Form and *Function* Cards with One-sided Cards of Analogous Manufactured Items

Preparation: There are 6 different sets here; one for each of the following animals: alligator, beaver, bluebird, owl, whale, and wolf. The animal cards are two-sided. Glue the card front from the left-hand column to the front of a piece of cardboard and the back side of the card, shown in the right-hand column, to the back of the cardboard. The manufactured object cards are one-sided and should also be glued to cardboard.

Directions for Student Work: Students should work in pairs or small groups of no more than four members. Students' task is to match the front of each animal card to the analogous object card that has the same form and function. After these have been paired, the work can be checked by turning the animal cards over and reading the backs of the cards.

An alligator's tail is wide and strong. When an alligator swims it uses its tail *to push* itself through the water.

Boat Oar

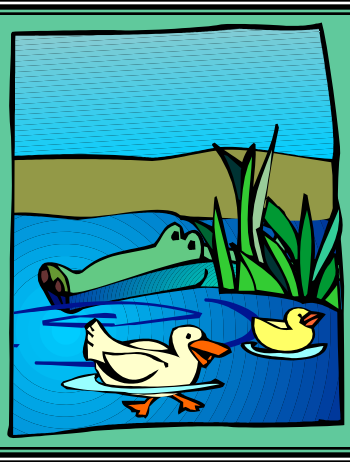
The boat oar is wide and strong and is used to *push through* water to move a boat. Similarly, the alligator uses its wide, strong tail for pushing it through the water.

An alligator's skin is colored brown, tan, and green *to help it blend into its environment*.

Camouflage Vehicle

Military vehicles, are colored brown, tan, and green *to blend into the environment*. Similarly, an alligator's brown, tan, and green colorings blend into its marshy environment.

An alligator has wide flared nostrils that sit above water *to help with breathing* while hiding under water.



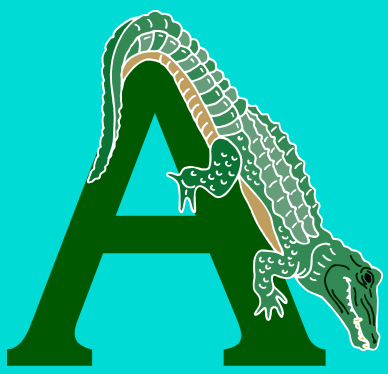
Snorkel

A snorkel is a wide tube that has an opening that sits above water. People use the snorkel *for breathing* while under water. Similarly, an alligator has wide, flared nostrils that sit above water to allow the alligator to breath while submerged.

An alligator bellows and growls *to communicate* with other alligators.

Door Bell

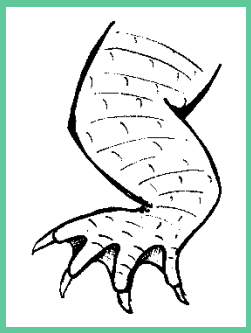
A door bell is pushed to make a noise *to signal that a person would like to talk.* Similarly, an alligator growls, bellows, or hisses to signal other alligators of danger, or as a sign of being frightened.



An alligator has a powerful jaw that snaps down quickly *to capture or pinch* its prey.

Binder Clip

A binder clip has a powerful wire hinge that snaps down quickly *to capture* a set of papers and *pinch* them together. Similarly, the powerful jaw of an alligator will snap down quickly to capture prey.



An alligator's webbed hind feet *allow it to maneuver in the water*.

Flippers

Divers wear flippers that are webbed to help them *maneuver in the water*. Similarly, the webbed hind feet of an alligator push against water for maneuvering.

Alligators have sharp canine teeth *for puncturing and gripping food.*

Soda Can Opener

A can opener is sharp for gripping and puncturing the can. Similarly, an alligator has sharp teeth for gripping prey and puncturing the prey to be swallowed easily.

An alligator has a flap in its throat called a glottis that opens and shuts *to let food in and out*.

Flap on Box

The flap on a box opens and shuts when we need to *put things in or take things out* of the box. Similarly, the flap in the alligator's throat opens and closes, depending on whether it is in the water or needing to swallow its food.

Each alligators' eye has a third eyelid that *covers the eyeball so the alligator can see while underwater*.

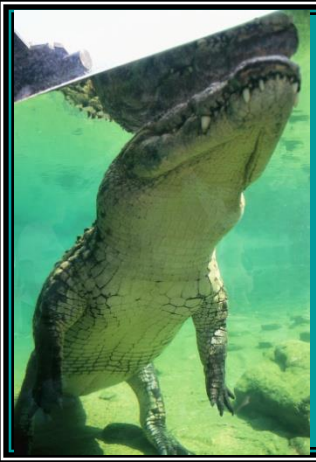
Goggles

Goggles are worn by swimmers to *protect their eyes and to allow vision underwater.* Similarly, the third eyelid covers an alligator's eye to protect its eyes while underwater waiting to catch its prey.

An alligator's ear has a movable flap that *closes to reduce water intrusion.*

Plug on an Inflatable Beach Ball

A plug on an inflatable beach ball keeps *air from escaping and water from getting in*. Similarly, the movable flap in alligators' ears allow them to reduce water intrusion while remaining underwater.



An alligator has smooth skin on its belly to *allow it to glide through the water*.

Inflatable Raft

The bottom of a raft has a smooth surface for *gliding through the water*. An alligator's smooth belly allows it to glide quietly through the water without friction or resistance. This enables the alligator to sneak up on its prey.

Alligators have a thick layer of skin to *prevent loss of fluid from the body.*

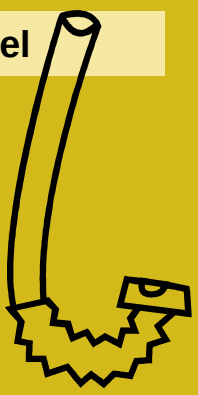
Diaper

Diapers have thick padding to *prevent liquid from leaking out*. Similarly, an alligator has thick dermal skin for the prevention of losing body fluid, which is needed to keep cool.

Object: Boat Oar

Object: Camouflage Vehicle

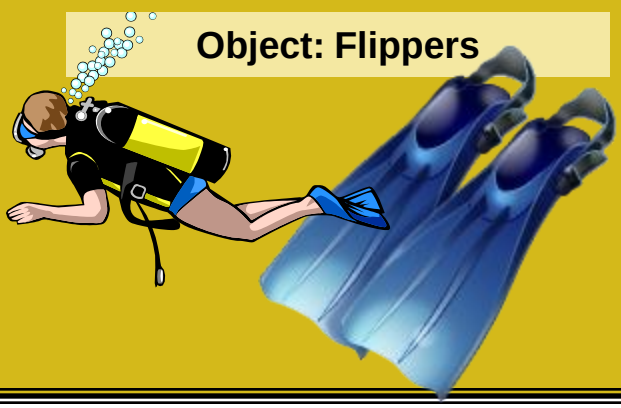
Object: Snorkel



Object: Doorbell

Object: Binder Clip

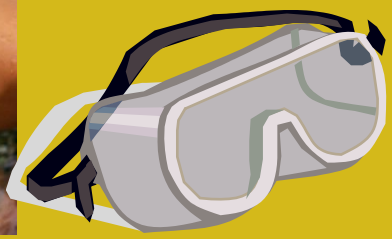
Object: Flippers



Object: Soda Can Opener

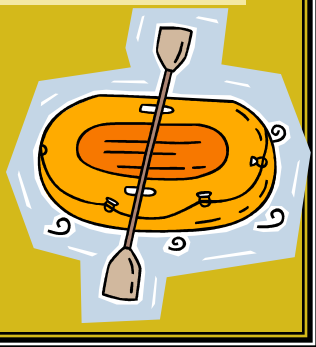
Object: Flaps on Box

Object: Goggles



Object: Plug on Beach Ball

Object: Inflatable Raft



Object: Diaper

Alligator

Form and Function Analogy Object Box

Designed by Lindsey Krohn

Edited by Dr. Audrey Rule

Assembled by _____

Alligator

Form and Function Analogy Object Box

Designed by Lindsey Krohn

Edited by Dr. Audrey Rule

Assembled by _____

Box or Bag Labels

Beavers have webbed feet with broad surfaces to *scoop up mud to put on their shelters.*

Shovel

A shovel is a tool with a broad surface *used to scoop up earth*. Similarly, beavers' feet are webbed to produce a broad surface. They are used like a shovel to scoop mud and place it on the beavers' shelters.

Beavers have large sharp front teeth to *cut* down trees and to *tear* off bark for food.

Hand Saw

A hand saw has large, sharp teeth *to cut and tear* through wood by a back and forth motion. Similarly, a beaver gnaws at a tree taking layer after layer of it off until the beaver cuts all the way through.

Beavers have large flat tails with which they *slap the water to create a loud noise* that warns of danger.

