ChemMatters

October 2004 Teacher's Guide

[A National Chemistry Week message from the Surgeon General of the United States](#)

About the Guide

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A message from the Surgeon General of the United States

Vice Admiral Richard H. Carmona, M.D., M.P.H., F.A.C.S., has endorsed the 2004 National Chemistry Week campaign and its theme, “Health & Wellness!”

“This year's National Chemistry Week focus on making healthy choices and being active will allow lots of people to live longer, healthier lives. But sometimes, the miracles of science have to step in and help out. By combining the benefits of prevention (eating well, exercising, and of course, not smoking) with the promise of scientific discovery we can ensure a healthier tomorrow for all of us.” - Vice Admiral Richard H. Carmona, M.D., M.P.H., F.A.C.S.

The Chemical Adventures of Sherlock Holmes

The *Journal of Chemical Education* has available a collection of their popular Chemical Adventures of Sherlock Holmes stories written by Thomas G. Waddell and Thomas R. Rybolt. The first of the series, "Sherlock Holmes and the Yellow Prisms", was published in 1989. That one story has now grown to 15 and by popular request the collection has been gathered into a single volume with standardized formatting, consistency among stories, and a binding convenient for photocopying. The stories are always popular with teachers (and their students!) for their education as well as entertainment value. More information and an order form may be found at www.jce.divched.org/JCEBooks/SherlockHolmes.html. Single copies are $19.95 (U.S.), $29.95 (non-U.S.), including shipping and handling. Volume discounts available; ready to ship.

Puzzle: Triple Cross

This puzzle's structure comes from famed puzzler Henry Hook. It has three parts. 1. Answer the across and down clues as best you can into the criss-cross grid. 2. Transfer letters in that grid to the QUOTE'S numbered spot(s); it may appear in there more than once! 3. As you begin to get the sense of the quote, you can work backwards to get clues missed first time around. We've filled in 1 across and 1 down to get you started.

You'll note every clue refers to a health/biochemical term, and the quote deals with a topic discussed in this issue of *ChemMatters*. It comes from a June 2004 *Consumers Reports* article on diet issues.

THE CLUES

ACROSS

1 Toxin associated with the mad hatter

13 Suffix denoting a sugar

16 Suffix denoting an aldehyde

26 Cocaine and serotine, for examples

39 Number of H atoms in a ribose molecule

48 C_2H_5OH and CH_3OCH_3, for example

59 Symbol of chemical in clue 1A

DOWN

1 Dura ____, a membrane protecting the brain

5 $(NH_2)_2C{=}O$, an important biochemical

10 Featured in the South Beach diet (hyphenated)

17 Environmental hazard released by discarded automobile batteries

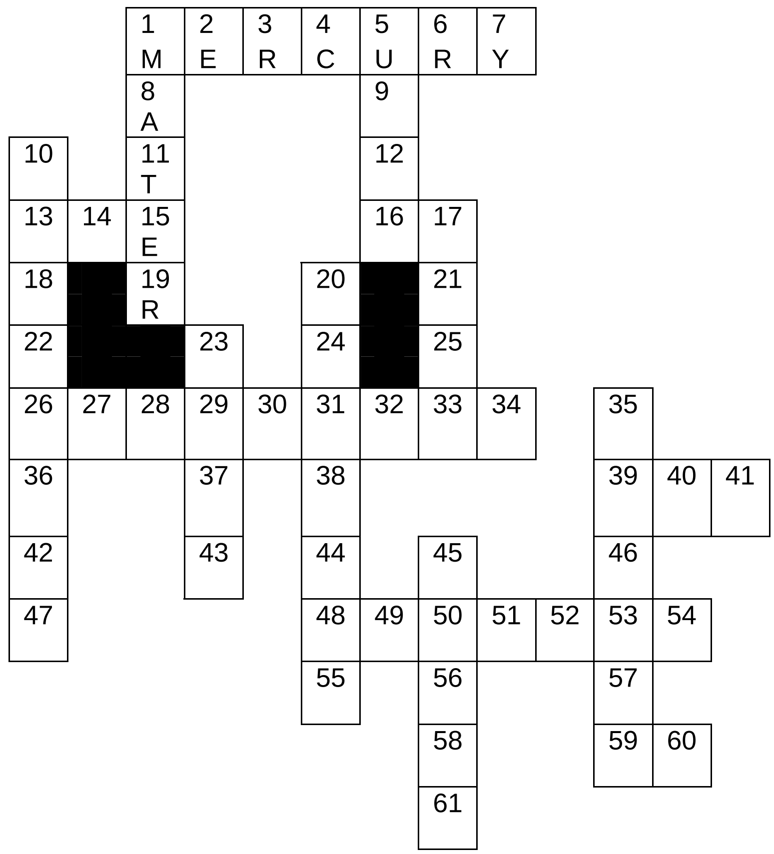
20 Chain of amino acids

23 Glyceryl esters; food group type

35 Long polymer of glucose units; a food group type

45 Any chemical that's hazardous to health

THE GRID



THE QUOTE

30 13 49 45 58 41 39 59 2 1 12 33 48 8 59 7 20 15 18 16 47 38 59 21 23 46 4 37 11 59 25 37 26 38 28 32 61 54

33 58 40 45 44 3 43 18 52 9 2 29 57 39 5 46 17 27 7 10 31 35 48 55 60 18 12 32 60 59 38 34 58 51 20 30 7

42 7 37 8 28 48 41 60 32 55 23 15 18 21 24 22 16 17 50 6 58 40 14 11 59 25 61 45 59 44 7 52 56 20 2 55 33 12 33

Puzzle Answers

THE QUOTE:

Lost in the media hype was the fact that Atkins dieters were actually losing weight simply by taking in fewer calories than they expended.

Consumers Reports, June 2004, p 14 in an article on low-carb diets and diet foods.

