Macromolecules

NGSS Standard

**HS-LS1-6.** Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]

**PRACTICE 3:** Planning and carrying out investigations

NGSSS Standards

**Standard 18**  Matter and Energy Transformation

**SC.912.L.18.1** Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules.

**Lesson essential question:**

Why are macromolecules essential for all living things?

**Learning objective:**

Students will be able to identify the structure and describe the function of the 4 basic types of macromolecules: proteins, carbohydrates, lipids and nucleic acids.

**Engagement**

Students will watch a short video clip from YouTube called "Molecules Gone Wild (Bio Style)” – a parody on the PSY song “Gangnam Style.”

Students will also take a short multiple choice pre-test (attached) on macromolecules (used for comparison during post-test).

**Exploration**

Students will complete lab investigation “Biomolecules In My Food” (attached) in which they examine various known and
unknown materials to determine which macromolecules are present in each.

Extension: This part of the lesson would also be a great point to introduce components of NGSS Practice 2 (“Developing and Using Models”) – a variety of links to ideas for building models of the 4 types of macromolecules are listed below:

- Activity in which students make “protein bracelets” and gift them to classmates and friends [http://www.scienceteacherprogram.org/pdf/GiftOfProtein.pdf](http://www.scienceteacherprogram.org/pdf/GiftOfProtein.pdf)
- Students build models of carbohydrates using gum drops and toothpicks [http://www.pbs.org/saf/1401/teaching/teachinghs.htm](http://www.pbs.org/saf/1401/teaching/teachinghs.htm)
- Students build paper models of lipids [www.teacherweb.com/MD/RiverHill/MrKerryMartin/Lipids-Activity.doc](http://www.teacherweb.com/MD/RiverHill/MrKerryMartin/Lipids-Activity.doc)

Explanation

Students will read an informational text (attached) and use a 4-flap foldable for directed note-taking to record information about the 4 types of macromolecules.

Elaboration

Students will work in small groups with the case study “A Can of Bull? Do Energy Drinks Really Provide a Source of Energy?” Each group will work with one of the four energy drinks presented in the case study and present their findings to the class at a mock meeting of the staff at Runner’s World magazine. See the attached case study packet for more information on this activity.

Evaluation

REVIEW: Students can use “Biomolecule vocabulary cards” (attached) to review content before the post-assessment.

Students will complete a short multiple choice post-test (same as pre-test) on macromolecules.

Students will fill out an index card in the format of a Frayer model, a visual organizer. Information about setting up the Frayer model index cards can be found here:

Biomolecules in My Food

Food is fuel: All living things need to obtain fuel from something. Whether it is from photosynthesis, or by ingesting something and breaking it apart into its components.

What makes food?
All organic (naturally occurring) molecules are classified into 4 general categories: carbohydrate, lipid, protein, and nucleic acid. Foods you consume consist of these 4 molecules. Let’s take a look into the unique characteristics of these 4 categories (not to be confused with food groups), and sketch or write a few notes in the boxes on the right to help remember what we learn.

1. Carbohydrates – sugars, starches (flour), grains. Carbohydrates can be found in almost all food sources. Rice, cereal, potatoes, fruits, pasta, vegetables, etc., have some kind of carbohydrate in them. Carbohydrates can be compounds that are as simple as a single glucose ring, to strings of these rings. How these rings are arranged determines what kind of carbohydrate we have. Carbohydrates are the main energy source for the body. Your brain needs it to think, muscles need it to make ATP for muscle contractions. As well, every cell in your body needs carbohydrates to function. There are some carbohydrates that cannot be digested, so it just passes right through us. Cows, goats, sheep and horses have figured out how to use this non-digestible material and turn it into energy with the help of bacteria that live in their digestive tracts.

2. Lipids – fat, oil, lard, butter. Depending on the state of the lipid it is classified as a saturated fat or a non-saturated fat. Saturated fats are solid at room temperature. Examples: butter, animal fat. Non-saturated fats are liquids at room temperature such as your various cooking oils. Fat is necessary in a diet to maintain the membranes of your cells, and they are used to make certain hormones. Fat is a huge energy source. However, it takes a lot of effort to break this molecule up to release the energy. That’s why carbohydrates are used first. Our bodies more easily break them apart.

