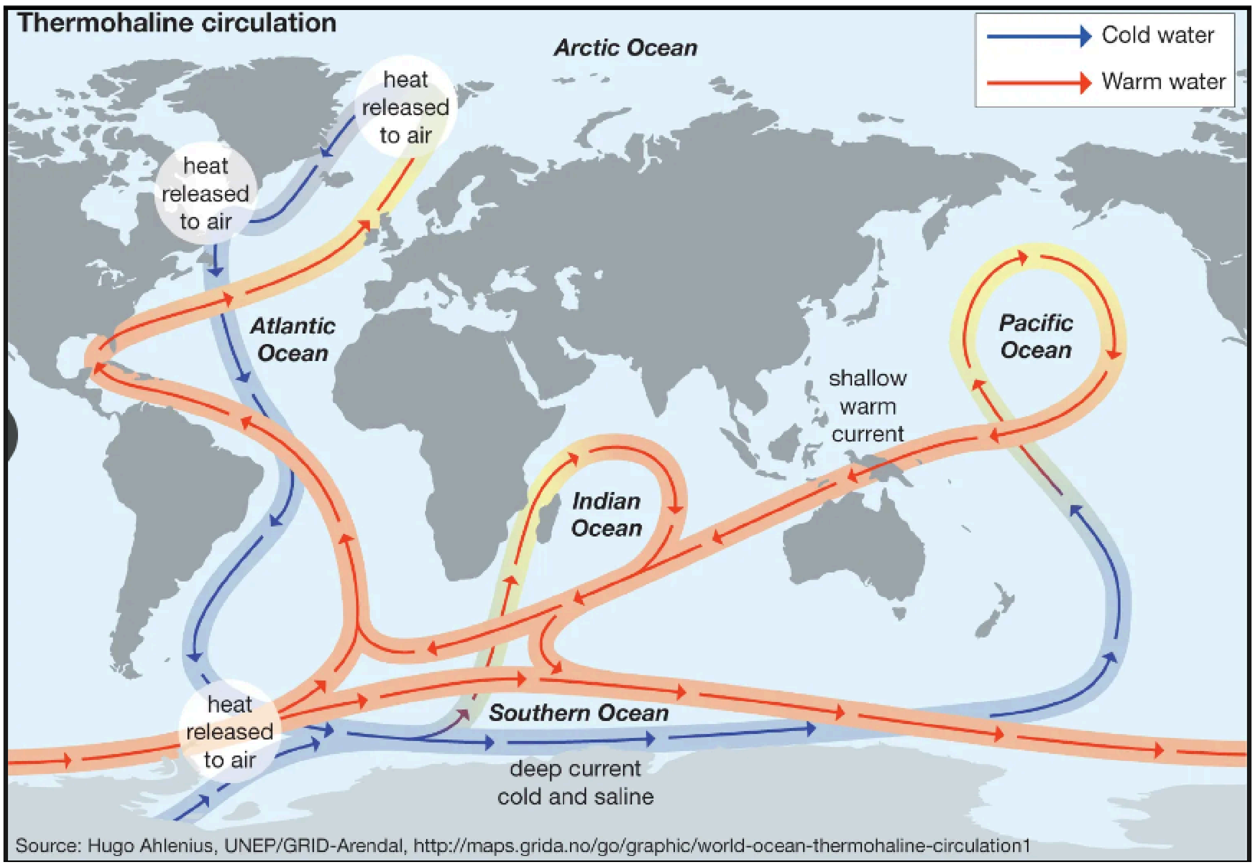
The Big Three Global Climate Pumps

When you think about it, the SUN delivers a huge amount of energy to the EARTH. **Most of the energy hits near the equator**, so, if it were to stay there, we'd have a far different planet.

The Three Big Energy Pumps are:

1. ***The Deep Ocean Great Conveyor Belt*** (**see CSSG-2.5, -2.6, and -2.7**). Note one of its important effects: moving heat from the equator to near the poles. This world-wide current is in the **deep oceans** and is **driven by the Thermo (temperature) - Haline (Saltiness) Circulation**. [Very cold, very salty waters at the surface near the poles plunge to the bottom; this water is removed from the surface and warmer, less salty deep water currents flow to replace it.]



