Food as Fuel:
The Physiology of Nutrition

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Overview

This unit provides a scientifically-based approach to health and nutrition. A physiological lens is employed to delve into components of meals, serving sizes, sugars, starches, carbohydrates, fats, calories, vitamins, and the roles they serve in body function.

Rationale

Philadelphia has the highest obesity rate of the nation's ten largest cities according to our city's Deputy Mayor for Health and Opportunity Commissioner.

Most of my students' breakfasts consist of three bags of Hot Cheetos and a Pineapple soda. Many are engaged in a seemingly unbreakable cycle of a cafeteria and corner-store diet, with little concept of the fuel that their bodies need for optimal functioning. The biology of health and nutrition is one of my students' favorite topics.

Education, specifically the broadening of food exposures and promotion of a thorough understanding of the molecular physiology that sustains the body and work, is the most effective way to keep our students healthy. It is imperative that our students are supplied with an understanding of the food chemistry of their lives!

This unit assumes little base knowledge of human physiology and biology. It can, therefore, be easily integrated into any middle or high school science or math curriculum.

Multiple reinforcements are offered to support the mastery of objectives in this plan. Should an educator face should constraints or desire a more specific concentration, this unit can be easily refocused as necessary to meet specific course goals. Objectives

directly align to mathematics, social science, literacy, health, and science standards prescribed by the School District of Philadelphia and the Common Core.

Objectives

Students will be able to:

Identify the digestive process as the necessary mechanism for the body to obtain nutrients essential for growth, development, and cell repair.

Describe the path of food through the body, citing the purpose(s) of each point of travel in the digestive system.

Explain the nutritional demands of the human body and identify sources that satisfy these needs.

Define calories as units of energy that power our cells' activity. Estimate personal caloric need based on weight and energy demands.

Demonstrate food label literacy by assessing the healthfulness of a given food in his/her diet, referencing servings, calories, fats, cholesterol, sodium, carbohydrates, proteins, vitamins, and minerals. Students will also be able to determine the amount of food that comprises one serving according to package details.

Assess the composition of foods common in student diets, such as bagged chips and soft drinks.

Extension:

Further taking advantage of popular interest in food science and processing, we can also explore the "life cycle" of different snack foods such as Twinkies and McNuggets.

- Students may be asked to create a biography of food—following and analyzing food from the origin of ingredients to the end product.

Strategies

This unit focuses on every student's favorite topic: Themselves! Established activities throughout the unit will support students in forming meaningful connections between the foods they currently consume, or make the choice to consume in the future, and the long and short term effects on their bodies. These learning experiences will demand the utilization and enhancement of mathematics, literacy, social science, inquiry and critical thinking skills.

Integrating mathematics and literacy, students will determine their caloric and nutritional needs, journal their food ingestion, assess discrepancies between need and intake, and author general diet and exercise plans that supports their needs.

Serving to refine laboratory skill sets and tap into student need for kinesthetic activity, students will utilize a combination of easily attainable "kitchen chemistry" supplies as well as equipment such as microscopes, triple beam balances, dissection tools and protocol to answer questions they form regarding the digestion of food.

Students will determine the more healthful food option of two choices based on a complete nutritive evaluation of the selected items. This decision-making requires synthesis of unit objectives.

Additionally requiring whole-unit synthesis as well as further utilization of kinesthetic and creative skill sets, students will produce either a children's book or adult health magazine that explains the components and functions of food and the digestive process.

Activities

To facilitate a thorough student understanding of nutrition physiology, it is optimal to incorporate as many of these activities as time allows. If this is not feasible, please consider the suggested manipulations that reduce reinforcement and bring focus to core objectives. Many of these lessons may also be implemented to support objectives tangential to nutrition physiology goals, and can therefore be a benefit to classrooms in isolation of suggested partner activities. To support teacher navigation, the "Activities" section of this curriculum is categorized into "Cells," "Digestive System," "Calories," "Nutrition," and "Summative Activity." Please adjust and implement these learning experiences to best support the needs of student and class goals.

Cells:

If students possess a thorough understanding of cells through previous course objectives, teacher can limit Activity A to approximately 45 minutes. If a foundation in cells has not been established, Activity A should be supplemented with lessons that focus on the basic structure and function of plant and animal cells.

