



OUTCOMES SCIENCE 4

EARTH & BEYOND

INSTRUCTIONAL MODULE 5: LESSON 5
TARGET YEAR GROUPS: 8 / 9 / 10 / 11 / 12

Student Name:

Tutorial Group:

In the Introductory Lesson of E & B Instructional Module 1, I defined **global environmental change** as restated below.

Global environmental change embodies the nature and consequences of natural and human induced changes to the interacting physical, chemical, geological, biological and social processes that regulate the environment supporting human life and influence the quality of that life on planet Earth.

You should be aware that many authors of earth science web sites and textbooks refer to global environmental change simply as global change? They intentionally leave out the word "environmental" for the sake of brevity.

In the Introductory Lesson of E & B Instructional Module 2, I defined the **environment** as stated below.

The environment of a living thing (or organism) is all the factors (things), either living (or biotic) or non-living (or abiotic), in its surroundings that have an effect on the living thing (or organism).

Therefore our environment is anything in our surroundings that has an effect on us, and any change in those factors on a global scale constitutes global environmental change. Probably the most researched example of global environmental change is **global climate change**.

Please be aware that the web sites of many earth science organisations incorrectly use the words global change when they are referring to global climate change.

The major focus of this E & B Lesson will be global climate change. In this E & B Lesson you will consider the following fundamental questions:

- Is the global climate changing?
- If the global climate is changing, how is it changing, and why is it changing?
- What will the future global climate be, given parameters like concentration of carbon dioxide gas?
- Has global climate changed in the geologic past? If it has, what was the cause of those changes?

You would appreciate that the global climate system is extremely complex involving many interacting processes, with both positive and negative feedback. Consequently, climate modelling, which requires the use of supercomputers, provides results that are dependent upon the particular climate model used.

Climate modelling using supercomputers is well beyond the scope of this middle school E & B Lesson.



ONLY HIGHLY MOTIVATED STUDENTS NEED APPLY

Highly motivated middle school students should now wish to be plugged into global climate modelling, and if so, they should visit the web sites whose Internet Addresses (URL's) are listed below? Who wants to be known as an unmotivated student?

1. <http://news3.news.wisc.edu/021climate/models.html>
2. <http://www.annapoliscenter.org/global.htm>
3. <http://cimss.ssec.wisc.edu/wxwise/climsim/index.html>
4. http://www.atmos.washington.edu/honors_220/model/2modelb.html
5. <http://pubs.acs.org/hotartcl/cenear/951127/pg1.html>
6. <http://katipo.niwa.cri.nz/ClimateFuture/Models.htm>
7. <http://www.gcrio.org/CONSEQUENCES/fall95/mod.html>
8. http://www.sprl.umich.edu/GCL/gc1_frameset.html lectures
9. http://stommel.tamu.edu/~baum/climate_modeling.html
10. <http://web.mit.edu/globalchange/www/reports.html>

On page 9 of E & B Lesson 1, Instructional Module 5, I asked this fundamental question: What is the difference between weather and climate?

1. Can you now **explain** the difference between weather and climate?

The Earth's climate system consists of five major interacting subsystems: the atmosphere, the hydrosphere, the cryosphere, the lithosphere, and the biosphere (including humans - the anthrosphere).