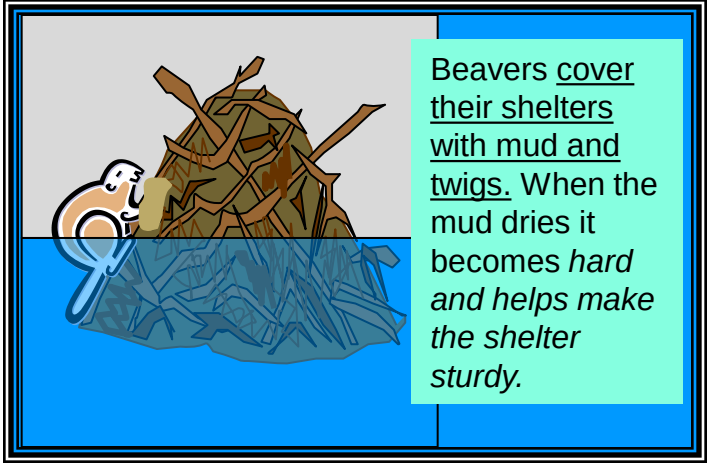
Cymbals

Cymbals are large flat, plate-shaped instruments *that are slapped together to make a loud noise*. Similarly, a beaver slaps its flat tail against the water making a loud sound which tells others of danger.

Beaver shelters are made of piles of logs and sticks stacked and woven together to make a sturdy framework for the beaver lodge.

Basket

A basket is made of many sticks that are woven together to produce a *strong framework.* Similarly, beavers weave sticks and logs together to make a sturdy framework for their lodges. Then they pack the lodge with mud to make it stronger and waterproof.



Beavers cover their shelters with mud and twigs. When the mud dries it becomes *hard and helps make the shelter sturdy.*

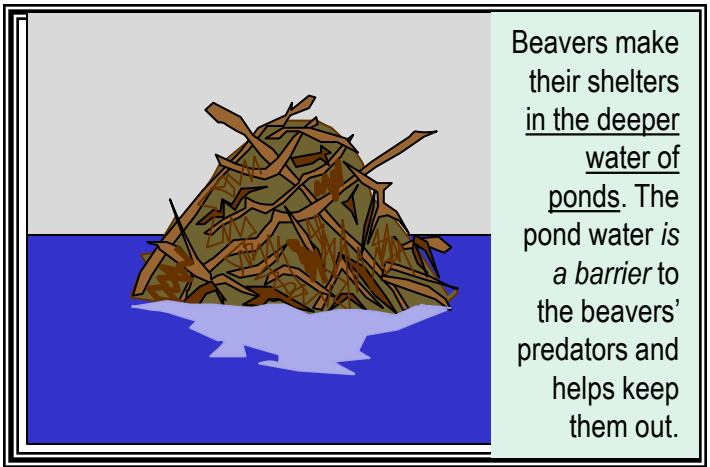
Primitive Mud Bricks

A primitive brick is a dried block of mud and grass (clay) which is used in the construction of buildings. In an adobe building, a layer of mud is smoothed over the brick wall to help hold the bricks together and to give a smooth surface. Similarly, the mud used on the outside of the beaver shelters becomes very hard and helps hold the lodge together.

A beaver's lodge is covered by a thick layer of mud and twigs. This layer *insulates* the lodge from the cold winter air and keeps the body heat generated by the beavers inside.

Insulation

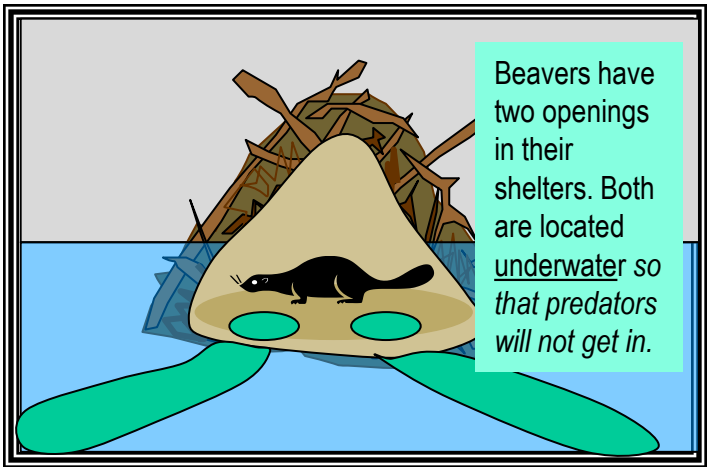
A layer of fiberglass insulation is used in the walls of buildings *to keep the cold outside and warmth inside*. The mud used on the walls of the beaver shelters insulates the beavers from the cold winter air and keeps air warmed by their bodies near them.



Beavers make their shelters in the deeper water of ponds. The pond water *is a barrier* to the beavers' predators and helps keep them out.

Castle Moat

Many castles are surrounded by a deep ditch filled with water - a moat. The moat *prevented enemies from entering* the castle. Similarly, a beaver builds a lodge in the middle of a pond to keep non-swimming predators out.

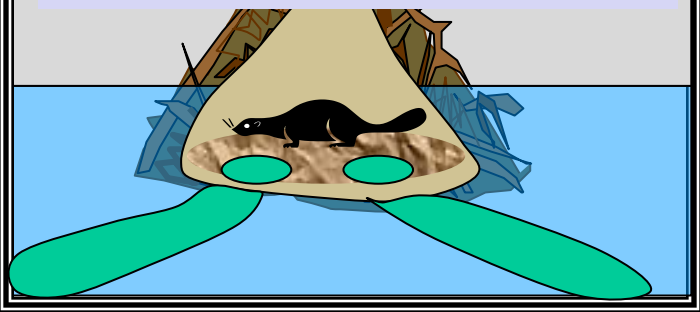


Beavers have two openings in their shelters. Both are located underwater *so that predators will not get in.*

Public Fountain Works

Many public fountains have doors to filters and pumps underwater *so that people will not disturb them.* Similarly, beavers make the entrances to their shelters underwater so that many predators that do not swim will not be able to get inside their homes.

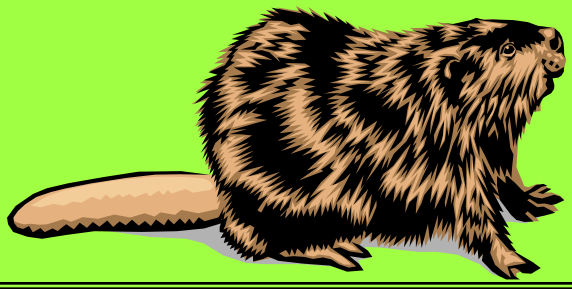
Beavers cover the floors of their shelters with small wood chips. *This keeps the interior from getting muddy and makes it more comfortable.*



Bark Mulch on a Playground

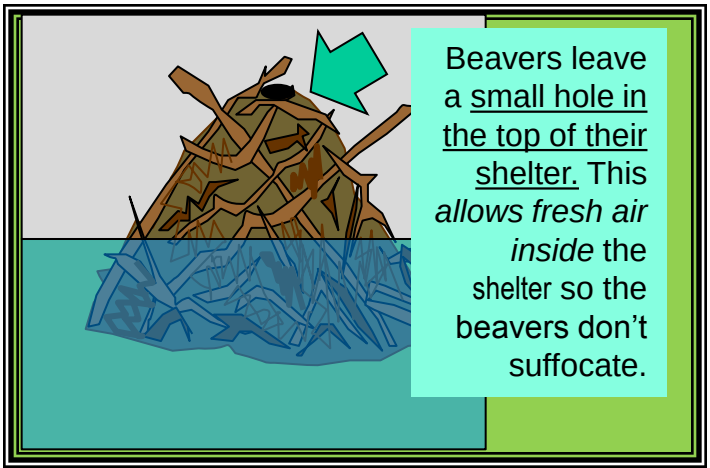
The ground around and under many outdoor playgrounds is covered with bark mulch. This layer of wood chips keeps the *ground from becoming muddy* in wet weather. Similarly, beavers cover the floors of their dens with wood chips to keep them from becoming muddy and to make them more comfortable.

Beavers have webbed feet that provide a broad surface for *effectively pushing against the water when swimming*.



Flippers

Swimmers often wear flippers on their feet to provide a broader foot surface for *effectively pushing against the water*. Similarly, beavers have webbed feet that effectively push against the water.

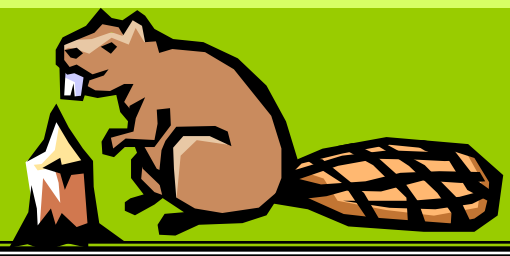


Beavers leave a small hole in the top of their shelter. This *allows fresh air inside* the shelter so the beavers don't suffocate.

Vent

Human dwellings have vents which *allow fresh air into* the house or apartment. A vent is a hole covered by a screen and often having a fan inside to draw air in or out. Bathrooms very often have vents. Similarly, a beavers' lodge has a small hole in the top to allow fresh air to circulate.

