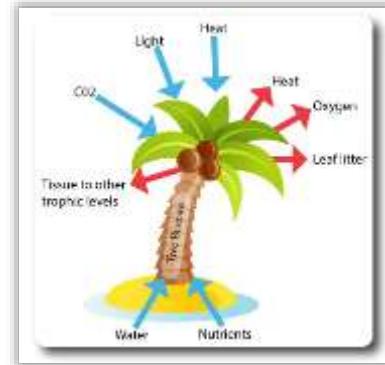


PROBLEM SOLVING ACTIVITY: CLIMATE CHANGE AND FEEDBACK LOOPS

Systems are made up of parts and the interactions between them. They are composed of:

- + **Storages of matter/energy:** tree biomass in trunk & leaves.
- + **Flows: inputs & outputs:** light, oxygen and heat.
- + **Processes which transfer or transform the energy/matter:** photosynthesis.
- + **Feedback loops:** affecting the stability of the system.



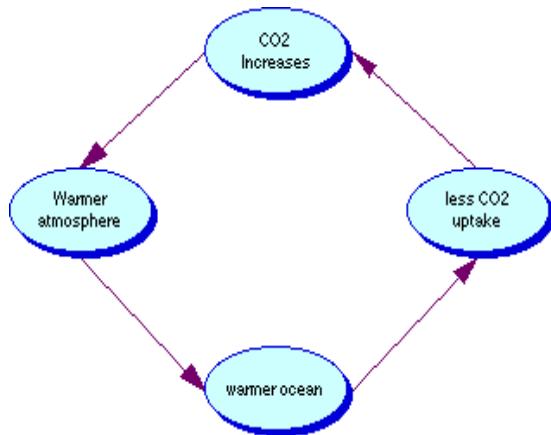
To be stable, all systems need to be self-regulating. **Feedback loops** permit systems to adjust their response to change (forcing factors) to return to stable conditions. Systems diagrams contain boxes that show circles and arrows which indicate flows.



A feedback is similar to a **cause and effect loop**, where information about a system is sent back to the system to improve its performance. An example is your body's ability to control temperature. The condition of the body's temperature is the information fed back to the brain, which is the controller. If the temperature is high, the body sweats in order to cool down. Since the process of sweating is done to stop the temperature change, this is a negative feedback.

Feedback loops come in two flavors: positive and negative. A **negative feedback loop** reduces the effect of change and helps maintain balance. A **positive feedback loop** increases the effect of the change and produces instability. In this case, the positive and negative naming of the loops do not indicate whether the feedback is good or bad. In climate change, a feedback loop is something that speeds up or slows down a warming trend. A positive feedback accelerates a temperature rise, whereas a negative feedback slows it down.

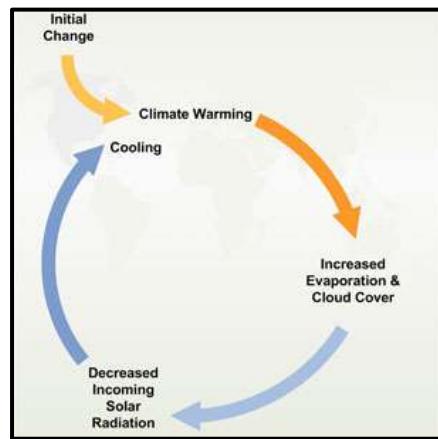
Student Sheet 2



Scientists have identified several positive feedback loops in the climate system. **Ocean warming** provides a good example of a potential positive feedback mechanism. The oceans are an important sink for CO_2 through absorption of the gas into the water surface. As CO_2 increases, it increases the warming potential of the atmosphere. If air temperatures warm, it

should warm the oceans. The ability of the ocean to remove CO_2 from the atmosphere decreases with increasing temperature. Because of this, increasing CO_2 in the atmosphere could have effects that actually intensify the increase in CO_2 in the atmosphere.

A good example of a negative feedback mechanism will be if the increase in temperature increases the amount of **cloud cover**. The increased cloud thickness or amount could reduce incoming solar radiation and limit warming. At the same time, it is not clear, that if additional cloud cover happens, at what latitudes and at what times it might occur. Also, it is not clear what types of clouds might be created. Thick low clouds would have a stronger ability to block sunlight than extensive high (cirrus) type clouds.



Various other feedbacks - related to emissions from soils and permafrost, for example, and changes to ocean evaporation - are known or thought to exist. Feedback loops such as these are very complex in themselves and even more complex when considered as part of an integrated global climate system. Some are already at work, while others have yet to kick in. Others still - both positive and negative - may yet be discovered.



THE SCENARIO

At an international conference on climate change, new information was presented by a team of scientists from Great Britain. Many of the people attending the conference are unclear about their findings and need more and better information. Your team of climate specialists has been asked to analyze their data and report back with your findings to the group at a later date. Their theory was presented in the form of a feedback loop with which you have extensive experience.