		1 M	2 E	3 R	4 C	5 U	6 R	7 Y				
		8 A				9 R						
10 L		11 T				12 E						
13 O	14 S	15 E				16 A	17 L					
18 W	■	19 R			20 P	■	21 E					
22 C	■	■	23 F		24 R	■	25 A					
26 A	27 L	28 K	29 A	30 L	31 O	32 I	33 D	34 S		35 S		
36 R			37 T		38 T					39 T	40 E	41 N
42 B			43 S		44 E		45 T			46 A		
47 S					48 I	49 S	50 O	51 M	52 E	53 R	54 S	
					55 N		56 X			57 C		
							58 I			59 H	60 G	
							61 N					

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Student Questions

Carb Crazy

1. What three elements are in a carbohydrate?
2. How is glucose used in the body?
3. What polysaccharide is a storage form of glucose?
4. What is the relationship between insulin and blood sugar?
5. By what basic principle do all diets work?
6. How is ketoacidosis different than ketosis?
7. Why would an athlete want to avoid a low carb diet?

Lab on a Stick

1. Why is sugar in urine a sign of a health problem?
2. What were two early tests for sugar in urine?
3. What is colorimetric test?
4. What additional test was developed to weed out false positive results for glucose?
5. How does the Multistix-10SG test for glucose?
6. Name any three medical conditions that the Multistix helps to identify?

Cleopatra's Perfume Factory and Spa

1. How did Cleopatra acquire a spa and perfume factory?
2. What did chemists find when they analyzed a jar of Dead Sea mud treatment?
3. Where does the saying "Flies in the ointment" come from?
4. How were perfumes made in Cleopatra's time?
5. What metal is present in Cleopatra's green eye makeup?
6. What unexpected discovery did chemists make when they tested Cleopatra's "signature" black eye makeup?

When Good Science Goes Bad!

1. Why was Patricia Stallings arrested?
2. What two substances found in Ryan Stallings blood led to the conclusion that he was poisoned?
3. Ryan was later thought to suffer from MMA. Why was this alternate explanation initially considered insufficient to overturn the conviction?
4. How and where do the separations of compounds occur in a gas chromatograph?
5. What happened when skeptical scientists doped blood samples with propionic acid and sent them for commercial GC-MS testing?
6. What treatment for ethylene glycol poisoning might have cause calcium oxalate crystals to form in Ryan's brain?

Answers to Student Questions

Carb Crazy

1. What is a carbohydrate? Carbohydrates are composed of three elements: carbon, hydrogen, and oxygen.
2. How is glucose used in the body? Glucose is the body's primary fuel source. It is broken down during cellular respiration to release energy. Carbon dioxide is released as a waste product.
3. What polysaccharide is a storage form of glucose? Glycogen.
4. What is the relationship between insulin and blood sugar? Insulin can be thought as the gatekeeper for blood sugar entering cells. When insulin is released by the pancreas, blood sugar levels drop.
5. By what basic principle do all diets work? You must burn more calories than you consume.
6. How is ketoacidosis different than ketosis? During ketosis, fat is not completely broken down and your body produces and excretes ketone bodies. Ketoacidosis is an extreme form of ketosis where acid ketone bodies build up faster than they can be excreted. The result is a dangerous drop in blood pH and, if left untreated, coma and death.
7. Why would an athlete want to avoid a low carb diet? Athletes rely on glucose and glycogen reserves for quick energy. Most low-carb diets have an induction phase that consumes available glycogen reserves.

Lab on a Stick

1. Why is sugar in urine a sign of a health problem? Sugar in urine is a sign of high blood sugar levels and diabetes.
2. What were two early tests for sugar in urine? One test was to pour urine on the ground to see whether it would attract flies. A second test was to heat urine, cupric sulfate ($CuSO_4$), and a complexing agent. Presence of the reducing sugar, glucose, was confirmed by reduction of Cu(II) to Cu(I). This caused the mixture to change form blue to green, brown, and red. Not mentioned in the article was that early healers went as far as to taste urine to see if it was sweet.

3. What is colorimetric test? A colorimetric test relies on a visible color change to track the presence of a chemical.

4. What additional test was developed to weed out false positive results for glucose? The chemists at the Miles-Ames laboratory developed a urinalysis test for ketone bodies, a byproduct in diabetics urine caused by metabolizing fat instead of glucose.

5. How does the Multistix-10SG test for glucose? It uses glucose oxidase, peroxidase, and benzidine impregnated on a paper strip. The enzyme glucose oxidase catalyzes the breakdown of glucose into peroxide. Peroxidase catalyzes oxidation of benzidine with peroxide. Benzidine is a chromogen that changes color when oxidized.

6. Name any three medical conditions that the Multistix helps to identify? Any three of the following: Urinary tract infections, diabetes, kidney diseases, dehydration, infections, acid-base balance off, and liver damage.

Cleopatra's Perfume Factory and Spa

1. How did Cleopatra acquire a spa and perfume factory? Marc Anthony (the Roman Consul, not singer) gave it to her as a gift

2. What did chemists find when they analyzed a jar of Dead Sea mud treatment? It was chemically similar to asphalt.

3. Where does the saying "Flies in the ointment" come from? If flies fall into a perfume preparation and die, proteins from the flies decompose into the foul smelling diamines called putrescene and cadaverine. The foul odor will spoil the whole batch of perfume.

4. How were perfumes made in Cleopatra's time? Perfumed oils were made by extracting scents from flowers and spices using olive oil or lard.

5. What metal is present in Cleopatra's green eye makeup? The green eyemakeup contains copper(II) carbonate.

6. What unexpected discovery did chemists make when they tested Cleopatra's "signature" black eye makeup? They discovered two compounds which don't occur naturally, laurionite ($PbOHCl$) and phosgenite ($Pb_2Cl_2CO_3$).

When Good Science Goes Bad!