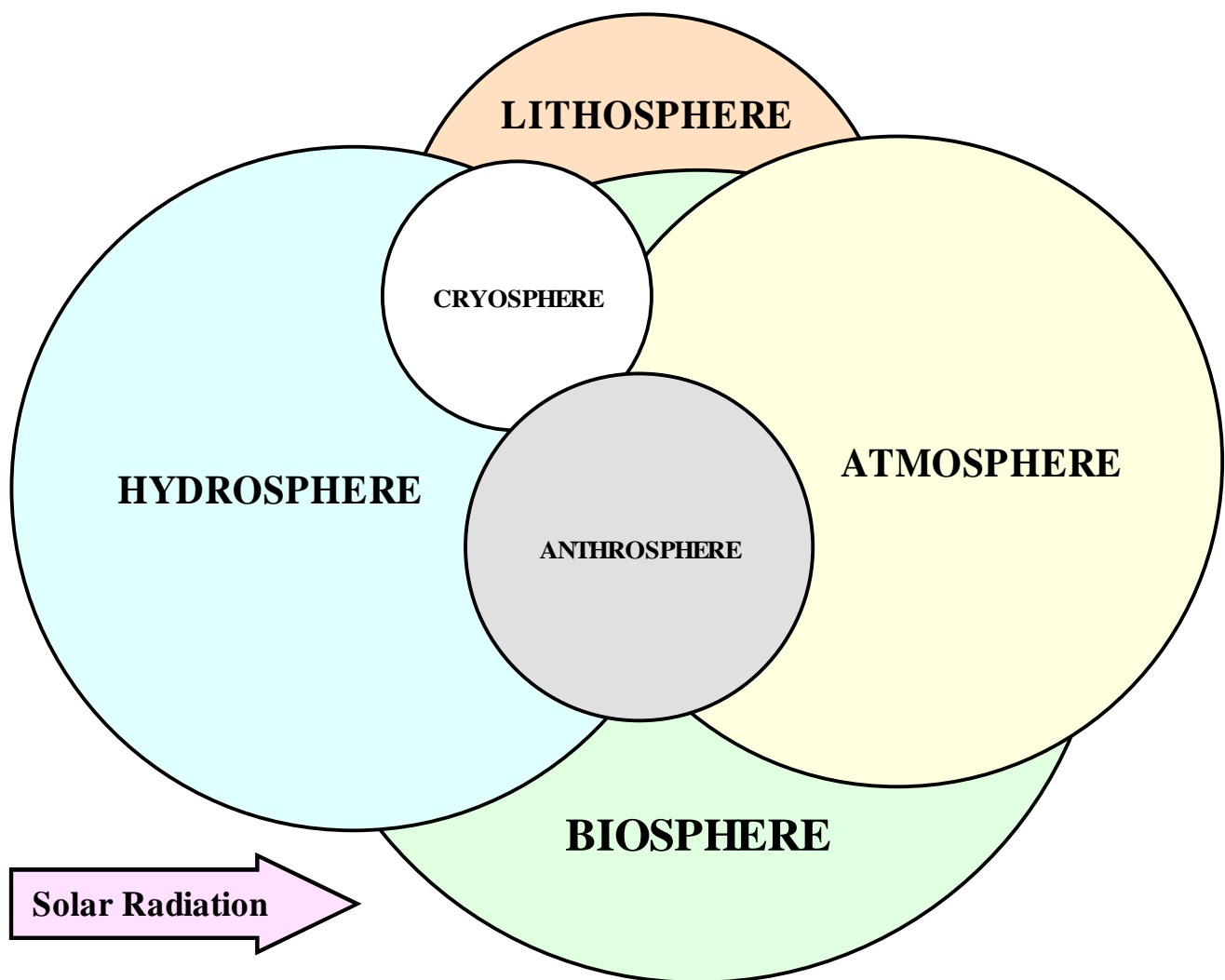


FIGURE 1: THE CLIMATE SYSTEM

2. Can you **identify** and very broadly **describe** how certain biogeochemical processes link (couple) each of the interacting subsystems of the Earth's Climate System, thereby controlling global climate?

Students in each Learning Group should now answer Question 2 by completing TABLE 1, given on the next page.

My intention of asking you to complete TABLE 1, at this early stage, is to probe your existing knowledge of Earth's Climate System.

Do NOT worry if you experience some difficulty in trying to complete TABLE 1.

As your knowledge of Earth's Climate System develops, from studying this E & B Lesson, you will be given further opportunities to complete TABLE 1.

TABLE 1: COUPLING WITHIN EARTH'S CLIMATE SYSTEM

SUBSYSTEMS COUPLED	BIOGEOCHEMICAL PROCESSES
Solar Radiation Atmosphere	
Solar Radiation Hydrosphere / Cryosphere	
Solar Radiation Lithosphere	
Solar Radiation Biosphere / Anthrosphere	
Biosphere / Anthrosphere Atmosphere	
Biosphere / Anthrosphere Hydrosphere / Cryosphere	
Biosphere / Anthrosphere Lithosphere	
Atmosphere Hydrosphere / Cryosphere	
Atmosphere Lithosphere	
Lithosphere Hydrosphere /Cryosphere	

You would be aware that within Earth's Climate System, coupling of subsystems does not only occur in pairs? In reality, coupling would simultaneously occur between all subsystems of Earth's Climate System.

I have shown coupling in pairs to simplify your analysis of the extremely complex climate system of our blue planet, Earth. Why is Earth referred to as the Blue planet?



Students in each Learning Group should now research the coupling between the various subsystems of Earth's Climate System by visiting the web sites whose Internet Addresses (URL's) are listed below.

This bracket of web sites provides information with which to complete TABLE 1 from the previous page, and to answer the focus questions given on the next page, which relate to global climate change.

Prior to visiting the web sites, you should read the focus questions provided on the next page so as to guide your research at the web sites. Otherwise, you could fall into the trap of wandering aimlessly through the web sites.

1. <http://www.geog.ouc.bc.ca/physgeog/contents/7y.html>

2. <http://unisci.com/stories/19994/1215993.htm>

3. <http://www-personal.umich.edu/~jmascaro/platefec.html>

4. <http://www.doc.mmu.ac.uk/aric/eae/enter.html>

5. <http://www.climateark.org/> Vital Climate Graphics

6. <http://www.climatechange.nrcan.gc.ca/english/html/>

7. <http://www.ngdc.noaa.gov/paleo/primer.html>

8. http://www.sprl.umich.edu/GCL/gc1_frameset.html lectures

9. <http://www.lter.uaf.edu/~fschapin/Chap2.html>

10. <http://www.ipcc.ch/>

11. <http://www.pewclimate.org/>

12. <http://www.pacinst.org/ccresource.html>

13. <http://www.gcrio.org/ipcc/qa/cover.html>

FOCUS QUESTIONS ON GLOBAL CLIMATE CHANGE

3. Is the global climate changing? What do you think? What do the other members of your Learning Group think?

4. If you think that the global climate is changing, how is it changing?

5. If the global climate is changing, how do you know that it is changing? What **evidence** is available to conclude that the global climate is changing?