Beavers have long, sharp front teeth that never stop growing. Tooth growth generally keeps up with wear so *the beaver always has strong teeth for gnawing.*

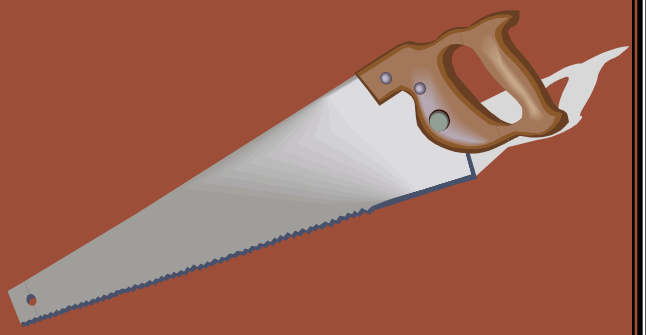


Hot Glue Gun

A hot glue dispenser takes long cylinders of glue and melts them for use in gluing things together. As the glue is used up, more long cylinders are added so that *there is always more glue to be melted*. Similarly, a beaver's teeth never stop growing. As the teeth are worn down, the beaver's body produces more tooth at the root so there are always teeth for gnawing.

Object: Shovel

Object: Hand Saw



Object: Cymbals

Object: Basket

Object: Mud Bricks

Object: Insulation

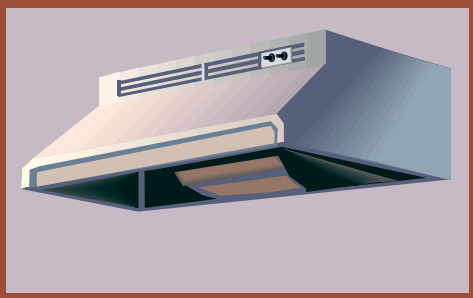
Object: Castle Moat

Object:
Public Fountain Works

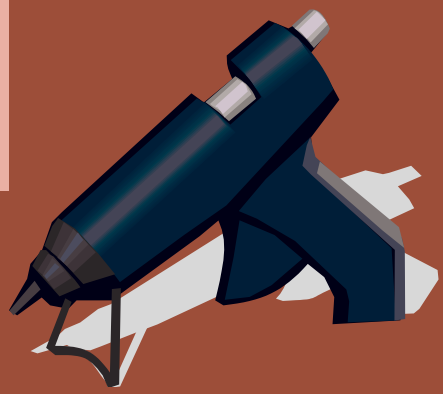
Object: Bark Mulch on Playground

Object: Flippers

Object: Vent



Object: Hot Glue Gun



Beaver

Form and Function Analogy Object Box

Designed by Kevin Shepherdson

Edited by Dr. Audrey Rule

Assembled by _____

Beaver

Form and Function Analogy Object Box

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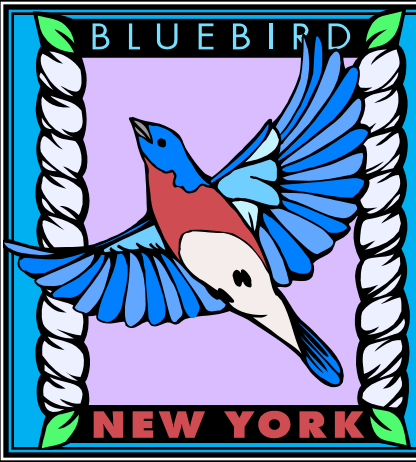
Assembled by _____

Box Labels



Bluebirds can position their tails at different tilts to *help control their movement as they fly.*

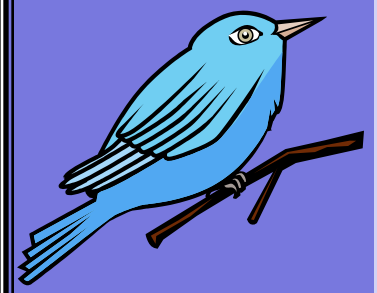
Rudder

Airplanes have a part called a rudder which can be positioned in different ways *to control the plane's movement.* Similarly, bluebirds can position their tails to help them as they fly.

The bluebird's feathers are oiled *to repel water so that birds can fly when it's raining*.

Raincoat

A raincoat is made of waterproof fabric to repel water so that the wearer can *go out in rainy weather and stay dry*. Similarly, the bluebird feathers repel water to help the bird stay dry when it is raining.



A bluebird's skeleton is made of lightweight, hollow bones that *support the body, without contributing excess weight.*

Bicycle Frame

Bicycle frames are made of lightweight, hollow cylinders that *provide the support without adding much weight.* This allows riders to travel more efficiently and quickly than walking. Similarly, bluebird skeletons have lightweight, hollow bones that provide the support necessary for flight.

Male bluebirds have bright blue plumage which *attracts* the female bluebird.

Advertisements

Many advertisements use bright colors and bold patterns to *attract* customers. Similarly, male bluebirds' bright plumage attracts female bluebirds.

The muscles in bluebird feet grip a branch when they are relaxed, so that *the bird doesn't tire of holding onto the branch*.

Clothespins

Clothespins are designed to grip the clothesline securely when the spring is relaxed, so that the *clothes are always held tightly in place*. Similarly, the muscles in a bird's feet are relaxed when they are in a position of gripping a branch.

A bluebird's beak is composed of an upper and lower part that can be pressed together to *clench worms and bugs* to take back to the nest.

Tongs

Tongs consist of two parts that are pressed together *to pick up objects*. Similarly, a bluebird can pick up worms and bugs with its beak.

Bluebirds make a raucous screech when they sense danger to *warn* other bluebirds or invaders.

Smoke Detector

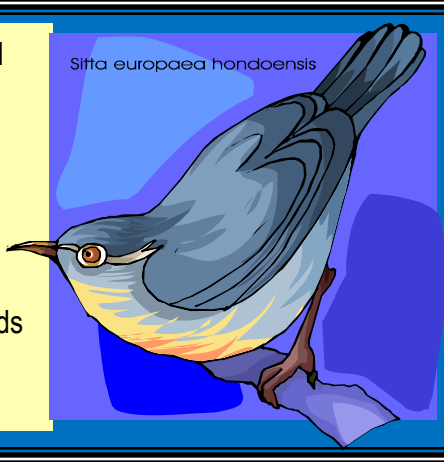
The smoke detector makes a raucous screech when in senses smoke to *warn* inhabitants of a home about danger of fire. Similarly, the bluebirds make a raucous screech when they sense danger to warn others.

Bluebird wings spread out to form thin, flat, broad surfaces that *enable the bird to fly quickly through the air*.

Airplane Wings

An airplane's wings are thin, flat, broad surfaces that *enable the aircraft to fly quickly through the air*. Similarly, bluebird wings spread out to enable the bird to fly through the air.

A female bluebird has a special marking - a white ring around each eye that distinguishes her from the males. This way, bluebirds *can tell each other's gender*.



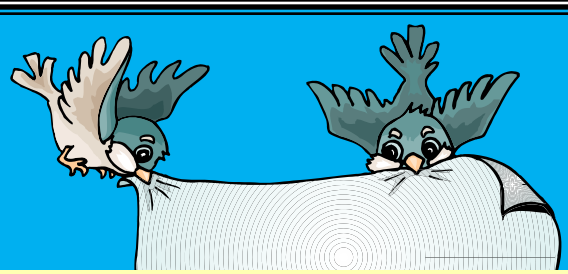
Restroom Signs

A ladies' restroom sign shows a special marking - the silhouette of a woman wearing a skirt. This way, people *can tell which gender* uses which restroom. Similarly, female bluebirds have different markings than male bluebirds.

Bluebird eggs are kept at a constant warm temperature in the nest *for necessary chemical changes* to help the baby bird grow.

Cookies

Cookie dough must be kept at a constant warm temperature in the oven *for the necessary chemical changes* to take place for cookies to bake. Similarly, eggs are kept at a constant temperature to aid chemical changes needed for growth.



The bluebird's small body size, wing shape, and flapping wing motion makes it one of the few birds that have the ability to hover *to look* for insects.

Rescue Helicopters

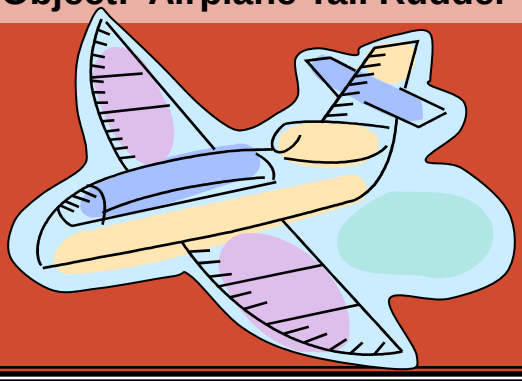
The helicopter's rotor blades allow it to hover to *look for* people who need to be rescued. Helicopters are one of the only flying machines that have the ability to hover. Similarly, bluebirds are able to hover to look for insects to eat.

