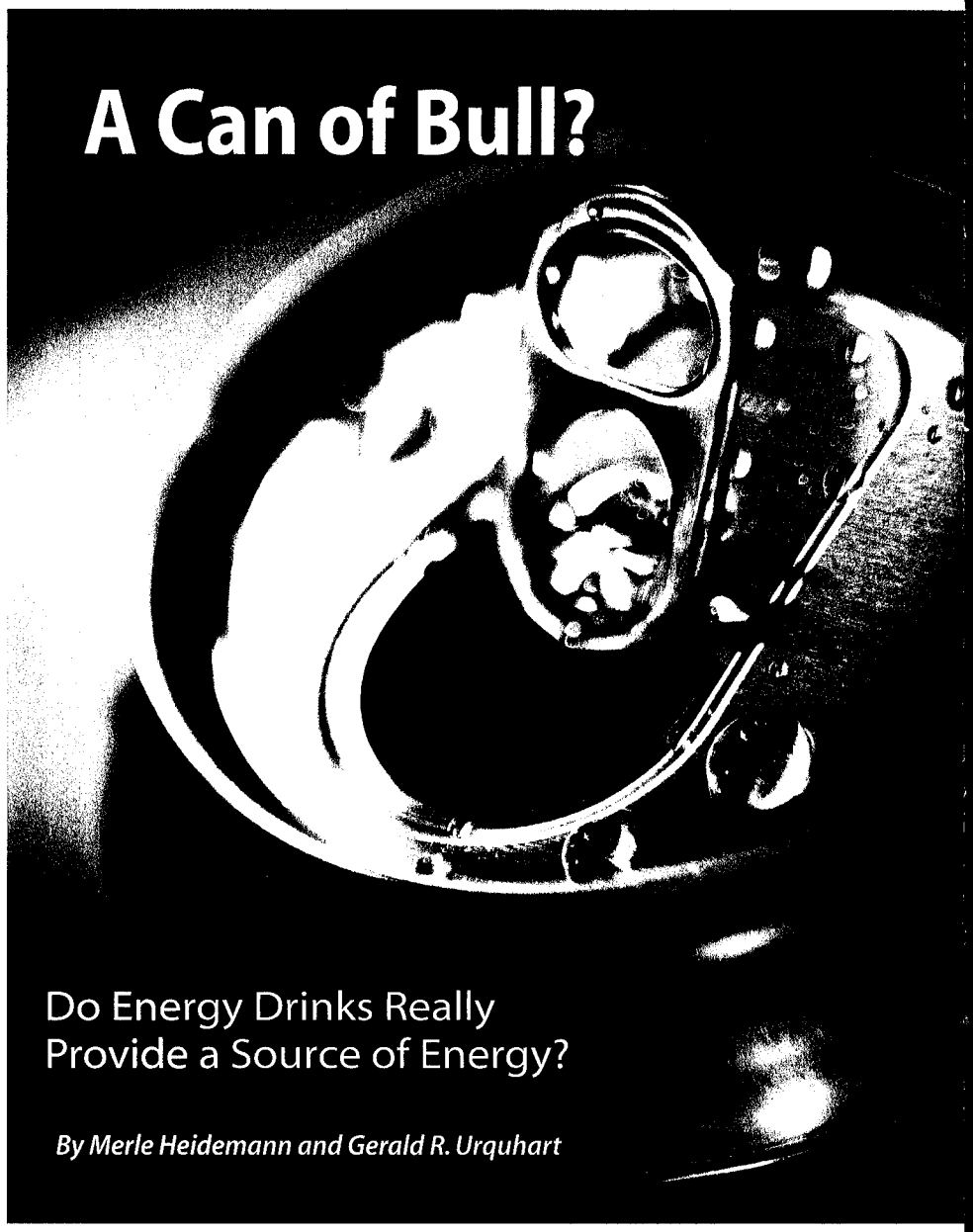

This case study involves the biochemical analysis of the components of commonly available energy drinks, which many students purchase at fairly high prices. Students research the ingredients in each product and their physiological role in the human body, and then attempt to match what they learn with the product manufacturers' marketing claims. The case can be used as a review of basic biochemistry and nutrition for upper level students in physiology, biochemistry, or nutrition courses—or to introduce this information in basic courses in these disciplines.

