



OUTCOMES SCIENCE 4

EARTH & BEYOND

INSTRUCTIONAL MODULE 5: LESSON 1
TARGET YEAR GROUPS: 8 / 9 / 10 / 11 / 12

Student Name:

Tutorial Group:

In concluding the Introductory Lesson of Instructional Module 5, I asked you to explain how the Earth's atmosphere is separated into four (4) distinct layers according to variation in temperature with altitude.

1. Can you recall **how** and **why** air temperature varies with altitude across each of the four layers of the Earth's atmosphere? If you can't satisfactorily answer this question? You will need to analyse the temperature versus altitude graph and study the supporting dot-point notes provided at the web sites whose Internet Addresses (URL's) are listed below.

1.

<http://radar.ou.edu/OK1/meteorology/VertStructure.html>

2.

<http://radar.ou.edu/OK1/meteorology/VertStructure2.html>

Students in each Learning Group now describe, and interpret the shape of the air temperature versus altitude graph, in each of the four (4) atmospheric layers, by completing TABLE 1 given below.

TABLE 1: ANALYSIS OF AIR TEMPERATURE VERSUS ALTITUDE GRAPH

Atmospheric Layer	Temperature Change	Reasons for Temperature Change
Troposphere		
Stratosphere		
Mesosphere		
Thermosphere		

In this E & B Lesson, we will be mainly concerned with the two lower layers of the Earth's atmosphere the Troposphere and Stratosphere.

The Troposphere is the lowest layer of the Earth's atmosphere and the site of all weather on the Earth.

The troposphere extends up to about 16 km above the equator and to only about 8 km above the poles.

2. Do you know why the troposphere is wider vertically at the equator than at the poles?

In general, air temperature in the troposphere decreases with altitude at an average rate of about 6.5 °C per 1000 m, whereas in the stratosphere air temperature increases with altitude.

3. Do you know why the troposphere is hotter near the Earth's surface (its lower boundary) than it is at its top boundary, the tropopause? What heat transfer process causes most heating of the troposphere? How is the troposphere heated? Explain using a labelled diagram supported with brief notes.

4. What is the primary energy source that heats the Earth's surface? How much solar radiation energy does the Earth's surface receive daily in your home city? How could you find out? Why is it important that we humans know this data? What organisations collect and display this data?

Insolation (*incoming solar radiation*) is the amount of electromagnetic energy received from the Sun per unit area of the Earth's surface on which it falls.

5. Would insolation data for your home city be constant from day to day and month to month, or would it vary? If you think that it would vary, why do you? What factors **determine** the insolation received by a specific location on the Earth's surface at a specific time and date?

6. How much solar energy does each of the planets receive compared to Earth? I have displayed the relevant data in TABLE 2, given below. What is the relationship between the data in Columns 2 and 3? Why does this relationship exist? To calculate planetary insolation, I have only taken into account distance from Sun. What other factors should be taken into account to calculate the actual insolation for each planet?

TABLE 2: PLANETARY INSOLATION RELATIVE TO EARTH

Column 1	Column 2	Column 3
Planet	Relative Distance from Sun	Relative Insolation
Mercury	0.38	6.9
Venus	0.72	1.9
Earth	1.00	1.00
Mars	1.5	0.44
Jupiter	5.2	0.037
Saturn	9.5	0.011
Uranus	19.1	0.0027
Neptune	30.0	0.0011
Pluto	39.4	0.00064



You can find insolation data for your home city by visiting the web site of you local weather bureau. I have provided a solar radiation map from the Bureau of Meteorology in my home country of Australia.

The Australian Bureau of Meteorology uses computer modelling to estimate the total amount of solar radiation that reaches the Earth's surface over Australia called the "daily global solar exposure".

Calculations of the amount of solar radiation reaching the Earth's surface are complex as demonstrated at web sites whose Internet Addresses (URL's) are listed below.