1. Why was Patricia Stallings arrested? She was arrested for poisoning her son with ethylene glycol.
2. What two substances found in Ryan Stallings blood led to the conclusion that he was poisoned? Ethylene glycol and calcium oxalate.
3. Ryan was later thought to suffer from MMA. Why was this alternate explanation initially considered insufficient to overturn the conviction? Because the presence of ethylene glycol in his blood was an unmistakable sign of poisoning.
4. How and where do the separations of compounds occur in a gas chromatograph? In a column packed with an absorbent (silica or alumina gel), compounds are separated by their relative attraction to the absorbent.
5. What happened when skeptical scientists doped blood samples with propionic acid and sent them for commercial GC-MS testing? Three out of seven labs misidentified propionic acid as ethylene glycol.
6. What treatment for ethylene glycol poisoning might have caused calcium oxalate crystals to form in Ryan's brain? If not monitored carefully, the ethanol treatment given for ethylene glycol poisoning can increase precipitation of calcium oxalate.

Content Reading Materials

National Science Education Content Standard Addressed As a result of activities in grades 9-12, all students should develop understanding	**Cleopatra**	**Lab on a Stick**	**Carb Crazy**	**Antifreeze**	**QFTC***
Science as Inquiry Standard A: of abilities necessary to do scientific inquiry					✔
Science as Inquiry Standard A: about scientific inquiry.	✔	✔	✔	✔	✔
Physical Science Standard B: of the structure and properties of matter.	✔	✔	✔	✔	✔
Physical Science Standard B: of chemical reactions.	✔	✔	✔	✔	
Life Science Standard C: of the cell.			✔		
Life Science Standard C: of matter, energy, and organization in living systems.		✔	✔		
Science and Technology Standard E: about science and technology.	✔	✔	✔	✔	✔
Science in Personal and Social Perspectives Standard F: of personal and community health.	✔	✔	✔	✔	✔
Science in Personal and Social Perspectives Standard F: of science and technology in local, national, and global challenges.	✔	✔		✔	
History and Nature of Science Standard G: of science as a human endeavor.	✔	✔	✔	✔	
History and Nature of Science Standard G: of the nature of scientific knowledge.	✔	✔	✔	✔	✔
History and Nature of Science Standard G: of historical perspectives.	✔	✔			

*QFTC-Question From the Classroom

Reading Strategies

These content frames and organizers are provided to help students locate and analyze information from the articles. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher if students are struggling. If you use these reading strategies to evaluate student performance, you may want to develop a grading rubric such as the one below.

Score	Description	Evidence
4	Excellent	Complete; details provided; demonstrates deep understanding.
3	Good	Complete; few details provided; demonstrates some understanding.
2	Fair	Incomplete; few details provided; some misconceptions evident.
1	Poor	Very incomplete; no details provided; many misconceptions evident.
0	Not acceptable	So incomplete that no judgment can be made about student understanding.

Cleopatra's Perfume Factory and Spa

Cleopatra's Spa Treatment or Makeup	Similar Current Spa Treatments or Makeup	Chemicals found in spa treatments or makeup

Lab on a Stick

History of Urinalysis

Date	Chemicals and methods used
Ancient times	
Early 1900s	
1930s	
1953	
Today	

Q & A with Helen Free

What H. Free liked about being a chemist	What H. Free didn't like about being a chemist
1.	1.
2.	2.
3.	3.

When Good Science Goes Bad!

Chemical evidence for ethylene glycol poisoning	Other possible explanation

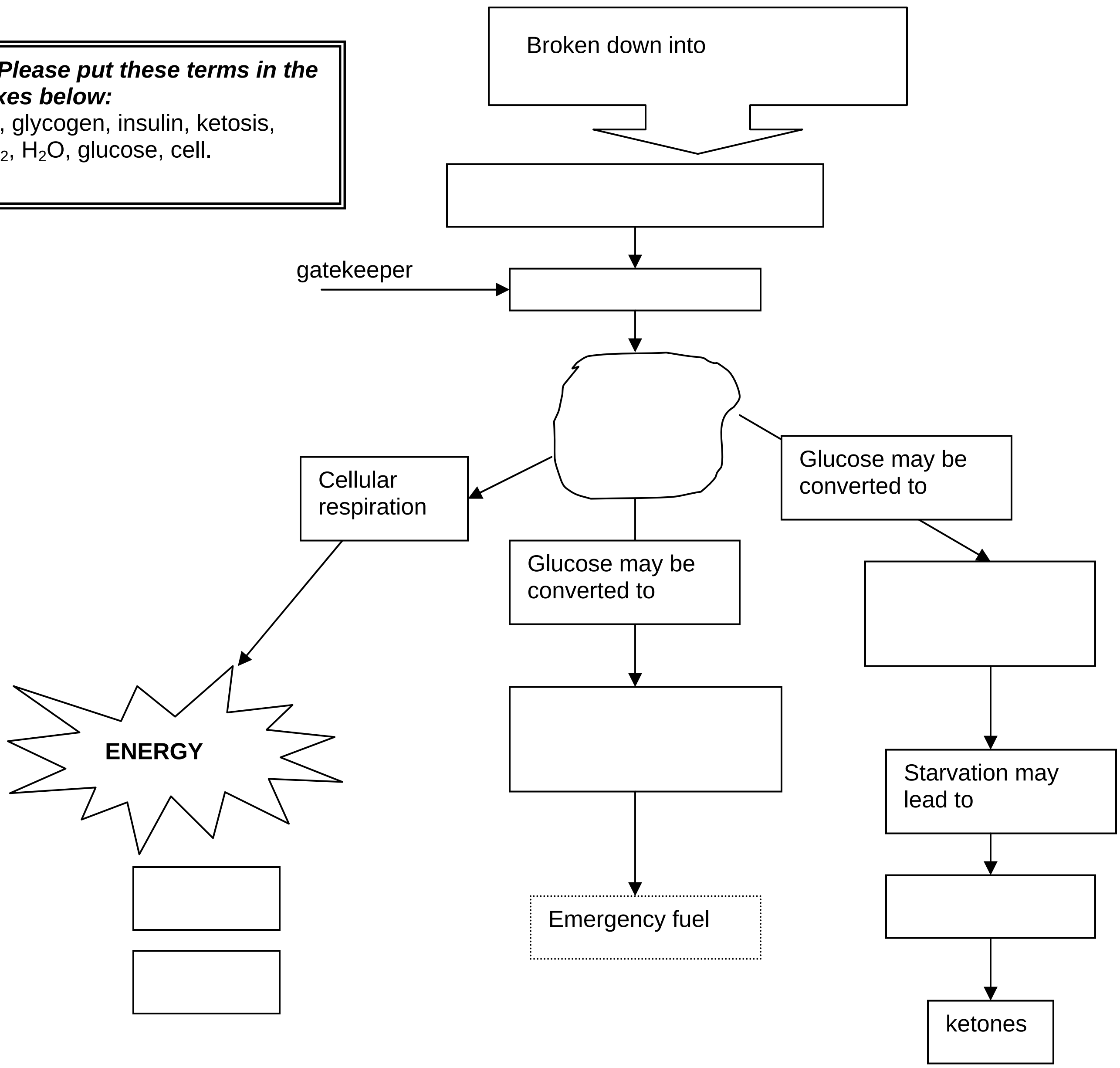
➔ **In the chart below, compare the differences in the quantitative and qualitative tests for ethylene glycol. Include the chemistry involved in each test.**

