FLORIDA PUBLIC ARCHAEOLOGY NETWORK

Pyrotechnology - Fire

Students learn the properties of fire as they study how the Timucua used fire to solve the problems of daily life.

STUDENT LEARNING GOAL:
Students will understand the properties of fire and identify how the Timucua used fire to solve the problems of daily life.

SUNSHINE STATE STANDARDS ASSESSED:

Science

- SC.7.N.3.2 Identify the benefits and limitations of the use of scientific models.
- SC.7.P.11.1 Recognize that adding heat to or removing heat from a system may result in a temperature change and possibly a change of state.
- SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another.
- SC.8.P.9.2 Differentiate between physical changes and chemical changes.

Language Arts

- LA.7.1.6.2 The student will listen to, read, and discuss familiar and conceptually challenging text.
- LA.7.4.2.2 The student will record information (e.g., observations, notes, lists, charts, legends) related to a topic, including visual aids to organize and record information, as appropriate, and attribute sources of information.
- LA.8.1.6.2 The student will listen to, read, and discuss familiar and conceptually challenging text.
- LA.8.4.2.2 The student will record information (e.g., observations, notes, lists, charts, legends) related to a topic, including visual aids to organize and record information, as appropriate, and attribute sources of information.
- LA.8.6.4.1 The student will use appropriate available technologies to enhance communication and achieve a purpose (e.g., video, digital technology).

Mathematics

- (MA.7.A.3.4) Use the properties of equality to represent an equation in a different way and to show that two equations are equivalent in a given context.
- (MA.7.G.4.4) Compare, contrast, and convert units of measure between different measurement systems (US customary or metric (SI)), dimensions, and derived units to solve problems.
- (MA.8.G.5.1) Compare, contrast, and convert units of measure between different measurement systems (US customary or metric (SI)) and dimensions including temperature, area, volume, and derived units to solve problems.

RESOURCES:

"A Comparison of Leavening Agents." 17 January 2012. http://www.orbitals.com/self/leaven/index.html
"About Wood Firing." 12 January 2012. <http://garyhootman.com/about-wood-firing.php>
Bennet, Charles E. editor: Laudonnière, Rene. Three Voyages, The University of Alabama Press, Tuscaloosa: 2001.
"Ceramics." 12 January 2012. <http://www.chemistryexplained.com/Bo-Ce/Ceramics.html#b>
"Chert." 12 January 2012 <http://web.mac.com/linnog/Fire_Arch/Chert.html>

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Compton, Robert. "Firing Methods and Results – Pit Firing." 12 January 2012. <http://robertcomptonpottery.com/Method%20of-Pit-Firing-Pottery.htm>
"Exploring Florida - Le Moyne Engravings." 12 January 2012. <http://fcit.usf.edu/florida/photos/native/lemoyne/lemoyne.htm>
"Fire Felling a Tulip Tree for a Dugout Canoe." Video hosted on YouTube. 12 January 2012. <http://www.burntmud.com/Burntmud/Home.html>
"Fire II: Color and Temperature." 12 January 2012. <http://maggiemaggio.com/color/2011/08/fire-ii-color-and-temperature/>
"Fire Water Balloon – Cool Science Experiment." 12 January 2012. <http://www.stevespanglerscience.com/experiments/>
"Heat Treatment of Microcrystalline Quartz." 12 January 2012. <http://donsmaps.com/heatflint.html>
Manthey, David. "A Braintan Short course." 21 January 2012. <http://yallerdog.com/amohkali/fileshare/tancourse.pdf >
Milanich, Jerald T. *The Timucua*. Blackwell Publications, Inc. Massachusetts. 1996.
Milanich, Jerald T. Personal Correspondence. November 13, 2011 – February 28, 2012.
Purdy, Barbara, *How to Do Archaeology the Right Way*. University Press of Florida. Gainesville: 1996.
"The Impact of Wildland and Prescribed Fire on Archaeological Resources." 12 January 2012 <http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/coop_agencies/cr_publications.Par.30817.File.dat/DissertationBuenger_for_merge.pdf>
"The Science of Candles." 12 January 2012. < http://www.candles.org/candlescience.html>
"Smoker Fuels for Beekepers." 11 January 2012 <http://www.beekeepingandbeehives.com/smoker-fuels-for-beekeepers/>
"Solid State Structure." 12 January 2012. < http://www.ndt-ed.org/EducationResources/CommunityCollege/Materials/Structure/solidstate.htm>
"Steam Bending Wood." 11 January 2012 <http://www.primitiveways.com/bending.html>
"Steam Bending." 11 January 2012 <http://danenbergboatworks.com/steam_bending.htm>
Volmar, Mike. "The Dugout Canoe Project." 12 January 2012. <http://www.fruitlands.org/media/Dugout_Canoe_Article.pdf>
"What Ancient Technology Assisted in Food Preparation?" 12 January 2012. <http://mhs.mt.gov/shpo/archaeology/Ancient%20Teachings/Ancient%20Teachings%203/Ancient%20Teachings%203D.pdf>

