Today:

- One more FEEDBACK LOOP ACTIVITY
- Continue:

  #10 on "How Climate Works
- Connecting the General Circulation of the Atmosphere to day-to-day weather & your WORLD MAPS so you can construct a GLOBAL CLIMATE MAP!
- Midterm Exam's Returned and a "Midterm Point-Recovery Opportunity"
- will be explained

Amount of melting

Amount of $\downarrow_{SW}$ Absorbed

Arctic Surface Temp

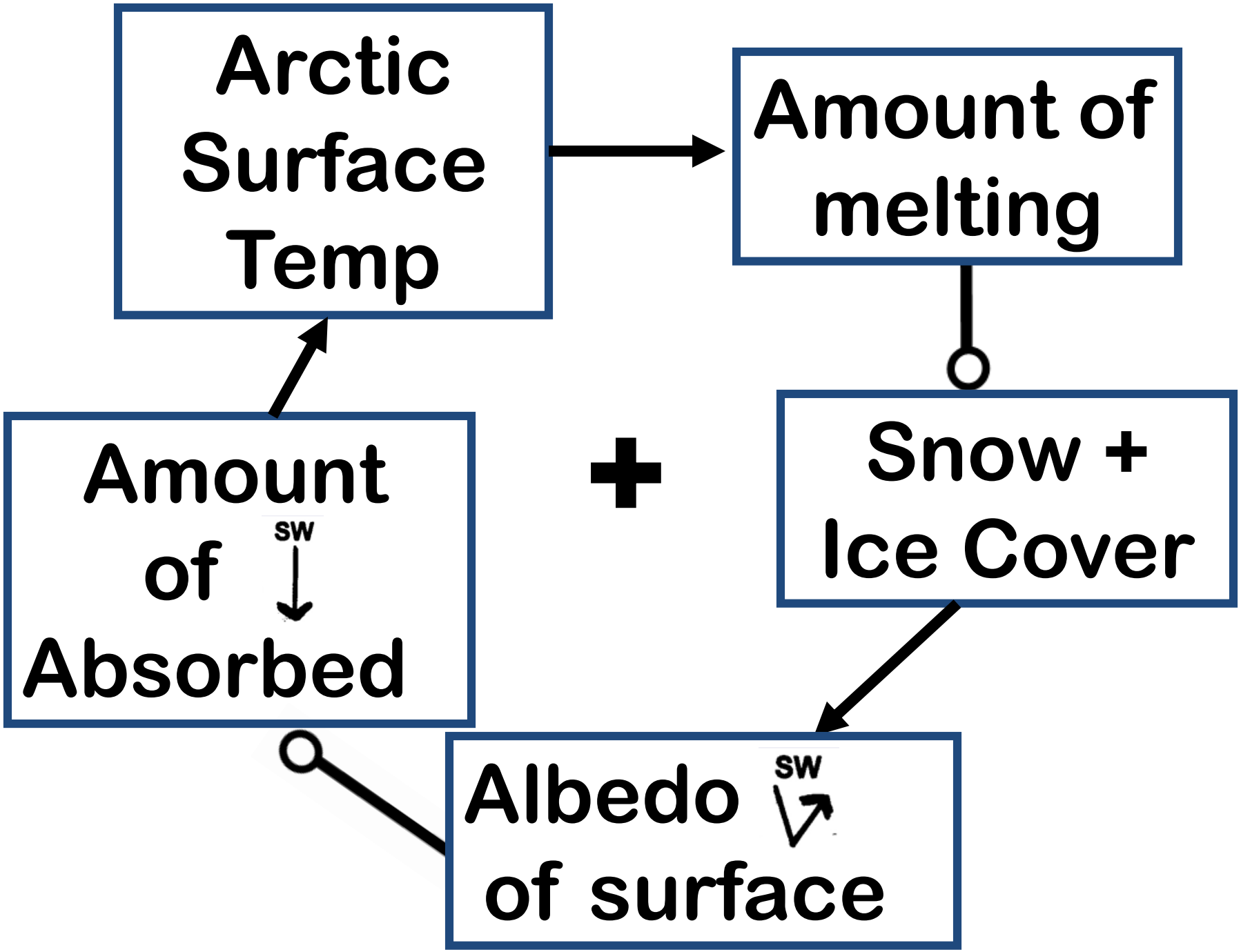
Snow + Ice Cover

Albedo of surface $\downarrow_{SW}$

Put the components in a logical loop + connect with the proper coupling arrows:

Then decide what kind of FEEDBACK LOOP IT IS.

When done & checked Give p 57 a try!


Arctic Surface Temp
Amount of melting
Amount of Absorbed SW ↓
+
Snow + Ice Cover
Albedo of surface SW ↗

albedo

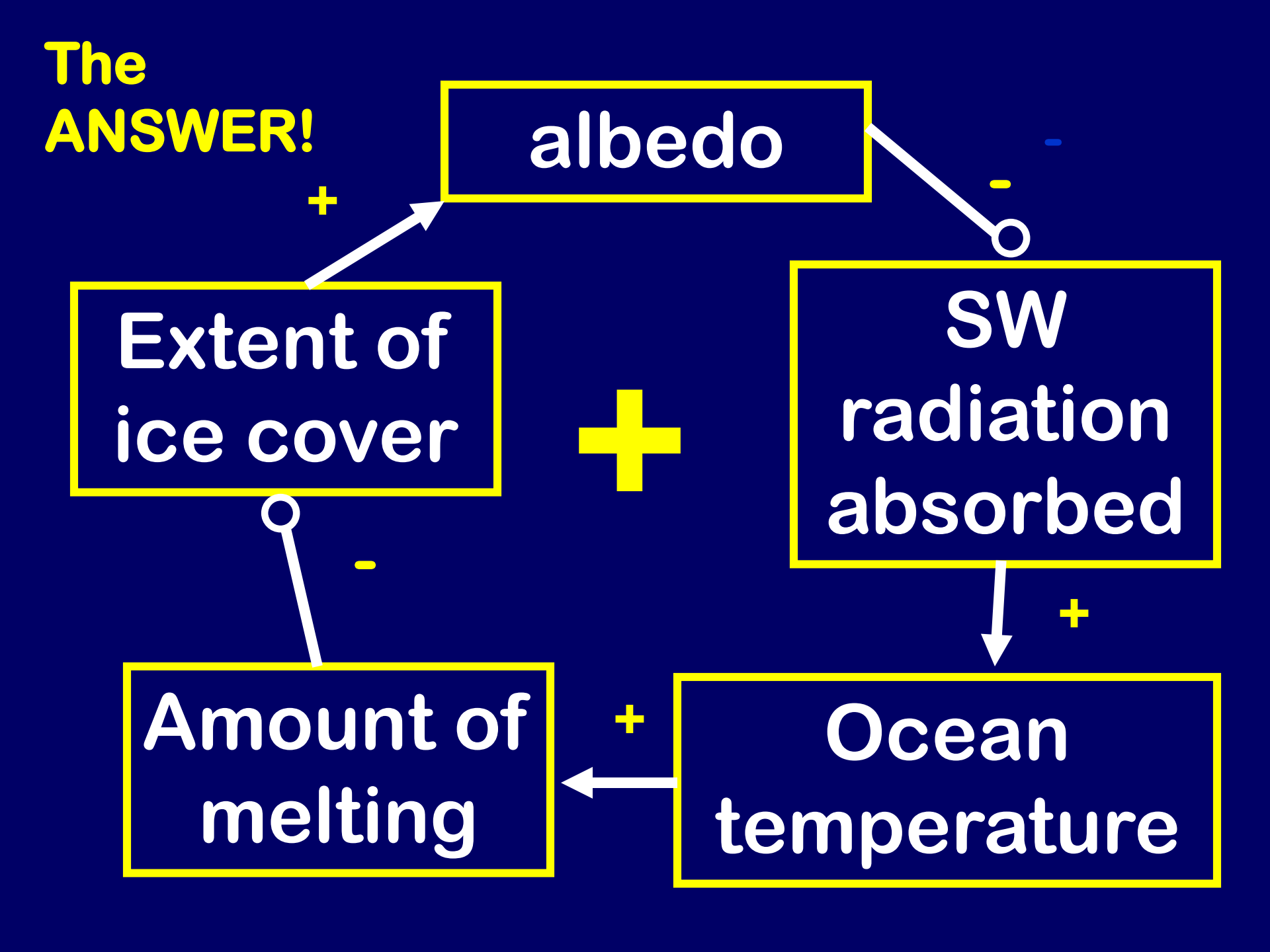
START HERE

Extent of ice cover

SW radiation absorbed

Amount of melting

Ocean temperature


The ANSWER!
albedo
+
-
Extent of ice cover
SW radiation absorbed
+
-
+
Amount of melting
+
Ocean temperature