Quantitative Test	Qualitative Test

Carb Crazy

	Carbohydrates		
	Monosaccharides	**Disaccharides**	**Polysaccharides**
Brief Description			
Examples			

➔ Please put these terms in the boxes below:
Fat, glycogen, insulin, ketosis, CO_2, H_2O, glucose, cell.



Anticipation Guides

Anticipation guides help engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss their responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

Directions for all Anticipation Guides: In the first column, write "A" or "D" indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

Carb Crazy

Me	Text	Statement
		1. All digestible carbohydrates are broken down into glucose so the body can use them.
		2. Fructose is more expensive and less sweet than sucrose.
		3. Indigestible carbohydrates are unhealthy.
		4. Eating sugary snacks can actually make you hungry sooner.
		5. To lose weight, you must burn more calories than you eat.
		6. Your body burns fat before glycogen.
		7. People on low-carb diets should restrict water intake.
		8. Proteins and fats are absorbed more quickly in the body than carbohydrates.
		9. Low carb diets are good for teenagers.

Cleopatra's Perfume Factory and Spa

Me	Text	Statement
		1. Cleopatra used asphalt on her skin.
		2. Deodorants were available to Cleopatra.
		3. Cleopatra added perfumed oils to wine.
		4. Flies were attracted to Cleopatra's perfumed oils.
		5. The diamines putrescine and cadaverine have a pleasant odor.
		6. Indole, used in today's skin-care products, is derived from animal excrement and urine.
		7. Many of Cleopatra's makeup pigments contained lead.
		8. Egyptians used only chemicals that occur naturally; they did not know how to manufacture synthetic chemicals.

➔***Alternatively***, you could list the spa treatments and ask students to <u>predict</u> what was in each treatment, and <u>whether they are used today</u>.

The treatments are: Dead Sea mud body polish; croc excreta facial; Dead Sea salt scrub; moringa manicure; ass-milk bath; Dead Sea mud bath; asphalite hair pack; Dead Sea salt foot scrub; horseradish body polish; and black-tar mask.

Lab on a Stick

Me	Text	Statement
		1. Type I and Type II diabetes have similar causes.
		2. Diabetes was known in ancient times.
		3. Diabetics have too much glucose in their urine.
		4. The 10-test strip developed by the Frees tests for the health of kidneys, liver, and blood sugar.
		5. Helen Free always wanted to be a chemist.
		6. Helen Free married her husband, then went to work for him.
		7. Helen Free earned millions from her 7 patents.
		8. Some chemists are needed in legal departments of chemical companies.

When Good Science Goes Bad!

Me	Text	Statement
		1. MMA (an inherited disease) and ethylene glycol (antifreeze) poisoning have similar symptoms.
		2. The metabolic products of MMA are similar to ethylene glycol.
		3. Quantitative analysis is superior to qualitative analysis.
		4. A gas chromatograph measures retention times of different compounds on an adsorbent material.
		5. Data from a mass spectrograph is compared to a database library to identify compounds.
		6. Colorimetric analysis is qualitative.
		7. Ryan's death was hastened by the treatment for ethylene glycol poisoning.
		8. Calcium oxalate dissolves in water.

Carb Crazy

Background Information

Both starch and glycogen are important polysaccharides which act to store the simple sugar monomers composing them. Both starch and glycogen polymerize within cells by a form of condensation synthesis in which a hydroxyl group of one monomer reacts with the anomeric carbon at the opposite end of a second monomer. Molecules of water are eliminated in the process. Simple sugars are released from storage when the polysaccaride undergoes the reverse process, hydrolysis, in which molecules of water are restored.

Starch is made by plant cells, and glycogen, by animals. Both of the polysaccarides, with their many exposed hydroxyl groups, become heavily hydrated in their cellular environments. Starch molecules— huge polysaccarides (m.w. often exceeding 1 million)—are generally of two types: amylose consisting of long, unbranched chains of D-glucose, and amylopectin, highly branched. Glycogen, similar to amylopectin, is even more highly branched. It generally appears in granules that also contain enzymes ready to degrade the molecule when conditions are right.

Both starch and glycogen are essentially insoluble. If the point is to have glucose ready for instant use as cellular fuel, why don't cells simply store the glucose molecules in solution? It turns out that having that many particles in solution would create a severe osmotic imbalance that would either cause the cells to swell and burst, or, at the very least, would reach an equilbrium state in which no additional net gain in glucose molecules would occur.