A bluebird's nest is woven of grasses and twigs to *make a cup-shaped container for eggs.*

Woven Basket

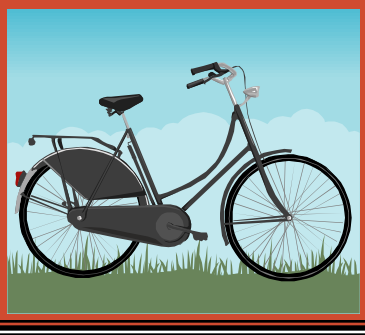
Most baskets are made from twigs, grasses and other natural materials that are woven into a *cup-shaped container*. Similarly, bluebirds gather natural materials from their environment to make their nests.

Object: Airplane Tail Rudder



Object: Raincoat

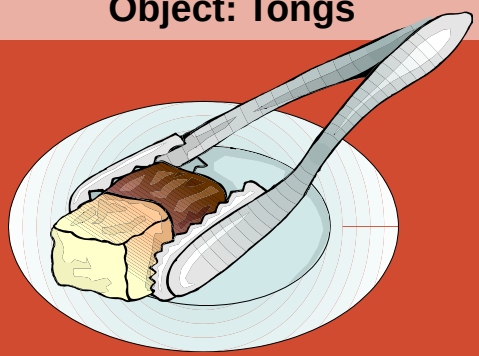
Object: Bicycle Frame



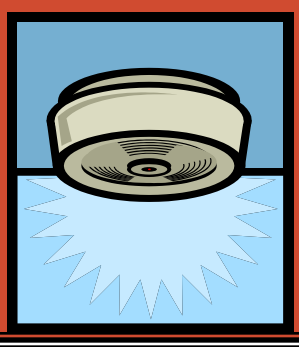
Object: Advertisement

Object: Clothespin

Object: Tongs



Object: Smoke Detector

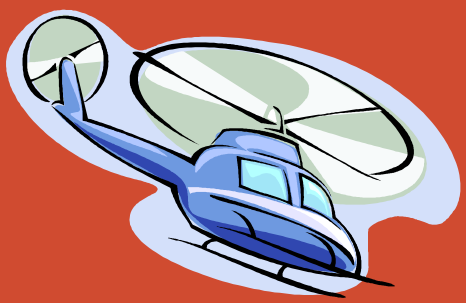


Object: Airplane Wing

Object: Restroom Sign

Object: Cookies

Object: Helicopter



Object: Woven Basket

Bluebird

Form and Function Analogy Object Box

Designed by Christine Morgan

Edited by Dr. Audrey Rule

Assembled by _____

Bluebird

Form and Function Analogy Object Box

Designed by Christine Morgan

Edited by Dr. Audrey Rule

Assembled by _____

Box Labels

Owls have very sharp and well-focused eyesight that *helps owls see* their prey in the dark.

Binoculars

The binoculars make images of things far away sharper and better focused so that they are *easier to see*. Similarly, the eyesight of an owl is sharp to help them see their prey better at night.

The neck joint allows the owl's head to *rotate as much as 270 degrees*. This *enables owls to watch a moving object in all directions* without moving the whole body.

Oscillating Fan

An oscillating fan has a swivel joint that allows the fan to *rotate about 270 degrees* to blow air in all directions of a room. Similarly, an owl is able to move it's neck 270 degrees to search all areas.

When the wings of an owl are open, they have a wide, broad surface that *pushes against the air* to help with flight.

Hand Held Fan

When a hand held fan is open, it creates a wide, broad surface that *pushes air* to cool people. Similarly, the wide, broad surface of an owl's wings allows the owl to glide through the sky by pushing against the air.

Facial disks are round, cupped surfaces around the eyes of an owl. They are designed to help an owl to hear better by *bouncing sound waves into the ear.*

Cupping Hand Around Ear

A person can hear better if the person cups his/her hand around the outer ear. Sound waves are gathered by the round surface of the cupped hand and *bounced into the ear.* Similarly, the facial disks on an owl help to make sound louder by bouncing sound into the owl's ears.

Many owls have ear tufts of long feathers that can be *moved or positioned to show whether they are excited, angry, or frightened.*

Cheerleader Pompom

Cheerleader pompoms are bundles of long fibers that are *waved to show emotion* to others. Similarly, the ear tufts on an owl are long and can be positioned to show the mood of an owl.

Owls have body coverings of feathers with fibers that trap air next to the body and repel rain to allow them to adapt to weather.

Coat

Coats have fibers that trap air next to the body and repel rain to *allow the wearer to endure different types of weather*. Similarly, feathers on an owl protect it in different types of weather. Short feathers keep out extreme heat and cold, and long feathers repel rain.

Owls have curved claws that encircle a branch to allow the bird *to securely hold on* and perch.

Padlock

A padlock has a curved bar or shackle that encircles a hasp or ring to securely hold on. Similarly, the claws of an owl encircle a branch to grip to perch securely and not fall off.

Some owls are out during the day, but most owls are active at night (nocturnal). Their sharp eyesight and hearing help them to *sneak up on prey in the dark.*

Police Officer

Many police officers are active at night to prevent to crime during late hours. Police officers sometimes *conceal themselves in dark places to catch criminals.* Similarly, because owls are nocturnal (sleep during the day and active during the night), they can use their super senses to help them sneak up on and catch prey.

The feathers on an owl are soft and downy. They are used to *muffle air flow* and create almost silent flight.

Ear Plugs

Ear plugs are made of a soft rubber that *absorbs sound waves.* They are used to muffle loud sounds. Similarly, the feathers on an owl help to muffle sound when hunting for prey at night. Owls rely on silent flight to sneak up on prey.

The feathers on an owl are multicolored (brown, black, tan, gray, white). Their colors help them to *blend in* with leaves, branches, and trees.

Camouflage Clothing

Camouflage is a cloth pattern that military people wear. It is multicolored (green, tan, brown, and black) to help them *blend in* with trees, leaves, and bushes. Similarly, the various colors on an owl help them to blend in with their surroundings when hiding from their enemies.

The talons on an owl are curved, thin, and sharp. They are used to *grip and pierce their prey*.

Hair Claw

A hair claw is curved, thin, and sharp. It *grips into hair* to hold it in place. Similarly, owls use their talons to grip and pierce into their prey.

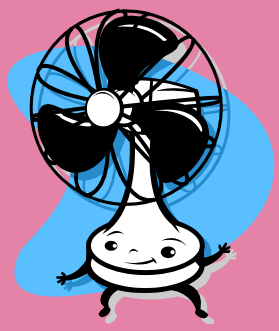
The beak on an owl is long and hooked. It is used to *poke and grab bits from its prey* prior to swallowing.

Crochet Needle

A crochet needle is long and hooked to *poke and grab* yarn when crocheting. Similarly, the beak on an owl is long and hooked to poke and grab at its prey.