#10 How Climate Works Part II

HOW IT ALL FITS TOGETHER:

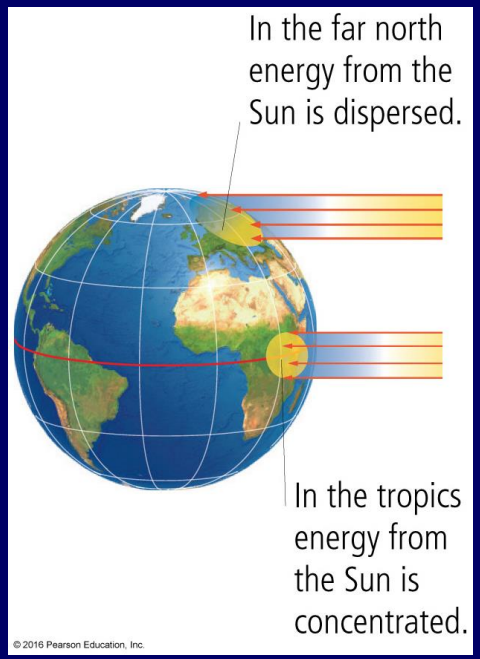
- INCOMING **SOLAR SW** (Insolation) varies by latitude *(more comes in near the equator, less near the poles)*

- OUTGOING **TERRESTRIAL LW** radiation varies by latitude *too (more LW emitted at warmer tropical latitudes, less in the cooler high latitudes)*

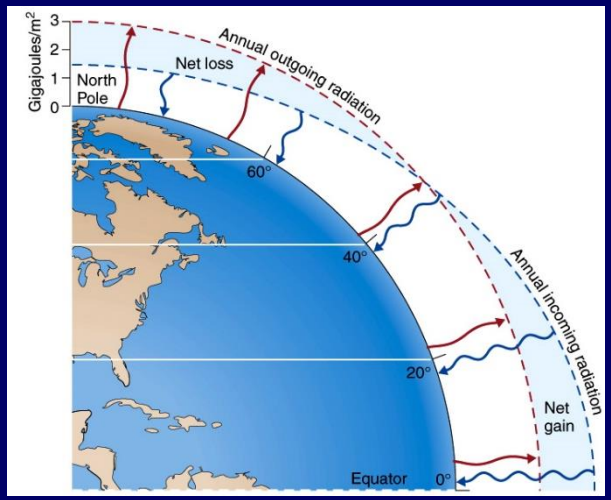
- The **EQUATOR–POLE DIFFERENCES** in how much LW radiates out are not as great as the equator-pole differences in how much SW comes in. Hence more comes <u>in</u> than goes out at the <u>low latitudes</u> and more goes <u>out</u> than comes in at the <u>high latitudes.</u>

- The result is a **NET SURPLUS** of energy in the low latitudes and a **NET DEFICIT** in the high latitudes.

- This energy imbalance leads to large **THERMAL DIFFERENCES** between low and high latitudes that drive the **GENERAL CIRCULATION OF THE ATMOSPHERE**, which moves surplus energy from the tropics to the deficit areas in the colder latitudes via **SENSIBLE HEAT (H) and LATENT HEAT (LE)** transport of energy.

