**Agri-science Resources
for High School Sciences**

Body Energy

Physics

Science

Grade 10-12

Physics Classroom

Individual reading

DESCRIPTION

The human body requires energy to perform all body functions. This energy is derived from the food we eat. In this exercise, students will see how much of the food that is consumed can be converted into mechanical energy.

LEARNING OUTCOMES

Students will:
• learn how the body can convert food energy into muscular work

READINESS ACTIVITIES

Students should:
• review the concepts of work, energy and power in physics

MATERIALS

• Copy of exercise

Body Energy

Introduction

Students have done many examples of **work**, **energy** and **power** in physics class. Most of these examples are made up word problems about hypothetical examples. One aspect of energy that is rarely considered is that humans require energy to power our body. Just like a light bulb needs electricity, humans must consume food in order to live. This exercise will try to relate the two subjects of nutrition and energy.

Energy

The chemical energy contained in the food we eat serves many functions. It is used to maintain body temperature, to drive bodily metabolic processes, some is used for growth and replacing worn-out tissue, and the energy that is no longer available to us is excreted. Most importantly, food energy is used to perform **mechanical work**. This includes running, pulling, lifting, hauling, and many other tasks. But just how much of the food we eat can be converted to muscular activity?

Conversion

All of the processes described above require a great deal of energy. Because there are so many of them, the fraction of the food energy converted to mechanical work must be fairly small. To prove that point, think about what you did this morning. Whether you sat in class all day or ran all morning in gym class, you were still hungry at lunchtime. This is because a large fraction of the **caloric intake** you ingest is used for maintenance and is not available for muscular work. In the following examples, a 15% conversion for food to muscular work will be used.

Consider how far a person can climb after consuming a specific food substance.

We will use the formula :   Work $= m\,g\,h$ where h = height
g = gravity
m = mass

Example 1 - Milk

For a liter of milk, the energy content is about 2.4×10^6 Joules. Using a conversion efficiency labeled ϵ, the amount of work that can be performed is related to the food energy input, Q, by $W = \epsilon Q$
If the person weighs 50 kg, we know the conversion of milk calories to muscular work is about 15%, and the force of gravity ($g = 9.8$ m/sec^2). Ignoring all the other possible complicating factors, what is the height a person could climb on a liter of milk?

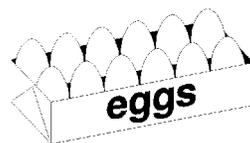# Solution

$$h = \frac{\text{(conversion efficiency)}(Q)}{mg} = \frac{(.15)(2.4 \times 10^6)(kg\,m^2/sec^2)}{(50\ kg)(9.8\ m/sec^2)}$$

$$= 700\ m$$

Example 2 - Eggs

a) A serving of two large eggs provides 149 kilocalories of energy. What is the height a person could climb after eating two eggs for breakfast? Use the same values as the previous problem with milk. Given: 1 Joule = 0.2390 calories

Solution

- First convert kcals into Joules   149 kcal   x $\dfrac{1000 \text{ cal}}{1 \text{ Kcal}}$ x $\dfrac{1 \text{ J}}{0.2390 \text{ cal}}$ =   623,430.96 J

- now solve $h = \dfrac{(\text{conversion efficiency})(Q)}{mg}$ = $\dfrac{(.15)(623,430.96)(\text{kgm}^2/\text{sec}^2)}{(50\text{kg})(9.8\text{m/sec}^2)}$

$$= \dfrac{93,514.64}{490} = \quad 190.85 \text{ m}$$

b) How high will a person weighing 250 pounds be able to climb? Given: 1kg = 2.2 lbs

Solution:

- first convert pounds into kilograms $\dfrac{250 \text{ lbs} \ \ x \ \ 1\text{kg}}{2.2 \text{ lbs}}$ =   113.64 kg

- solve $h = \dfrac{(\text{conversion efficiency})(Q)}{mg}$ = $\dfrac{93,514.64}{(113.64\text{kg})(9.8\text{m/sec2})}$

$$= \quad 83.97 \text{ m}$$

c) This time use the same factors from the first problem. If two large eggs provide 149 Kcal of energy, how many eggs would a person have to eat in order to climb a mountain that was 500 meters high. Round up to find the exact number of eggs.

Solution

- find the amount of energy required to climb the mountain (E)

$$h = \frac{(\text{conversion factor})(Q)}{mg}$$

$$500m = \frac{(0.15)(E)(kgm2/sec2)}{(50kg)(9.8m/sec2)}$$

$$(500)(490) = 0.15(E)$$

$$E = 1,633,333.33 \text{ Joules}$$

- convert joules to kilocalories $1,633,333.33J \times \dfrac{0.2390 \text{ cal}}{1J} \times \dfrac{1kcal}{1000cal} = 390.37 \text{ kcal}$

149 kcal   divided by 2 = 74.5 kcal for every egg

390.37 kcal   x $\dfrac{1 \text{ egg}}{74.5 \text{ kcal}}$ = 5.24 eggs

This person would have to eat about 6 eggs to be able to climb the 500 meter mountain

Body Energy

Glossary of Terms

work   product of force and displacement in the direction of the force
energy   non-material property capable of causing changes in matter
power   rate of doing work or rate of energy consumption
mechanical work   physical activity that requires energy
caloric intake   the number of calories contained in consumed food

Source

Harte, J. 1985. Consider a Spherical Cow: A course in Environmental Problem Solving.
    William Kaufmann, Inc., California.

Reference

Zitzewitz, P.W., R.F. Neff and M. Davids. 1992. Merrill Physics: Principles & Problems.
    Maxwell Macmillan Canada Inc., Toronto.