The case

After spending several years working the sports' desk of the Lansing State Journal, Rhonda had landed the job of her dreams as a writer for *Runners' World* magazine. The job was fantastic! Since high school, where she had excelled in cross country, Rhonda had been a consistent runner, participating in local races and now those assigned to her for work. For her last *Runner's World* assignment, she had run and reported on a Leadwood, South Dakota, marathon—it was a blast!

As if reading her mind, her boss Charley walked in just then with a can of XS Citrus Blast in one hand and a list of several other energy drinks in the other.

"We've been getting a lot of inquiries about the different energy drinks on the market, including XS Citrus Blast. Do you know anything about them?" Charley asked.

"I know that people use them for various reasons," replied Rhonda. "It seems they're primarily used by athletes to provide some 'fuel' as they practice and compete. Other people use them more casually as a way to become 'energized.' That's about all I know."

"That seems to be about all any of us knows," Charley said.

"For your next assignment," Charley continued, "I want you to find out what each of the ingredients in these drinks is and what it does for a runner or for a nonathlete. You need to be very accurate in your analysis—determine what each component really does for the body, not what the marketers want you to believe it does. Then look at the marketing claims of some of these drinks and see if the scientific facts match up to them. Many of our readers are using these drinks with some general notion that they're helpful, but they're basing their use of them on no scientific information. I've got the marketing claims (Figure 1), a short list of questions that should get you started (Figure 2), and a list of ingredients and nutrition facts provided on the cans for consumers (Figure 3, page 42). When you research these, be sure to document all your sources, keeping in mind that all resources are not equal. Here's the material."

With that, Charley left the office. Rhonda looked over the lists.

"Guess I'll have to brush up on my biochemistry. No problem. I'm interested in knowing if my running

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FIGURE 1

Marketing claims.

Rhonda perused the marketing claims for each drink:

Red Bull

- The Red Bull energy drink is a functional product developed especially for periods of increased mental and physical exertion.
- It can be drunk in virtually any situation: sport, work, study, driving, and socializing.
- Improves performance, especially during times of increased stress or strain.
- Improves concentration and reaction speed.
- Stimulates metabolism.

XS Citrus Blast

- There is less than ½ a calorie of sugar in XS Citrus Blast. This qualifies for the government-approved statement "no sugar added." The eight calories in XS Citrus Blast are from amino acids and are protein calories that aid your body's natural metabolic process.
- Most 8-ounce energy drinks in the market today have over 100 calories from 27 to 30 grams of sugar, which are simple carbohydrates. Most 12-ounce, non-diet soft drinks have 170 calories from 40 grams of sugar. Most 5.5-ounce juice drinks have 80 calories from 20 grams of sugar.
- Calories from sugar and carbohydrates may increase fat deposits. Simple carbohydrates are also called high glycemic (high sugar) foods. High glycemic foods cause your body to pump insulin to digest the sugar, which sends a message to your body to store calories as fat. Low glycemic foods do not pump insulin to the same degree and aid in your body's natural metabolism of fat, using your body's fat resources as fuel. Many experts fear that the epidemic incidence of diabetes in North America today may be significantly contributed to by high-glycemic diets.
- XS Citrus Blast uses a proprietary blend of sucralose, acesulfame potassium (Ace K), and fruit essences to give the drinks their great flavor without sugar or empty calories. In fact, the eight calories in the drink come from the two grams of amino acids, which are protein calories.

Sobe Adrenaline Rush

- This maximum energy supplement delivers an energy boost with a natural passion fruit flavor. It's lightly carbonated with a clean smooth feel.
- This maximum energy supplement is fortified with a unique blend of natural energizing elements, including d-ribose, l-carnitine, and taurine. It's pure, concentrated energy in an 8.3-fluid-ounce can.