Approximate "Cheat Sheet":

1 meter → 3 feet **1 degree Celsius** (**^{0}C**) → 2 degree Fahrenheit (^{0}F)
ppm = parts per million **CO_2** = Carbon Dioxide
1 tonne = 1000 kilograms = 2205 pounds **1 gigatonne (1 Gt)** = 1 billion tonnes
1 trillion tonnes (1Tt) = 1000 gigatons

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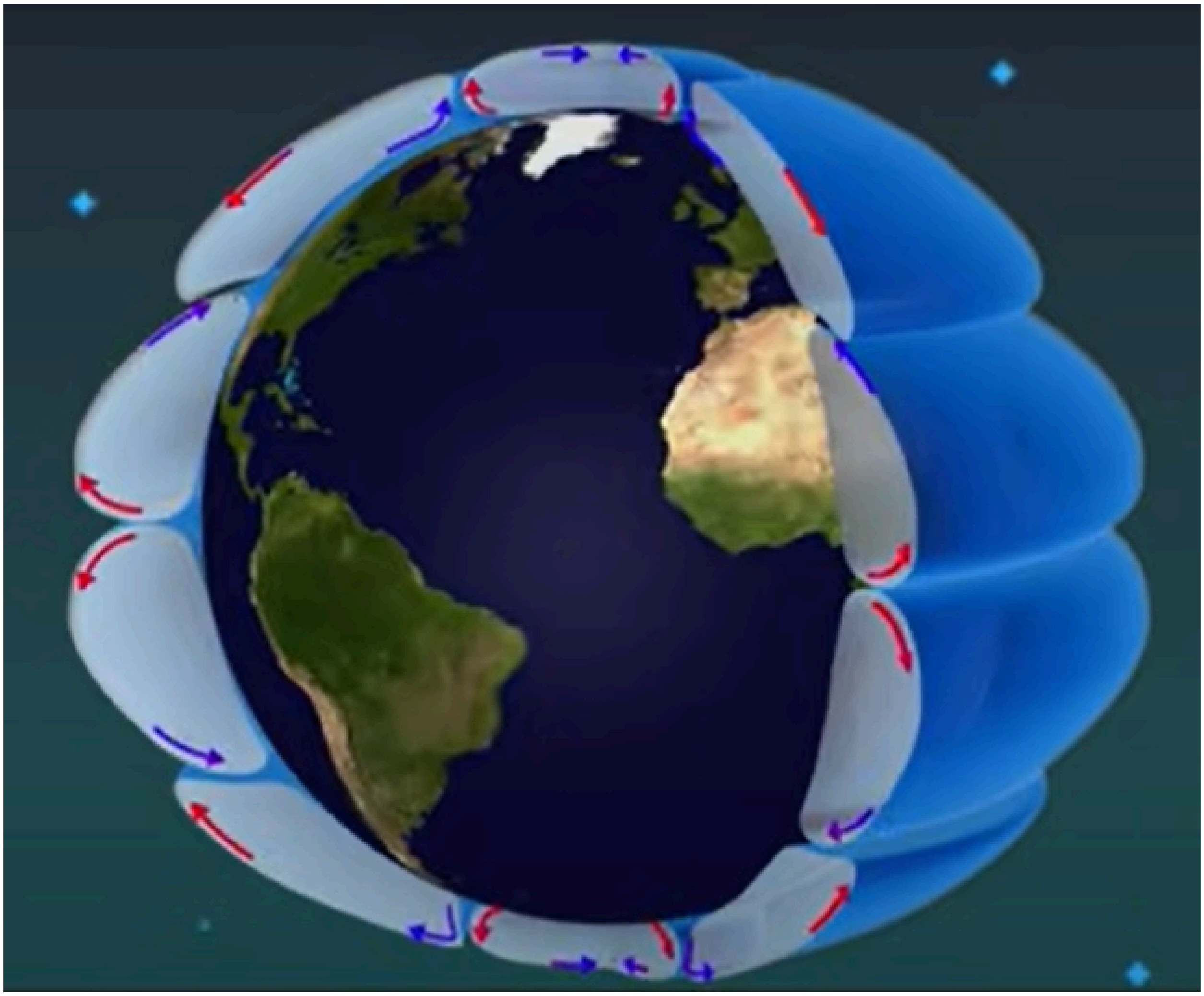
2. The ***Atmospheric circulation cells.*** You can see this might be crazy complex, but it's a kick! It explains so much and we'll sort it out another time. The atmospheric circulation is driven by the **temperature differences** between the equator and the poles and the **rotation of the earth**.