Are all carbohydrates created equal?
Do all carbohydrates contribute equally to a rise in blood sugar? Fortunately, no. There are "good" and "bad" carbohydrates, depending on how quickly that carbohydrate is converted to glucose in the bloodstream, as measured by the glycemic index (GI). The GI rates glucose at 100, and foods are ranked according to how fast they enter the bloodstream, relative to glucose. For example, if a food has a GI of 50, it is absorbed into the bloodstream half as fast as that of glucose. Good carbohydrates have a low GI, and bad carbohydrates have a high GI. White bread, for example, has a GI of 70, while pumpernickel has a GI of 41. Watermelon has a GI of 72, but a plum has a GI of only 24. Instant white rice has a GI of 91, while brown rice only has a GI of 55. Generally, the more refined the food, the quicker it can be broken down and the higher its GI. The more work our body must do to break down a substance, the slower it will be absorbed into the bloodstream. Apple juice has a higher GI than apples. Baked potatoes have the highest GI of all potatoes at 85. To avoid spikes in blood sugar, with the resultant insulin spike followed by a crash in blood sugar, choose carbohydrates with a low GI.

The GI is not a perfect measure of what foods to eat, however. Fructose, for example, has a GI of only 20. Scientists actually give rats large does of fructose to make them insulin resistant.

Connections to Chemistry Concepts

Relating the Caloric values of foods to the concepts surrounding Heats of Combustion is relevant to the article's discussions about diet plans.

Possible Student Misconceptions

Students frequently mistake food Calories (actually kilocalories) for the unit of energy the calorie. The "kilo" portion is of course very important. Just warming a 200 g cup of water from room temperature to normal body temperature (25 ^{o}C to 37 ^{o}C) requires 2400 calories. Is a 2400 calorie (not 2400 Calorie or 2400 kilocalorie) diet sufficient to maintain human body temperature for 24 hours?

Students may also wonder about the term "burning" food for calories. Misconceptions are compounded by hearing foods described as "fuels". The way the cells depend on enzymes to lower the activation energy necessary for breaking chemical bonds during metabolism is a basic topic in many modern biology curricula. A brief discussion may clear up the confusion if it occurs.

Demonstrations and Lessons

The *ACS Chemistry in the Community, 4th Ed.* textbook as well as other basic high school chemistry textbooks, has a laboratory investigation in which students construct a calorimeter using a soda can containing 100 ml of water. Students relate the temperature increase in the water to the weight of paraffin consumed by a burning candle in order to determine the Heat of Combustion of paraffin in kJ/g. A similar procedure might be devised to determine the heat of combustion of small piece of wood. Comparisons between paraffin (lipid) and wood (carbohydrate) heats of combustion would be relevant to a discussion about the relative roles of fats and carbohydrates in a diet plan.

Connections to the Chemistry Curriculum

Organic chemistry, thermal energy, and polymers are topics that relate to the content of the article. In addition, the ways in which information is collected and analyzed for making informed consumer choices is a critical goal of every good high school science program.

Suggestions for Student Projects

1. Students can run analyses of their own diets. The analysis can be a quick and simple activity such as keeping a list of what is eaten on one typical day and then placing each food into the appropriate place on the food pyramid. A more complex analysis might involve a record of what was eaten over several days followed by a detailed analysis of Caloric content, as well as carbohydrate, fat, and protein content (on a percent by Calorie basis), including even the amounts of vitamins and minerals. *ChemCom* provides a rather extensive table of foods showing this type of nutritional information. See also the list of suggested Web sites for this article.
2. Students can perform "blind taste tests" of "low-carb" or "sugar-free" food products to compare them to their sugary counterparts
3. Students could examine one of the current "fad" diets and either prepare a paper or give a class presentation on the rationale behind the diet. Different teams of students could debate the merits of the diet—one side arguing in its favor, the other opposing the diet.

Anticipating Student Questions

Students will want to know if a diet like the Atkins diet is good for them. As the article points out, there have been no significant long-term studies to find out whether minimizing carbs in a teenager's diet plan advisable or even safe for losing weight.

Websites for Additional Information and Ideas

Students will be interested in finding out about, and perhaps, comparing other diet plans.
For an informative and entertaining account of several diet fads of the past go to

http://www.dietbites.com/article0159.html

More of diet plans are found at this site. Be sure to check out the Paleolithic Diet!
http://www.channel4.com/science/microsites/B/bodystory/fat_diets.html#fplan

Lab on a Stick

Background Information

ChemMatters has run several articles focusing on the use of urinalysis as a means for diagnosing a variety of diseases and conditions.

In April 1995, "Seeds of Doubt" by Bruce Goldfarb told the story of a nurse who tested positive for heroin in a urine sample as a result of eating a poppy seed bagel the evening before her drug screening test.

Following the Sydney Olympic Games, Australian writer Robert Morton contributed "Drug Detection at the Olympics—A Team Effort" (December, 2000). The article described how the use of various banned substances by athletes could be detected by analyzing urine samples collected prior to an event. Ways that unscrupulous competitors devise to hide these substances continues to challenge chemists hired to monitor the games.

In the October 2002, Doris Kimbrough authored the highly rated "Urine: Your Own Chemistry", to describe how urine reflects the chemistry of the body. This article, explaining how the kidney's perform their excretory functions, would make an effective companion to the current article. (Suggestion: Order the 20-year CD Rom of ChemMatters articles online at www.chemistry.org/education/chemmatters.html. Here you'll find all of the articles from 1983-2003 with all available Teacher's Guides in a printable, searchable format.)

Kidneys and Urine

A normal 24 hour urine output contains about 60 grams of solid material. About half of this is organic, consisting of substances like urea, uric acid, and creatinine. The inorganic portion will contain substances like sodium chloride, phosphates, sulfates, and ammonia. Normal urine should not contain any glucose or amino acids.