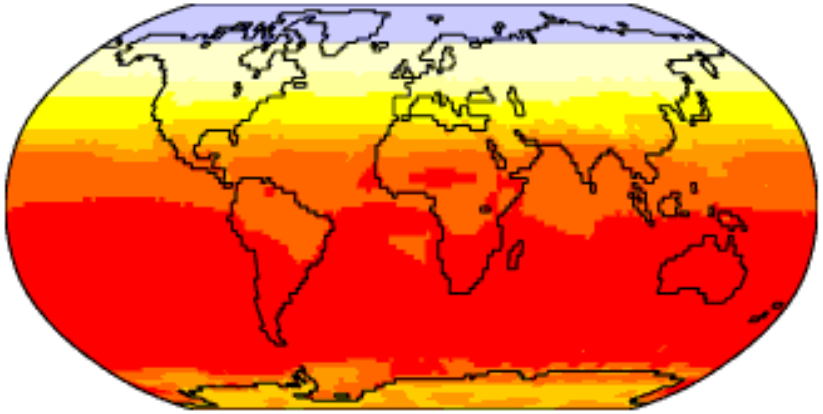


Solar is less intense



Solar is MORE intense

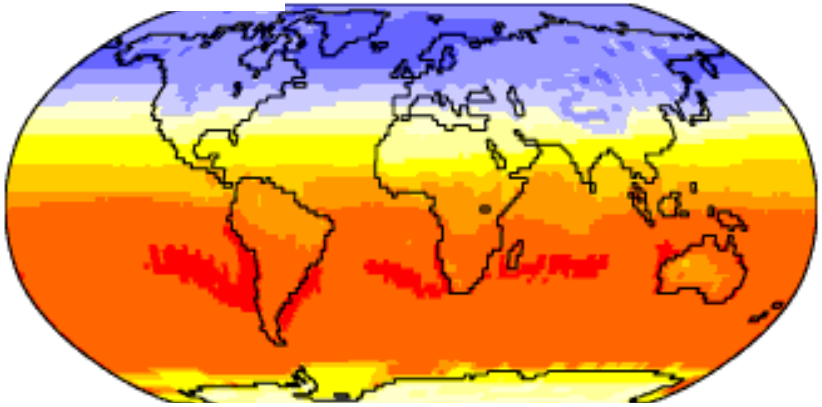
Short-Wave Radiation



Dec

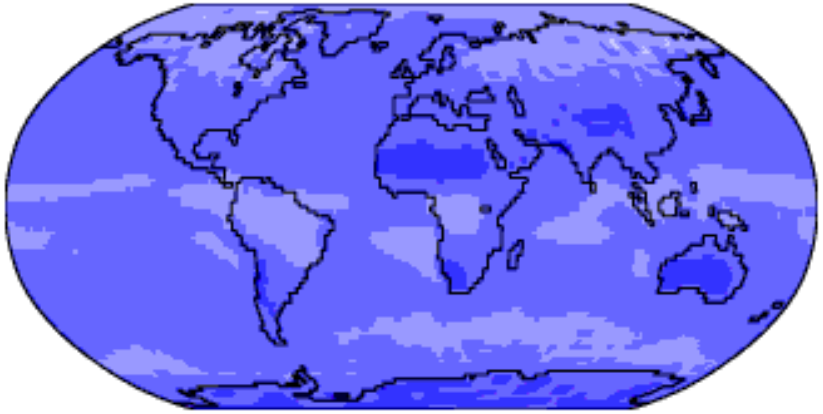
Absorbed solar energy

SW + SW - SW



Net Radiation R_{NET}

Long-Wave Radiation



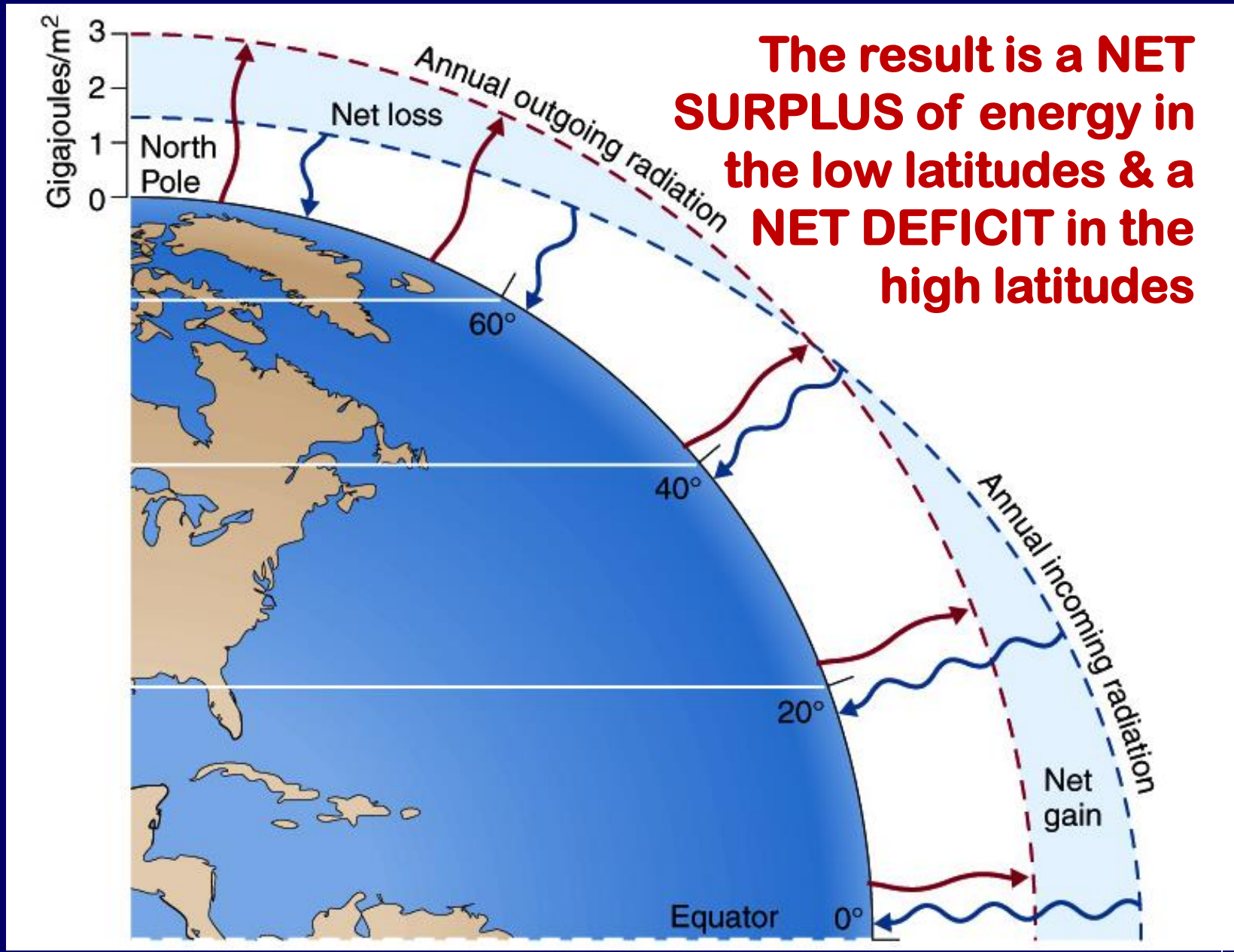
- LW

Emitted infrared energy

-100 -50 -25 0 25 50 100 125 150 200 W/m**2

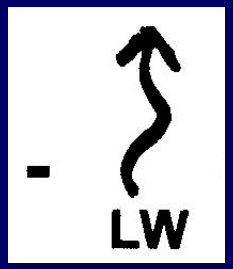
Data: NCEP/NCAR Reanalysis Project, 1959-1997 Climatologies
Animation: Department of Geography, University of Oregon, March 2000

http://geography.uoregon.edu/envchange/clim_animations/



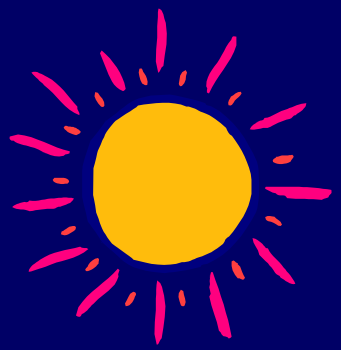
The result is a NET SURPLUS of energy in the low latitudes & a NET DEFICIT in the high latitudes

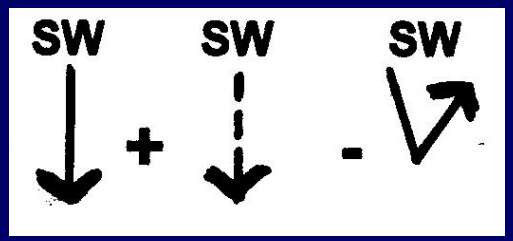
The EQUATOR-POLE DIFFERENCES of what goes OUT from the EARTH