3. Proteins – beans, meat, green leafy vegetables. Most people think of meat when protein is discussed. True as that may be, there are other means of obtaining your protein. There’s an array of beans, all of which have protein. Everything from kidney beans to peanuts. We need proteins to maintain our muscles and the components of proteins help us put together almost everything in our bodies – from something as small as markers on our cells and antibodies, to steroid hormones, muscle tissue, hair and nails.

4. Nucleic acids – the genetic material. We consume the cells of an organism. Therefore we are also eating its DNA. We actually digest it. No, it does not become part of our DNA, but eating other organisms breaks down the DNA found in them into its components so they can be ‘recycled’.

How do you know what your food is made of? The ‘Biomolecules in My Food’ lab will show you! This lab will test various food sources for various types of compounds: fats, proteins, simple sugars, and starch. This lab will take about 90 min. to finish. Allow time for a lengthy clean up.
Materials

Test Tube  Spot Plate  Biuret
Test Tube Rack  Boiling Water Bath  Benedict’s Solution
Toothpicks  Brown Paper
Plastic Knife  Iodine
Food items: potato, potato chips, apples, burger, oil, water, sugar, starch, egg

Preview of Lab Procedures & Purposes

- Fats are nutrients that provide a source of energy that carry vitamins to body cells. To test for fat: Spread food within circles on a brown bag. Wait for foods to evaporate and check for grease spots by holding up to the light. The size of the grease spot indicates the amount of fat.

- Protein is a nutrient in food that helps build muscle. To test for protein: Place foods in a spot plate. Add Biuret solution to each food – a color change from blue to purple indicates protein is present.

- Carbohydrates are nutrients in food that provide energy. Simple starches and sugars are produced in plants during photosynthesis and broken down by animals during respiration. To test for Starch: Place foods in a spot plate. Add Iodine solution – a color change from brown to a blue-black indicates starch is present. To test for Simple Sugar: Place foods into test tubes. Add Benedict’s solution – any immediate color change from blue to green or orange indicates that simple sugars are present.

Procedures

Part 1: Testing known food Biomolecule sources

Goal: Today you will need to LEARN and PRACTICE conducting these tests by experimenting with known substances: water, egg whites, oil, starch and sugar.

Step 1: Get into your lab groups and review your data sheet. Take a few minutes to fill in the different foods to be tested and write a hypothesis regarding the presence of each nutrient sample within that particular food. You can use short-hand notes such as + and – signs to reflect the presence or absence of a nutrient within each sample.

Step 2: Fat Test

a) Draw 5 circles on your brown paper and label each circle; water, egg whites, oil, starch, and sugar.
b) Take your brown paper to the lab buffet table and put 2 drops of water in the water circle, 2 drops of egg in the egg white circle, continue with oil, starch, and sugar.
c) Leave the brown paper on the side to dry. Once dry, record your results.

Step 3: Conduct protein test and starch test on water

a) Take your spot plate to the buffet table. Add 5 drops of water into 2 spaces on the spot plate.
b) Add 3 drops of Biuret solution to one spot of water.
c) Add 3 drops of Iodine to the second spot of water.

Step 4: Rinse and drying your spot plate with water and a paper towel

Step 5: Conduct a protein and starch test on the remaining 4 samples. Your spot plate will look something like this:
**Part 2: Testing Food items**

**Goal:** You are testing your own foods. You will be testing 4 different foods (apple, potato, potato chips, burger), and one of which will be an unknown. Be sure to mash your food into a paste before testing.

**Step 1:** Test for starch, protein, and fat.
- a) Get a spot plate and go the buffet table to get 3 samples of each food.
- b) Test each sample for starch, protein, and fat.
- c) Record results.

**Step 2:** While waiting for the fat test to dry, conduct the sugar tests on all samples and record results.

**Step 3:** CLEAN UP!!!! Return trays and wipe down lab table.
Biomolecules Lab: Chemistry of Life

Part 1: Testing known (use lab handout and follow all steps to complete you data table)

<table>
<thead>
<tr>
<th>Question: Which Biomolecules are present in each of the tested items?</th>
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<tbody>
<tr>
<td>Claim:</td>
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</table>

<table>
<thead>
<tr>
<th>Evidence:</th>
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<th>Reasoning:</th>
</tr>
</thead>
</table>

DATA CHART

<table>
<thead>
<tr>
<th>Known</th>
<th>Carbohydrate</th>
<th>Protein</th>
<th>Lipid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Oil</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Egg</td>
<td></td>
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<td></td>
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<tr>
<td>Starch</td>
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</tr>
</tbody>
</table>

Note: you use X or + to complete you data chart.