Object: Binoculars

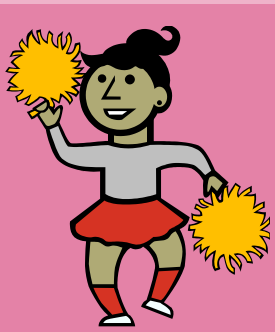
Object: Oscillating Fan

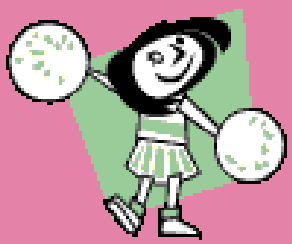


Object: Hand-Held Fan

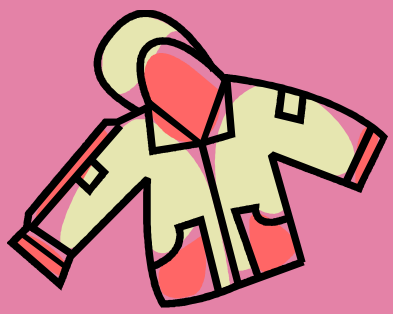
Object: Cupping Hand to Ear

Object: Cheerleader Pompom





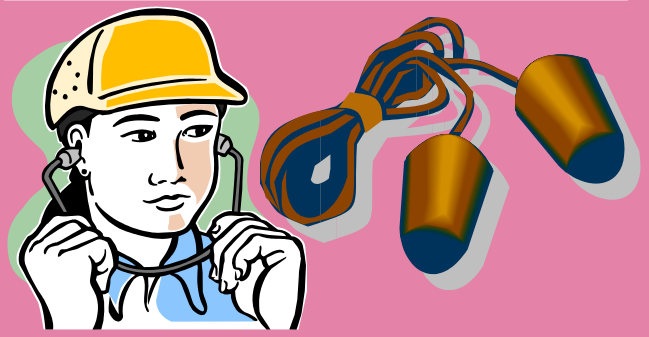
Object: Coat



Object: Padlock

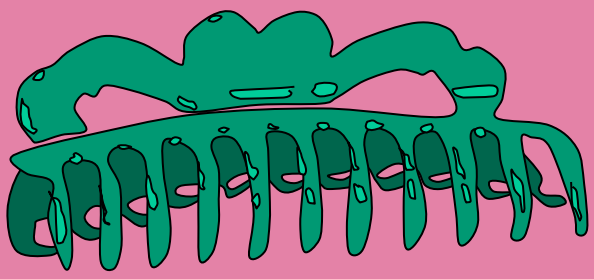
Object: Police Officer

Object: Ear Plugs

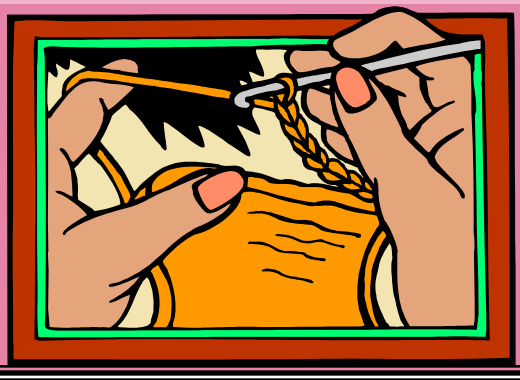


Object: Camouflage Clothing

Object: Hair Claw



Object: Crochet Needle



Owl

Form and Function Analogy Object Box

Designed by Heidi Seely

Edited by Dr. Audrey Rule

Assembled by _____

Owl

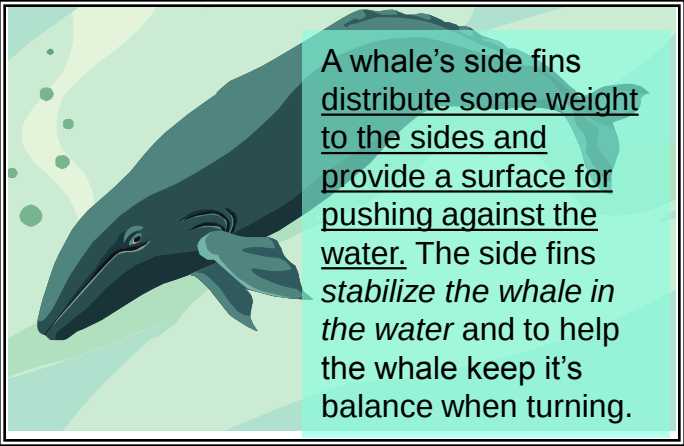
Form and Function Analogy Object Box

Designed by Heidi Seely

Edited by Dr. Audrey Rule

Assembled by _____

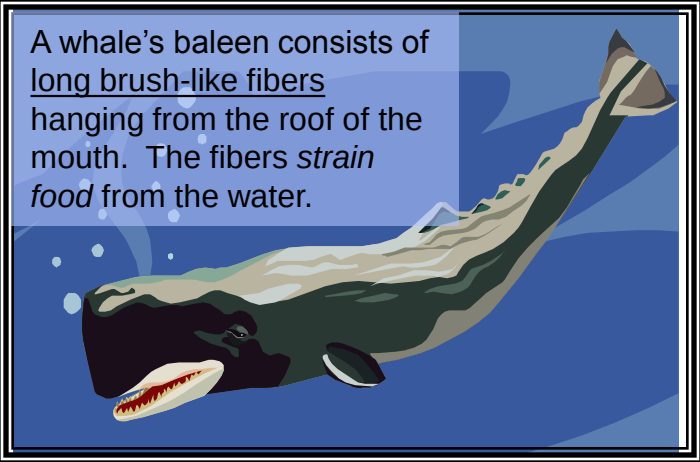
Box Labels



A whale's side fins distribute some weight to the sides and provide a surface for pushing against the water. The side fins *stabilize the whale in the water* and to help the whale keep it's balance when turning.

Bicycle Training Wheels

Training wheels on a bicycle *help a child balance the bike*. The wheels distribute some of the weight farther from the central axis and provide extra surfaces for balancing the bike on the road. Similarly, a whale has side fins to stabilize it in the water.



A whale's baleen consists of long brush-like fibers hanging from the roof of the mouth. The fibers *strain food* from the water.

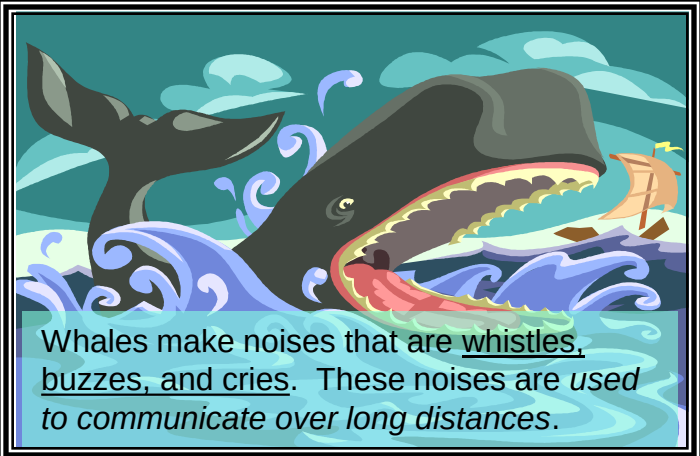
Push Broom

A push broom has a brush made of long stiff fibers. These fibers *trap and push dirt* ahead of the broom. They allow air to pass through the bristles, but dirt cannot. Similarly, the baleen fibers trap krill and other foods while water passes through.

Whales of the same species travel and feed together in pods. Whales travel in groups to *socialize and for mutual protection.*

School Bus

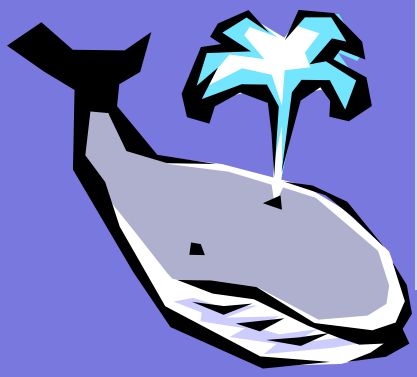
A bus is a form of transportation in which children travel the same route. Children ride a bus to *socialize and for mutual protection.* Similarly, whales travel together in the same group.



Whales make noises that are whistles, buzzes, and cries. These noises are *used to communicate over long distances*.

Whistle

People may use a whistle to *communicate with one another over a large crowd or long distances.* Similarly whales use a whistling sound to communicate with each other over long distances.



A whale's blowhole is a passage *through which air is expelled from the lungs and fresh air is drawn in.*

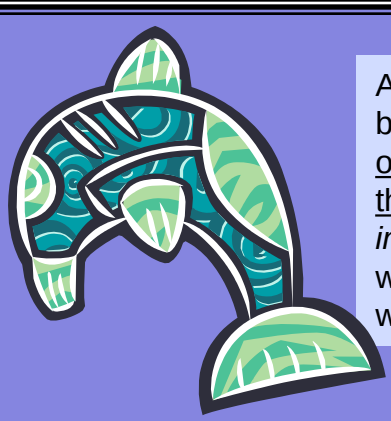
Snorkel

A snorkel is a passage *through which a swimmer can breath*. Similarly, a whale blows out and takes in air through the blowhole.

A whale holds food in its mouth until it can be swallowed. The baleen *prevents food from escaping.*

Cage

A cage has bars that *prevent small animals from escaping*. Similarly, a whale's baleen holds food in the mouth until it can be swallowed.



A whale has blubber, a layer of fat just below the skin, that *insulates* the whale to keep it warm.

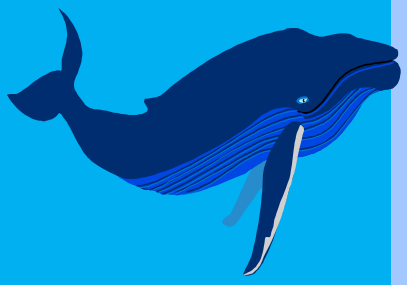
Jacket

A jacket is a layer of different materials that hold pockets of air next to the body for *insulation*, keeping a person warm in cold weather. Similarly, a whale has a thick layer of blubber just below the skin to insulate its body.

A whale is a mammal. It has mammary glands that contain milk and teats *to feed to the young*.

Milk Bottle

Milk bottles contain milk and have nipples *to feed young children*. Similarly, whales have mammary glands that contain milk and teats for feeding their young.



A whale's eye is small compared to its body size, *but receives light for excellent eyesight*.

Camera

A camera has a very small aperture, *but can produce a clear picture with the light it receives*. Similarly, a whales eye is small but allows for excellent eyesight.

A whale has pleats of folded skin from chin to belly. These pleats *expand* when a whale gulps in water and contract as the wale expels it.

Bellows

Bellows is a device for producing strong air currents that consists of a pleated chamber that *expands and compresses* to force air out through a hole. Similarly, a whale's underside expands as the whale takes in a large volume of water.

Barnacles often hitch-hike on whales. Barnacles are sea animals that secrete calcium carbonate *to permanently cement their shells* to the whale's skin.

