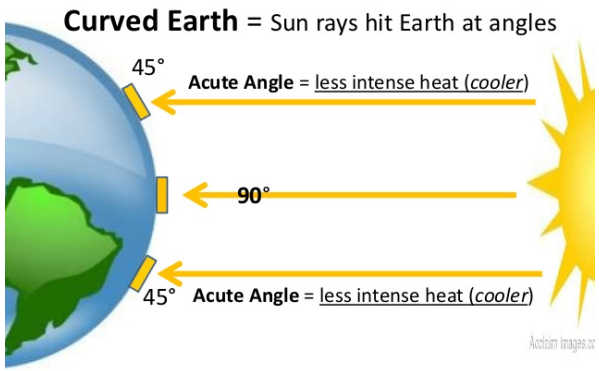
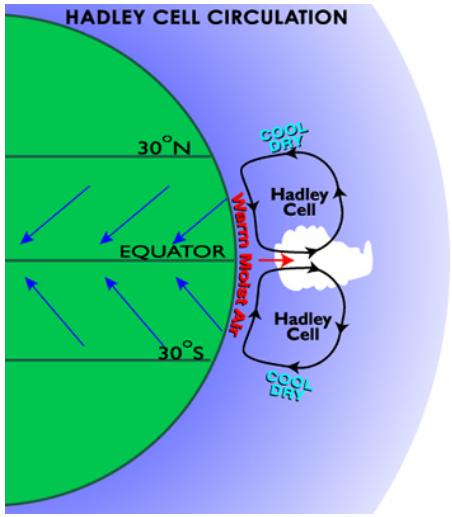
Assessment Schedule – 2020

Earth and Space Science: Demonstrate understanding of processes in the atmosphere system (91414)

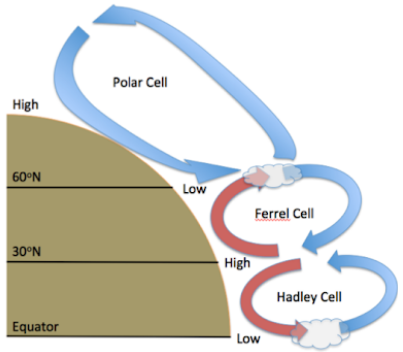
Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE	A convection cell is a circulation caused by density differences within a body of air (liquid / gas) where warmer, less dense air rises, and cooler, denser air drops.  https://www.pmf.unizg.hr/_download/repository/2_Osnove_ekologije_ZRACENJE.pdf The Sun's rays strike the Equator at a direct angle (90°), leading to the greatest amount of heating of the Earth's surface. At the poles, the rays strike at an indirect angle, leading to the least amount of heating. Both the Hadley and polar cells form as a result of surface temperature differences. Warm, moist air at the Equator rises, as it is less dense, cooling as it ascends, and is pushed northwards / southwards by the rising warm air below. The air continues towards the poles, cooling until it descends at 30°N / S. Some of the descending air then flows back towards the Equator, producing the Hadley cell.	To demonstrate understanding of processes, the candidate: • correctly labels diagram with Hadley and Polar cells. Explains by: • linking convection cell to air movement • linking angle of Sun to Earth with heating effect of surface (differential heating) • linking Hadley and polar cell formation to surface temperature differences (pressure differences) • linking rising warm, moist air to high precipitation rates • linking sinking cold, dry air to low precipitation rates.	To demonstrate in-depth understanding of processes, the candidate: • explains the formation of a convection cell in terms of heating / density • explains how the unequal heating of the Earth's surface between the Equator and the poles leads to the formation of the Hadley and polar cells • explains the formation of the Hadley / polar cells • explains why there are high precipitation rates at the Equator OR why there are low precipitation rates at the poles • explains that precipitation is a result of cooling water vapour uplifted from surface passing through dew point.	To demonstrate comprehensive understanding of processes, the candidate: • gives a comprehensive discussion explaining why precipitation rates are different at the Equator and the poles, with reference to the Hadley and polar convection cells.