6. What do you think are some possible causes of global climate change? Which of those causes are human-induced (anthropogenic), and which are natural? **Complete TABLE 2 on the next page.**

TABLE 2: SOME POSSIBLE CAUSES OF GLOBAL CLIMATE CHANGE

Column 1	Column 2
NATURAL CAUSES	ANTHROPOGENIC CAUSES

In Column 2 of TABLE 2, completed above, you most probably would have identified global warming as the most frequently quoted example of human-induced (anthropogenic) global climate change?

In Lesson 4 of E & B Instructional Module 5, I defined **global warming** as restated below.

Global warming is a warming of the Earth's atmosphere owing to the anthropogenic enhancement of the greenhouse effect.

7. What does this definition of global warming mean to you? What does it mean to the other members of your Learning Group? Can you restate my definition of global warming in a simpler way?

8. If global warming is occurring, then there should be an increasing upward trend in averaged global temperature, which corresponds to the increasing concentration of anthropogenic greenhouse gases, such as CO₂ in Earth's tropospheric atmosphere? Why is this so?



Has there been an upward trend in globally averaged temperature over the past two decades? Find out by visiting the web sites listed below. To satisfy your curiosity, you may also wish to locate and study regional temperature data for your own country.

Has your own geographical region been subjected to increasing near-surface air temperatures over the past "x" number of years?

Students in each Learning Group should now visit the web sites whose Internet Addresses (URL's) are listed below to locate and study globally averaged temperature data.

1. http://wwwssl.msfc.nasa.gov/newhome/headlines/essd5feb97_1.htm

2. <http://wwwghcc.msfc.nasa.gov/temperature/>

3. <http://www.giss.nasa.gov/research/observe/surftemp/>

4. <http://www.gristmagazine.com/grist/heatbeat/weather012800.stm>

5. <http://grads.iges.org/pix/head.html>

6. <http://www.all.mq.edu.au/online/envsci/atmdat/>

7. <http://www.bom.gov.au/climate/how/index.shtml>

8. <http://www.dnr.qld.gov.au/longpdk/>

9. <http://globalchange.gov/>

9. Do you now believe that global warming is occurring and that it will cause the sea level to rise?



If fish could talk and reason, what would be their opinion about global sea level rise? Students in each Learning Group should now research the answers to the following focus questions by visiting the web sites whose Internet Addresses (URL's) are listed below.

- Is mean global sea level rising?
- If mean global sea level is rising, what is causing it to rise?
- What factors (or variables) determine the mean global sea level?
- How can oceanographers determine what proportion of sea level rise is caused by global warming, rather than other causal factors like tectonic plate movement?
- How does global warming cause the sea level to rise?
- How do oceanographers determine mean global sea level?
- What are the likely consequences of global sea level rise on the various subsystems of System Earth?

1. <http://www.pbs.org/wgbh/nova/warnings/waterworld/>

2. http://pubs.usgs.gov/factsheet/fs133-99//gl_vol.html

3. <http://www.giss.nasa.gov./research/intro/gornitz.01/>

4. http://www.ucusa.org/warming/gw_seas.html

5. <http://www.usatoday.com/weather/wsealevl.htm>

6. <http://earth.agu.org/revgeophys/dougla01/dougla01.html>

7. <http://www.soest.hawaii.edu/SEAGRANT/global/gcenseal.html>

8. <http://www.ntf.flinders.edu.au/TEXT/PRJS/BASE/base.html>

9. <http://www.csr.utexas.edu/gmsl/>

10. <http://www.ae.utexas.edu/courses/ase389p/moody/home.html>

11. <http://www.epa.gov/globalwarming/publications/impacts/sealevel/>

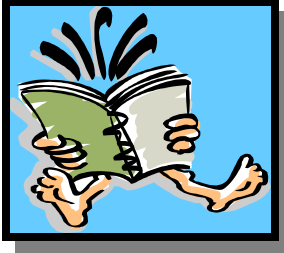


Students in each Learning Group should now collaborate to produce an electronic group report on the effect of climate change on the humans (the Anthrosphere).

Can you list some of the ways by which we humans adapt to climate change?

Students now research how climate change affects humans by visiting web sites whose Internet Addresses (URL's) are listed below. **Please note that any images you use are subject to copyright.**

1. <http://phe.rockefeller.edu/DCSM/>
2. <http://www.bom.gov.au/climate/environ/index.shtml>
3. http://eos.atmos.washington.edu/~dennis/OCC_Final_961216.html
4. <http://www.rppi.org/environment/peg3.html>



REFLECT AND RE-LEARN

Students in each Learning Group are to firstly identify and list, as a dot-point summary, all those key science concepts (ideas) that they have come to understand by studying this Earth & Beyond Science Instructional Module.

Secondly, they are to identify and list those words and concepts (ideas) that are unclear to them. They then seek help from other students in their Learning Group, and then from other Learning Groups.

Your teacher will assist you, only after your science class has expended every effort to clarify the difficult content on their own.