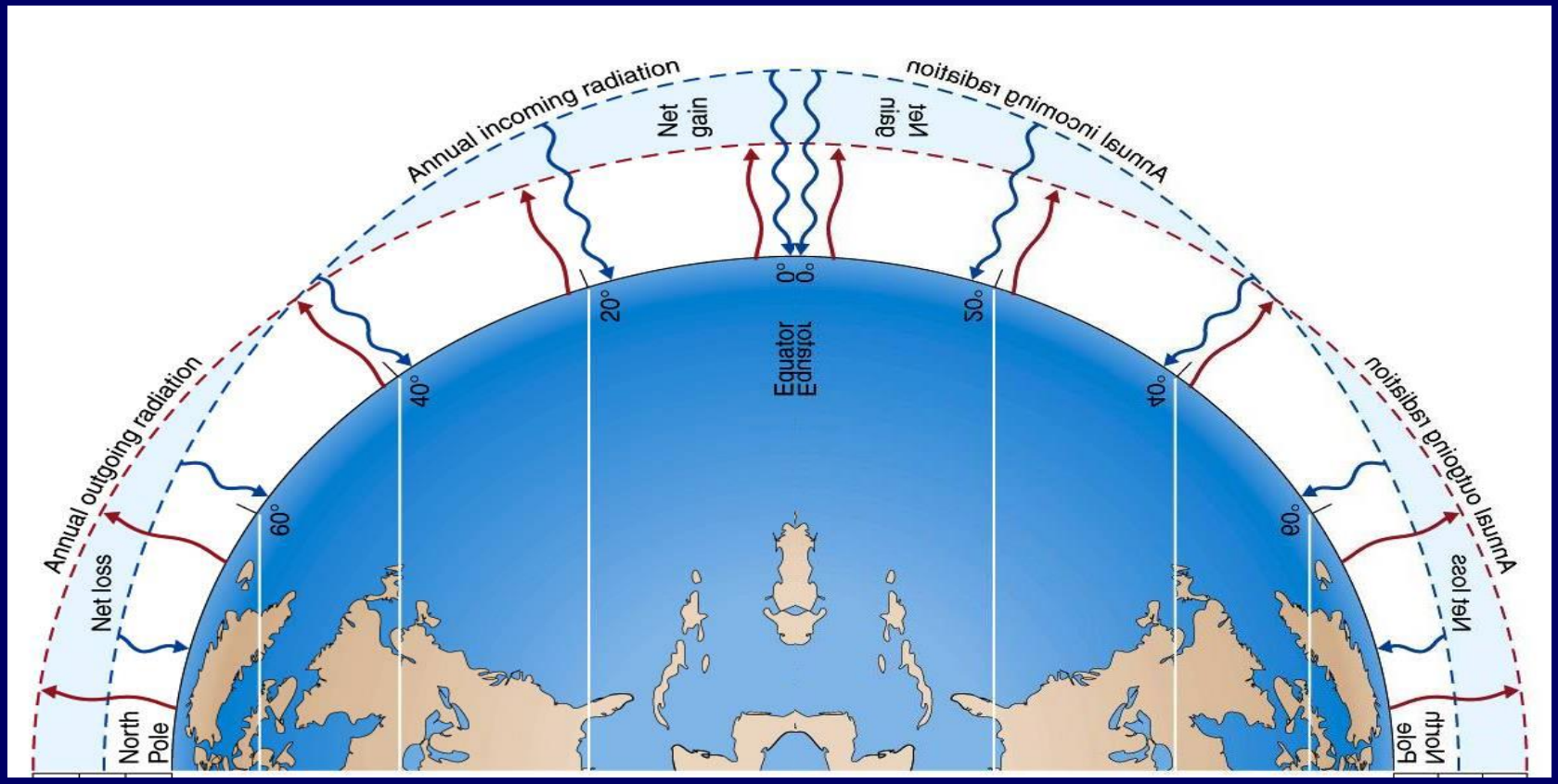


are less than the

EQUATOR-POLE DIFFERENCES of what comes IN from the SUN

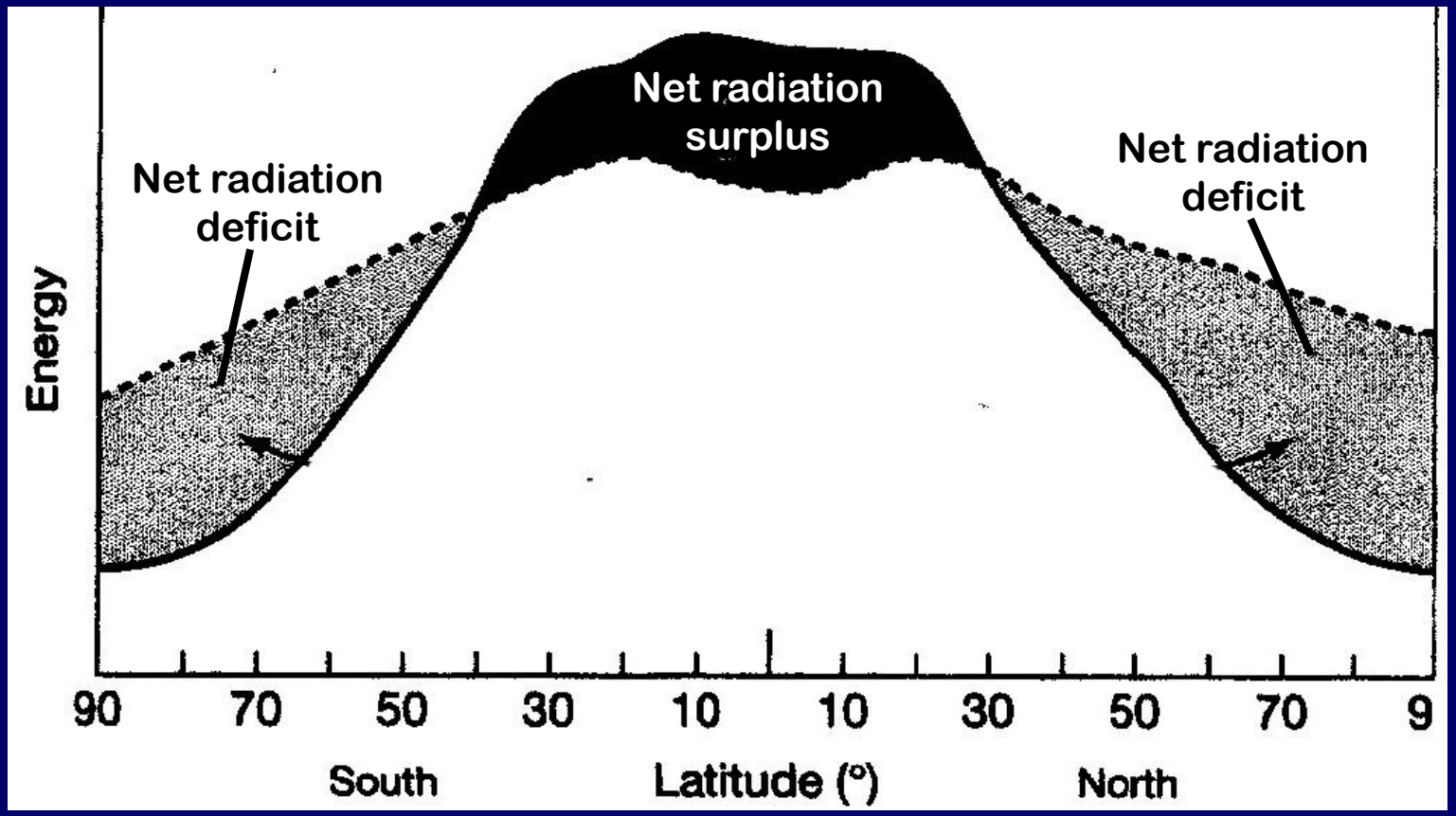




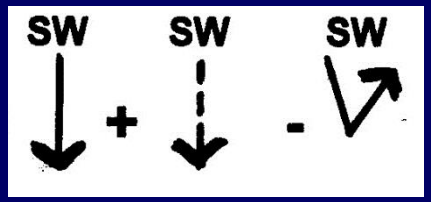


POLE **EQUATOR** **POLE**

Now lets look at a Pole to Pole Transect

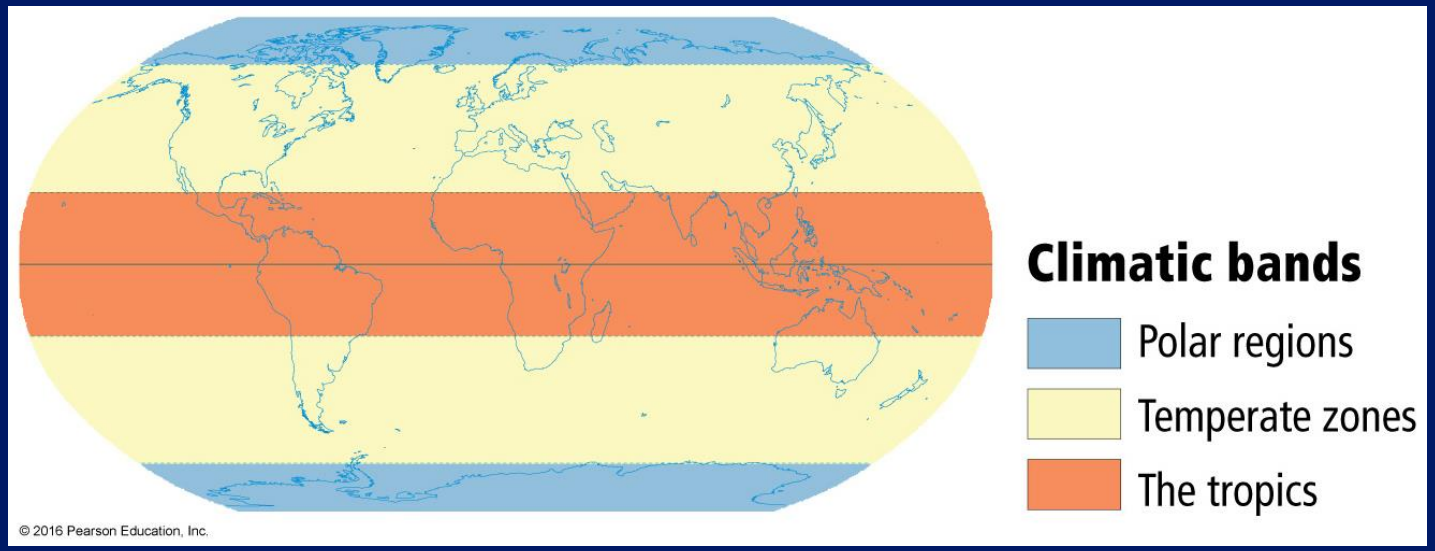


Absorbed solar energy



Emitted infrared energy

(at top of atmosphere)


