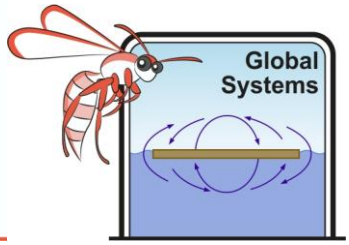
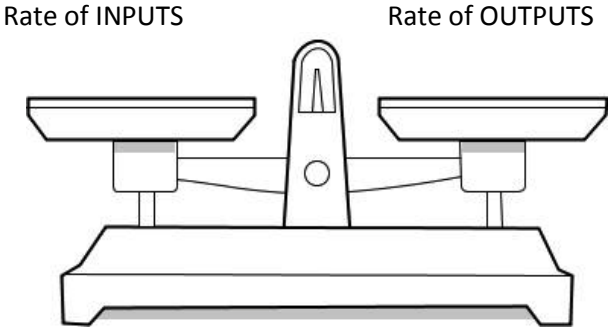


Global Systems - Teacher Background

In order to understand changes in weather over hours or days, seasons over months and climate over tens to thousands of years, we have to treat the Earth as a series of systems which affect each other in the same way as the systems in our bodies react to change to maintain balance (homeostasis). In a variable environment, our body systems have to interact and respond to change through a series of positive and negative feedback loops. Imbalance would result in illness. Similarly our planet at its surface relies on a series of interconnected global systems to maintain its balance. Materials and energy must be moved around these systems in a balanced way.



At a purely human level:
Too much nitrogen in the atmosphere and our breathing would stop. Too little nitrogen and we would catch fire.
Too much carbon dioxide released into our atmosphere will result in heating and desertification. Too little carbon dioxide and it will be too cold for our enzymes to work efficiently and we will die.

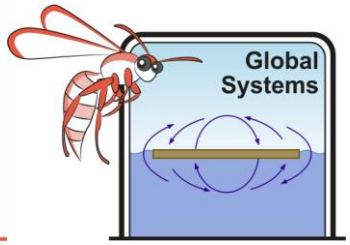
Earths systems:

1. **Atmosphere**: This consists of gases, mostly nitrogen 78.09%, oxygen 20.95% and carbon dioxide 0.039%. Air contains a variable amount of water vapour (average 1%). This zone is one of small molecules of low density bound by weak intermolecular forces.
2. **Lithosphere**: This consists of solid rock. It is the cold, brittle and elastic outermost shell of our planet. It is made of minerals whose atoms are joined with ionic lattices e.g. alumina-silicates.
3. **Hydrosphere**: This is the mass of water lying over, on or under the surface of the Earth as oceans, seas, lakes and rivers. 97.5% is saline and 2.5% is fresh, of which 68.7% is ice. The hydrosphere is mostly small molecules with dissolved ions. The **cryosphere** is that part of the hydrosphere where water is frozen.
4. **Biosphere**: The biosphere is the very thin layer in which all living organisms exist. Life is based on long chain polymers.

There is continual movement between all of these spheres. Elements will be moved through natural and manmade processes from sources to sinks and from sphere to sphere at various speeds. In Nature the balance of input and output should be about the same. When inbalance occurs the whole Earth can be affected.
We can describe the movement of specific materials between systems in cycles such as the carbon cycle or the nitrogen cycle.

We know that the climate of Earth has noticeably changed in the recent past:

- In May 2014, the average temperature over global land and ocean surfaces was the hottest since records began in 1880 according to NOAA (National Oceanic and Atmospheric Administration). “The majority of the world experienced warmer than average monthly



temperatures with record warmth across eastern Kazakhstan, parts of Indonesia and central and northwestern Australia.

- Archaeological evidence demonstrates farmers colonised Greenland during the "Medieval Summer" between 1200AD and 1500AD. They grew wheat and vines until the climate cooled and they had to leave or starve to death.
- Aboriginal people laid fish traps in lakes and swamps near Broken Hill about 20,000 years ago. It is now desert.
- Genetic evidence suggests that our own species was reduced to about 600 breeding pairs during the coldest period of the last Ice Age about 70,000 years ago. Later warming melted the ice and they moved out to colonise most of the land on Earth while mammoths, sabre toothed tigers and cave bears which were suited to severe cold became extinct.

Geological evidence suggests that the Earth has undergone long periods of extreme heating and cooling. Glacial deposits suggest that we have undergone at least three major periods of global glaciation. Desert sands indicate global drought. These extremes of climate have associated evidence of mass extinctions.

On a shorter term, we now have evidence that our planet has undergone a sequence of cycles of warming to an average of 22^{o}C and cooling to 12^{o}C about every 10,000 years. These cycles are named after the Czech scientist Milankovitch who suggested they occur in response to natural variations in the Earth's rotation and tilt and in solar activity. We are presently coming out of a cool period.

There is no doubt that climate changes over time. The natural rate of change is slow and this permits some plants and animals to change their geographic location or behaviours to suit the changed environment. Those best suited will survive and multiply. However for some specialised organisms change can be lethal. After the largest global mass extinction, between the Permian and Triassic periods, it took 10 million years to recover biodiversity. The forcing factor was volcanic activity and a rise in global temperature due to volcanic carbon dioxide in the atmosphere.

Human activities can affect global systems and the survival of species on our planet. If our behaviours accelerate the tolerable rate of climate change we will cause imbalance in Earth Systems and may be responsible for the loss of many species, perhaps including our own.

What is happening within our global systems needs much scientific investigation and informed debate free of economic and political bias.

An updated version of "The Science of Climate Change" will be released by the Australian Academy of Science in mid 2014. It is an excellence reference source. The following quote is from the earlier 2012 publication.

"We are very confident of several fundamental conclusions about climate change: that human activities since the industrial revolution have sharply increased greenhouse gas concentrations; that these added gasses have a warming effect: that the Earth's surface has indeed warmed since the Industrial Revolution. Therefore, we are very confident that human-induced global warming is a real phenomenon."