The amount of uric acid in a healthy person's urine tends to vary over a relatively wide range from day to day. Normal serum levels of uric acid range from about 2.0-7.5 mg/dL for males and 2.0-6.5 mg/dL for females. Normal urine contains between 250-750 mg over a twenty-four hour period. Medical experts disagree about the exact range of uric acid to be considered normal. Uric acid is formed as the end product of purine metabolism. Purines are obtained from foods. Some foods high in purines include liver, kidneys, sweetbreads, sardines, anchovies, lentils, mushrooms, spinach and asparagus. Additional purines are produced from the breakdown of bodily proteins. The kidneys excrete about two-thirds of the uric acid the body produces. The remainder is eliminated in the stool.

Recently, high levels of uric acid in a person's blood has been linked to an increased risk of dying from heart disease, especially in women and African Americans. In one study, 6,000 people aged 25-74 were followed for a period of sixteen years. They were divided into four groups— serum uric acid levels below 5.4, between 5.4-6.1, between 6.1-7.0, and above 7.0 respectively. Women at the highest level were about three times more likely to die from heart disease than women at the lowest level. The risk was 77% higher for similar groups of men. For all groups, the risk only showed itself for people aged 45 or older.

Urea holds a special place in the history of chemistry. First discovered in human urine in 1773, it is most notable because of Friedrich Wohler's laboratory synthesis of the compound in 1828. What made this relatively simple synthesis so noteworthy was that prior to that time "organic" chemicals were considered to be molecules that could only be synthesized by living organisms. It was widely believed that molecules synthesized by a living organism could not be synthesized from their atoms in a laboratory because their synthesis required a "vital force" that only living things possessed. When Wohler synthesized urea while trying to synthesize ammonium cyanate and then demonstrated that the compound produced could not be distinguished from urea obtained from organic sources, it dealt a great blow to the concept of "vital force". Even today, a version of the "vital force" idea persists in the popular notion that vitamins obtained from "natural" sources are superior to vitamins synthesized in the laboratory.

Connections to Chemistry Concepts

Enzymes are biological *catalysts*. There is no all-encompassing definition of a catalyst, but an adequate definition is the following: A catalyst is a substance that speeds up the rate of a chemical reaction without being permanently consumed in the reaction.

Catalysts work by lowering the energy needed to get the two reacting molecules to react with each other. This energy is often referred to as the *activation energy* for the reaction, and the lower the activation energy, the greater the percentage of colliding molecules that are capable of reacting upon collision.

Some catalysts are never actually consumed. For example, a "surface" catalyst can function by simply holding a reacting molecule on its surface in a position where it is more likely to react with another molecule in its environment. Other catalysts are temporarily "consumed," in an early step in the reaction mechanism, but then regenerated in a later step.

Most biological catalysts are enzymes. A few are *ribozymes* with the catalytic activity occurring in the RNA part of the molecule rather than in the protein part.

For a more thorough discussion of catalysts in general and enzymes in particular, go to: http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/E/Enzymes.html

Possible Student Misconceptions

Both this article and the article on low-carb diets focus on the growing incidence of diabetes in our society. Students may have several misconceptions about the disease, e.g. That it is always hereditary, that it is caused by eating too much sugar, that it is easily "cured" by taking insulin, that all types of diabetes are the same, and many others. Excellent information is available from the American Diabetes Association at http://www.diabetes.org/about-diabetes.jsp. You might want to initiate a discussion by devising a simple True-False quiz to check how much your students know about the disease.

Demonstrations and Lessons

1. The publication "Celebrating Chemistry—Health and Wellness" posted by the ACS National Chemistry Week office for upper elementary and middle school students, contains an interesting activity in which multiple-test urinalysis strips are used to test a concocted "urine sample" for the presence of glucose and protein. The sample is actually pediatric electrolyte solution mixed with a small amount of powdered milk. While the procedure is fairly simple, it serves as an interesting demonstration of the test strip. Other additions to the "urine sample" might demonstrate other tests on the strip. Students could be challenged to design and, with your approval, perform related experiments to extend the use of the test strips beyond their use in urinalysis.

2. Testing for simple sugar in solution is accomplished by using a test reagent called Benedict Solution. The following instructions for making the reagent (also easily obtained from any chemical supply source) is as follows:

> A solution of 17.3 g of sodium citrate and 10.0 g of anhydrous sodium carbonate in 80.0 mL of water is heated until the salts are dissolved. Additional water is added to bring the volume up to 85.0 mL. A solution of 1.73 g of hydrated copper sulfate in 10.0 mL of water is poured slowly with stirring into the solution of the citrate and the carbonate. Add water to make a final volume of 100 mL.

The article describes how the presence of a strong reducing agent like glucose reacts upon heating with the blue cupric ions, readily changing them to Copper I which precipitates as an orange copper (I) oxide solid.

3. It might be of interest to invite a medical technician to talk to the class about current advances in screening and diagnostic testing.

Connections to the Chemistry Curriculum

The article connects to curriculum topics on solutions, oxidation and reduction, enzymes, catalysts, acids and bases, and several others. It also describes the importance of chemical testing in the diagnoses of disease and in the forensic urinalysis employed in screening for drug use.

Suggestions for Student Projects

Students might be challenged to devise their own test papers by using strips of filter paper and various testing reagents.

They might be challenged to invent other uses for the commercial test strips described in the article. Before doing so, they would need to read the information enclosed with the commercial strips as well as other information related to the tests.

Anticipating Student Questions

See the section on Possible Misconceptions for questions your students might have about diabetes.

Websites for Additional Information and Ideas

The following website offers a detailed account of the drug-screening urinalysis procedure used by the U.S. Department of Defense for recruits.
http://usmilitary.about.com/library/milinfo/bldrugtests.htm

Cleopatra's Perfume Factory and Spa

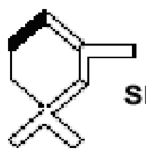
Background Information

How you smell perfumes

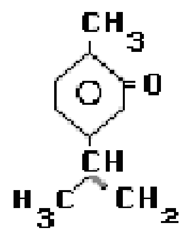
Musk, camphor, anise, woody odors, spearmint, rose, cinnamon, and caraway are all aromatic compounds. There are about 40 million receptor sites for smells in your nose. Each site is a hole of a certain shape, which will accommodate a certain chemical. When a molecule fits one of the sites, it acts as a key to trigger a nerve signal to your brain, which registers the smell.