Climatic bands
Polar regions
Temperate zones
The tropics
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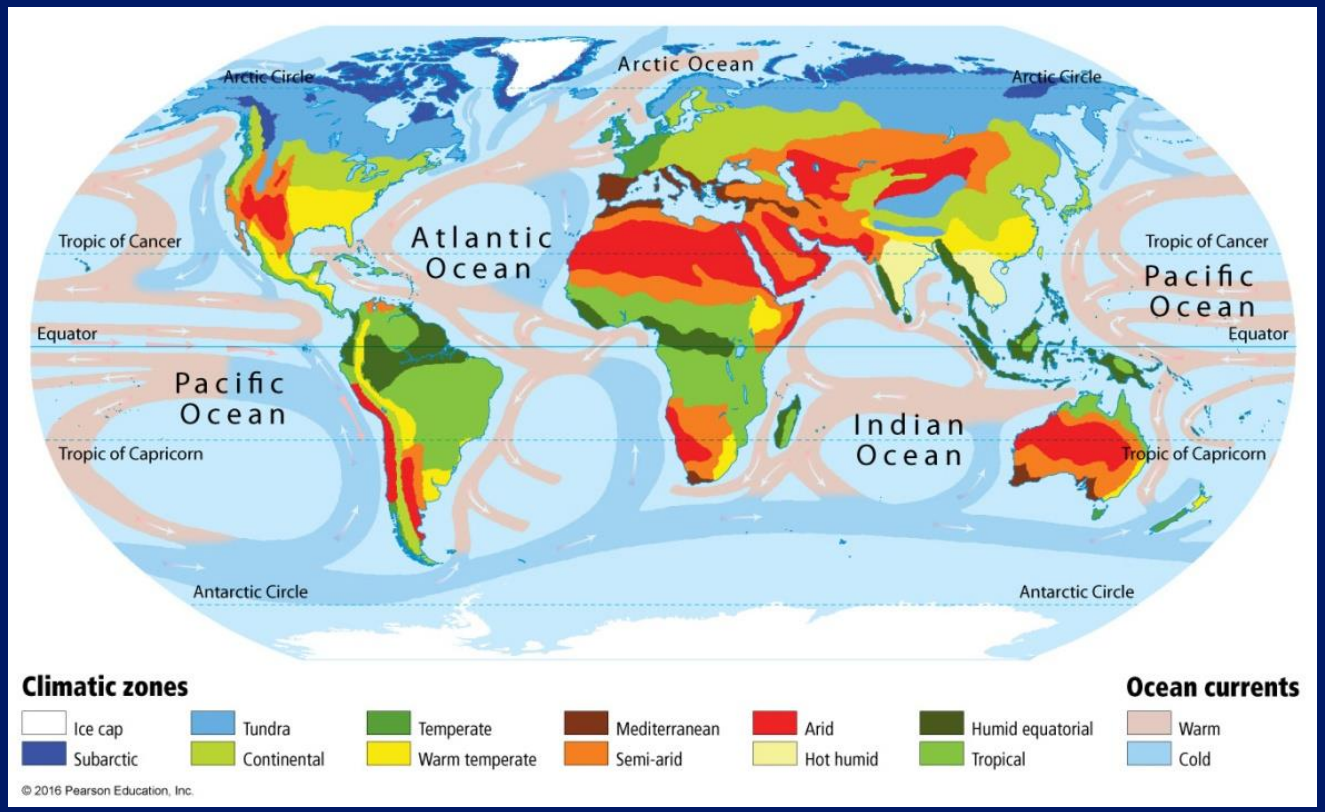
Arctic Circle
Arctic Ocean
Arctic Circle
Tropic of Cancer
Atlantic Ocean
Tropic of Cancer
Pacific Ocean
Equator
Equator
Pacific Ocean
Indian Ocean
Tropic of Capricorn
Tropic of Capricorn
Antarctic Circle
Antarctic Circle
Climatic zones
Ice cap
Subarctic
Tundra
Continental
Temperate
Warm temperate
Mediterranean
Semi-arid
Arid
Hot humid
Humid equatorial
Tropical
Ocean currents
Warm
Cold
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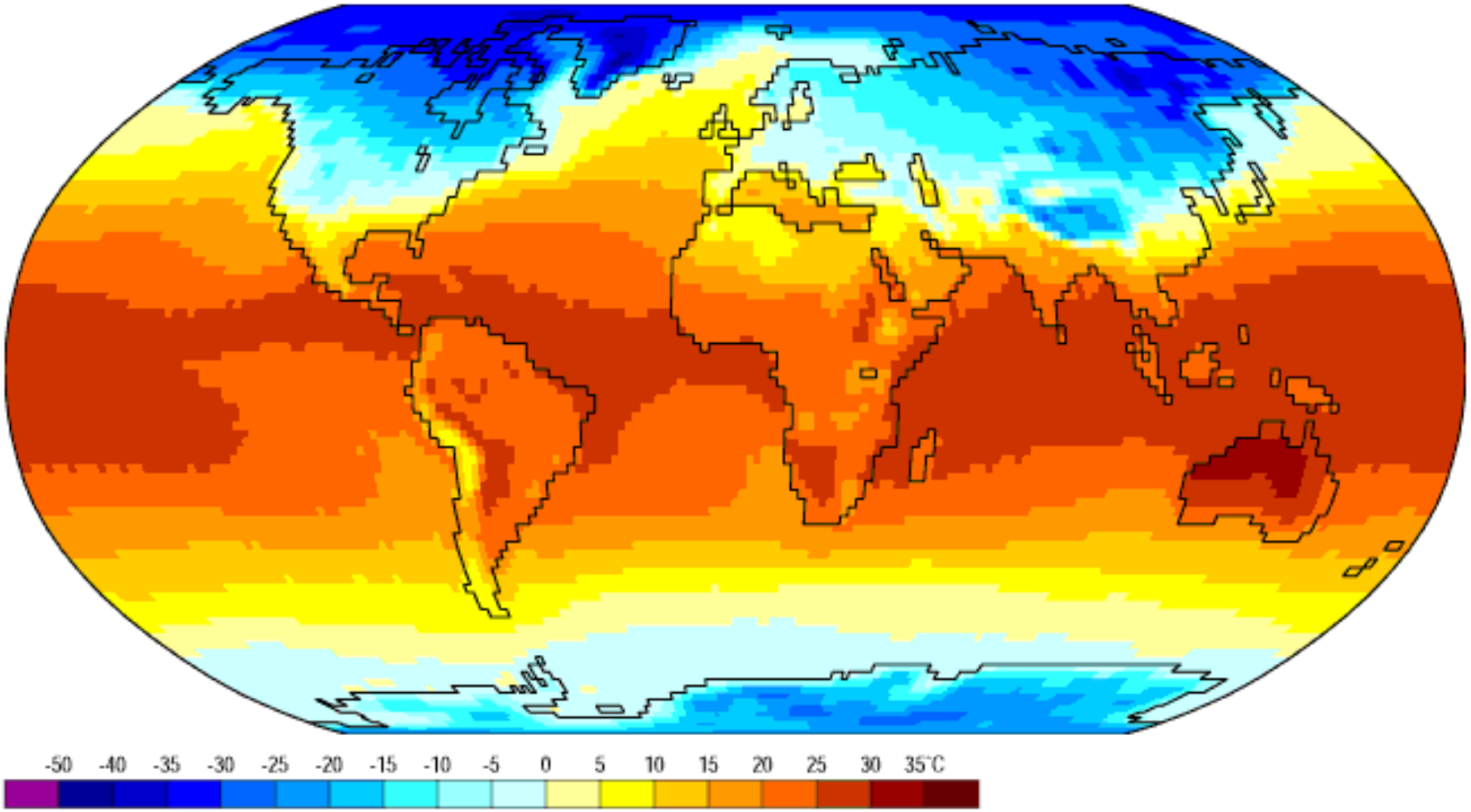
Surface Air Temperature



Data: NCEP/NCAR Reanalysis Project, 1959-1997 Climatologies
Animation: Department of Geography, University of Oregon, March 2000

The General Circulation of the Atmosphere
Let's draw it!