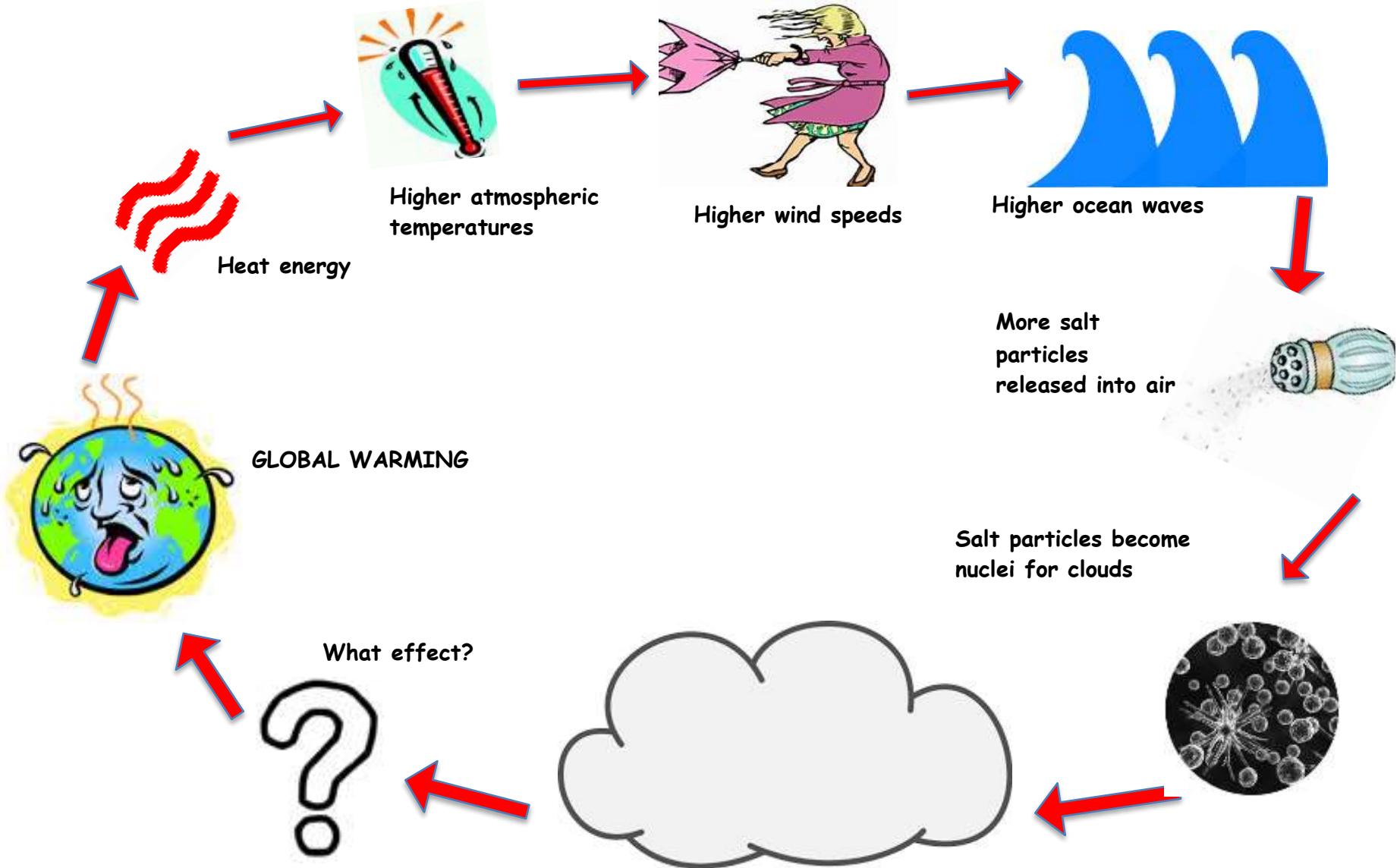
"If the temperature of the Earth rises significantly as a result of an enhanced greenhouse effect (global warming) the speed of global winds will increase. Increased wind speed will cause a greater disturbance of ocean water, which then will cause larger clouds to form. The clouds might either increase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

TASK:

1. **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.
2. Your job is to **interpret** the diagram, **analyze** how this particular feedback mechanism might influence global warming and **report back** to the conference members.
3. Answer the questions below and use them as a guide to planning your presentation.
4. Create a visual representation of your report to help clarify the problem for your audience.

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?
2. What do you think will cause these changes to occur?
3. How will the changes in the atmosphere affect the ocean? Explain.
4. How will the changes in the ocean affect cloud formation?
5. Based on your knowledge of weather and climate, how might larger clouds make the Earth warmer? How might larger clouds make the Earth cooler?
6. Do you think that this feedback mechanism will increase (a positive feedback) or decrease (a negative feedback) the effects of global warming? Why?



ANALYZING A FEEDBACK LOOP