1. <http://www.bom.gov.au/sat/solrad.shtml>
2. <http://www.bom.gov.au/sat/solradinfo.shtml>
3. <http://fridge.arch.uwa.edu.au/topics/thermal/sun/radiation.html>
4. <http://www.imsa.edu/edu/geophysics/atmosphere/energy/Blackbody2.html>
5. <http://www.uwinnipeg.ca/~blair/physclim/lab2.htm>

Winds caused by convection heating circulate the air in the troposphere. **Winds are convection currents of air set in motion by the uneven heating of the Earth's surface that produces differences in air pressure.**

7. Why is the Earth's surface heated unevenly? Identify and describe the processes that cause uneven heating of the Earth's surface. You should include a labelled diagram in your answer.

What are convection currents and what causes them?

Convection is the process of transferring thermal energy from one part of a fluid to another part, by movement of the hotter portions of the fluid away from the source of heat, owing to density changes.

Convection Currents occur when the hotter less dense portions of fluid are forced to rise away from the source of heat by incoming colder more dense portions of fluid.

A fluid can be either a liquid or a gas.

Your teacher will now demonstrate how convection currents are established in air using the experimental set-up shown in FIGURE 1, given below.

In FIGURE 1, we are using smoke from a smouldering cloth to show the path taken by convection currents of air inside the glass-fronted box, which contains a lit candle.

8. Can you **predict** the path taken by the smoke? If you think that you can, ask the other members in your Learning Group for their predictions? Compare and contrast your predictions.

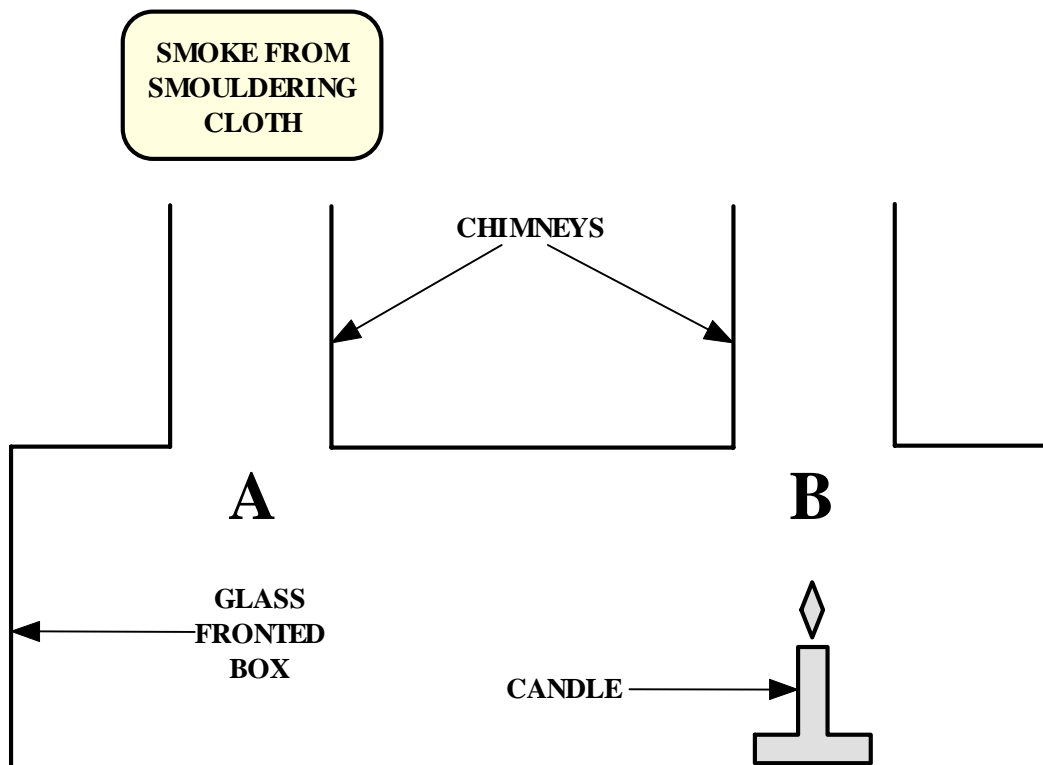


FIGURE 1: CONVECTION IN AIR

Students in each Learning Group should now assess their understanding of convection currents by completing the assigned tasks and answering the focus questions, given below, which relate to FIGURE 1 given above.