90 ° N

60 ° N

30 ° N

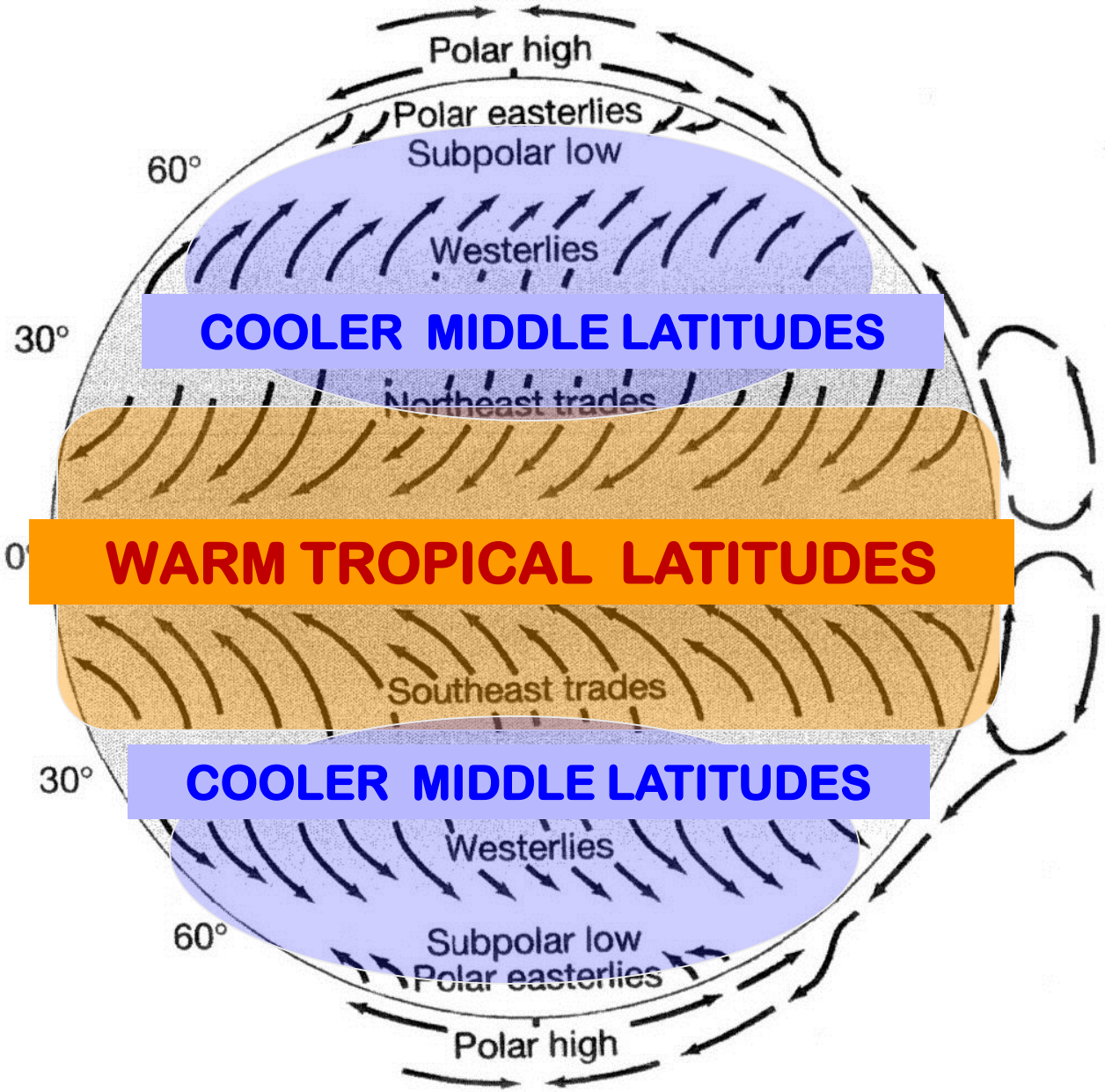
Equator

30 ° S

60 ° S

90° S

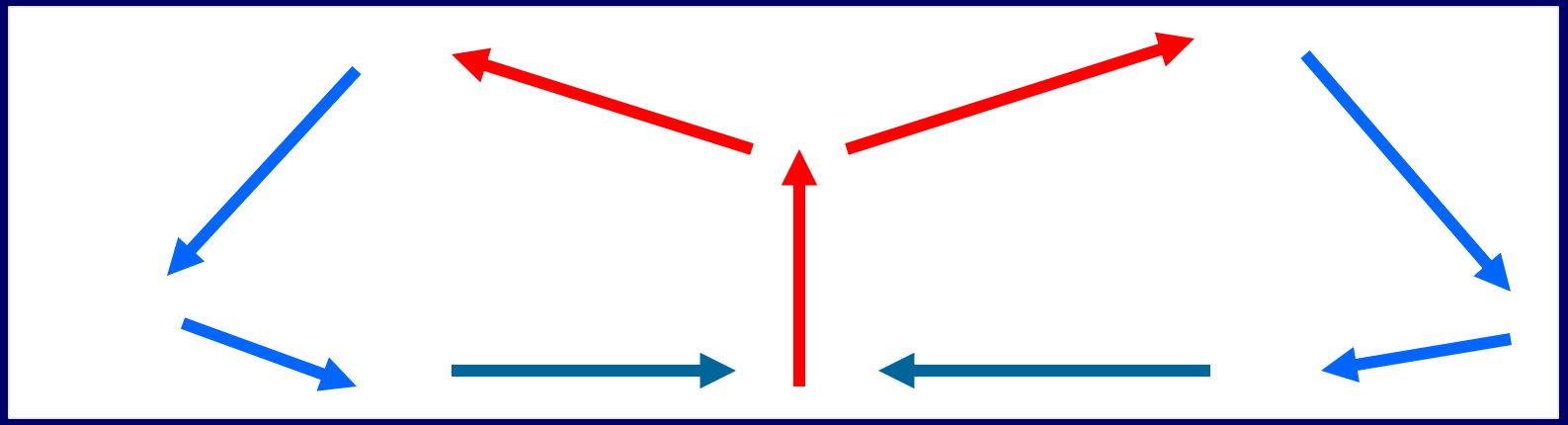
Is YOUR blank globe on Class Notes p 63 filled out?