Craft Glue

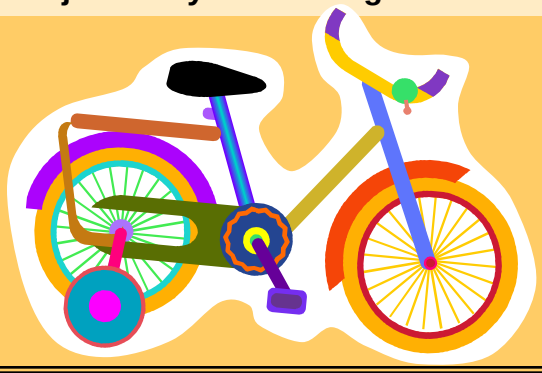
White craft glue is a sticky, fast-hardening substance that seeps into pores. *It can be used to permanently attach* paper items together. Similarly, barnacles secrete a substance to cement their shells to the whales' skin.

A whale's flukes are the tail. The tail is strong and moves up and down, not side to side like a fish's tail. The flukes *propel the whale* through the water.

Bicycle pedals

A bicycle's pedals are physically moved up and down *to propel the bike*. Similarly, the whale's flukes move up and down to enable a whales to move through the water.

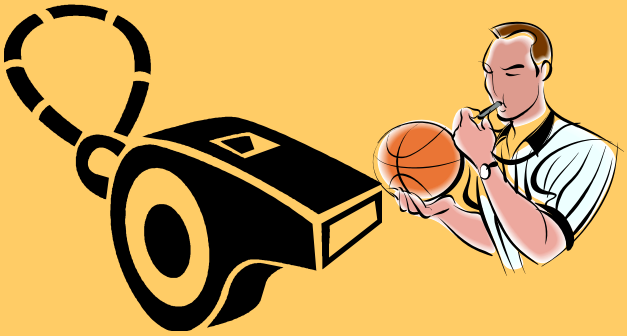
Object: Bicycle Training Wheels



Object: Push Broom

Object: Bus

Object: Whistle

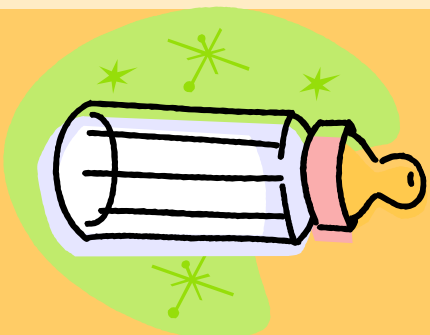


Object: Snorkel

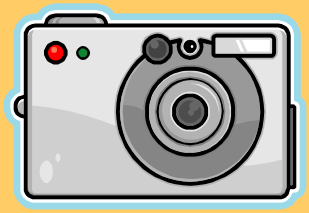
Object: Cage

Object: Jacket

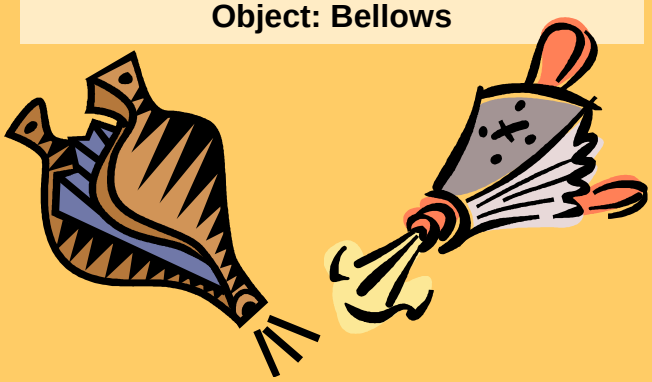
Object: Milk Bottle



Object: Camera



Object: Bellows



Object: Craft Glue

Object: Bicycle pedals

Whale

Form and Function Analogy Object Box

Designed by Lisa Carson

Edited by Dr. Audrey Rule

Assembled by _____

Whale

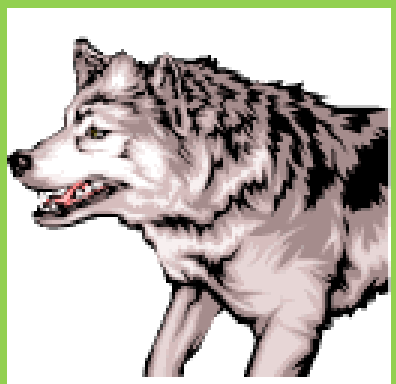
Form and Function Analogy Object Box

Designed by Lisa Carson

Edited by Dr. Audrey Rule

Assembled by _____

Box Labels



A wolf's undercoat is thick, soft, and dense. The undercoat *protects a wolf's skin from extreme heat and cold*.

Potholder

A potholder is thick, soft, and dense. It is designed to *protect a person's hand* from extreme heat. Similarly, the thick, soft, and dense undercoat of a wolf protects the wolf's skin.

A wolf's tail is long, somewhat flexible, and carried in different positions. A wolf uses its tail *to signal and communicate with others.*

CAUTION DO NOT ENTER Ribbon

A "Do Not Enter" ribbon is long, flexible, and can be positioned in different ways when it's used. The ribbon *communicates to people* that they should not cross into the marked area. Similarly, a wolf's long, flexible, tail can signal to another wolf not to trespass into its territory.

A wolf's den is typically completely enclosed with an opening on one side. The enclosed den is *a shelter for resting and a safe place for pups*.

Birdhouse

A birdhouse is completely enclosed with an opening on one side. A bird *uses a birdhouse as shelter for rest and from weather, and protection for young*. Similarly, a wolf's den is an enclosed space with one opening that is used as shelter for resting, from weather, and for protection of young.

Wolves have toenails that are small, pointed, cupped, and curved. They are used *to dig for prey or to dig holes* to bury things.

Small Garden Claw

A garden claw is small, pointed, cupped, and curved. People use small garden claw *to dig holes in their gardens* for planting. Similarly, wolves' toenails are small, pointed, cupped, and curved and are good for digging.

A wolf can run long distances at a high speed *to chase down its prey*.

Police Car

A police car travel long distances at high speeds *to chase down a speeding car*. Similarly, a wolf's ability to run long distances at high speed allows it to chase down prey to feed its pack.

A wolf's howl is a loud, high pitched noise *used to communicate* to other wolves, animals, and people.

Cell Phone

A cell phone makes a loud, high pitched noise *to communicate* with the cell phone's owner that there is an incoming call. Similarly, a wolf has a loud, high pitched howl that communicates with any wolves, animals, or people who can hear it.

Wolves use their sharp incisor teeth *to rip and tear* their food.

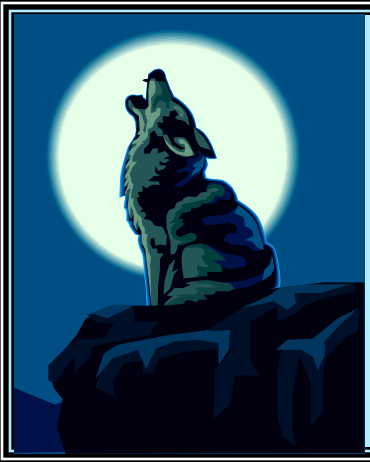
Fork and Knife

Forks and knives have sharp points and edges *to rip and tear* food for humans. Similarly, wolves use their sharp incisor teeth to rip and tear their food.

A wolf's topcoat is long and smooth. The topcoat *repels rain and snow to help keep the wolf dry.*

Rain Coat

Rain coats are long and smooth. They *repel rain and snow to help keep people dry.* Similarly, the long and smooth topcoat of a wolf repels rain and snow to help keep the wolf dry.



Wolves have cupped ears that point upward and move to gather sound waves. They also use the position of their ears to communicate to other wolves.

Satellite Dish

A satellite dish is cup-shaped, points towards the sky, and moves *to gather waves.* A satellite dish then communicates the signal it receives to a television set. Similarly a wolf's ears are cupped to gather sound waves.

A wolf has a nose with such a keen sense of smell that it can *detect* its prey up to a mile and a half away!

Smoke Detector

A smoke detector's sensory system is so keen it *can detect* smoke in a burning house early enough for everyone to get out to safety. A smoke detector senses smoke in much the same way a wolf can smell its prey.

Wolves live in groups called packs. A pack usually consists of 4 to 7 members. *The members of a pack work together to solve problems such as getting food.*

Tool Set

A tool set consists of several different tools that are used together *to solve household problems*. Similarly, a wolf pack has members that work together to solve their problems of providing food and caring for the young.

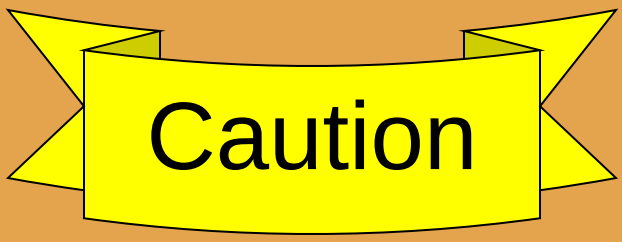
Wolves use their long, flexible, wet tongues *to lick liquids and dirt* from their faces and to clean their pups.

Washcloth

A wet washcloth has a large, flexible surface and is used *to clean food and liquids from the face*. Similarly, wolves will use their tongues to clean the dirt off of themselves and their pups.