- A. Analysis of cells, tissues, and organs through the lens of nutrition—microscope-based activities. Appreciation of life-function on the cellular level is essential to a genuine understanding of nutrition. Introduction to this unit will

begin with the consideration of the chicken egg as a cell, a true connection between cells and food!

Activity B can be divided into two segments that can be further adjusted based on time constraints and prior student knowledge. Segment 1: It is imperative to equipment integrity and the minimization of student frustration that a thorough introduction to microscope structure and function is provided. Teacher should allot at least forty-five minutes to this establishing activity, allowing for students to practice proper handling and utilization of microscope technology. Segment 2: Students collect, analyze, and sketch epithelial cells. Repeat process for onion cells. Compare and hypothesize reasons for structural differences between these two cell types. Teacher should avail approximately fifteen minutes with each portion of Activity B.

- B. Collection and examination of epithelial and onion cells. This lab will further establish a personal connection to our curriculum as students will be examining cells they have culled from their own bodies! Students will also have the opportunity to compare personal cells to those of a plant. Practice and refinement of microscopy skills will also support interest in this unit.

Depending on time constraints and desired unit outcome, teacher can elect to skip Activity C, conduct as a demonstration, or allow students to complete in groups. Teacher can also manipulate level of inquiry required by students by either prescribing steps to complete lab or encouraging students to create tests for yeast metabolism. Teacher demonstration and group lab can be completed within forty-five minutes to an hour. Discussion and synthesis should occupy an addition fifteen minutes.

- C. Yeast lab. Students will conduct an experiment to determine if yeast is capable of energy utilization, a characteristic of living things. Proving that yeast cells metabolize sugars, as determined by the output of carbon dioxide, this opportunity will serve as an additional hands-on support of the scientific process that will enforce the concept that living things require energy.

Digestive System:

Should time limitations present a concern, select either Digestive System Activity A or C. Activity A provides for a thorough exploration of the digestive system. This activity requires computer technology, but involves no physical preparation or clean up. To conserve time, guide students through Activity A, allowing up to one hour for the digestive system tour. Students may also engage in this activity independently or outside of the classroom. Activity C is a kinesthetic introduction to the digestive system that pairs well with Activity A, but can also be completed in isolation to a similar, though less comprehensive end.

- A. A trip through the digestive system. Students will utilize the KidsHealth website to explore this organ system. Students should be particularly familiar with nutrient absorption sites.

Activity B is an enrichment tool that supports higher-order thinking, information application and synthesis. This activity is not essential for a basic understanding of digestion. Should time constraints present an issue, students can engage in this opportunity outside of the classroom.

- B. Students will hone and apply digestive system knowledge by virtually assembling a functioning organ system and evaluate improperly functioning structures through BrainPop.

    - To utilize higher-order thinking skills, students will participate in website case studies. These scenarios present opportunities to identify which organs would be affected by situations of dietary decisions and hereditary differences. For example, students are presented with the case of cirrhosis and hepatitis. It is explained that both can be caused by excessive alcohol intake and that both can result in concerning levels of blood toxicity. From a selection of organs, once student makes the diagnosis of "liver" he or she will then be provided with a more in-depth explanation of the disease. Playing doctor through in this game supports an immediate, realistic, and engaging opportunity to apply and manipulate their new knowledge.

- C. Digestive system simulation. A hands-on interaction to support student understanding of digestive system structure and function. Adapted from Stephanie M.'s teaching blog.
    - Mouth: Students will place crackers in a plastic bag and lightly crush them with their fingers. They will add water to represent saliva. This will ready the crackers to enter the esophagus.
        - SIDE LAB: Bread break down. Students will be given a small piece of bread with no sugar added. Students will allow bread to sit on their tongues for one minute and analyze the taste and texture of the food. Perception of sweet taste will help students understand that the digestive enzyme salivary amylase breaks down the starches in breads into the sugars maltose and glucose.
    - Stomach: Muscle action and acid is represented by the addition of orange juice and gentle student kneading.
    - Small intestine: A piece of paper, folded accordion style, will aid in demonstration of maximization of surface area in absorption of nutrients.