PICTURE RESOURCES (Image URLs and Permissions):

De Bry Engraving of Saturiwa Leading his Men to Battle http://fcit.usf.edu/florida/photos/native/lemoyne/lemoyne3/photos/lemoy307.jpg
De Bry Engraving of Timucua Men Canoeing to Storehouse http://fcit.usf.edu/florida/photos/native/lemoyne/lemoyne0/photos/lemoy021.jpg
De Bry Engraving of Timucua Fashion http://fcit.usf.edu/florida/photos/native/lemoyne/lemoyne0/photos/lemoy037.jpg
De Bry Engraving of Timucua Warfare http://fcit.usf.edu/florida/photos/native/lemoyne/lemoyne0/photos/lemoy030.jpg

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Fire Drill http://upload.wikimedia.org/wikipedia/commons/thumb/6/6f/Bow_Drill.png/220px-Bow_Drill.png
Palm Hut, from *The Timucua Indians – A Native American Detective Story,* reprinted with permission from the University Press of Florida
Raw Chert http://upload.wikimedia.org/wikipedia/commons/thumb/5/56/ChertUSGOVjpg.jpg/220px-ChertUSGOVjpg.jpg

Photographs and illustrations without attribution were provided by Kelley Weitzel MacCabe.

MATERIALS LIST for "What Fire Products did the Timucua Use?": no additional materials

ANSWER KEY for "What Fire Products did the Timucua Use?":

Timucua Need or Task	Light	Heat	Smoke	Ashes
Seeing at Night	X			
Staying Warm		X		
Cooking		X	X	X
Repelling Insect Pests			X	
Making Clothing		X	X	X
Antiseptic and Healing		X		X
Shaping Wooden Tools		X		
Firing Pottery		X		
Making Stone Tools		X		
Building Houses		X		
Making Canoes		X		
Managing Forests and Hunting		X	X	X
Warfare		X		

MATERIALS LIST for Balancing Equations Activity: no additional materials

ANSWER KEY for Balancing Equations Activity:
$C_6H_{12}0_6 + 6\ 0_2$ ----------→ $6\ C0_2 + \mathbf{6}\ H_20$

MATERIALS LIST for "Cooking Before Pottery" Experiment: **Per student:** Safety glasses. Per 2-student Team: **One candle** (plus a back-up): white, unscented tapers work best. Votives are workable. Tea-lights do not work. **4-6 balloons**. Clear balloons are best if you can find them, because you can easily see condensation inside. All balloons should be the same size. **1 paper cup** that holds at least ¼ cup of water. Access to more water. Paper towels for water clean-up.

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ANSWER KEY for "Cooking Before Pottery" Experiment:

The black mark is not the balloon burning. It is the result of incomplete combustion of the candle wax.

***Teacher Tips**: Balloons without water in them will pop the moment they touch the flame. Balloons with water can last longer than five minutes. Adding more than ¼ cup of water will increase the cleanup proportionally. The best place to do this activity is outside on a basketball court. Be sure that all of the exploded balloon bits make it into a trash can afterwards. Students should hold the balloon so that it just touches the tip of the flame. The balloon surface will blacken where the flame touches it. Why? The balloon blocks some of the flame's access to oxygen. The result is incomplete combustion, which produces soot. This is what causes the "fire shadows" on pottery (discussed more fully in the unit on Tool Technology). The photo of a replica pot shown later in this unit has a "fire shadow."*

In 25 test runs, nine balloons burst in less than 20 seconds. (See the photo showing a flaw in a balloon that will result in this kind of speedy burst.) For this experiment, any balloon that lasts longer than 20 seconds is a success.

