Name: _____ ***Period:*** _____

Student Questions for *"Chocolate: The New Health Food. Or Is It?" (Worksheet 3)*

1. At what temperature does chocolate melt?

2. Why is the above temperature a key to chocolate's properties?

3. Approximately how many chemicals make up chocolate?

4. Name two of the well-known chemicals in chocolate.

5. How do the formulas of the two chemicals in question 4 differ?

6. List the names of two chemicals produced by the brain which are also found in chocolate.

7. What are the physiological effects of the two chemicals in question 6?

8. What are "antioxidants" and how do they protect the body?

9. If chocolate can be shown to be one of the healthiest foods available, why is it often classified as a "junk" food?

10. Cocoa is rich in chemicals called flavanols. What are some of the health benefits of flavanols?

11. It is a popular belief that chocolate causes acne and other skin problems that afflict teenagers. According to the article, is this true? Explain.

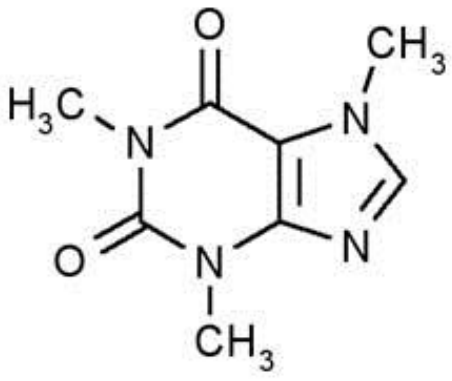
12. Briefly describe the steps in chocolate production.

13. What is the chemical composition of cocoa butter?

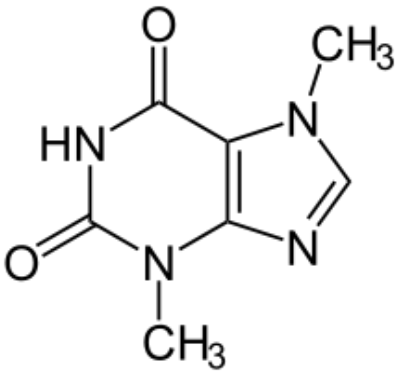
14. What are scientists doing to find ways to make cocoa trees more resistant to pests and disease and provide healthier, more nutritious, and better tasting chocolate?

Answers to Student Questions for "Chocolate: The New Health Food. Or is it?"

1. **At What temperature does chocolate melt?**
   Chocolate melts between 94 and 97 ^{o}F.
2. **Why is the above temperature a key to chocolate's properties?**
   Normal body temperature is 98.6 ^{o}F, just above the melting point of chocolate. "Melts in your mouth" is true. "A morsel of chocolate slides across your tongue and liquefies into a perfect puddle of taste sensation."
3. **Approximately how many chemicals make up chocolate?**
   According to the article, chocolate contains more than 300 chemicals.
4. **Name two of the well-known chemicals in chocolate.**
   The two chemicals are caffeine and theobromine. Caffeine is present in small amounts, with theobromine present in slightly higher amounts than caffeine.
5. **How do the formulas of the two chemicals in question 4 differ?**
   The two chemicals are identical except for one methyl group (CH3-) present in the caffeine molecule, but not in the theobromine molecule.



Caffeine



theobromine

6. **List the names of two chemicals produced by the brain which are also found in chocolate.**
   The two chemicals produced by the brain which are also found in chocolate are anandamide and phenylethylamine.
7. **What are the physiological effects of the two chemicals in question 6?**
   Anandamide blocks out pain and depression. Chemicals in chocolate appear to slow down or inhibit the breakdown of anandamide and, as a result, the chemicals' persistent presence makes us feel good longer. Phenylethylamine stimulates the parts of the brain that keep one alert and mimics the brain chemistry of a person in love.
8. **What are "antioxidants" and how do they protect the body?**
   Antioxidants protect the body from free radicals – atoms, molecules, or ions with unpaired electrons. The unpaired electrons are usually highly reactive and more likely to take part in chemical reactions. Inside cells, free radicals damage DNA and have been associated with Alzheimer's disease, heart disease, and cancer. Antioxidants prevent this damage from happening by blocking the action of free radicals.
9. **If chocolate can be shown to be one of the healthiest foods available, why is it often classified as a "junk" food?**

It is all in the processing of the chocolate. Processing determines whether chocolate is a healthy food or a high calorie indulgence. Roasting and fermenting wipe out scores of antioxidants. Food stores sell mainly processed chocolate, with sugar, milk, and extra fat added because they taste good and cost less, but the more non-cocoa items added to cocoa, the more dilute the healthy chemicals become. And the cheaper the cost, in general, the more a chocolate qualifies as a junk food.