The **Stratosphere** is above almost all of what we experience as weather. (***Strato***- means "layer" and reflects its general calm). The Stratosphere is the calm layer just above the cells depicted above.

The **Troposphere** is where the cells in the above graphic are located. (***Tropo*** means "turn", "reaction, response", "change" - reflecting that this is the surface layer where the weather we experience is. It's definitely churning!)

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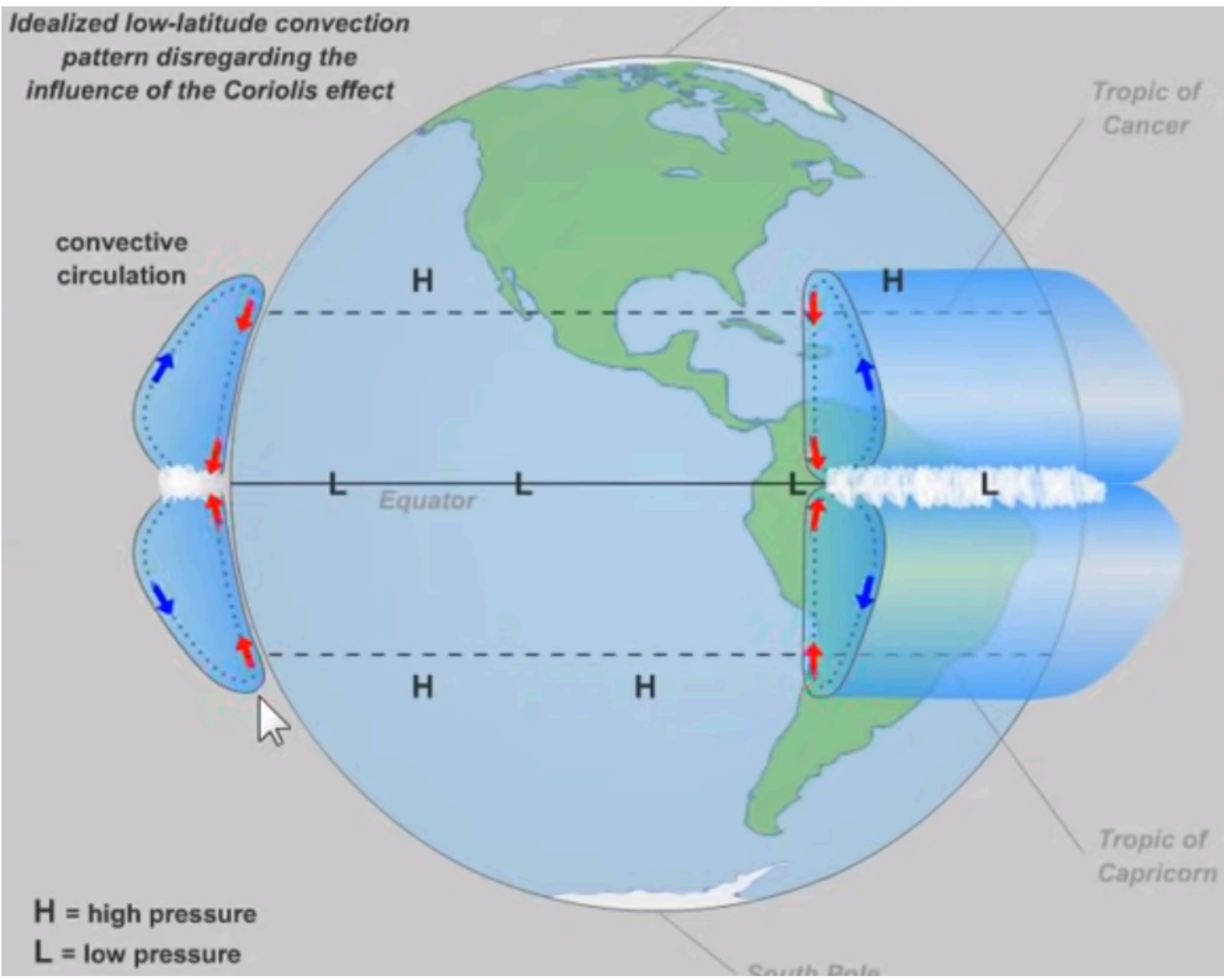
It doesn't take long to notice why the Troposphere is so named. **Let's start in the region of the strongly-heated equator**. The heated air picks up an enormous amount of water from the ocean surface, which then has to rise directly up. This leaves a very low-pressure band at the surface, which demands to be refilled. So air is sucked in from both North and South along the surface. Meanwhile, the hot, wet, rising air is drilling into the cold, high air. This causes the water to be squeezed out of the rising air, **dumping an enormous amount of rain right back down**.