Chemical formulas and names

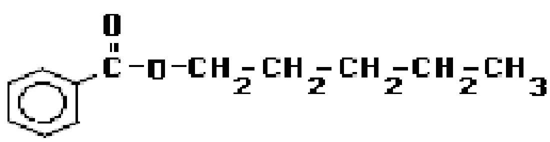
Aroma of roses = 2-phenylethanol
Hyacinths and lilacs = phenylacetaldehyde
Jasmine = amyl salicylate



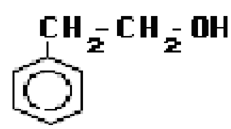
Shape of receptor site for spearmint



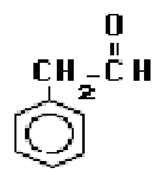
Spearmint



Jasmine



Roses



hyacinths and lilacs

Connections to Chemistry Concepts

- Structure versus function
- "Like dissolves like"
- Non polar versus polar molecules

The article presents a number of molecular structures and their related odors. The relationship between the structure of a given organic molecule and its name is described in detailed rules set by the IUPAC (International Union of Pure and Applied Chemists), an organization concerned with clear and accurate communication of chemical information among researchers. While a presentation of the myriad and complex rules for naming molecules is beyond the scope of this Teacher's Guide, there is a Web site with a thorough treatment of the topic:

www.ouc.bc.ca/chem/nomenclature/nom-i.htm

Possible Student Misconceptions

Students may think that humans are capable of only detecting a relatively small number of different odors, perhaps a few hundred. In fact, it is estimated that we can distinguish approximately 10,000 different odors. They may also believe that each specific odor is connected to some sort of specific receptor or other type of detector in our nose. Most odors actually trigger the firing of many receptors. They may not realize that it is only in the past ten years or so that scientists have really come to any meaningful understanding of how our sense of smell really works and how it is connected to genes.

One misconception that is fueled by cosmetic advertising is the skin can be *nourished* even *deeply nourished* by applying vitamin-rich substances to the surface. In fact, fortunately for our health and safety, the skin resists absorbing substances that are topically applied. Only very few molecules can penetrate the outer layers of dead cells (stratum corneum) to reach the underlying cells bathed in body fluids. The molecules able to penetrate are generally small nonpolar molecules able to dissolve and diffuse in the lipid content of the outer layers. An article on medical patches used to deliver drugs through the skin is scheduled for the December 2004 issue of *ChemMatters*.

Demonstrations and Lessons

The article mentions the use of emulsions in cosmetics preparations. An example of an edible emulsion is mayonnaise. A demonstration or student activity is available at http://www.iit.edu/~smile/ch9509.html.

Connections to the Chemistry Curriculum

Intermolecular bonding. Transition metal properties.

Suggestions for Student Projects

Visit a local rock shop and try to find some of the minerals used to make ancient perfumes. Compare the ingredients of ancient cosmetics and perfumes to their modern counterparts.

Experiment 1: Lard with boronea heather

1. Place one large teaspoon full of lard on a large watch glass.
2. Spread the lard over the watch glass until it is dispersed evenly, covering the majority of the glass face.
3. Sprinkle a thin layer of boronea heather over the lard.
4. Place another large watch glass over the the lard and boronea heather.
5. Press down, squishing the boronea heather and lard between the two watch glasses.
6. Let sit overnight.
7. Add more boronea heather, and let sit for another 24 hours.
8. Add more boronea heather, and let it sit for another 24 hours.

Experiment 2: Lard with rosemary

1. Place one large teaspoon full of lard on the indented side of a large watch glass.
2. Spread the lard over the watch glass until it is dispersed evenly, covering the majority of the glass face.
3. Sprinkle a thin layer of rosemary over the lard.
4. Place another large watch glass over the one with the lard and rosemary.
5. Press, squishing the rosemary and lard between the two watch glasses.
6. Let sit overnight.
7. Add more rosemary, and let sit for another 24 hours.
8. Repeat with another layer of rosemary, and let sit for another 24 hours.

Anticipating Student Questions

Students may have questions about the history of personal hygiene and fragrances. Doris Kimbrough wrote “How We Smell and Why We Stink” for the December 2001 issue of *ChemMatters*. In the article, she explains the different functions of various sweat glands and their characteristic secrections. She notes that the sweat is odorless, but that skin bacteria quickly turn it to less innocuous products.

Students may wonder about the way we react to odor. What is it that repels us when we smell garbage, but pleases us when we smell baking bread? Kimbrough wrote the following in her 2001 article:

> Why are some smells pleasant and others extremely disagreeable? There are a lot of hypotheses but not much in the way of experimental evidence. What ***is*** known is that some odors are universally disagreeable to all humans (skunks, rotten food, decaying animals, or fecal odors) while others are objectionable only to some (cigar or pipe smoke, certain spices, or the perfume worn by that girl in your English class). It’s likely that our hate of certain smells is even a survival advantage. Avoiding rotten food and decaying animals automatically makes you a healthier person who will live longer!

Websites for Additional Information and Ideas

Make perfume! Edmund Scientific offers a $30 kit for distilling essential oils from flowers at http://scientificsonline.com/product.asp_Q_pn_E_3071684

Check it out! Swipe and Smell
In *National Geographic* article titled “Perfume, The Essence of Illusion” (October 1998, p 110 and p 111), there are two “swipe and smells” where you can smell historical fragrances by rubbing your fingers over pictures that have encapsulated perfume mixed with a lacquer and printed on the pages.

- Bennette, T. “Perfumery and Fragrance: Fragrant Thoughts.” http:/www.mindspring.com/~tbennett//perfumes/ancient_perfumes.html.
- Hill, James W. *Chemistry for Changing Times*. Prentice Hall: New Jersey, 2003.