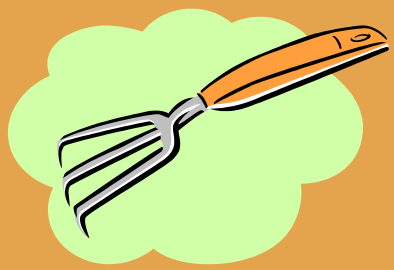
Object: Potholder

Object:
Caution Do Not Enter Ribbon



Object: Birdhouse

Object: Garden Claw



Object: Police Car

Object: Cell Phone

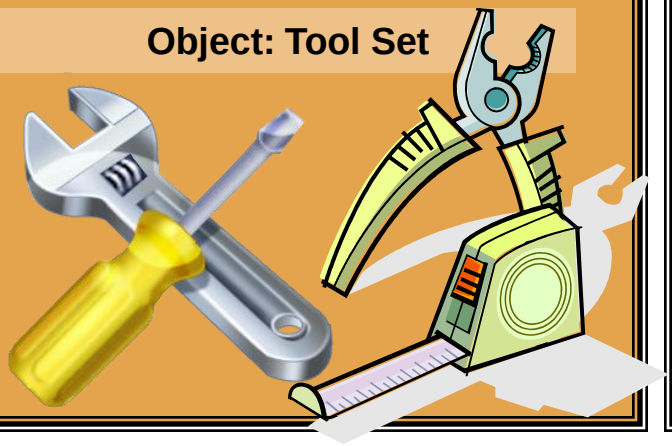
Object: Fork & Knife

Object: Raincoat

Object: Satellite Dish

Object: Smoke Detector

Object: Tool Set



Object: Washcloth

Wolf

Form and Function Analogy Object Box

Designed by Mickie Barrett

Edited by Dr. Audrey Rule

Assembled by _____

Wolf

Form and Function Analogy Object Box

Designed by Mickie Barrett

Edited by Dr. Audrey Rule

Assembled by _____

Box Labels

Card Set # 7

Form and Function Inspirational Ideas for New Products

Preparation: These are one-sided cards that should be cut apart and mixed before being given to the student. The first page shows heading cards that should be used at the top of each column. A small group of students should be given this complete set or half of it. Therefore, depending upon class size, several sets will need to be made.

Directions for Student Work: Students should work in pairs or small groups of no more than four members. Students' task is to form a chart-like layout with the cards in each row arranged as shown in the sets here. The order of the rows is not important. Students should use the heading cards to form the columns of the layout.

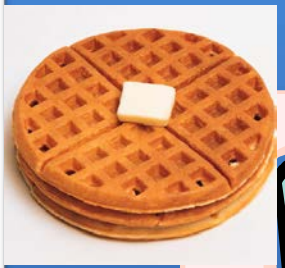
Inspirational Idea

Form and Function

Inventor

New Product

Inspirational Idea



A waffle iron *produces a pattern* of squares as the batter cooks.

Form and Function

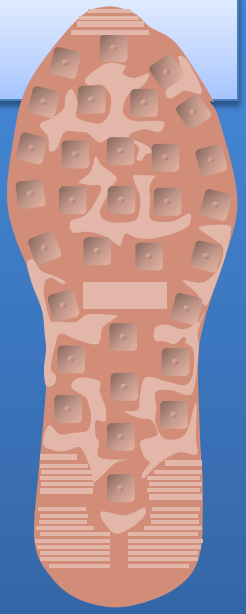
A liquid fills square holes in a mold to *produce a square pattern*.

Inventor

Oregon Coach **Bill Bowerman** who wanted his track athletes to perform better. He co-founded Nike.

New Product

Rubber was poured into a mold to make a **waffle-soled shoe**. This sole *allowed athletes better traction and cushioning*.



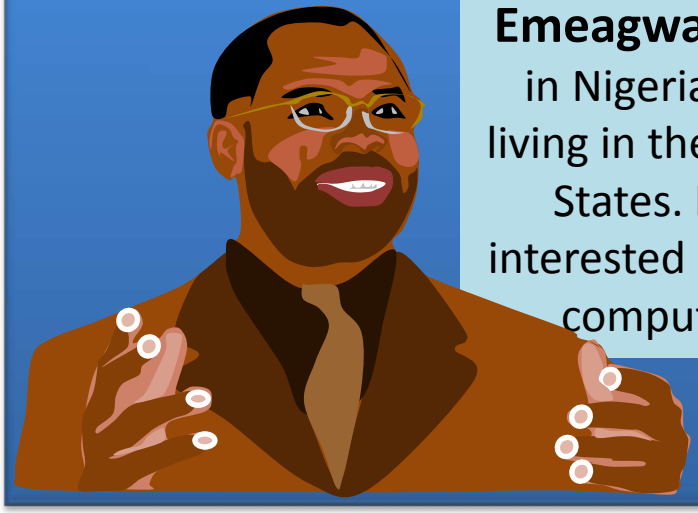
Inspirational Idea

Thinking about how many things in nature are spherical, including the Earth.

Form and Function

Points on the surface of a sphere are all *equally-distant* from the center.

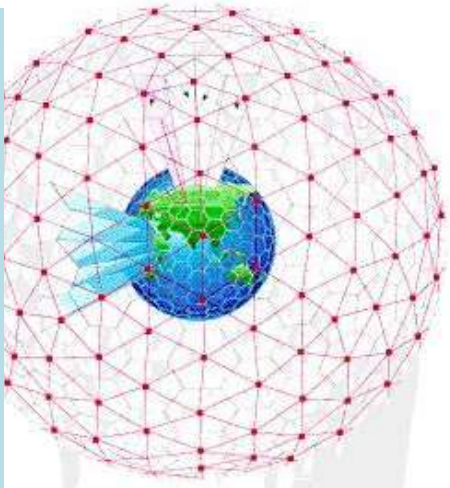
Inventor



Dr. Philip Emeagwali, born in Nigeria, now living in the United States. He is interested in super computers.

New Product

Hyperball computer with numerous processing nodes that are spherically connected to calculate global warming effects.



Inspirational Idea

Images and letters on coins were made by pressing a die (metal stamper) into the metal. Could this idea be applied to making letters on paper?

Form and Function

The shape of a die (a metal stamper) is produced on a flat surface by stamping.

Inventor

German printer **Johannes Gutenberg** was interested in printing papers and books more quickly.

New Product

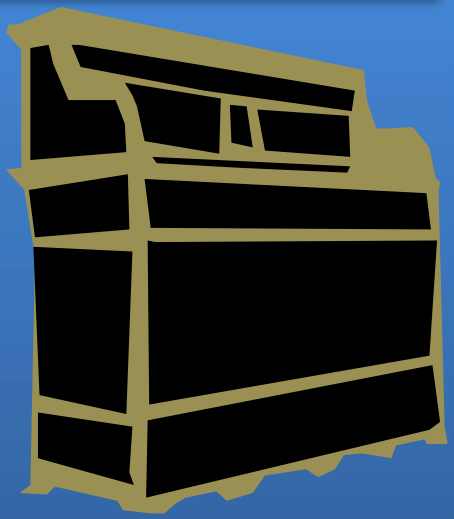
The **printing press** had metal letters that could be arranged to form words. These were inked and *pressed onto the paper to make many copies*.

Inspirational Idea

People in small apartments in New York City need compact furniture *to make the best use of the space.*

Form and Function

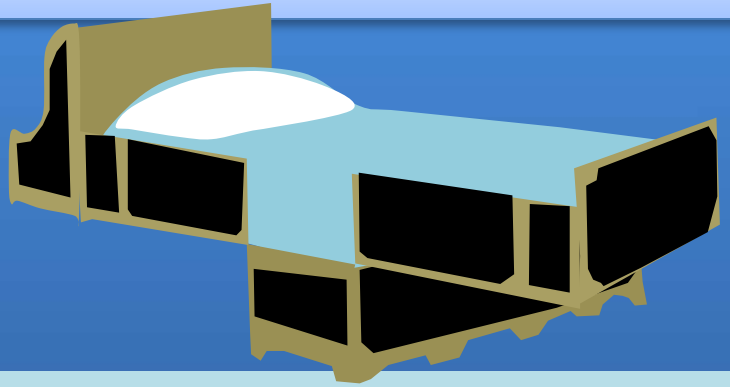
Hinges in the furniture *allow* a bed *to be folded* into a writing desk *to make the best use of limited space.*



Inventor

Sarah E. Goode was a former slave and the first African-American woman to hold a U.S. patent.

New Product



Folding Cabinet Bed, U.S. Patent Number 322,177; issued July 14, 1885

Inspirational Idea

As steam builds inside the pot, the lid *vibrates with the pressure*.