Students will pour their cracker mixture over the representation of this organ.

- Large intestine: Demonstrate water reabsorbing back into the body by pouring cooked oatmeal into pantyhose and squeezing out excess liquid.
  - SIDE LAB: Humans do not have the digestive enzymes necessary to fully break down kernels of corn. Interested students can keep track of how long it takes corn to work its way through their bodies from ingestion to expulsion in order to become aware of how long it takes the body to process food.

Fetal pig dissection requires approximately one hour of introduction and three hours of lab time. This activity is highly recommended for enforcement of objectives if access and time are possible!

- D. Fetal pig dissection. Students will have the opportunity to explore the digestive system through dissection of a fetal pig. Humans and fetal pigs share a similar internal anatomy, allowing students to have a unique interaction with digestive organs. Students will trace the path of food from ingestion to exit, measuring intestines and analyzing stomach content.

Calories:

Activities A and B pair well to encourage student investment and understanding of calories on a personal level. While some classroom time is essential to establish and evaluate activity A, the majority of this food journal endeavor is completed outside of the classroom.

- A. Food journaling. Students will track food consumption for a typical forty-eight hour span, documenting and researching nutrition information. Student must be mindful of serving size when recording and analyzing data.

Activity B requires students to consider and manipulate personal and potential data. Teacher should allow two hours of in-class time in order to ensure thorough student understanding of the task and opportunity to seek correction, feedback, and support. Students may desire additional time outside of the classroom to refine calculations and strategy.

- B. Caloric need vs. intake assessment. Students will form a rough estimate of their caloric need by multiplying their weight by ten and adjusting for their energy demands. Students will classify their activity level and increase caloric allowance by 40% if active, 20% if moderately active, or 10% if sedentary.

- Given that the use of 3500 calories will burn one pound of fat, student will calculate caloric and expenditure adjustment necessary for a weight goal to be achieved healthfully in eight weeks. Students will be supplied with an extensive list of activities and caloric expenditure for each endeavor and make arithmetic adjustments for each activity depending on the amount of time they expect to allot [refer to NutriStrategy]. This exercise will support students in forming a mathematical understanding of energy.
- To reinforce the idea of food as fuel, class will engage in a discussion about swimmer, Michael Phelps' 12,000 calorie diet. The Olympian's unique lunch, for example, includes multiple energy drinks, one pound of pasta, and two ham and cheese sandwiches! Students will analyze Phelps' meal choices, and as an extension, the diets of people of various employments and athletic pursuits [refer to Sarah Rubenstein article].

If time is available, allow students to complete Activity C in groups. To conserve time, present Activity C as a demonstration, video, or skip.

- C. Chip burning. This activity enforces the concept that food has energy! Students will calculate caloric punch of various chips by assessing the temperature differential in a classroom calorimeter before and after a selected food item has been consumed by a flame.
    - Refer to article "Twenty-Six Calories can lift an SUV," to explain how caloric information and nutrition content is calculated for food labels.

Nutrition:

Activity A is essential to a foundation in nutrition. Limit this instruction to thirty-minute blocks in order to maximize retention and reduce opportunity to overwhelm. This activity can be completed within three sessions.

- A. Students will engage in a class discussion and complete guided notes that can be used as a reference for the duration of this unit. These notes will contain essential points regarding necessary nutrients as well as tips for navigating food labels. [Source: Module 2, Intro: Making Healthy Food Choices]
    - Serving size: How much food is in one serving. All percentage values on the label are in reference to this amount.
    - Calories: Units of energy. Calories come from carbohydrates, proteins, and fats.
    - Total fat: Fats create hormones, help eater feel sated.
        - Saturated: Too much can lead to heart disease
        - Polyunsaturated & monounsaturated: Healthy for heart, hair, and skin. Essential omega 3 and 6. Found in oils and nuts.

