Teaching Activity: Distribution of Solar Energy

Introduction: The currency, or money, in the global energy budget is solar energy, referred to as insolation , or the short wave energy the Earth receives from the Sun. As insolation penetrates the atmosphere and makes its way toward the Earth's surface, several processes affect the solar energy income and how it is spent in the global-energy budget.

At an altitude of 150 km, the Sun's radiation spectrum is almost at full strength as the rays head toward the Earth's surface. The rate of energy production by the Sun shows little variation over the short term. A very constant rate of insolation is recorded when measured above the atmosphere, at right angles to the incoming energy. If an average Earth-Sun distance is assumed, this insolation rate has a value of two gram calories per square centimeter per minute. A gram calorie is the amount of energy needed to raise the temperature of 1 gram of pure water 1 degree C. This rate of incoming energy is known as the *solar constant.*

The amount of radiant energy reflected, known as albedo, varies significantly, especially in the case of clouds and snow. Insolation received at a given point on the Earth's surface depends largely on the bangle of the Sun's rays and the length of daylight, factors that vary depending upon and season. Generally, overall absorption is 68 percent of the energy received by the Earth, while reflection is 32 percent. The Earth does not overheat due to a variety of factors that keep the energy budget in balance.

Remember that longwave radiation is constantly emitted from the entire surface of the Earth, while shortwave radiation falls only on the illuminated part, or one half, of the Earth's surface at any given time. Also, only 68 percent of the incoming radiation is absorbed and needs to be reradiated. The result of longwave emission to space is a global balance of energy input and output. Water vapor and carbon dioxide are good absorbers of infrared wavelengths emitted by the Earth, and keep temperatures from dropping excessively during the winter months. Both of these gases are referred to as "greenhouse gases" because the allow the shorter wavelengths to penetrate, but trap returning lower-energy radiation from the Earth's surface, functioning somewhat like the glass in a greenhouse. Clouds also affect the energy budget to a varying degree, depending upon their type and altitude. Despite the general radiation balance, areas of energy surplus and energy deficit occur in the cycle that we call *seasons.*

Objective:

- To describe and illustrate the distribution of solar energy received by the Earth;

Important Terms: Radiation, shortwave, longwave, absorbers, infrared, cycle, radiation spectrum, gram calorie, solar constant, albedo, seasons;

Materials: Two different colored pencils per student;

Procedure:

1. *Net radiation* is the difference between all solar radiation received by the Earth and the longwave radiation that it puts back out. Generally, the net radiation is zero, indicating that the Earth is in radiative balance. To determine the global energy budget for different location on the Earth's surface, students will plot yearly average net radiation in relation to latitude. Because yearly average data are used, seasonal effects will no be noticeable.
    a. Students should plot the yearly average net radiation data measured in energy units on the graph provided. Net radiation data is provided on the **Data Table**.

2. Students should connect the dots with a smooth line and label the line: **Net Radiation**.

3. Students should then shade in the area between the line labeled **Net Radiation** and the -0- energy-units line. This area represents the location and amount of energy surplus.
    a. Students should label this area: **Energy Surplus**.

4. Students should then shade in the areas above the **Net Energy** line and below the -0- energy-units line. This area represents the location and amount of energy deficit.
    a. Students should label these areas: **Energy Deficit**.

5. Students should then answer the questions in the **Analysis and Comprehension** section.

DATA TABLE

Latitude	Energy Units	Latitude	Energy Units
90° N	–92	10° S	28
70° N	–70	20° S	26
60° N	–49	30° S	12
50° N	–24	40° S	–10
40° N	0	50° S	–35
30° N	16	60° S	–58
20° N	26	70° S	–72
10° N	28	90° S	–89
0°	28		

Note: Interpolate readings for 80° N and 80° S.

Student Activity Sheet: Distribution of Solar Energy

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At an altitude of 150 km, the Sun's radiation spectrum is almost at full strength as the rays head toward the Earth's surface. The rate of energy production by the Sun shows little variation over the short term. A very constant rate of insolation is recorded when measured above the atmosphere, at right angles to the incoming energy. If an average Earth-Sun distance is assumed, this insolation rate has a value of two gram calories per square centimeter per minute. A gram calorie is the amount of energy needed to raise the temperature of 1 gram of pure water 1 degree C. This rate of incoming energy is known as the *solar constant.*

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Objective:

- To describe and illustrate the distribution of solar energy received by the Earth;

Procedure:

1. Using the information from the **Data Table**, plot the yearly average net radiation data measured in energy units on the graph provided.
   a. Connect the dots with a smooth line and label the line: **Net Radiation.**