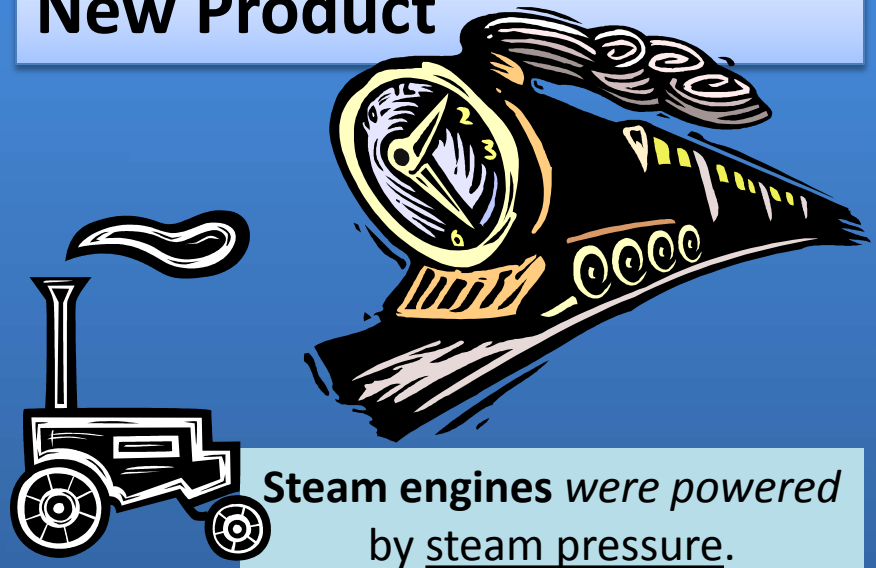
Form and Function

Steam produced by hot liquid takes up more space and *produces pressure*.

Inventor

Scottish Mechanical Engineer **James Watt** was fascinated with steam.

New Product



Steam engines *were powered* by steam pressure.

Inspirational Idea

A customer complained that the French fries were too thick. As a joke, Chef Crum cut the potatoes *so thin they could not be eaten with a fork.*

Form and Function

The thin, crispy potato chips *crunched in a pleasing manner.* Customers loved them.

Inventor

George Crum was a Native American/ African-American chef at a restaurant in Saratoga Springs, NY in 1853.

New Product

Potato chips were thin and crispy to *delight customers with a new snack.*

Inspirational Idea

A coiled loop of a flexible garden reminded the inventor of a *wheel*.

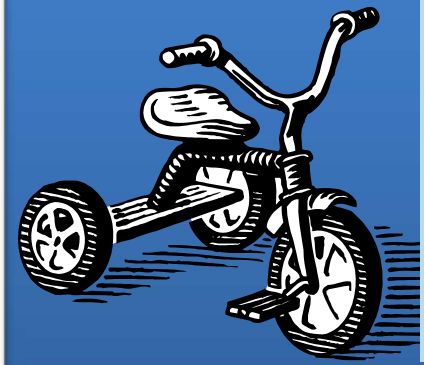
Form and Function

A long fluid-filled cylinder made of flexible material can be bent into a circle and used to *cushion impacts*.

Inventor

Scottish Inventor **John Dunlop** with a young son who liked to ride a tricycle.

New Product



The first **air-filled tire** was made for the inventor's son's tricycle. The inventor wound an air-filled piece of a garden hose around the wheel and covered it with a rubber tread. The tire now *absorbed shocks*.

Inspirational Idea

Soaring birds <u>twist their wings</u> to *retain balance while flying.*

Form and Function

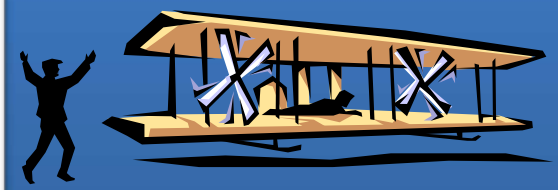
<u>Curved surface</u> *deflects air giving lift and stability to vehicles.*

Inventors

The **Wright Brothers** wanted to build and fly planes.

New Product

<u>Warped wings</u> on aircraft for *lift and stability*.

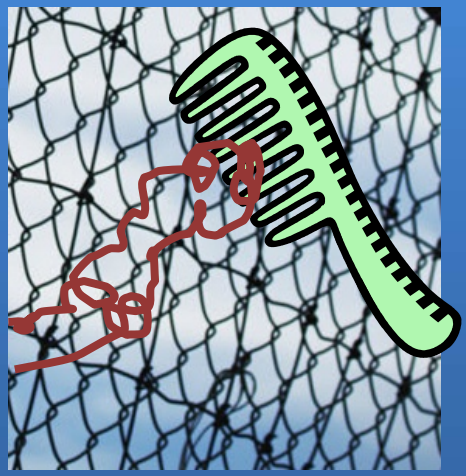


Inspirational Idea

A cat clawing at chickens through a wire fence and *only pulling feathers* through the fence sparked an idea of separating cotton seeds from cotton fibers.

Form and Function

Flexible cotton fibers are *pulled through* a grating by claws or a comb.



Inventor

Former American farm laborer Inventor **Eli Whitney** who wanted to improve agriculture

New Product

The **cotton gin** *separated cotton fibers from the seeds* that were tightly attached. The comb reached through a grating to pull out the cotton fibers, leaving the seeds.

Inspirational Idea

A telescoping shower head *adjusts to different heights and distances from the showering person.*

Form and Function

The device is jointed so that *length or distance of parts can be finely adjusted.*

Inventor

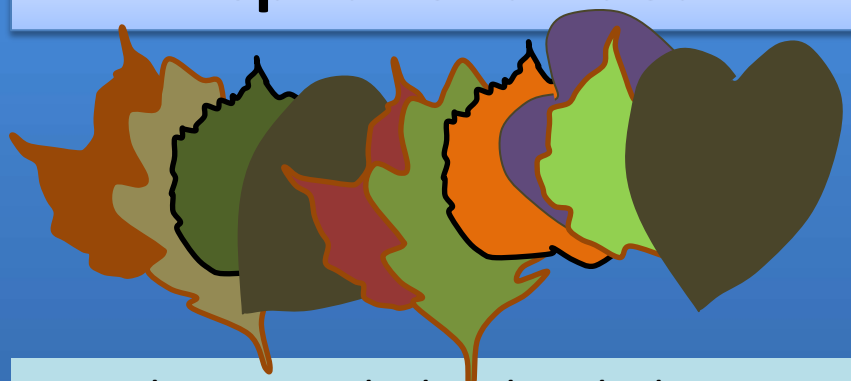
NASA Engineer **James Crocker** wanted to fix the Hubble space telescope by putting on adjustable lenses.

New Product

Automated arms that could be adjusted were used *to position the mirrors* at the exact distance needed to repair the Hubble Space Telescope.

http://www.nasa.gov/mission_pages/hubble/story/

Inspirational Idea



Wet leaves *stacked and packed* in a rain gutter with *none broken or damaged*, but all of them <u>bent into a curved shape</u>

Form and Function

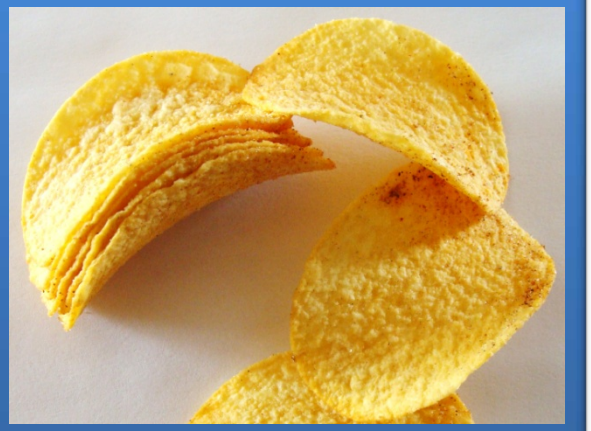
The flat shapes are warped into <u>saddle shapes</u> (two opposite sides bent up while the other two sides are bent down) and *stack closely together*.

Inventor

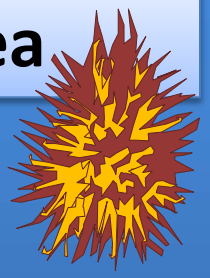
Frederic Baur, an American chemist and food storage technician.

New Product

Pringles chips have a <u>saddle shape</u> that *allows them to stack.*



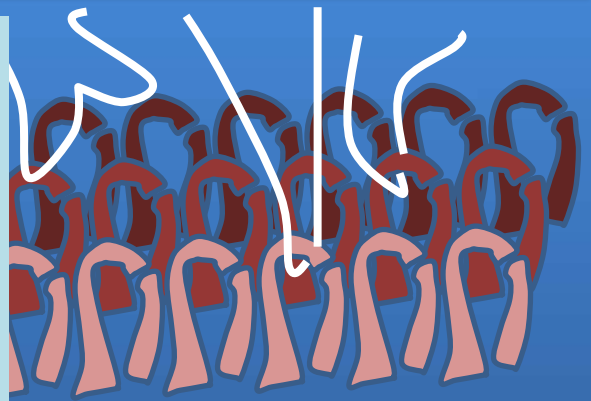
Inspirational Idea



Cockleburs have hooks *that stick* to dog's fur

Form and Function

Small hooks of burs *become attached* to looped fibers of fur or fabric.



Inventor

Swiss Engineer **George de Mestral** who liked to walk the fields with his dog.

New Product

Velcro fasteners are made of a looped fiber tape and a tape covered in hooks that *stick together.*