Energy Transfer via Convection Cells

Figure from SGC E-text Chapter 4

GIANT CONVECTION CELLS
driven by thermal differences:



90 60 30 0 30 60 90

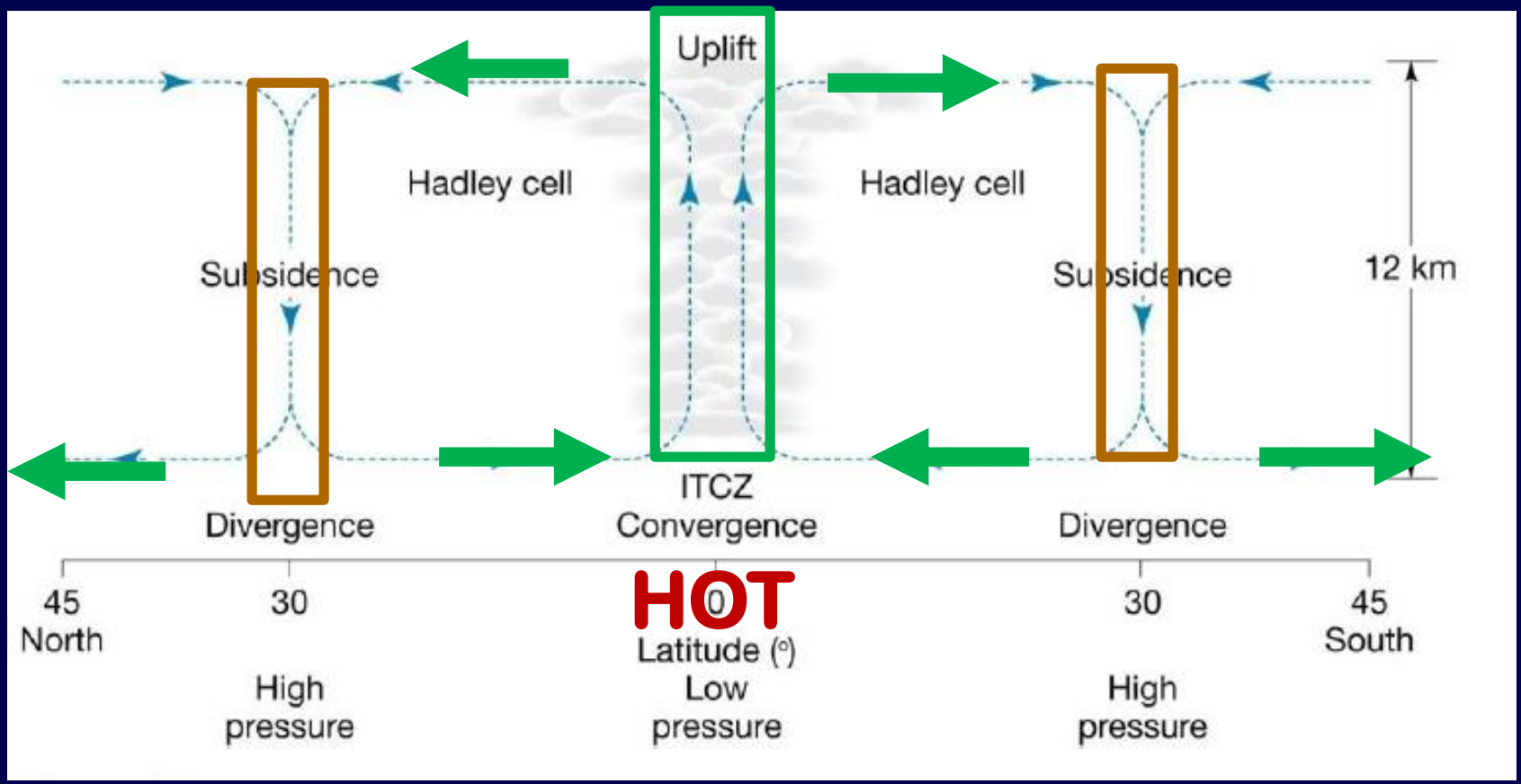
Northern Hemisphere EQUATOR Southern Hemisphere

COLD POLAR REGIONS

HOT TROPICS

COLD POLAR REGIONS

"HADLEY CELL"
← TRANSPORT →



Subtropical HIGH BELT

HOT TROPICS

"HADLEY CELL"