10. **Cocoa is rich in chemicals called flavanols. What are some of the health benefits of flavanols?**
    Flavanols appear to increase blood flow to the brain and, as a result, might be used to treat vascular impairments in the brain resulting from a stroke. Consumption of a flavanol-rich cocoa beverage also increases the amount of nitric oxide in the blood vessels, allowing them to dilate and keep them pliable. Cocoa flavanols might then be used to clear clogged arteries in heart disease and stroke.
11. **It is a popular belief that chocolate causes acne and other skin problems that afflict teenagers. According to the article, is this true? Explain.**
    Current research does not connect any specific food to skin problems. Chocolate husks contain chemicals that prevent tooth decay, although the added sugar in chocolate confections may offset the health benefits.
12. **Briefly describe the steps in chocolate production.**
    Tiny flies called midges pollinate the trees. (2) The pods containing 20 to 60 seeds are removed from the trees, split with a machete, and the pulp and beans are removed and allowed to ferment under banana leaves in the sun. (3) After fermentation, the beans are dried on bamboo mats or wooden floors. (4) The dried beans are shipped to manufacturing plants, where they are cleaned, sorted, and roasted. (5) After removal of the bean shells, the dark chips, called nibs, are crushed to form the solid fat called cocoa butter.
13. **What is the chemical composition of cocoa butter?**
    "Cocoa butter is essentially all fat. There are three major kinds: a 'bad-for-you' saturated fat called palmitic acid; oleic acid, a heart-healthy monounsaturated fat; and stearic acid, part of which later converts to oleic acid in the liver. Overall, one third of chocolate's fat is known to be unhealthy. But all three kinds of fats raise the amount of calories they produce in the body, although they do not cause an increase in blood cholesterol when consumed in chocolate."
14. **What are scientists doing to find ways to make the cocoa tree more resistant to pests and disease and provide healthier, more nutritious, and better tasting chocolate?**
    Last June, scientists from Mars, Inc, partnered with IBM and the U.S. Department of Agriculture to launch a five year project to unravel the genome of the cocoa bean. Once unraveled, the scientists may be able to modify the genes of the cocoa tree to produce the desired effects.

Talking Points For Follow Up Class Discussion (10-15 minutes)

Note: When the teacher returns, if a quick discussion follow up to the classwork is desired, the teacher could use related questions to reinforce what the students learned by reading the article:

1. Where do cocoa beans grow?
2. Can students describe the path from tree to chocolate bar?
3. What kind of health benefits are claimed for chocolate? What is the evidence for these benefits? How were the studies done?
4. On the other hand, why might chocolate not be good for you?
5. What are some differences among different types of chocolate (baking chocolate, dark chocolate, milk chocolate)?
6. Did reading the article change their views on chocolate? Did they learn something new? Would you like to share your ideas with the class?

Possible Discussion Questions for Relating the Article to Chemistry Concepts (10-20 minutes)

1) Ask for an example from the article that shows how chemical structure affects chemical function.
2) Can students describe the role of antioxidants in terms of electron transfer?
3) What effects in terms of molecular structure of the chemicals in the cocoa beans might be caused by drying or roasting?
4) Chemically speaking, why do oils and fats have so many calories?

Background Information for the Teacher

- More on the history of chocolate
- Connections to Chemistry Concepts
- Possible Student Misconceptions
- Student Projects

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Further Explorations Online (Worksheet 4) (30 - 45 minutes)

Supplies (for group work)

- Chart paper or poster board
- Colored markers
- Cards with names of chemicals (one chemical name per card):

    1. Caffeine,
    2. Theobromine,
    3. Anandamide
    4. Phenylethylamine
    5. Epicatechin
    6. Epigallocatechin
    7. Phenol and its derivatives

Equipment (optional) - Computer with Internet access connected to LCD projector

(Optional) If computer access with an LCD projector is available, go to the Exploratorium website http://www.exploratorium.edu/exploring/exploring_chocolate/index.html to investigate more about chocolate and watch a few video clips. ***Note:*** RealVideo must be installed on the computer for students to watch the videos.