Take notes of any changes you observe while conducting the lab (changes in color, etc)

Which substance is used as a control? Why?

Revised claim: After conducting the lab, revise your claim and write it in the space below, including lab evidence and reasoning.
Part 2: Testing unknown  (use lab handout and follow all steps to complete you data chart)

**Question:** Which Biomolecules are present in each food item (apple, potato, potato chip, and burger)?

**Claim:**

<table>
<thead>
<tr>
<th>Evidence:</th>
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<th>Evidence:</th>
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</table>

DATA CHART

<table>
<thead>
<tr>
<th>Known</th>
<th>Carbohydrate</th>
<th>Protein</th>
<th>Lipid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
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<td></td>
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</tr>
<tr>
<td>Apple</td>
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<td></td>
<td></td>
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<tr>
<td>Potato</td>
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<td></td>
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<tr>
<td>Potato chips</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Burger</td>
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</tr>
</tbody>
</table>

**Note:** you use X or + to complete you data chart.
Take notes of any changes you observe while conducting the lab (changes in color, etc)

**Analysis**

1. Identify the major biochemical in each unknown:
   - Water:
   - Apple:
   - Potato:
   - Potato chip:
   - Burger:

2. **Revised claim:** After conducting the lab, revise your claim and write it in the space below, including lab evidence and reasoning.
**Extension**: You can also test plant tissue to review how plants are also composed of Biomolecules as all living things are.

**Additional materials:**
Peas  
Distilled water  
Mortar and pestle

**Plant tissue preparation:**
1. Soak 10 peas in distilled water overnight
2. Use mortar and pestle to crush peas into a paste, ready to be used

**Part 3: Testing plant tissue**

**Goal**: You are testing plant tissue for the presence of Biomolecules

**Step 1**: Test for starch, protein, and fat.

a) Get a spot plate and go the buffet table to get a sample of plant tissue.
b) Test each sample for starch, protein, and fat.
c) Record results.

**Step 2**: While waiting for the fat test to dry, conduct the sugar tests on all samples and record results.

**Step 3**: CLEAN UP!!!! Return trays and wipe down lab table.

| **Question**: Which Biomolecules are present in plants? |
| **Claim**: |
| **Evidence**: |
| **Reasoning**: |

**DATA CHART**

<table>
<thead>
<tr>
<th></th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td></td>
<td></td>
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<tr>
<td>Lipid</td>
<td></td>
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</tbody>
</table>

**Note**: you use X to complete you data chart.

Take notes of any changes you observe while conducting the lab (changes in color, etc)

1. Was the plant tissue composed of key cellular chemicals?
2. **Revised claim:** After conducting the lab, revise your claim and write it in the space below, including lab evidence and reasoning.
aminoacid
carbohydrate
lipids
monomer → polymer
monosaccharide

Glucose

Galactose

Fructose
nucleic acid
nucleotide
protein
Objectives

- Describe and categorize chemically 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.

The Case

After spending several years working the Sport’s 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 those assigned to her for her job. For her last assignment, she had run and reported on the 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 non-athlete. 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, a list of ingredients and nutrition facts provided on the cans for consumers, and a short list of questions that should get you started. When you research these, be sure to document all your sources of information, keeping in mind that all resources are not equal. Here’s the information.”
With that, Charley left the office. Rhonda looked over the list. “Guess I’ll have to brush up on my biochemistry. No problem. I’m interested in knowing if my running 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 the following numbers of calories:

<table>
<thead>
<tr>
<th>Energy Drink</th>
<th>Calories:</th>
</tr>
</thead>
<tbody>
<tr>
<td>XS Citrus Blast*</td>
<td>8</td>
</tr>
<tr>
<td>Red Bull*</td>
<td>110</td>
</tr>
<tr>
<td>Sobe Adrenaline Rush*</td>
<td>140</td>
</tr>
<tr>
<td>Impulse*</td>
<td>110</td>
</tr>
</tbody>
</table>

For comparison:

| Coca Cola* (12 oz)   | 140       |
Marketing Claims

Next, 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: at sport, work, study, driving and socializing.
- Improves performance, especially during times of increased stress or strain.
- Improves concentration and reaction speed.
- Stimulates the metabolism.