        - Trans: In processed foods. Can lead to heart disease.
    - Cholesterol: Only found in animal products. Too much can lead to heart disease.
    - Sodium: Found in salt. Necessary for heart and kidney function. Overconsumption may lead to high blood pressure.
    - Total carbohydrate: Carbohydrates come from fiber, sugars, starches. They are broken down into sugar during digestion. Source of energy for the brain.
        - Fiber: Keeps us full and regular. Can reduce risk of cancer and diabetes. Found in fruits, vegetables, and whole grains.
        - Sugars: Found naturally in some foods like fruits and vegetables, added to others like cakes and cookies.
    - Protein: Composed of amino acids. Used to build and maintain muscle and fight infections. Source of energy. Found in meats, dairy, beans, nuts, fish.
    - Vitamins and minerals:
        - Calcium: Needed for strong bones, found in dairy products and fortified juices.
        - Zinc: Maintains healthy immune system. Found in shellfish, red meat, beans, and whole grains.
        - Vitamin C: An antioxidant, aids in iron absorption. Found in citrus, strawberries, and spinach.
        - Potassium: An electrolyte. Found in bananas and potatoes. Necessary for heart function.
        - Iron: Facilitates oxygen transport in blood. Found in red meat.
        - Folic Acid: Prevents birth defects. Helps body make DNA. Found in dark green leafy vegetables.
        - Vitamin B-12: Keep nerve and blood cells healthy. Found naturally in animal products.
        - Vitamin D: Aids in calcium absorption. Found in fatty fish and dairy products. Can also be made in the body with exposure to sunlight.

Activity B is an engaging reinforcement that supports student movement! Teacher can allow as little as fifteen minutes for this activity if time is a concern.

- B. Function fun!
    - As one method of nutrient reinforcement, students will match nutrient names [“Hi my name is: Calcium”] to its function poster.
    - A similar, more competitive reinforcement requires students to identify the correct nutrient as teammates provide hints. Winning requires utilization of as few hints as possible!

To conserve time, perform activity C as a demonstration, limit the amount of items students will evaluate, or skip.

- C. Calculation and measurement of sugars. Students will use triple beam balances to mass the amounts of sugars in various food items.

Allow one hour for Activity D. If classroom time is not available, time allotment can be reproportioned to thirty minutes in class, thirty minutes homework.

- D. Nutrition label collection and analysis (including popular corner store snacks and fast food items). Nutrition labels are useful sources for understanding the amount of each nutrient present in a serving of food. It must be emphasized that statistics on nutrients are applicable to one serving of food; food is typically packaged to contain multiple servings.
    - Most sugary beverages common in a Philadelphia student's diet demonstrate this point. For example, despite its deceptive fruit-illustrated label, one 20 oz container of Arizona brand "Mucho Mango" contains 2.5 servings of 5% juice. Many students may assume that this one bottle is one serving, or worse, that this is a healthful component of their diets!
    - Students will be shown general tips for assessing portion sizes using familiar points of reference, i.e., two tablespoons of peanut butter is the size of one golf ball, one cup of fruit is the size of a fist, three ounces of meat is the size of the palm of one's hand.
    - This activity will also serve as a forum for discussing calories, fat, cholesterol, sodium, carbohydrates, protein, and vitamins and minerals. Each category will be discussed in the context of function within the body. Students will be supplied with a list of suggested nutrient quantities based on their age and sex.
    - Independently, students will select food labels to consider. He or she will collect or reflect on the following:
        - Serving size. If eaten as usual, how many servings would you consume at one time?
        - How much fat is contained in one serving?
        - How much dietary fiber is contained in one serving?
        - What types of vitamins and minerals are found in this food?
        - Would you consider this food to be "healthy?" Why or why not?
        - Which nutrients are missing?
        - What are other foods you could consume that would provide these nutrients?
        - What is the calorie count of your item? Does this number surprise you? Why?

- Do you think you engage in enough physical activity throughout the day to utilize these calories?

Activity E encourages the synthesis of learned information and the transition of this new skill set to real-world decision-making. As this is a fundamental goal of this unit, considerable time should be allowed for this lesson. Activity E should be modeled and "thought-aloud" with at least two examples, ensuring that students have a thorough understanding of essential comparison points of questioned foods. This activity is modeled after the David Zinczenco series "Eat this, Not that," Zinczenco's books and articles can be offered to the students as models and reference points. Allow twenty minutes for the student evaluation of offered each food pair. Teacher can either provide or require students to supply relevant examples from student experiences.