A. **Decide on seven teams, one for each chemical.**
B. Each group should analyze their chemical to determine:
    a. The structural formula (given in the article)
    b. The molecular formula ($C_xH_yN_zO_w$). Students must figure this out from the structural formula.
    c. Properties, both chemical and physical
    d. Effects in the body
    e. Other interesting information
C. Students should include the information in an informative, engaging, attractive format on their chart paper, poster board, or unlined paper.
D. Each team will share their findings with the class. In particular, they should explain how they determined the molecular formula by using the structural formula.

Background Information for the Teacher

More on the history of chocolate

Theobroma cacao, the botanical name for chocolate, literally means food of the gods. (In Greek, theo = god(s) and broma = food). Linnaeus, the Swedish scientist who gave us our modern binomial classification scheme for plants and animals, gave chocolate its botanical name in 1753. The second term "Cacao" has pre-Columbian roots. It can be traced to the term "akawa" found in the Olmec culture which thrived in the hot and humid southern region of Mexico between 1500 and 400 BC. The pre-Columbian Aztecs of Mexico made xocolatl (xoco means bitter and atl means water) from the cacahuatl. The Spanish conquistadors in Mexico, circa 1520, were the first Europeans to be introduced to the wonders of chocolate by the Aztecs. The Aztecs learned the secrets of processing and preparing chocolate from the Mayans who, in turn, learned the techniques from the Olmec. Since the cacao beans are rich in fat, simply mixing the crushed beans with water would cause the mixture to separate. The problem was solved by stirring vigorously while adding the water to the crushed cacao beans. The process is similar to today's homogenization of milk in which the milk fat particles are reduced to a uniform size and suspended in the mixture. The Aztecs then poured the mixture from one container to another from a height high enough to create the froth that was considered the ultimate feature in drinking the beverage.

The Golden Book of Chocolate produced by Anne McCrae of McRae Books provides the following added historical anecdotes:

> Among the Aztecs the drinking of chocolate was confined to the elite: the royal house, the lords and nobility, the long-distance merchants and the warriors. The ceremonial importance of the substance was profound. Not only was it provided at banquets at which noblemen and merchants displayed their wealth, it was also offered to the gods, and was used to anoint newborn children on the forehead, face, fingers and toes.
>
> A report by Bernial Diaz del Castillo noted that Montezuma drank xocolatl several times a day from a beaker made of pure gold, and that warriors and nobles of the court kept the ground cacao in golden containers, which they carried around with them. The local dignitaries spiced the drink with native vanilla, wild honey, pita juice, and occasionally chili, whereas the Spanish officers preferred anise seed, cinnamon, almonds, and hazelnuts. Moreover, they increasingly chose to make their drink with hot water, and sweeten it with the cane sugar they had introduced into the New World. Instead of obtaining the coveted broth with pouring, their slaves used a wooden whisk called a molinello to stir the hot beverage until it foamed invitingly.
>
> Fortunately for the Spaniards, the Church recognized the new drink as a beverage rather than a food, which meant it could be enjoyed during periods of fasting. This must have encouraged them to bring chocolate back to Spain in the late 1500's. A hundred years later it had become the new national drink.

McCrae goes on to fill in the details of the spread of the use of chocolate. She also traces the founding of the firms whose names are still with us today; e.g., Cadbury, Tobler, Nestle, and Hershey. The book includes a discussion the discoveries that led to what we today call cocoa, as well as the processes that led to the development of a solid chocolate/cocoa bar. As with most products, costs of production and profit motives resulted in adulterated chocolate products that have given chocolate the stigma of being a "junk" food. The development of organic chocolate, the spread of cacao plantations to Hawaii, and the desire by the public for the healthy, beneficial chocolate are well documented. The sale of this "gourmet" accounted for roughly 10% of

chocolate sales in the US. Estimates place total "gourmet" chocolate sales at $1.3 billion in 2005 with a projected $1.8 billion in 2010.