At the top of that line of equatorial thunderheads, the squeezed-out air is now dry and still somewhat warm from the moisture losing heat as it condensed out as rainfall. It now experiences a sucking action from the North (and South)where the surface air has itself been sucked down(and up) to the equator. As it loses altitude, the dry air is warmed further (because it's warmer lower), becoming, as a result, even dryer.

The surface air returning to the equator, then, is hot and dry, as indicated by the red arrows below. It's thirsty for water, and absorbs tons from the surface of the ocean. (Over land, it absorbs what little moisture is left in the arid deserts.)



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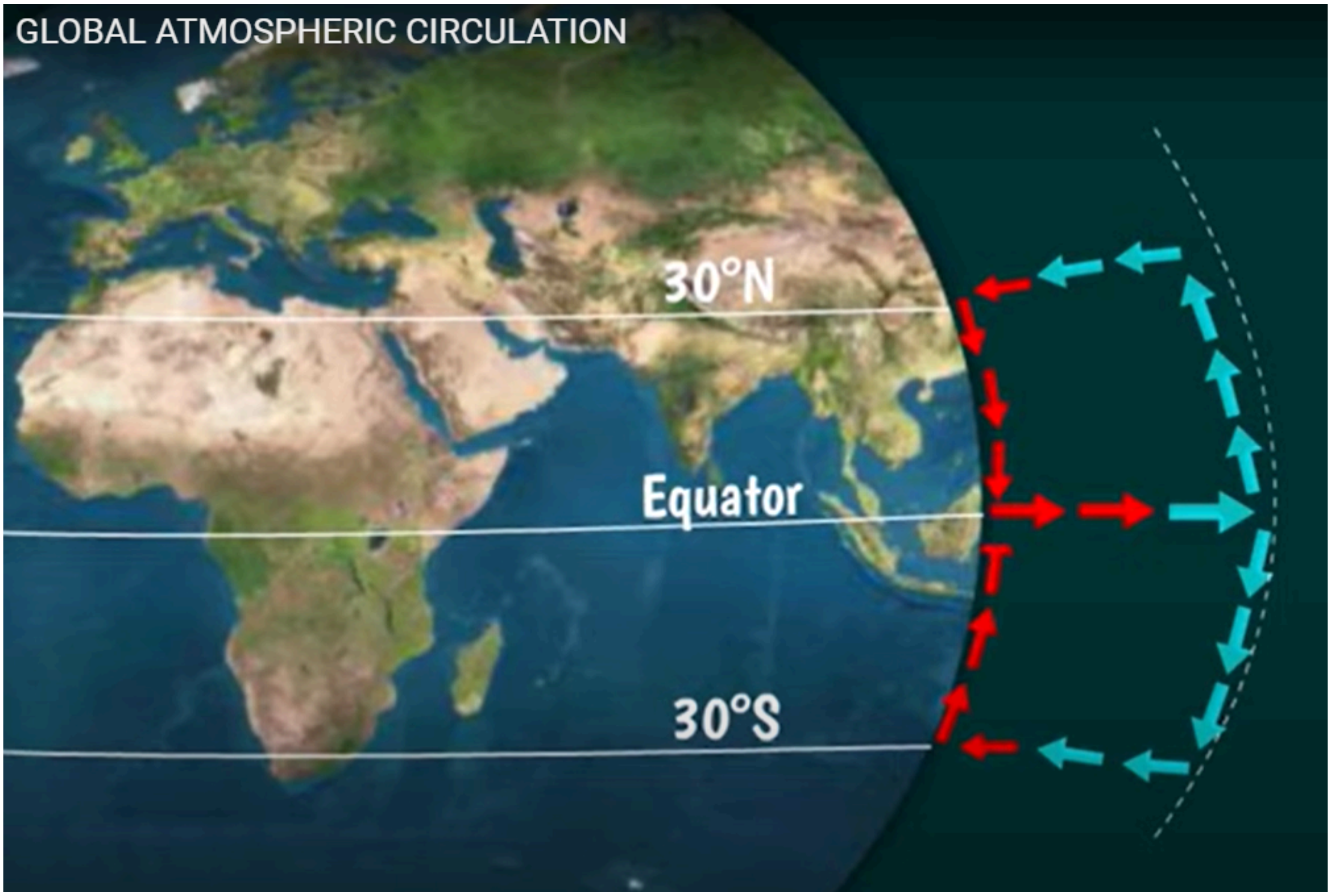
You can notice the general effects of the enormous rainfall near the equator and the hot, dry, return air in this circulation (which is dubbed the Hadley Cell after the first scientist to describe it). **Near the equator, we are most likely to find the tropics and rain forests; near the descending air, we are more likely to find dryer regions and deserts.**