Optionally, teachers may provide a graphic organizer to further assist students in classification of considered nutrients and/or sentence frames [as needed] to organize student articulation of results. As enrichment, students may create a catalogue of findings, documenting and explaining their recommendations. This endeavor may also be incorporated into the students' summative activities.

- E. Eat this or that?
    - Serving as a synthesis of the nutrition activities, students will use their assessments of the healthfulness of two items and assert a recommendation as to the more beneficial food option for him or herself or a subject with specific nutritive needs.

Summative Activity:

Allow for twenty-minute planning and discussion blocks within class and the completion of this project can be achieved in class, at home, or extra-curricularly.

- Creation of a children's book that explains the components of food and role in body function OR an adult health magazine with the same end. Teacher will furnish and review examples of health magazines and children's stories.
    - Children's book idea: Following a cheeto and a piece of broccoli through the body.
    - Rubric. At minimum, students will explain the function of the mouth, esophagus, liver, stomach, small, and large intestines. Students must describe how the body utilizes at least five of the nutrients discussed within our unit. Credit will be granted based on scientific accuracy, prose, and aesthetic effort.

Annotated Bibliographies/Works Cited/Resources

Teachers:

Aubrey, Allison. "Teaching Kids the Science of Calories." NPR. 16 Nov. 2006. Web. 20 Mar. 2014.

Aubrey documents St. Joseph's University Professor Joe Cifelli's approach to nutrition education in a Philadelphia Elementary School. Cifelli's techniques translate beautifully to a middle and high school audience.

Evers, Connie Liakos. *How to Teach Nutrition to Kids*. Portland: Carrot Press, 2003.

An integration of nutrition content as well as creative and engaging reinforcement activities that support cross-curricular connections. Importantly, this book also addresses the social and cultural value of food.

Glenn, Denise E. "Mix it up and Squeeze." http://medibotics.njit.edu/DG11.pdf. Jul. 2009. Web. 19 Mar. 2014.

Instructions for creating a hands-on digestive system. Functions and diagrams of organs are provided. Considered in conjunction with Stephanie M.'s below-referenced lesson plan.

M., Stephanie. "Teaching in Room 6: The Digestive System." *Teaching in Room 6: The Digestive System*. Web. 23 Mar. 2014.

Instructions for creating a hands-on digestive system. This project utilizes basic household items. Considered in conjunction with Denise Glenn's above-referenced lesson plan.

Necessary supplies for this activity include: Bread, orange juice, oatmeal, pantyhose, plastic bags, and paper.

McGee, H. (2004) *On Food and Cooking: The Science and Lore of the Kitchen. 2nd Edition*

Focuses the scientific lens used to consider food within this curriculum. This book provides seemingly unlimited biological connections to nutrition, sure to entice any student's investment in this subject.

Poethig, Scott. "Biology of Food," Teachers Institute of Philadelphia. Course content 2014. "Food, food chains, and humans: A complex interaction," "The chemical nature of food: Milk," The cell biology of food: Cell structure, and cell types," "Using energy: Where do calories come from?," and "What are you eating? Plant and animal structure and function."

Scott Poethig's "Biology of Food" course was the source and motivation of many of the laboratory and instructional activities found within this curriculum unit.

Journal of the Academy of Nutrition and Dietetics.

A monthly journal worth evaluation to keep course material current.

"Physiology." *Harvard University MCB/HHMI High School Science Outreach Program: Lesson Plans*. Web. 20 Mar. 2014.

A series of physiology-based lesson plans and resources developed by high school biology teachers. Can be referenced should student interest demand a direction not covered within this unit.

"Project Healthy Lifestyle." Center for Young Women's Health, Boston Children's Hospital. Web. 20 Mar. 2014.

A superb resource for food label literacy and engaging games that serve as reinforcements on this topic.

Students:

Ettlinger, S. (2007) *Twinkie, Deconstructed.*

An approachable read on the "food" components of the Twinkie.
This not only serves to advance literacy and garner student interest in food physiology, but is also the inspiration for one of the curriculum extension activities.

"Gameup | Build-A-Body: Digestive System." *Gameup| Build-A-Body: Digestive System*. Web. 23 Mar. 2014.