- Studd, Helen. “Scientists sniff out recipe for pharaoh’s perfume.” http://virus.lucifer.com/bbs/index.php?board=5;action=display;threadid=24846 accessed 3/18/04.
- Wetula, Lauren. “Egyptian Cosmetics.” http://www.angelfire.com/realm2/amethystbt/Egyptmakeup.html

When Good Science Goes Bad!

Background Information

Antifreeze poisoning

Your car needs antifreeze because water increases in volume about 10% when it freezes, and this expansion can crack and ruin the engine block. To prevent cold-weather damage, ethylene glycol antifreeze is commonly added to the water that flows through the engine. When equal volumes of water and ethylene glycol antifreeze are mixed, the freezing point is lowered from the 0 °C (32 °F) of pure water to about –37 °C (–35 °F). Because outside temperatures rarely fall this low, your engine is protected from cracking. In addition, even when the ethylene glycol solution does freeze, it forms a "mushy" solid that exerts little mechanical impact on the radiator or engine head.

In his book *Chemistry in the Marketplace,* author Ben Selinger notes that freezing point depression and boiling point elevation depends on the *number* of molecules in solution, not upon the size or mass of these molecules. It follows that low-molecular weight species like methanol (MW= 32) would be particularly efficient, but methanol tends to boil away at fairly low temperatures. Ethylene glycol (MW= 62) works better at engine temperatures, but it is only about half as effective as methanol at freezing point depression.

Although vital for preventing engine damage, ethylene glycol antifreeze poses a serious threat to animals and humans. It is a rapid poison, quickly causing severe kidney and brain damage that often leads to death. It is also a powerful poison; as little as a few teaspoons of ethylene glycol is lethal to humans and wildlife. As poisons go, ethylene glycol has a particularly cruel and pernicious twist: It has a sweet flavor, which makes it appealing to many animals and children. About 4,200 people—including more than 700 children age five or under—are poisoned by antifreeze annually, according to the federal Consumer Product Safety Commission.

Treatment

In humans and other animals, ethylene glycol is broken down by alcohol dehydrogenase. This is the same enzyme that acts on ethanol and propylene glycol, the safer antifreeze. But the metabolism of ethylene glycol is dramatically different. Ethylene glycol is metabolized by alcohol dehydrogenase into several toxic organic acids. One of the most important of these is oxalic acid, which reacts with calcium ions in the blood to form solid calcium oxalate in the bloodstream. The insoluble calcium oxalate crystals block the flow of blood and cause severe damage to the lungs, brain, heart, and kidneys. Although calcium oxalate crystals cause brain damage, the most serious injury is to the delicate blood-filtering structures of the kidneys.

The ingestion of very small amounts of ethylene glycol can be fatal. Sixty mL of ethylene glycol—just 2 fluid ounces or 4 tablespoons—can kill a large dog or an adult human. A child can die by drinking 30 mL, about 2 tablespoons. The treatment is to administer ethanol—beverage alcohol. This treatment is recommended because the enzyme alcohol dehydrogenase has an affinity for ethanol that is 100 times greater than for ethylene glycol.

As medical staff closely monitor the patient's status, ethanol is administered over a period of days or weeks while ethylene glycol is slowly eliminated from the body. Eventually, ethylene glycol will pass through the kidneys into the urine. In severe cases, hemodialysis with an artificial kidney machine may be used to filter ethylene glycol and toxic organic acids from the bloodstream.

A Deadly Bit of History

The article “Sweet Elixir of Death” in the August 28, 2004 issue of New Scientist offers a fascinating account of a tragic misstep on the part of a drug manufacturer trying to supply patients with the new wonder drug Sulfanilamide in the late 1930s. Many children who received this particular batch of the drug died in agony with liver and kidney failure. The toxic ingredient was soon identified as the sweet tasting solvent, diethylene glycol. The FDA launched a massive search for any remaining bottles, recovering 234 gallons of the 240 that had been released for sale. The tragedy left 107 dead and 240 severely disabled victims. The astonishing thing was that no laws were broken. At that time, the Pure Food and Drug Act enacted in 1906 only prohibited mislabeling of contents.

In 1938, President Roosevelt signed into law the Federal Food, Drug, and Cosmetic Act mandating that no drug can be marketed withoug proof of its safety.

Mass spectrometry
The article mentions the use of mass spectrometry. The sample of material must be vaporized and then bombarded with electrons so the fragments become ionized. After being accelerated through an electric field, the charged fragments are then passed through a magnetic field. Charged particles move through a magnetic field traveling in a circular path. The radius of curvature of the circle depends upon the mass and charge on the fragment.

Connections to Chemistry Concepts

Some organic structures were presented in the article. If it would be beneficial to access a Website for information on the naming of organic compounds, a few good ones can be found at:

http://www.angelfire.com/bc2/OrgChem/

http://www.acdlabs.com/iupac/nomenclature/

http://www.chem.ucalgary.ca/courses/351/Carey5th/nomenclature/

Possible Student Misconceptions

Students may logically assume that the freezing point of a solution would depend more on the chemical nature of the substance you dissolve rather than how “much” you dissolve in a given amount of solvent. But the freezing point of a solution (at least for very dilute solutions) is much more closely related to the concentration of the substance dissolved rather than its chemical identity.

Connections to the Chemistry Curriculum

Freezing point depression, organic chemistry

Suggestions for Student Projects

Ethylene glycol poisoning has figured into many crime scenarios. While explaining the toxicity of the substance, Slate writer Brendan Koerner offers links to several forensic cases in which evidence supported the use of ethylene glycol in crimes. Students might research some of these cases to report on the way evidence was gathered and analyzed.

Anticipating Student Questions

Students may ask about safer, less toxic alternatives to using ethylene glycol for anti-freeze. One such product, called Sierra, is made with propylene glycol, often used as a sweetener in cough syrups.

Websites for Additional Information and Ideas

For a more thorough description of a mass spectrometer, see:
http://www.chem.vt.edu/chem-ed/ms/ms-intro.html