Impulse

- Elevate your performance.
- Impulse energy drink contains special supplements to immediately enhance mental and physical efficiency and give you the energy boost you deserve... replenishing your strength.
- Impulse gets its energy from a simple source: nutrients, minerals, and vitamins that occur naturally in the body and foods we eat. Enjoy the wake-up power of caffeine, the alertness-inducing properties of taurine, the lift you get from vitamins B6 and B12. Combined with Impulse's other ingredients, these are known to increase mental focus and physical well being, enhance performance, and accelerate metabolism.

would be improved by drinking this stuff."

Rhonda recalled that a food's calorie content was the simplest reflection of its energy content. Looking at Charley's list she saw that the different energy drinks contained varying numbers of calories (Figure 4, page 43).

Your task

Your task is to research each ingredient found in these energy drinks. This information can be found in biochemistry and nutrition textbooks. In addition, web sources may provide valuable information, but be critical in their use because many will make unsubstantiated claims. One website that can get you started for basic information is *www.chemindustry.com*. Basic information can also be gathered from *www.usda.gov/wps/portal/usdahome* (click on the "Food and Nutrition" link). Determine the chemical structure, the type of chemical each is, and the physiological role played by each compound. You should have sufficient information to answer Charley's list of questions. Your assignment is to complete Figure 5 and answer the questions. Please cite any websites that you use in your analysis.

Then, using what you have learned, individuals or groups should write an analysis of the marketing claims. This will be evaluated by the instructor to reflect learning goals. You may write the evaluation in the form of an article for readers of *Runner's World*. Be sure to include answers to the questions in Figure 5.

Teaching notes

This multipart case study was designed for students at various levels to learn about or review aspects of large biomolecules, nutrition, and product analysis. The case focuses on a number of energy drinks that are popular with high school and college students. The case examines the question, Do these drinks nutritionally match their marketing claims?

The case consists of the following parts:

FIGURE 2

Charley's list of questions.

Rhonda realized that before she could start analyzing the energy drinks, she needed to know the answer to the following question:

When we say that something gives us "energy," what does that mean? What is a biological definition of energy?

After satisfying herself that she had a good definition, she turned to the first set of questions on Charley's list.

1. What is the nature (sugar, amino acid, vitamin, and so on) of each ingredient listed on the cans?
2. What is the physiological role of each in the human body?
3. Which ingredients provide energy?
4. Which ingredients contribute to body repair, i.e., which help build or rebuild muscle tissue?

- Case scenario, in which students read about a writer at *Runner's World* magazine who has been assigned the task of evaluating the usefulness of a selection of energy drinks.
- Marketing claims for each of the energy drinks under review, which include Citrus Blast, Red Bull Energy Drink, Sobe Adrenaline Rush, and Impulse Energy Drink (Figure 1).
- Charley's list of questions, which serves to orient students to their task and guides their research (Figure 2).
- Ingredients and nutrition facts for the chemical components of each energy drink (Figure 3).
- Student task, including a post-research analysis, consisting of a table students complete along with a series of questions; students also compose a concise magazine article reviewing the information they have gathered (Figure 5).

FIGURE 3

Ingredients and nutrition facts.

Rhonda was determined to wade through the confusing labeling of the drinks. For example, XS Citrus Blast® boasted that it had no calories but still provided "energy." That made absolutely no sense based on what Rhonda knew about biological energy! The first thing she needed to do was sort out the various ingredients on the labels—a task that consumers rarely undertake.

As in most labels, listed in order of drink mass (highest to lowest):

XS Citrus Blast

Ingredients• carbonated water, l-taurine, l-glutamine, citric acid, adaptogen blend (eleutherococcus senticosus, panax ginseng, panax quinquefolium, echinacea purpurea, schisandra, astragalus, and reishi), natural flavors, acesulfame potassium, caffeine, sodium benzoate, potassium sorbate, sucralose, niacin, pantothenic acid, pyridoxine HCL, yellow 5, cyanocobalamin

Nutrition facts• serving size: 8.4 fl oz; servings per container: 1; calories: 8; fat: 0g; sodium: 24mg; potassium: 25mg; total carbs: 0g; sugars: 0g; protein: 2g; vitamin B3: 100%; vitamin B6: 300%; vitamin B5: 100%; vitamin B12: 4900%