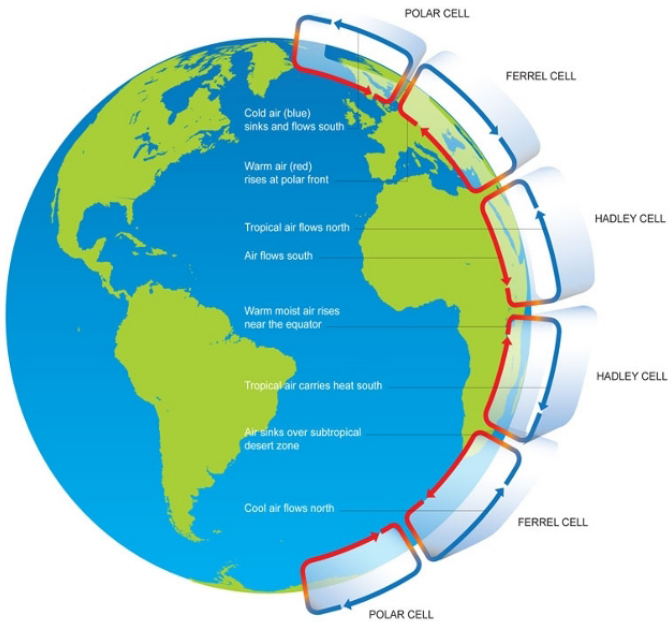
www.windows2universe.org/earth/Atmosphere/hadley_cell.html

The polar cells are similar to the Hadley cell, but occur between the 60° latitudes and the poles. At the poles, cold, dense air descends, causing an area of high pressure. As the air sinks, it spreads back towards the Equator. Close to the 60° latitudes, the air moving along the surface collides with the weak surface moving air from the 30° latitudes, leading to an area of low pressure.



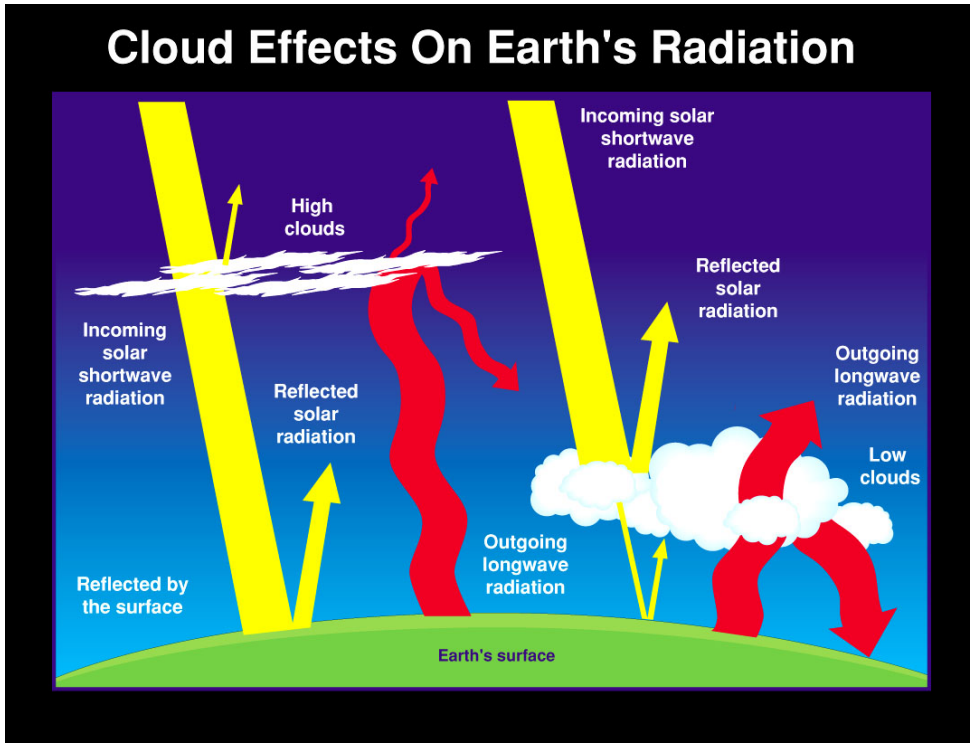
http://idaholyoaks3.blogspot.com/2012/11/understanding-climate-change-part-4.html

At the Equator, the high evaporation rates due to maximum solar radiation lead to warm, moist air. As the air rises, it decreases in temperature, causing it to condense and form precipitation. This leads to high rainfall over the Equator. However, at the poles, the air over the poles is cold, dry air that is descending. The lack of moisture and low temperatures means that there is little to no precipitation at the poles.

	 https://blog.aviation.metoffice.gov.uk/2017/03/03/jet-streams-a-river-in-the-sky/			

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence.	1 partial point from Achievement.	2 partial points or 1 point from Achievement.	2 points from Achievement.	3 points from Achievement.	2 points from Merit.	3 points from Merit.	Detailed discussion (minor errors).	Fully detailed discussion on the formation of surface circulation.