XS Citrus Blast®
- There is less than 1/2 calorie of sugar in XS Citrus Blast. This qualifies for the government-approved statement “No Sugar.” The 8 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 and from 27 to 30 grams of sugar, which is a simple carbohydrate. 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. The 8 calories in XS Citrus Blast are from amino acids and are protein calories that aid your body’s natural metabolic process.
- 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 8 calories in the drink come from the 2 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.
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:

\textit{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, etc.) 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?

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.
Ingredients & Nutrition Facts

As in most labels, listed in order of mass in drinks (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
Biochemical Information

Acesulfame Potassium (Sunett)
- **Chemical formula:** $\text{C}_4\text{H}_4\text{KNO}_4\text{S}$
- **What it is:** Simple ring structure that resembles glucose
- **What it does:** Artificial sweetener to provide taste.

Aspartame
- **Chemical formula:** $\text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_5$
- **What it is:** Dipeptide
- **What it does:** Low calorie artificial sweetener that provides taste.

Caffeine
- **Chemical formula:** $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$
- **What it is:** One of the most widely used psychoactive substances in the world. Caffeine is a mild CNS stimulant with a transient effect that usually passes within a few hours but varies between individuals.
- **What it does:** Some studies have shown that caffeine may improve memory and reasoning responses on tests; other studies have shown that ingesting 3-9mg of caffeine one hour before physical activity improves endurance running and cycling in athletes. No adverse effects in humans have been documented.

Citric Acid
- **Chemical formula:** $\text{C}_6\text{H}_8\text{O}_7$
- **What it is:** Organic acid
- **What it does:** It is a precursor for the citric acid cycle (Kreb’s Cycle), which is a major pathway in the cell’s production of chemical energy.

Cyanocobalamin
- **Chemical formula:** $\text{C}_{63}\text{H}_{88}\text{CoN}_{14}\text{O}_{14}\text{P}$
- **What it is:** Synthetic form of Vitamin B-12
- **What it does:** Important for growth, cell reproduction, blood formation, and protein and tissue synthesis.

Folic Acid
- **Chemical formula:** $\text{C}_{19}\text{H}_{19}\text{N}_7\text{O}_6$
- **What it is:** Vitamin
- **What it does:** Required for metabolism of carbon compounds, nucleic acids, and amino acids.

Fructose
- **Chemical formula:** $\text{C}_6\text{H}_{12}\text{O}_6$
- **What it is:** Simple sugar
- **What it does:** Can be converted into a form for entry into the primary metabolic pathway in which the chemical energy of its bonds is converted into ATP, the primary “energy” molecule in the body.

Glucose
- **Chemical formula:** $\text{C}_6\text{H}_{12}\text{O}_6$
- **What it is:** Simple sugar
- **What it does:** Enters the primary metabolic pathway in which the chemical energy of its bonds is converted into ATP, the primary “energy” molecule in the body.
Glucuronolactone
- **Chemical formula:** C₆H₆O₆
- **What it is:** Simple saccharide (sugar)
- **What it does:** It is a normal human metabolic byproduct formed from glucose. Glucuronolactone is found in connective tissue in animals. Also regulates formation of glycogen. Small amounts shouldn’t be harmful.

1-Glutamine
- **Chemical formula:** C₅H₁₀N₂O₃
- **What it is:** Amino acid
- **What it does:** Aids in muscle building and maintenance.

Inositol
- **Chemical formula:** C₆H₁₂(OH)₆
- **What it is:** A sugar that is a member of the Vitamin B complex
- **What it does:** Controls cholesterol levels and has potential antioxidant capabilities.

Niacin (nicotinic acid)
- **Chemical formula:** C₆H₅NO₂
- **What it is:** Water soluble vitamin
- **What it does:** Derivatives such as NADH are required for metabolism. It is said to aid in the synthesis of amino acids, the subunits of proteins. It has not been directly linked to improving athletic performance.

Niacinamide
- **Chemical formula:** C₆H₈N₂O
- **What it is:** Water soluble vitamin
- **What it does:** See niacin above; both are components of the coenzymes NAD and NADP, important in the redox reactions of metabolism.

Pantothenic Acid (also known as D-pantothenol)
- **Chemical formula:** C₉H₁₇O₅N
- **What it is:** Synthetic form of Vitamin B-5
- **What it does:** Precursor of coenzyme A. Helps you use fats and carbohydrates to make molecules used for energy. Is involved in more than 100 different metabolic pathways including energy metabolism of carbohydrates, proteins and lipids, and the synthesis of lipids, neurotransmitters, steroid hormones, porphyrins, and hemoglobin. It’s found in a wide array of energy drinks and supplements, but its toxicity has not been evaluated.