Red Bull

Ingredients• carbonated water, sucrose, glucose, sodium citrate, taurine, glucuronolactone, caffeine, inositol, niacin, D-pantothenol, pyridoxine HCL, vitamin B12, artificial flavors, colors

Nutrition facts• serving size: 8.3 fl oz; servings per container: 1; amount per serving: calories: 110; total fat: 0g; sodium: 200mg; protein: 0g; total carbohydrates: 28g; sugars: 27g

Sobe Adrenaline Rush

Ingredients• filtered water, high fructose corn syrup, citric acid, taurine, d-ribose, l-carnitine, natural flavor, inositol, sodium citrate, ascorbic acid, caffeine, monopotassium phosphate, salt, gum arabic, ester gum, siberian ginseng root extract, pyridoxine hydrochloride, guarana seed extract, caramel color, beta-carotene, folic acid, cyanocobalamin

Nutrition facts• serving size: 8.3 fl oz; servings per container: 1; amount per serving: calories: 140; total fat: 0g; sodium: 60mg; protein: 1g; total carbohydrates: 36g; sugars: 34g; taurine: 1000mg; d-ribose: 500mg; l-carnitine: 250mg; inositol: 100mg; siberian ginseng: 50mg; guarana: 50mg

Impulse

Ingredients• carbonated water, sucrose, taurine, glucuronolactone, caffeine, inositol, niacinimide, pyridoxine HCL, vitamin C (citric acid), vitamin B12, artificial flavors, colors

Nutrition facts• serving size: 8.3 fl oz; servings per container: 1; calories: 110; fat: 0g; sodium: 200mg; total carbs: 28g; sugars: 27g; protein: 1g; niacin: 100%; vitamin B6: 250%; vitamin B12: 80%; pantothenic acid: 50%: vitamin C: 100%

Coca Cola (for later comparison)

Ingredients• carbonated water, high fructose corn syrup and/or sucrose, phosphoric acid, natural flavors, caffeine

Nutrition facts• serving size: 12 fl oz; servings per container: 1; calories: 140; fat: 0g; total carbs: 38g; sugars: 38 g; protein: 0 g

The case can be used as a review of basic biochemistry and nutrition for upper-level students in physiology, biochemistry, or nutrition courses or to introduce this information in introductory courses in these disciplines. We have also used the case successfully in a capstone course for senior biology majors wishing to become secondary teachers. In this setting, the case was used to provide a review of basic biochemistry and nutrition as well as to introduce these students to product analysis. The capstone course involves students in the study of all science disciplines. Students in the course have previously studied biochemistry and human physiology, and have background knowledge in basic metabolism. The case was also used successfully with students who had little formal training in biology at a teacher-training workshop on case studies in science education that took place at Michigan State University in August 2004. In this situation, we assumed our student audience had only a high school knowledge of basic biology and knew generally that sugars make good fuels.

Objectives

- Describe and chemically categorize the components of various popular energy drinks.
- Determine the physiological role of these components in the human body.
- Explain scientifically how the marketing claims for these drinks are supported (or not).
- Determine under what conditions each of the energy drinks might be useful to the consumer.
- Write an analysis of energy drinks for a popular magazine.

FIGURE 4
Energy drink calories

Energy drink	Calories
XS Citrus Blast	8
Red Bull	110
Sobe Adrenaline Rush	140
Impulse	110
For comparison	
Coca Cola (12-oz)	140

Classroom management

There is no preparatory homework, and all in-class work is done in groups. The case is designed to be modular and, as a result, can be presented in different ways in different learning situations. The first sections of the case (the case scenario and marketing claims) can be given to students separately or all together, as the instructor wishes. Reading through this material should take students no more than 15 to 20 minutes. The instructor then asks the critical question: "When we say that something gives us energy, what does that mean? What is the biological definition of energy?" Student responses may be listed on the board by the instructor. This question is followed by a 10- to 15-minute class discussion of chemical energy and the biological use of chemical energy and appropriate food sources.