https://www.youtube.com/watch?v=-yS1O7Rnqc4

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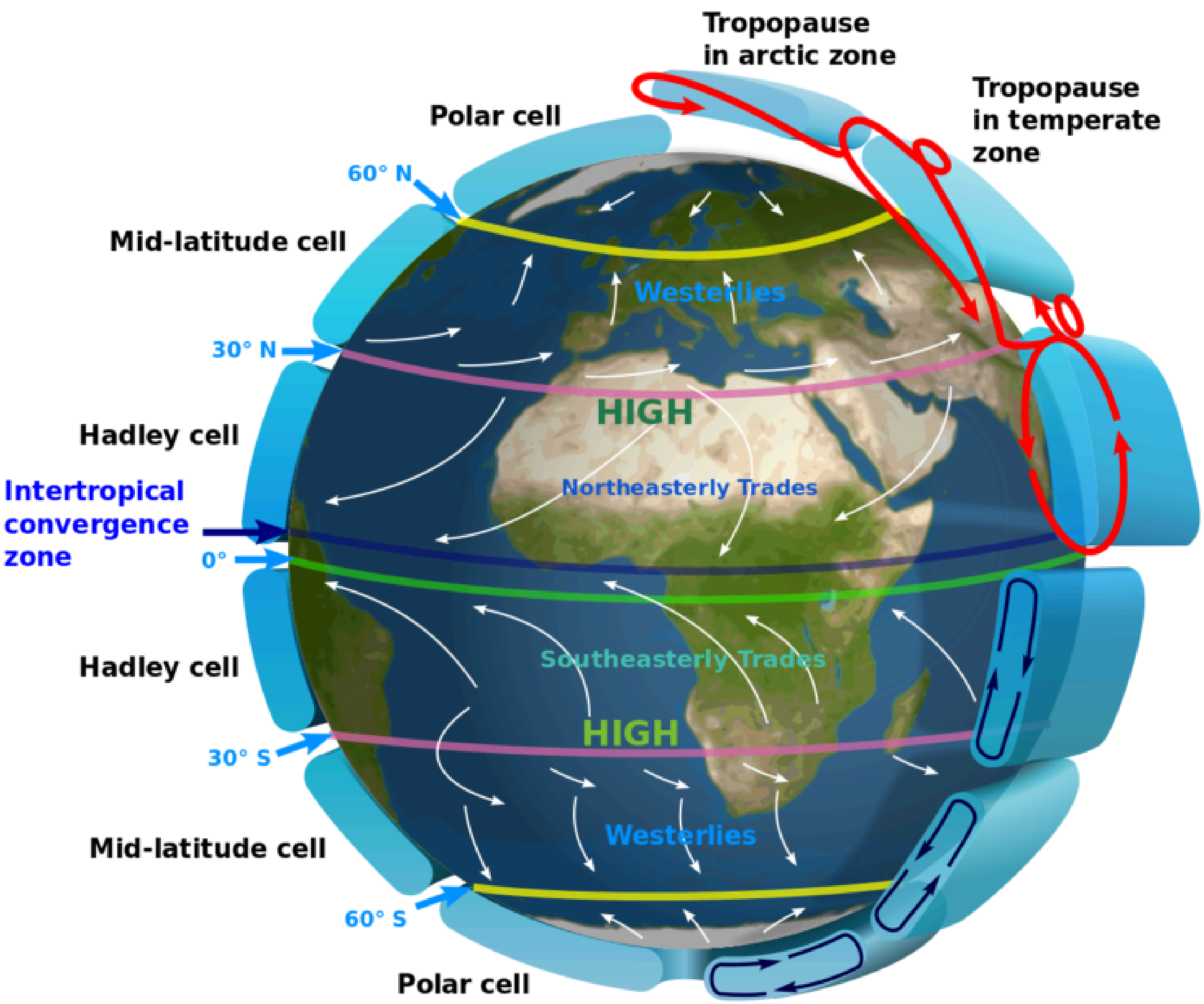
In similar fashion, **two more cells** form in each hemisphere. **One is at the poles**, where the "downhill flowing" stratospheric air returns to the surface. This must flow South. **A mid-latitude cell also forms** as shown. The details of these flows explain the Polar Vortex, the jet streams, trade winds, behaviors of weather fronts, etc. , which we will pick up at another time. But leaving the details is sufficient for study at this point.



