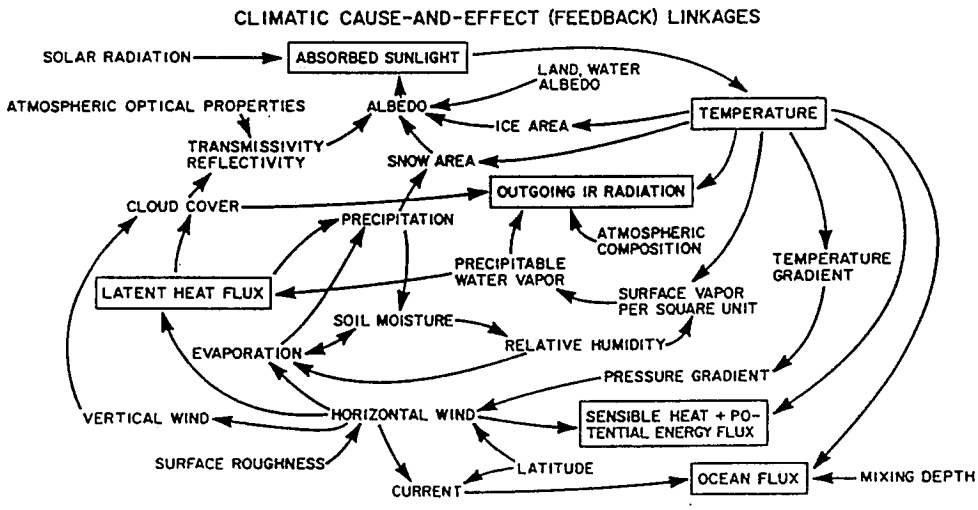
Teaching Activity: Analyzing a Feedback Mechanism

Introduction: The most important processes to deal with when evaluating climate data either on Earth or other planets are known as *feedback mechanisms*. The word feedback is common outside of the climate research field. For instance, you may ask a friend for feedback on a piece of work you are doing. Then you can, if you want, modify your project in response. As the term implies, information can be "fed back" to you that will possibly alter your behavior.

It is much the same in the climate system: processes interact to modify the overall state of the climate. One important feedback mechanism is easily visualized. Suppose a warm wind blows over a valley covered lightly with snow. The temperature will rise, melting the snow cover and replacing a bright, highly reflective snow surface with a much darker, more sunlight-absorbing meadow. The temperature rise caused initially by the warm wind will be further enhanced by the *positive feedback* effect on temperature of disappearing snow cover. In the same way, a cold snap brings on a snow cover that tends to reduce the amount of solar heat absorbed, thereby intensifying the cold.

Unfortunately, other feedback mechanisms are not so well understood. The most difficult is the so-called *cloud feedback*. Generally, more cloudiness means less solar energy is absorbed by the Earth because clouds are highly reflective of solar radiation. Suppose a warm wind blows over a large lake. Warm, wet surfaces usually evaporate more water than cooler or drier surfaces. Therefore, the warming lake puts more moisture into the air. Clouds form, blocking some sunlight from reaching the lake's surface, and cooling it down. This is a stabilizing or *negative feedback mechanism*: the cloud formation, in response to initial surface warming, "feeds back" on that warming in a way that inhibits large temperature changes. Below is a diagram of the many feedback processes that may need to be included in a model of the Earth's climate system.



A schematic of the many feedback mechanisms within the Earth's climate system

Objective:

- To relate climate change to the theory of feedback mechanisms;

Important Terms: Feedback mechanisms, hypothetical, model, conduction, convection, radiation;

Materials: Copy of problem solving worksheet, overhead diagrams of possible feedback relationships;

Procedure:

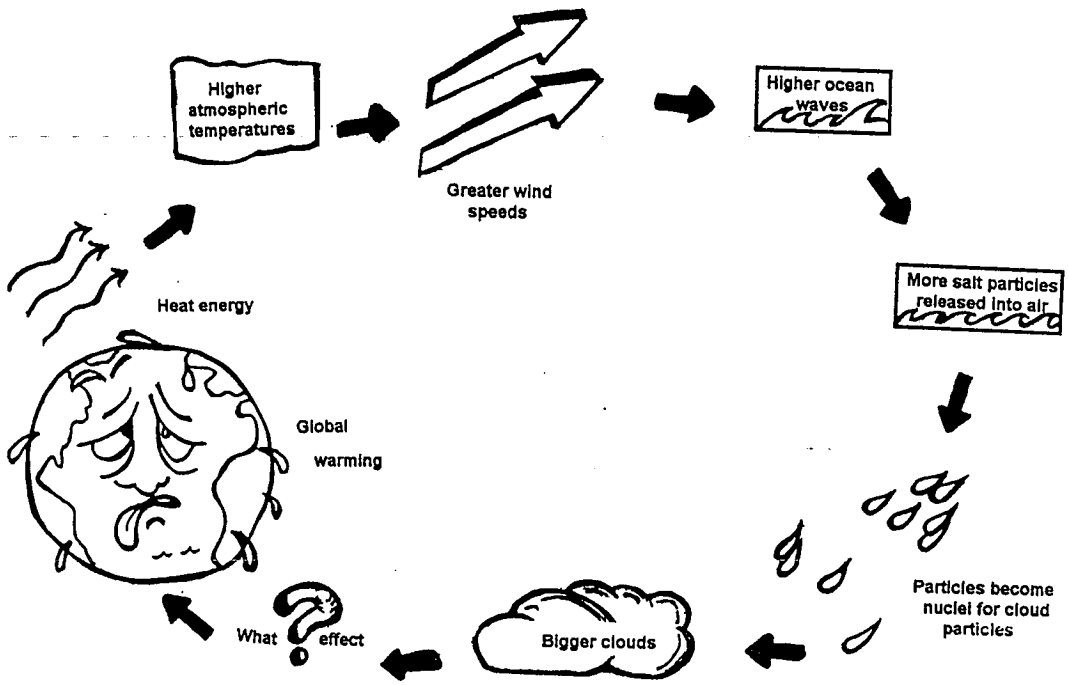
1. Before beginning the activity, point out that scientists can only create hypothetical models of changes in the climate system.

2. Present some diagrams to the class of simple feedback mechanisms.
   - Discuss each with the class and decide if it would be positive or negative feedback.
3. Read through and discuss the introduction on the **Student Activity Sheet**.
   - Be sure students understand what a feedback mechanism is.

4. Allow students to work with partners to interpret the diagram in **the Problem Solving** activity.
   - Students should write complete sentences explaining what occurs in each part of the diagram.

   - Students should then complete the questions in the **Relating Cause and Effect** section.

Analyzing a Feedback Mechanism



Additional Feedback Scenarios:

* **Atmospheric water vapor concentration (positive feedback)**
  - Water vapor in the atmosphere increases as Earth warms;
  - Increased water vapor absorbs more infrared energy causing the temperatures to go up;
  - Increased evaporation results from increased temperature.

* **Ice/ albedo relationship (positive feedback)**
  - Higher temperatures cause melting of sea ice;
  - Albedo of the surface is reduced;
  - More heat is absorbed, less re-radiated back to space;
  - Warming increases;

* **Fog/low clouds scenario (negative)**
  - Higher temperature cause increased evaporation;
  - Increased water vapor in the atmosphere causes low level clouds and fog to form;
  - Fog and cloud particles reflect incoming sunlight back into space;
  - Temperatures reduced;

* **Trees/ soil scenario (negative)**
  - Agricultural development demands increased burning of biomass;
  - Disturbed vegetation and soils give up carbon stored in them when burned;
  - Re-growth vegetation takes CO_2 out of the air lowering the overall concentration in the atmosphere;

Student Activity Sheet #1

Problem ??????????

Solving Activity

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At an international conference on global climate change British scientists presented the following theory:

> **If the temperature of the Earth rises significantly as a result of an enhanced greenhouse effect (global warming) the speed of global winds will increase. Increased wind speed will cause a greater disturbance of ocean water, which in turn will cause larger clouds to form. The clouds might either increase or decrease the Earth's average global temperature.**

This theory is an example of a *feedback mechanism*, in which one event causes a series of other events, which in turn influence the first event.

Imagine that you are a scientist at the conference and have been given a copy of a diagram illustrating the feedback mechanism described by the British scientists. Your job is to interpret the diagram, analyze how this particular feedback mechanism might influence global warming and report back to the conference members. Answer the questions below and use them as a guide to planning your presentation.

Student Activity Sheet #2

Guide Questions for Relating Cause and Effect

1. According to the diagram, what changes will occur in the atmosphere as a result of global warming? What do you think will cause these changes to occur?

2. How will the changes in the atmosphere affect the ocean? Explain.

3. How will the changes in the ocean affect cloud formation?

4. Based on your knowledge of weather and climate, how might larger clouds make the Earth warmer? How might larger clouds make the Earth cooler?

5. Do you think that this feedback mechanism will increase (a positive feedback) or decrease (a negative feedback) the effects of global warming? Why?

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