Although the major intent of the case is for students to learn basic biochemistry and nutrition, they also engage in product analysis. Generally, students find energy drinks appealing and believe that they provide an extra kick. Is the kick due to increased energy available, or to the feeling of increased energy? On what basis can they make this evaluation? Can any of the drink components contribute to either kind of kick? Why are these drinks so expensive? Other questions that might be posed in the classroom to generate discussion include:

- What types of components in energy drinks could provide biological energy? Why?
- What is the source of biochemical energy in a sugar-free energy drink?
- According to your research, what other molecules besides sugars are related to the production of biochemical energy? Do these molecules help make the drink an energy drink? Why or why not?
- Does caffeine really increase available chemical energy? Why or why not?
- What is the role of caffeine in some of the energy drinks?
- Why are energy drinks attractive to young people, despite their cost?
- What can an energy drink provide that a can of Coke cannot? Is this worth the extra cost?
- Should a runner consume an energy drink "on the run"? Why/why not?
- Are there sufficient amino acids in the energy drink to affect muscle repair? Is there any way to determine this by looking at the ingredients?
- How can a drink without any source of sugars or carbohydrates claim to be an energy drink?

Next, students are given the list of ingredients and nutrition facts in Figures 2 and 3 and asked to determine what they need to know to match the ingredients list with the marketing claims (15 minutes) and to answer the questions. (The answer key for this case study is available on the website of the National Center for Case Study Teaching in Science at *www.sciencecases.org/energy_drinks/energy_drinks_notes.asp*.)

FIGURE 5
Post-research analysis.

Using the information that your group gathered, place each of the ingredients for your drink under the proper heading in the table below.

Sources of energy	Amino acids	Stimulants and vitamins	Other—please categorize

Questions

When we say that something gives us energy, what does that mean? What is a biological definition of energy?

What is the physiological role of each of the molecules in your table?

Which ingredients provide energy? How do they do that?

Which ingredients contribute to body repair, i.e., which help build or rebuild muscle tissue?

In what ways might the one(s) that does (do) not have a metabolic energy source (caffeine) provide the perception of increased energy after consumption?

How are the ingredients in these drinks helpful to someone expending a lot of energy, e.g., a runner?

Does your analysis substantiate the claim that this is an energy drink? If so, what molecules are the sources of energy?

Could your drink serve different purposes for different consumers? Explain.

What is the normal physiological response to increased intake of sugars? To increased intake of caffeine?

Is there such a thing as a sugar high? Explain your answer.

Evaluate, in terms of basic physiology and biochemistry, the statement: A lack of sleep causes a lack of energy.

Are the product claims legitimate? Why?

Should you simply buy a can of Coke rather than one of these energy drinks? Why/why not?

If the rest of the case is done in class, we give students an additional table with biochemical information (see *www.sciencecases.org/energy_drinks/energy_drinks5.asp*) for each ingredient including its chemical formula, a brief description of what it is (e.g., amino acid), and a brief description of what it does (e.g., aids in muscle building and maintenance). If the case is done over more than one classroom period, instructors can have students find this information on their own and bring it to the next class.

Students then work in their groups to sort the biochemical information and complete the post-research analysis (15–20 minutes), which can be completed on the board, if the instructor wishes. The instructor may choose to recap this analysis before assigning the writing task. The writing assignment can be given to students to complete as homework or it can be completed in class as a group project (approximately 30 minutes).

The case can be completed as either a self-contained, one-day exercise or as an extended, multiday exercise. For a one-day case format (for use with both introductory and advanced students), students are given information for discussion and evaluation in stages: the case and marketing claims; the list of ingredients and nutrition facts; Charley's list of questions; and the biochemical definitions. They discuss the claims of each drink in light of their research to determine biochemical definitions and physiological roles of components. The writing assignment is completed as homework. Running the case in this way should require approximately two hours.

For the multiday case format (for students with a biology background), students are provided with the case and the marketing claims, followed by Charley's list of questions and the list of ingredients and nutrition facts. On their own, students research the chemical nature and physiological function of each chemical component. When students reconvene, they discuss the claims of each drink in light of their research. They can complete the writing assignment in class or as homework. If time constraints limit students from analyzing all of the different energy drinks, each student group can be assigned one energy drink to research.