What we today know to be the physiological effects of the many chemicals in chocolate took on almost mystical proportions in the early 1500's and into the 1600's when use of chocolate was spreading through Europe. Today's association of chocolate with Valentine's Day and all things romantic, traces its roots to the belief that chocolate was an aphrodisiac. As such, chocolate was first considered a drug, a medicine with a pleasant taste, something new and different for the time. Samuel Pepys, the English diarist, wrote in his entry for April 24, 1661 of chocolate's ability to settle the stomach and alleviate the discomfort of a hangover. Chocolate's psychological attraction may have been documented for the first time by the mid-seventeenth century French letter writer, Marie de Rabutin-Chantal, marquise de Sevigne. She wrote, "I have reconciled myself to chocolate. I took it the day before yesterday to digest my dinner, to have a good meal, and I took it yesterday to nourish me so that I could fast until evening: it gave me all the effects I wanted. That's what I like about it: it acts according to my intention." The article discusses the physiological response of the brain to some of the chemicals present in chocolate which stimulate the brain to produce natural opiates and which slow the breakdown of other chemicals which produce the overall feeling of well being.

A temperature than never drops below 60 ^{o}F (16 ^{o}C), high humidity, protection from the direct rays of the sun are three conditions required for the cacao tree to produce the fruit from which chocolate is made. The rainforests that spread between Southern Mexico and the northern Amazon basin provide the necessary conditions. The rain forests also provide the natural habitat for the midges which are responsible for the pollination of the cacao tree flowers.

Connections to Chemistry Concepts

1. **Interpretation of organic structures**—Review the writing of organic structures, two different types are present in the article.
2. **Organic nomenclature**—Discuss the important of suffixes in determining the functional groups that make up organic molecules.
3. **Free radicals**—Explain the importance of unpaired electrons in accelerating the rate of chemical reactions.
4. **Saturated vs. unsaturated molecules**—Discuss the structure of saturated molecules (no carbon double bonds) and unsaturated molecules (those with at least one carbon double bond).
5. **Oxidation and reduction**—Review oxidation as involving the loss of electrons and reduction the gain of electrons.

Possible Student Misconceptions

1. **"I always get zits from eating chocolate."** *The article states that research does not support this widespread belief.*
2. **"Chocolate is a junk food."** *Popular literature labels chocolate as a junk food. The general public may not know and appreciate the different varieties of chocolate, and which of those are healthy and which are not.*

3. **"I don't think the role of free radicals and antioxidants in food is well understood."** *The article discusses the role of free radicals and how they may damage DNA, as well as, the role of antioxidants in terminating the reactions that produce free radicals.*
4. **Students may not fully understand the interpretation of the structural formulas presented in the article.** *Representing chemical structures in various ways provides a chance to review the rules for writing organic structures.*

Student Projects

1. The first of the questions in the "Anticipating Student Questions" (below) lists the chemical names of the chemicals that have been identified in chocolate. Depending on the number of students in the chemistry classes, assign each student one or more of the chemicals. Have the students print the name and chemical structure and create a major display in the classroom or in a hallway that portrays all of the chemicals found in chocolate.
2. If the above project seems too imposing, a similar project was proposed in the Teacher's Guide for the Dec. 1999 issue of ChemMatters. "A group of students could study and prepare a presentation of the different structures of many of the different types of organic molecules that might be encountered in discussing the substances that are either contained in chocolate or are involved in its creation from the cocoa bean."
3. If your school teaches statistics or psychology on the introductory level or on the AP level, your students might propose a project in conjunction with one or both classes. Again, the Dec. 1999 issue of the Teacher's guide proposes that "a group of students might survey their classmates to determine both their perceived craving for chocolate and their actual consumption, both by quantity and by type of chocolate consumed. If they wanted to extend the study, they could consult with the school's psychology teacher or guidance counselor to obtain or develop a test for determining whether personality profile and chocolate consumption are, in any way, related. Students could develop a Likert scale test in which individuals could rate their craving for chocolate. The data could be grouped in various ways—by gender or age, for example."
4. Have students visit the sites of the various chocolate manufacturers and report back on the resources available at the commercial site. The following site has links to all of the chocolate manufacturers. (http://www.mce.k12tn.net/chocolate/index.htm)