Time Before Balloon Burst	Number of Balloons
< 20 seconds	9
20-60 seconds	6
1-2 minutes	3
2-3 minutes	2
3-4 minutes	4
> 5 minutes	1

The hole is not all the way through the rubber. But the moment heat stresses it, this flawed balloon will break.

The drops of condensation indicate that the water inside is boiling. (3 minutes)

If you have similar results, you should expect a 36% failure rate. That's why each group is allotted four balloons: one to burst dry, and three to try wet. Take an average if you'd like to include math. Be aware that when wet, a candle wick sputters and produces a wavering flame. During the trials, this inconsistent flame seemed to cause more early bursts. That's why you need reserve candles, to replace drenched ones if a team has repeated balloon breakages.

After 2-3 minutes, the water inside the balloon does boil into steam. You can't hear it happening, but you can, if you look closely, see the condensed steam dripping back down the inside of the balloon. If all of the water turned to steam, the balloon would pop immediately; however, none of the trials lasted long enough to boil off all of the water. So why did the balloons break? Latex melts around 260°F, but it probably weakens at a lower temperature. Balloons that reach the 2-3 minute level may have reached 260°F, causing the balloons to break.

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Answer: Balloons differ from hide pots because they are made of different materials. The balloon is sealed, and the pot is open. The pot will eventually hold water and food materials; the balloon just holds water. Water soaks into the hide, but it does not soak into the rubber of the balloon. The balloon is a closed system, so the water that boils into steam stays inside the balloon. Steam rises out of the open pot.

MATERIALS for "Converting Temperatures" Activity: no additional materials
ANSWER KEY FOR ACTIVITY 1:

Important Timucua Temperatures	Degrees Fahrenheit	Degrees Celsius
Water Freezes	32° F	***0° C***
Healthy Body Temperature	98° F	***37° C***
Water Boils	***212° F***	100° C
Fire-Treating Chert	***662° F***	350° C
Firing Pottery	1400° F	***760° C***

MATERIALS for "Getting to Know Fire" Activity: Safety glasses for each student. One candle per lab team (2 students). White, unscented tapers work best.

ANSWER KEY for "Getting to Know Fire" Activity:

Teacher Tips: *If you have access to Bunsen Burners, students should observe the flame while adjusting the amount of oxygen, then record their observations. Low oxygen produces a wavering reddish flame. Increased oxygen makes a yellow, cohesive flame. High oxygen produces a compact blue flame.*

Candle Diagram: 1) Yellow, 2) Shadowy Orange, 3) Blue

Part One: **The hottest part of the flame is located** closest to the wick / at the bottom of the flame / on the thin outer edge (where the flame meets oxygen).
The coolest part of the flame is located in the middle (away from the oxygen).
The smoke is located above the top of the flame / it moves around in a breeze / none.

Part Two: The flame becomes longer and wavers. The flame has less blue and more oranges and yellows, so it's cooler. There's a thin line of wavering black smoke without much odor.

Part Three: The amount of smoke increases. It moves up and spreads out. It is lighter in color and smells stronger. The wick is still glowing at first, then the fire goes out completely.

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STUDENT ARTICLES, EXPERIMENTS, & ACTIVITIES:

1) What is Pyrotechnology?
2) ACTIVITY: Fire Products
3) Light at Night
4) Staying Warm
5) ACTIVITY: Balancing Equations
6) Creative Cooking
7) EXPERIMENT: Cooking Before Pottery
8) The Prehistoric War on Bugs
9) Fashion in the 1560s
10) Wooden Tools
11) Firing Pottery
12) ACTIVITY: Converting Temperatures
13) Stone Tools
14) Home Sweet Home
15) Canoe Building
16) Land Management
17) Warfare
18) ACTIVITY: Getting to Know Fire

NEW TERMINOLOGY:

alumina (aluminum dioxide Al_20_3), artisan, baking soda, bow drill, carbon dioxide, caustic, cell walls, ceramic, char, chemical bond, chemical change, chert, clay, coals, collagen fiber, combustion, compound, compressed, conductor, corrosive, crystalline, denature, diameter, fibroblasts, fire drive, flint-knapper, formaldehyde, friction, generator, hematite (red iron oxide Fe_20_3), impurities, iron (Fe), land management, leaf litter, loin cloth, lye, matchcoat, niacin, nutrients, obsolete, oxide, oxygen (0_2), palm fronds, pelt, pheromones, physical change, pliable, prescribed fire, preserve, projectile point, pyrotechnology, quartz, rawhide, silica (silicon dioxide $Si0_2$), spindle, tinder, turbines, venison, water molecules, water vapor gas, whelk

ASSESMENT OPTIONS:

Writing Prompt #1: Fire was as important to the Timucua as electricity and fossil fuels are to modern Floridians. Think about the ways your life would be different if electricity and fossil fuels suddenly disappeared. Write to explain how your day would be different, starting when you wake in the morning.