Potassium sorbate
- **Chemical formula:** C₆H₈O₂
- **What it is:** Potassium salt of sorbic acid
- **What it does:** Used to inhibit fungal growth in foods.

Pyridoxine HCL
- **Chemical formula:** C₉H₁₇NO₃
- **What it is:** Synthetic form of Vitamin B-6
- **What it does:** Energy production, efficient metabolic functioning, protein digestion, as well as maintaining healthy nervous system, skin, hair and nails. The B-compound vitamins are probably the single most important set of factors needed for proper maintenance of the nervous system as well as proper functioning of the cell and its energy metabolism.
Sucralose (splenda)

- Chemical formula: \( C_{12}H_{19}O_8Cl_3 \)
- What it is: Derivative of sucrose
- What it does: Artificial sweetener to provide taste.

Sucrose

- Chemical formula: \( C_{12}H_{22}O_{11} \)
- What it is: Simple sugar
- What it does: Can be converted into a form for entry into the primary metabolic pathway in which the chemical energy of its bonds is converted into ATP, the primary “energy” molecule in the body.

1-Taurine

- Chemical formula: \( C_2H_7NO_3S \)
- What it is: A non-essential amino acid
- What it does: Improved reaction time, concentration, and memory (not proven); essential amino acid for cats.

Water

- Chemical formula: \( H_2O \)
- What it is: A solvent for the other ingredients
- What it does: Essential for physiological processes.
Your Task
Research each ingredient found in these energy drinks. This information can be found in biochemistry and nutrition textbooks. Web sources may provide valuable information, but be critical in their use. Many will make unsubstantiated claims. One that can get you started for basic information is http://www.chemindustry.com. Basic information can also be garnered from http://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 as well as the additional questions listed below. Fill out the table and answer the questions. Please cite any websites that you used in your analysis.

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.

<table>
<thead>
<tr>
<th>Sources of Energy</th>
<th>Amino Acids</th>
<th>Stimulants and Vitamins</th>
<th>Other—please categorize</th>
</tr>
</thead>
</table>

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“A Can of Bull?” by Heidemann & Urquhart
Questions

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

2. What is the physiological role of each of the molecules in your table?
   a. Which ingredients provide energy? How do they do that?
   b. Which ingredients contribute to body repair, i.e., which help build or rebuild muscle tissue?

3. 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?

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

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

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

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

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

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

10. Are the product claims legitimate? Why?

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

Assessment

Individually, or as a group, write an evaluation of the marketing claims for your drink. 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 above.
PRE/POST ASSESSMENT: Macromolecules

Identify the choice that best completes the statement or answers the question.

1. Amino acid is to protein as
   a. fat is to lipid.
   b. DNA is to RNA.
   c. sugar is to fat.
   d. simple sugar is to starch.

2. Which of the following is NOT a monomer?
   a. A glucose molecule
   b. An amino acid
   c. A nucleotide
   d. A protein

3. Which of the following is NOT a function of proteins?
   a. Store and transmit genetic information
   b. Help to fight disease
   c. Control the rate of reactions
   d. Move substances into or out of cells

4. Which statement is true about macromolecules?
   a. Simple sugars are made of polysaccharides.
   b. Glycerol is made of fatty acids.
   c. Proteins are made of amino acids.
   d. Nucleotides are made of nucleic acids.

5. What is the generalized structure of a carbohydrate?
   a. (CH2O)n
   b. (CH4)n
   c. (C3H7O)n
   d. (CCN)n

6. Which of the following is a polymer of glucose?
   a. Glycogen
   b. Starch
   c. Cellulose
   d. Lactose

7. Which of the following elements is found in all macromolecules?
   a. Hydrogen
   b. Oxygen
   c. Carbon
   d. Nitrogen

8. Lipids do not dissolve in water because they are
   a. Non-polar, making them hydrophobic
   b. Polar, making them hydrophilic
   c. Special carrier proteins
   d. Enzymes that catalyze reactions

9. Genetic information is passed from parents to offspring through molecules of
   a. Lipids
   b. Carbohydrates
   c. Amino acids
   d. Nucleic acids

10. Which of the following are the primary building blocks of all cell membranes?
    a. Proteins
    b. Lipids
    c. Nucleic acids
    d. Carbohydrates