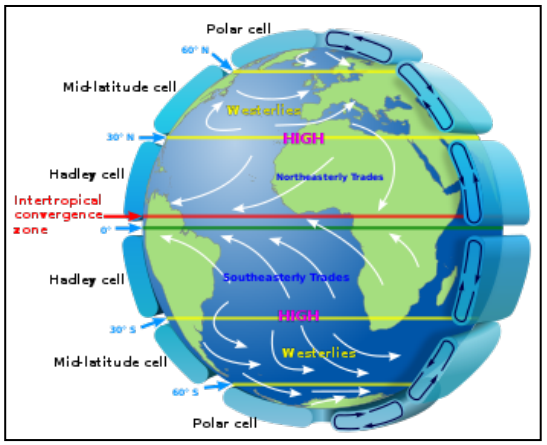
Q	Evidence	Achievement	Merit	Excellence
TWO	**Air Temperature:** The troposphere is mostly heated by infra-red energy transfer from the surface of the Earth, so temperature is highest at the lowest point, and decreases with increasing altitude. (15° at sea level to –60° in the upper troposphere). **Air pressure:** Atmospheric pressure is the force per unit of area exerted on a surface by the weight of air above the surface. The force exerted on the air is due to gravity. The molecules that make up the atmosphere are pulled close to the Earth's surface by gravity. This causes the pressure to be highest at the Earth's surface and to decrease with height. Air pressure depends on the temperature and density of the air mass. Temperature affects air pressure by causing the air to either become more or less dense. Warm, less dense air has low pressure, while cold, denser air has high pressure. As you move up in the troposphere, there are fewer molecules above you, so the air pressure is lower. **Air density:** Atmospheric density is the mass of air molecules per unit of volume. Air density decreases with increasing altitude because there are fewer air particles the higher you go in the troposphere. The troposphere is denser than the layers of the atmosphere above it (because of the weight compressing it), and it contains up to 75% of the mass of the atmosphere. **Cloud formation:** Clouds predominantly form in the troposphere because nearly all of the Earth's water vapour and aerosols are found there. Clouds form when air containing water vapour rises and then cools to its dew point, the temperature at which air becomes saturated, and vapour condenses around small particles in the air called condensation nuclei / seeds. The moist air may originate over the ocean or inland e.g. evapotranspiration. **High- and low-level clouds:** Cloud cover affects the overall temperature of the Earth's surface and atmosphere. Low-level clouds tend to be thick and reflect much of the short-wavelength radiation coming from the Sun back into space. Also because of their low altitude, they will absorb long-wave radiation from Earth's surface, which may then be re-radiated back to Earth or into space. When more of this long-wavelength radiation is re-radiated back to Earth, it creates a heating effect; when more is re-radiated out to space, it creates a cooling effect. High clouds tend to be thin and virtually transparent. They reflect very little short-wave radiation from the Sun and emit only small amounts of long-wave radiation towards space, so most of the radiation reaches the Earth and increases its temperature, creating a warming effect. High clouds also will re-radiate some long-wave radiation back to Earth, enhancing their warming effect.	To demonstrate understanding of processes, the candidate: • links temperature gradient to surface heat source • links high air density in troposphere to weight / gravity • links decreasing density to increasing altitude • links decreasing air pressure to increasing altitude • links cloud formation in troposphere to water vapour and aerosols • links role of temperature and / or air pressure on cloud formation • links high clouds to little reflection of solar radiation • links low clouds to high reflection of solar radiation or high absorption of infra-red radiation from surface • links low clouds to greenhouse effect • links more low-level clouds to global warming • links changes in temperature gradient to global warming.	To demonstrate in-depth understanding of processes, the candidate: • explains the temperature gradient for troposphere • explains the air density gradient in the troposphere • explains the air pressure gradient in the troposphere • explains how clouds are formed in the troposphere • explains how low clouds affect the temperature of the Earth • explains how high clouds affect the temperature of Earth • explains one possible consequence of global warming on the troposphere.	To demonstrate comprehensive understanding of processes, the candidate: • gives a comprehensive discussion explaining the reasons for different characteristics observed in the troposphere. (Must include reference to air temperature, pressure and density and clouds, and possible consequence of global warming on troposphere.)