Students utilize provided hints to build a digestive system. "Build-A-Body" requires an upper- middle/high school reading level if intended as an independent endeavor.

Classroom:

"Gameup | Build-A-Body: Digestive System." *Gameup| Build-A-Body: Digestive System*. Web. 23 Mar. 2014.

Students utilize provided hints to build a digestive system and engage with interactive case-studies.

Human Physiology/Nutrition. Wikibooks. Web 20 Mar 2014.

Succinct explanations of a wide range of nutrition and physiology related topics. Useful for many aspects of this course, can be of particular value for students in completion of their summative activity.

Hyman, Mark. "Why Calories Don't Matter." *The Huffington Post*. TheHuffingtonPost.com, 11 Apr. 2014. Web. 11 Apr. 2014.

Addresses the misconception that all calories are created equal! Allows for a reconciliation of the understanding of calories within the framework of nutrition.

Kramer, Melody Joy. "Twenty-Six Calories can lift an SUV." NPR. 16 Nov. 2006. Web 20 Mar. 2014.

An explanation of how dietary value of foods is ascertained as well as the translation of nutritive terms to real-world examples.

"How the Body Works Main Page." *KidsHealth*. The Nemours Foundation, Web. 17 Apr. 2014. <http://kidshealth.org/kid/htbw/>.

An interactive survey of the digestive system. Can be employed as either a teacher or student-led resource.

"NutriStrategy Nutrition and Fitness." *NutriStrategy Nutrition and Fitness*. Web. 17 Apr. 2014. <http://www.nutristrategy.com/index.htm>.

A wide-ranging compilation of calorie expenditure estimates for various physical activities.

Rubenstein, Sarah. "The Michael Phelps Diet: Don't Try It at Home." *Health Blog RSS*. 13 Aug. 2008. Web. 17 Apr. 2014.

A student-friendly presentation and analysis of Michael Phelps' highly caloric diet. A sports medicine doctor evaluates the food choices of the Olympian.

Sifferlin, Alexandra. "8 Shocking Foods Full of Sugar." *@menshealthmag*. 16 Mar. 2014. Web. 16 Mar. 2014.

An engaging slide show that highlights sugar content of foods such as yogurt, pizza, grapes, and Chinese take-out. A helpful reminder about making assumptions regarding the healthfulness and nutritive contents of foods, and a great introduction to our sugar measurement activity.

Spiegel, Alison. "'What I Eat: Around The World In 80 Diets' Shows Stunning Portraits Of Daily Meals." *The Huffington Post*. TheHuffingtonPost.com, 28 Mar. 2014. Web. 28 Mar. 2014.

Stunning displays, costs, and calorie counts of foods consumed by people engaged in a variety of situations and professions around the world. This pictorial supports students in thinking beyond their habits.

United States Department of Agriculture. "Choose My Plate." Web. 17 Apr. 2014.

Extensive breadth of concise explanations of food components and exercises.

Zinczenco , David, and Matt Goulding. *Eat This, Not That! 2013: The No-Diet Weight Loss Solution*. : Rodale, 2012.

Zinczenco and Goulding select a series of popular restaurant, holiday, and children's foods that are often made available as dichotomous choices with no transparently clear "better" option. This series helps users navigate the nutrition of each item to inform better eating-habits.

Appendix/Content Standards

This high-interest topic lends itself beautifully to cross-curricular connections in reading, math, and social studies. The following are a selection of the numerous standards addressed within this unit.

CC.3.6.9-10.C.
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CC.3.6.9-10.D.
Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

CC.3.6.9-10.E.
Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

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Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

CC.3.6.9-10.G.
Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

CC.3.6.9-10.H.
Draw evidence from informational texts to support analysis, reflection, and research.

16.1.K.D.
Establish goals independently and recognize their influence on choices.

10.1.3.C.
Explain the role of the food guide pyramid in helping people eat a healthy diet/

10.1.9.C**.**
Analyze factors that impact nutritional choices of adolescents.

10.1.12.B.
Evaluate factors that impact the body systems and apply protective/ preventive strategies.

10.1.12.C.
Analyze factors that impact nutritional choices of adults.