One further note: We saw that the rising air at the equator causes a low pressure region, which is a typical location of unsettled weather. Look at the Northern edge of the Hadley cell. Here the air is plunging back towards the surface - a High Pressure circumstance. High pressures generally portend quieter weather. This is related to the Temperate climate zone depicted below.

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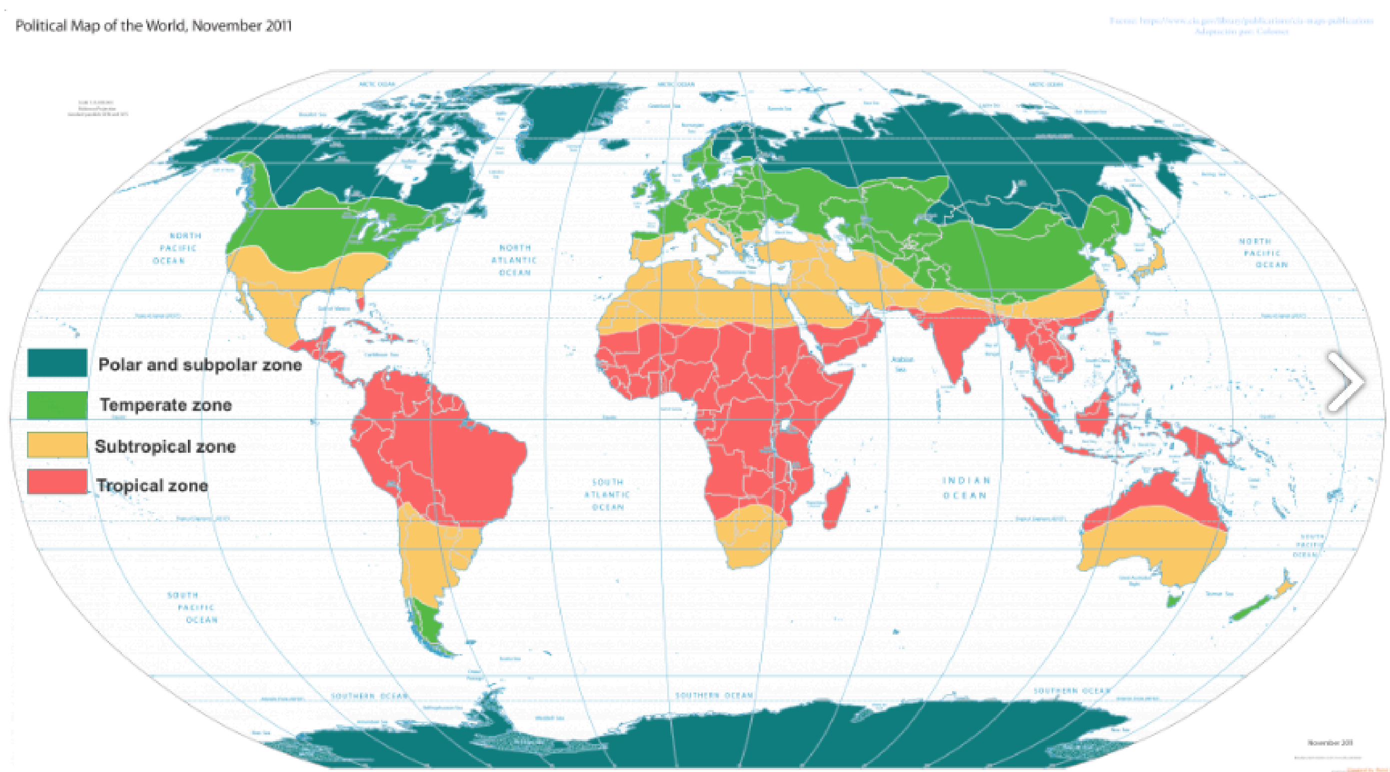
Note how Scandinavia and Northern Europe are more in the Temperate Zone than might be expected from their latitudes. Obviously, these atmospheric circulation cell effects are being modified by ocean currents, topography, and the like.