2. Shade in the area between the line labeled **Net Radiation** and the -0- energy-units line.
   a. Label this area: **Energy Surplus.**

3. Shade in the areas above the **Net Energy** line and below the -0- energy-units line. This area represents the location and amount of energy deficit.
   a. Label this area: **Energy Deficit.**

4. Answer the questions in the **Analysis and Comprehension** section.

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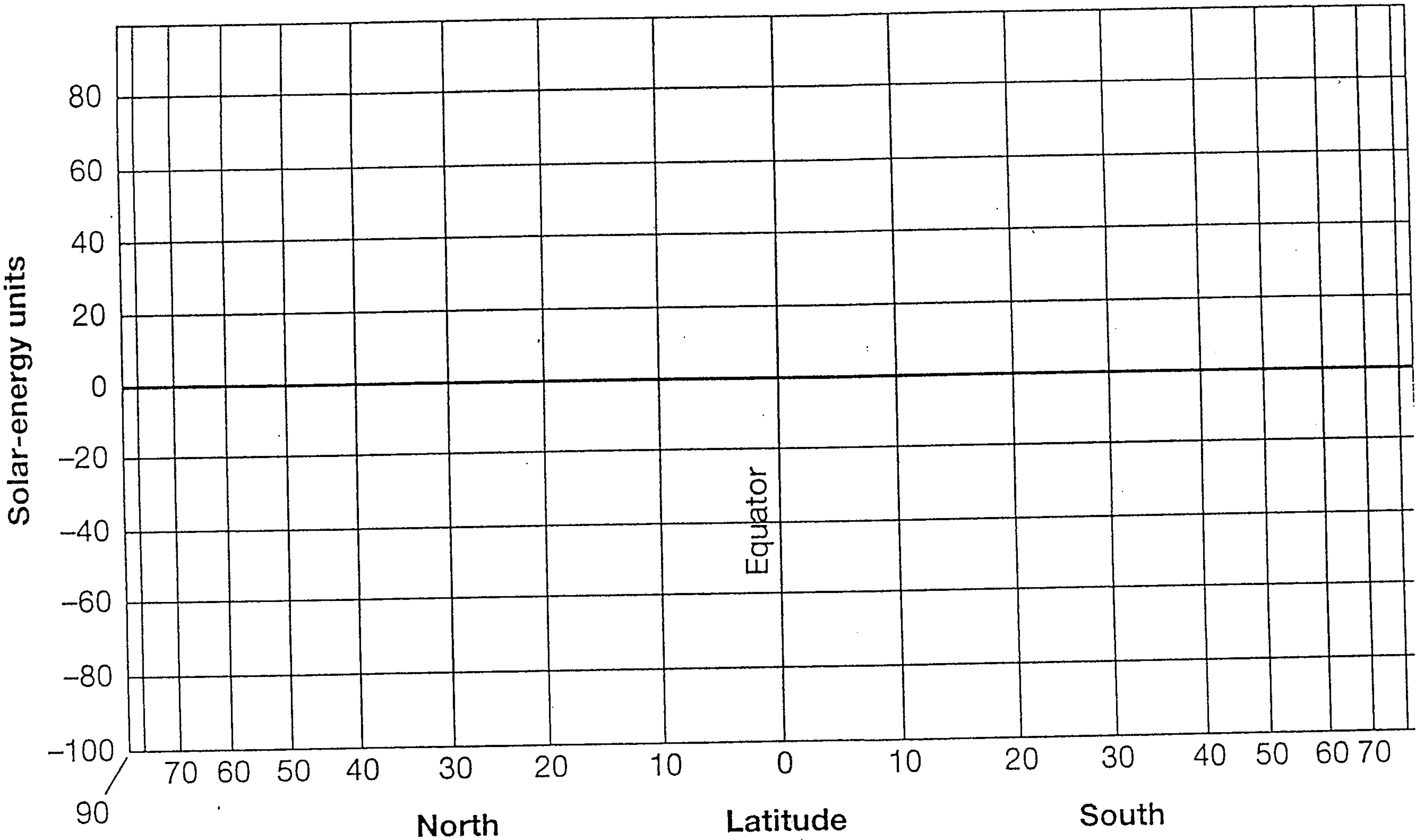
GRAPH: Solar Energy Distribution at the Earth's Surface



Analysis and Comprehension:

1. Where are the energy-deficit regions located? Why?

2. Where are the energy-surplus regions located? Why?

3. What is true of the area on the graph labeled: **Energy Deficit** and the area on the graph labeled: **Energy Surplus**? What does this suggest about the net radiation for the entire Earth?

4. How is energy carried from energy of energy surplus to areas of energy deficit? Draw a diagram to illustrate your idea.