Grade Level Expectation: 8
Transportation Efficiency
Content Area: Science

Lesson Time:
1 class period plus homework

Materials:
1. Internet access

Take home: None

Objectives:
This lesson gives students a chance to compare the energy used to get from home to school using a car, bus, bike, or by walking. It also discusses how energy is changed from one form to another.

8th Grade Standards:
2. Physical Science
   1. Identify and calculate the direction and magnitude of forces that act on an object, and explain the results in the object's change of motion.
   2. There are different forms of energy, and those forms of energy can be changed from one form to another – but total energy is conserved.

Background:
- A 130 pound person burns approximately 35 calories per mile when bicycling at a moderate or light pace (12 -14 mph).
- A 130 pound person burns approximately 75 calories per mile when walking a moderately brisk pace (4 mph).
- A 130 pound person burns approximately 75 calories per hour while traveling on a bus (assumed to take 20% more calories than reading).
- A 130 pound person burns approximately 125 calories per hour while driving a car.
- A gallon of gas contains about 31,000 calories.
- A gallon of diesel fuel contains about 35,000 calories.
- Cars and light trucks average a fuel efficiency of 20.8 mpg.
- School busses have an average fuel efficiency of 7 mpg.
- The average car weighs approximately 3,500 pounds.

Internet resources:
http://www.healthstatus.com/calories_burned.html
http://www.americanschoolbuscouncil.org/index.php?page=fuel-calculator
http://www.convertunits.com/from/kilogram+calorie/to/gallon+%5BU.S.%5D+of+diesel+oil
http://www.nhtsa.gov/cars/rules/cafe/NewPassengerCarFleet.htm

When one compares the energy consumed moving a certain distance as a function of body weight for a variety of animals and machines, one finds that an unaided walker and does fairly well (consuming about .75 calorie per gram per kilometer), but he is not as efficient as a horse, salmon, or jet transport. With the aid of a bicycle, however, the man's energy consumption for a given distance is reduced to about a fifth (roughly .15 calorie per gram per kilometer). Therefore, apart from increasing his unaided speed by a factor of three or four, the cyclists improves his efficiency rating to No. 1 among moving creatures and machines.
- Stuart S. Wilson, Scientific American (1973)

Vocabulary: energy, calorie, Kilocalorie

Procedure:
1. Discuss the calorie as a unit of measure, the amount of energy required to raise 1 gram of water 1 degree Celsius. Note that the calories listed on food containers are actually Kilocalories (as is the value for gasoline and diesel above).

2. Ask the students how far they travel to school.

3. Have the students calculate how many calories it would take to get to school by walking, biking, taking a bus, or driving in a car. Alternatively, if a significant number of students ride bikes or walk to school, each student could calculate how many calories it takes him or her to get to school.

4. Have them adjust the number of calories based upon how many people are being transported to school. For instance if two students are being transported in a single car, each would require half the calories required for the complete trip. If a parent drops off the students and then goes home, the number of miles traveled to school should be doubled to account for the total car trip. They will need to estimate or count the number of students using a school bus.

5. Have the students determine the calories per pound needed to travel one mile by each of the modes.

6. Discuss why the calories needed to transport students varies by mode. Ask how the students feel the forces acting upon the transportation mode impact the number of calories required to travel one mile.

7. Discuss the forces that are acting on each mode. How are they different for motorists as opposed to bicyclists or pedestrians? Such forces include gravity, friction within the mechanical workings of the bike or motor vehicle, and wind resistance due to the frontal area of the person or vehicle.

8. Discuss what sorts of fuels are needed to power each mode of transportation. What sort of energy is contained in the food? What sort of conversion does it undergo to provide energy to the mode of transport? What impacts how much of the food energy is translated directly into transport energy? Where does the rest of the energy go?

Activity: Graphing Assignment

Several presentation projects could be used to supplement this project. Some examples include the following:

- Prepare a chart showing the distance that could be traveled using different travel modes with the calories provided from various common foods.
- Prepare a chart showing the relative efficiency (energy used per mile traveled) for each mode.

- Prepare a chart showing how much time one would have to spend travelling to use the calories in a common fast food product: number of minutes would someone have to walk, bike, drive, or ride a bus.