https://visibleearth.nasa.gov/images/54219/cloud-effects-on-earths-radiation/54219t

Possible consequences of global warming
When greenhouse gases trap incoming solar radiation, they tend to increase the temperature of the surface and lower atmosphere (troposphere). These rising temperatures lead to changes in the temperature gradient of the troposphere, as temperatures will be higher at the surface and above. Higher surface temperatures lead to greater amounts of evaporation (and transpiration), leading to more cloud formation. These clouds will be low-level clouds, which will absorb more infra-red heat and re-radiate it back to the surface, causing more heating.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence.	1 partial point from Achievement.	2 partial points or 1 point from Achievement.	2 points from Achievement.	3 points from Achievement.	2 points from Merit.	3 points from Merit.	Detailed discussion (minor errors).	Fully detailed discussion on the formation of surface circulation.

Q	Evidence	Achievement	Merit	Excellence
THREE	Aerosols are minute solid and liquid particles suspended in the atmosphere. (They range in size from approx. 1–20 microns in diameter.) The smaller and lighter the particle is, the longer it stays in the air. Once blown to high altitudes by wind, the absence of weather in the upper troposphere means that large amounts of dust can remain there for a long time, allowing them to travel such great distances. The Sahara Desert and the Amazon rainforest both lie within the Hadley convection cell (which lies between the equator and 30°N / S). The Hadley cell forms as a result of warm, moist air rising at the Equator, creating an area of low pressure. The air then descends as it cools at around 30°N / S, creating an area of high pressure. Air moves from areas of high pressure to low pressure, resulting in winds. In the Hadley cell, this results in the trade winds. In the upper troposphere of the Hadley cell, air moves in a south-west direction. As it begins to drop and move closer to the Earth's surface, it is affected by the north-east trade winds. The Coriolis effect deflects these winds to the right in the Northern Hemisphere, creating north-east trade winds. It is these north-east trade winds that carry the suspended Saharan dust across the Atlantic Ocean to the Amazon rainforest.  https://en.wikipedia.org/wiki/Atmospheric_circulation As the Saharan dust nears the Equator, high amounts of water vapour in the rising air can condense around the dust particles as the surrounding air cools, leading to cloud formation. This increases the overall mass of individual particles, allowing the aerosols to fall as rain from the sky over the Amazon Basin, allowing the dust to reach the surface.	To demonstrate understanding of processes, the candidate: • explains what an aerosol is • links the Hadley cell to the position of the Sahara Desert and Amazon rainforest • links wind formation in Hadley cell to areas of high and low pressure • links trade winds to movement of dust across the Atlantic • links the Coriolis effect to the deflection of the trade winds • links rain to dust reaching the Amazon rainforest surface • links rising water vapour to the Equator • links cloud formation to dust as condensation nuclei.	To demonstrate in-depth understanding of processes, the candidate: • explains the lack of weather in the upper troposphere and / or the size as reason for dust staying suspended in atmosphere for long time • explains the formation of the north-east trade winds in terms of pressure and Coriolis effect • explains how the dust acts as a condensation seed to form droplets leading to a cloud • explains how an increase in mass in the cloud leads to the dust reaching the Amazon rainforest surface • explains how the dust reaches the Amazon basin as rain.	To demonstrate comprehensive understanding of processes, the candidate: • gives a comprehensive discussion explaining how the dust stays suspended in the atmosphere for a long time, AND how the dust ends up on the Amazon rainforest surface.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence.	1 partial point from Achievement.	2 partial points or 1 point from Achievement.	2 points from Achievement.	3 points from Achievement.	2 points from Merit.	3 points from Merit.	Detailed discussion (minor errors).	Fully detailed discussion on the formation of surface circulation.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 07	08 – 13	14 – 18	19 – 24