Just for fun: Note where you are with respect to these cells. The Hadley Cell comes down around 30^0 N, forming the large, dryer, more subtropical zone. In **West Palm Beach**, we are still in an extension of the tropics, at 26^0 N. The trade winds (which we will address another time) generally come out of the northeast. Our weather is warmer and wetter. Joe O. is around 48^0 N in **Montana**, but seems close to the subpolar region above. Joe L., in **Sweden**, is at 58^0 N, but enjoys a more temperate climate than would be implied by his proximity to the intersection of cells at around 60^0 N.

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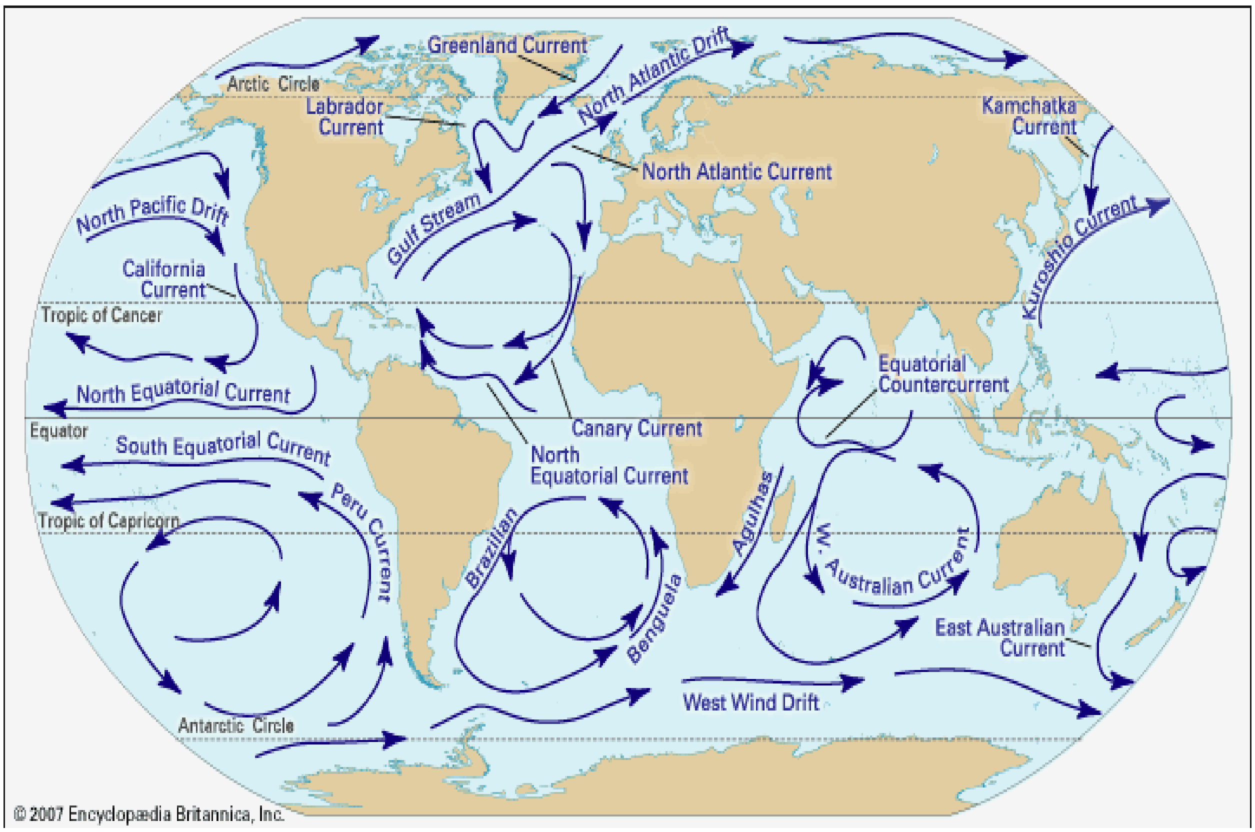
3. ***Wind-driven ocean surface currents.*** Stirred up and driven along by the winds, major ocean currents move along the surface. So, if we get a feel for the winds, we will understand these ocean surface currents. In a later session, we will see just how the big cells, in 2 above, drive these surface currents, because of the famous Coriolis Effect (remember the skater spinning faster as she brings her arms in).



In Summary, the PUNCHLINES of this overview:

1. The **Global Conveyor** and the **atmospheric cells** move huge amounts of energy from the equator towards the poles, thereby **driving the formation of climate bands** around the globe.

2. The **Winds** generated by the circulation of the atmospheric cells and the rotation of the earth (which we will sort out a bit more carefully next time) drive the **surface currents of the ocean**. Together, they **modify the climate bands into the prevalent regional climates**.

So, those are the main points we've touched on, but what has this to do with Climate Change?

It appears likely that warming the poles faster than the equator (they are warming 4x faster than the equator) will slow down the conveyor belt and atmospheric circulations. The result is likely strong climatic impacts, as we will discuss.