9. Carefully study FIGURE 1. Now, draw arrows to show the path taken by convection currents of air inside the chimneys and inside the glass-fronted box. Print this page.

10. What would the comparative air temperatures be in regions **A** and **B**?

11. What would the comparative air densities be in regions **A** and **B**?

12. What would the comparative air pressures be in regions **A** and **B**?

13. Now explain the path taken by convection currents of air inside the chimneys and box in terms of differences in air temperature, density and pressure. You should draw a well-labelled diagram to illustrate your explanation.

14. The experimental set-up, shown in FIGURE 1 on the previous page, is a scientific model that shows how convection currents of air (winds) arise in the troposphere. What does the candle represent?
HINT: What causes heating of the troposphere? Why do winds arise in the troposphere?

In your answer to Question 13 from the previous page, you should have applied these two (2) key science concepts concerning air pressure to explain the movement of the smoke inside the glass-fronted box.

(1) Air becomes less dense (resulting in lower air pressure) when heated and denser (resulting in higher air pressure) when cooled.

(2) Air moves from regions of higher air pressure to regions of lower air pressure.

You have observed a small-scale convection current of air inside the glass-fronted box shown as FIGURE 1 on page 5. You should be informed that large-scale convection currents of air called **Hadley cells** occur on both sides of the Earth's equator.

15. Can you explain, with a labelled diagram supported with brief notes, why Hadley cells arise on both sides of the Earth's equator? Show wind directions with arrows on your labelled diagram.



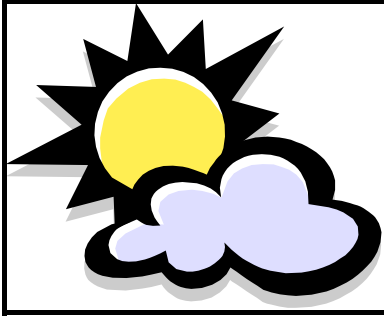
Students in each Learning Group should now research the cause of Hadley cells by visiting the web sites whose Internet Addresses (URL's) are listed below. They should also research the effect of the Coriolis 'force' on the pattern of global winds.

1. <http://www.indiana.edu/~geol105/G105L7.html>

2. <http://ess.geology.ufl.edu/ess/Notes/AtmosphericCirculation/atmosphere.html>

3. <http://hendrix.uoregon.edu/~dlivelyb/phys161/L14.html>

4. <http://www.windpower.dk/tour/wres/coriolis.htm>



Have you ever observed that cloudy days are relatively cool, whereas cloudy nights are relatively warm? Do you know how clouds affect temperatures at the Earth's surface?

How can clouds produce a cooling effect during the day and a warming effect at night? Explain.

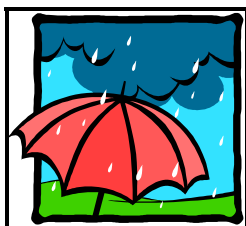
Students in each Learning Group should now research the role played by clouds in the energy balance of the Earth's climate system by visiting the web sites whose Internet Addresses (URL's) are listed below.

1. <http://www.dkrz.de/dkrz/broschuere-eng/research/climatesystem.html>
2. <http://titan.srrb.noaa.gov/radiation/rad.htm>
3. <http://cimss.ssec.wisc.edu/wxwise/homerbe.html>
4. <http://climate.gsfc.nasa.gov/radiation.html>
5. http://eosps0.gsfc.nasa.gov/eos_homepage/misc_html/nasa_facts.html

16. Can you now explain why low clouds have a cooling effect, whereas high thin cirrus clouds have a warming effect?

We will now conclude this E & B Lesson on the Atmosphere with a study of weather forecasting.

The Australian Bureau of Meteorology now provides a seven-day weather forecast to the various media outlets like TV Stations, Newspapers and Radio Stations. But how accurate are these seven-day forecasts? How could you check on the accuracy of these seven-day weather forecasts?