Writing Prompt #2: Wood was the primary source of fuel for the Timucua people. Think about the many different kinds of fuel Floridians use today. Write to explain three different fuel sources used by modern Floridians.

Assessment #1: Chemical changes occur when chemical bonds are broken and formed. Review the articles titled "Firing Pottery," and "Fashion in the Fifteen-Sixties." Explain how fire causes a chemical change in both the clay pots and the animal hides.

Assessment #2: Review the articles titled "Creative Cooking," "The Prehistoric War on Bugs," and "Fashion in the Fifteen-Sixties." Based on your reading of the articles, describe three ways the Timucua utilized smoke to solve every day problems.

Assessment #3: Consider the articles you've read in the Pyrotechnology lesson. Brainstorm a list of ways that modern Floridians depend on fire. Choose two from your list that are NOT discussed in the Pyrotechnology lesson and describe them here.

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Student Learning Enhancement

The Timucua used fire in nearly every aspect of their daily lives. The **New Terminology** reflects this diversity. The bullets below group **New Terminology** according to the type of tool they describe.

Ask student groups to look through the unit and pinpoint which fire technology is linked to each vocabulary group. Once matched, have them review that section to look for contextual definitions of each word. If no contextual definition is apparent, they should look for the definition in another source. Finally, groups should share their words and definitions with the class, noting which technology they are linked with.

- **STARTING FIRES / CHEMISTRY OF FIRE**: bow drill, carbon dioxide, combustion, friction, oxide, oxygen, spindle, tinder, pyrotechnology, water vapor gas
- **HEAT-TREATING STONE**: alumina, chert, crystalline, flint-knapper, hematite, impurities, iron, oxide, projectile point, quartz, water molecules, whelk
- **PRESERVING ANIMAL HIDES**: chemical bond, chemical change, collagen fiber, formaldehyde, loin cloth, lye, matchcoat, pelt, rawhide
- **HUNTING**: fire drive, land management, leaf litter, pheromones, prescribed fire
- **COOKING**: baking soda, carbon dioxide, caustic, compound, conductor, corrosive, denature, lye, niacin, nutrients, preserve, venison
- **BENDING WOOD**: artisan, cell walls, compressed
- **FIRING CLAY POTTERY**: ceramic, clay, physical change, pliable, silica, water molecules
- **BUILDING HUTS AND CANOES**: char, coals, diameter, palm fronds
- **IMPROVING HEALTH**: fibroblasts
- **MODERN TERMS**: generator, turbine

Classroom Technology Strategies

Webquest – The Timucua used prescribed fire to maintain healthy agricultural and hunting lands. What variables did they need to consider to use prescribed fire safely?

First, research what modern foresters need to understand about using prescribed fire. Then, use your knowledge of the Timucua to explain what you think they would have considered important in planning a safe, successful burn.

- "Prescribed Burning Regulations in Florida" http://edis.ifas.ufl.edu/fr055
- "Benefits of Prescribed Burning" http://edis.ifas.ufl.edu/fr061
- "Effects of Fire on Florida's Wildlife and Wildlife Habitat" http://edis.ifas.ufl.edu/uw132
- "Fuel, Weather, and Considerations" http://www.bugwood.org/pfire/weather.html

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- "Environmental Effects" http://www.bugwood.org/pfire/environmental.html

For the Teacher: Please preview these sites for readability. Like most public documents, they're written somewhere near a 7th grade level, but the terminology may need explaining. These sites are sponsored by the USDA and the University of Florida Extension Service.

Teachers can visit http://fireinflorida.org/educators-zone/curriculum/ to download the Fire in Florida curriculum for free.

You can use the following links to create a web quest or treasure hunt for your students. AT&T Filamentality Free Web quest building site: http://www.kn.pacbell.com/wired/fil/index.html