The following perspectives in italics are from: *Climate Change: Observed Impacts on Planet Earth Copyright © 2009 by Elsevier B.V. All rights of reproduction in any form reserved.* *https://www.inscc.utah.edu/~reichler/publications/papers/Reichler_09_Widening.pdf*

The strength, direction, and steadiness of the prevailing winds are crucial for climate. Winds associated with the atmospheric circulation lead to transports of heat and moisture from remote areas and thereby modify the local characteristics of climate in important ways.

The purpose of this chapter is to discuss changes in the structure of the atmospheric circulation and its associated winds that have taken place during recent decades. ***These changes are best described as poleward displacements of major wind and pressure systems throughout the global three-dimensional atmosphere.*** *The associated trends are important indicators of climate change and are likely to have profound influences on ecosystems and societies.*

Atmospheric circulation change may also alter ocean currents. Because oceans are important regulators of climate, this may induce complicated and unexpected feedbacks, which either amplify or diminish the original cause for change. Given the important role of the atmospheric general circulation for climate, any change in its structure is of concern. It may lead to profound changes in other parts of the global climate system with potentially important implications for natural ecosystems and human societies.

What this author reports is a Northward migration of warmth and wind effects with global warming. Various studies have averaged the drift at around 0.1^0 to 0.5^0 per decade since around 1980. Results are still quite uncertain in the context of natural variabilities, but such changes are anticipated to emerge as techniques, data, and models are refined.