Before you commence your study of weather forecasting, I would like you to answer this fundamental question.

What is the difference between weather and climate?

Just how accurate are seven-day weather forecasts? How can you check on their accuracy?

Students in each Learning Group should now collaborate to devise a plan to check the accuracy of medium-range weather forecasting in their home city. You can obtain weather forecasts for your home city by visiting the relevant web site selected from the list of Internet Addresses (URL's) listed below.



WEB-BASED WEATHER FORECASTING: (Students are to select and open the relevant web site for their home country.)

Australian Weather Forecasts

1. <http://www.bom.gov.au/>

U K Weather Forecasts

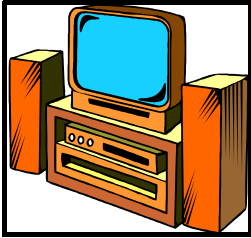
2. <http://www.bbc.co.uk/weather/>

European Weather Forecasts

3. <http://www.ecmwf.int/>

U S Weather Forecasts

4. <http://www.usatoday.com/weather/wfront.htm>
5. <http://www.weather24.com/>



TV NEWS AND WEATHER

Would you agree that in the past most people would have obtained weather reports from daily newspapers? Would you also agree that these days most people watch the evening weather report and forecast on TV, especially Dads?

Students in each Learning Group should now access the weather page of web sites owned by their local TV stations. Listed directly below are the online weather pages of two Australian TV Stations.

1. <http://news.ninemsn.com.au/weather/>

2. <http://www.abc.net.au/news/weather/default.htm>

So just how informative are the weather maps presented on TV? Which weather maps are more informative, those printed in newspapers, or those presented on TV?

Students in each Learning Group should collect the weather reports from their local daily newspapers over a seven-day (7) cycle. Then each evening, they should compare and contrast them with the nightly TV weather report, following the evening news.

How do you read a weather map? You can learn how to read a weather map and learn about weather forecasting from the web sites whose Internet Addresses (URL's) are listed directly below.

3. <http://www.bom.gov.au/info/weathmap/weathmap.htm>

4. <http://mirror.bom.gov.au/weather/radar/>

5. <http://www.usatoday.com/weather/wforecast0.htm>

6. [http://ww2010.atmos.uiuc.edu/\(Gh\)/home.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/home.rxml)

7. <http://www.nws.noaa.gov/>

Which weather maps are more informative, those printed in newspapers or those presented on TV? Why is the format of a weather map presented on TV different to that printed in a newspaper?

Give your opinions in a collaborative electronic group report.



Students in each Learning Group should now produce an electronic group report on the cause, energy released and effect on communities of cyclones, hurricanes, typhoons and tornadoes. **Please note that any images you use are subject to copyright.**

Is there any difference between tropical cyclones, hurricanes, typhoons and tornadoes?

Students in each Learning Group should now visit the web sites whose Internet Addresses (URL's) are listed below to conduct research for their group report on cyclones.

1. <http://www.aloha.com/~edung/marswcyc.html>
2. <http://www.miamisci.org/hurricane/howhurrwork.html>
3. <http://www.cotf.edu/ete/modules/sevweath/sevweath.html>
4. <http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html>

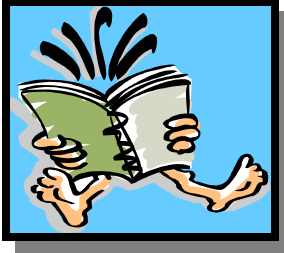
Do you wish to know more about Australian weather? Have you questions about the weather that haven't been answered yet? Would you like a list of web weather links?



LIFE LONG LEARNING BY SURFING WEB WEATHER LINKS

Our need to understand the weather is an ongoing quest in which our societies invest millions of dollars world-wide. Probably the easiest way to continue your study of the weather is to 'surf' the world wide weather web.

1. <http://www.schools.ash.org.au/paa/paa.htm>
2. http://www.atmos.ucla.edu/ugrads/classes/win99/win99_3/screens.html
3. <http://sln.fi.edu/tfi/hotlists/weather.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.