← TRANSPORT →

Subtropical HIGH BELT

LOWS

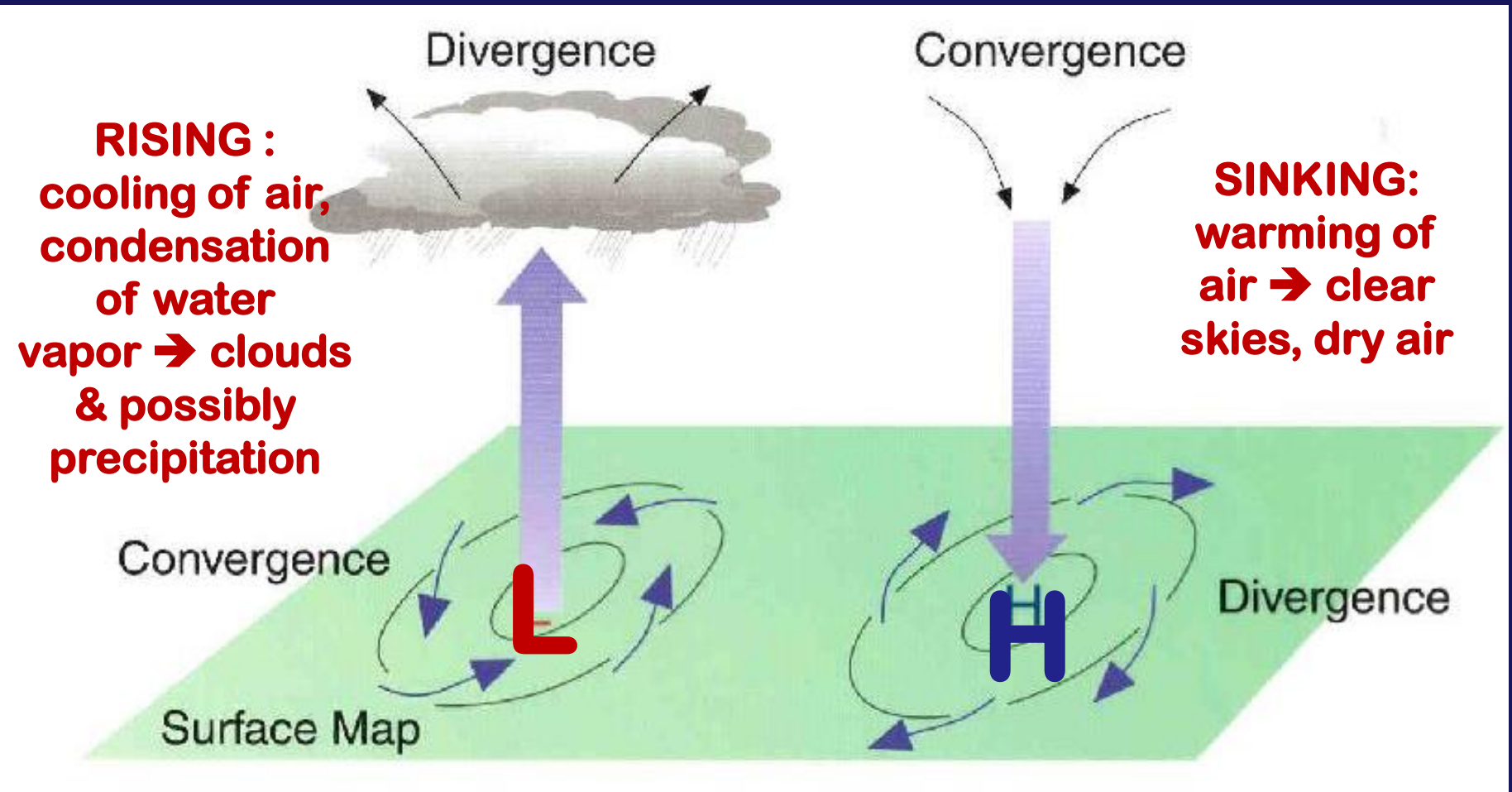
- air converges into surface Low

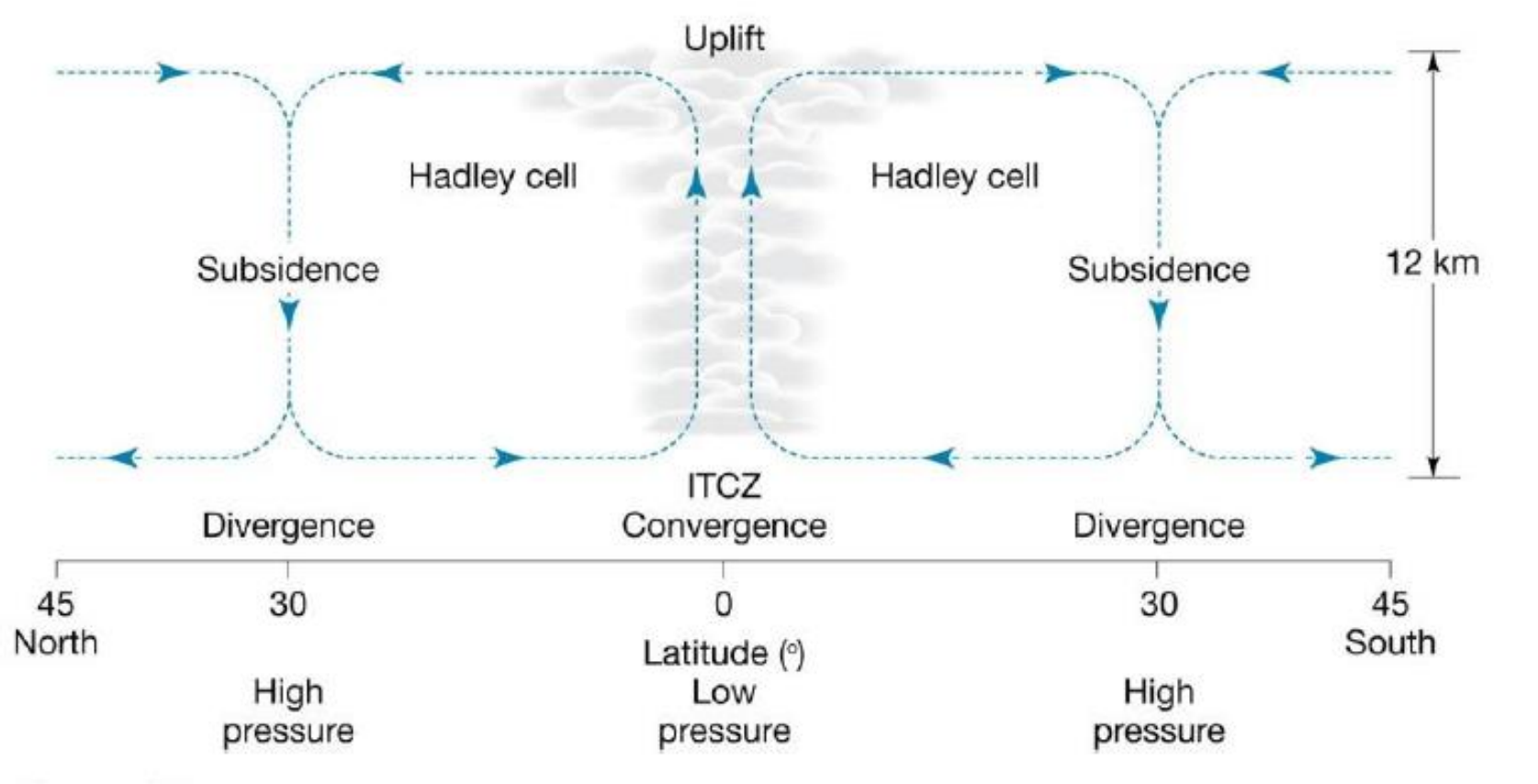
and then rises in the center of lows

HIGHS

- air subsides over surface HIGH

and then diverges out of the centers of surface highs





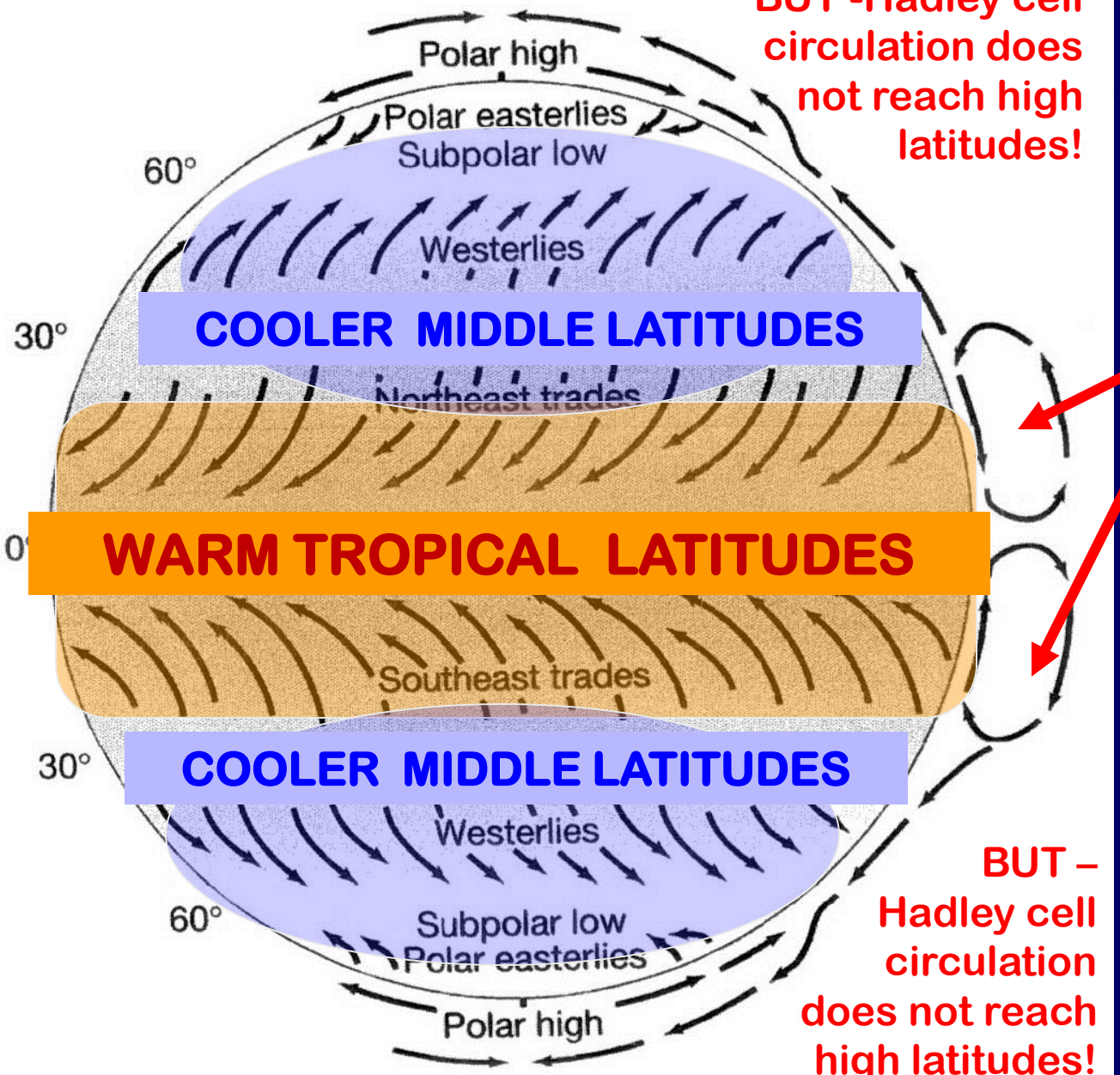
Subtropical HIGH BELT

HOT TROPICS

"HADLEY CELL"

← TRANSPORT →

Subtropical HIGH BELT



BUT -Hadley cell circulation does not reach high latitudes!

HADLEY CELLS = key drivers!

Convection cell transfer of thermal energy

(as **H**)

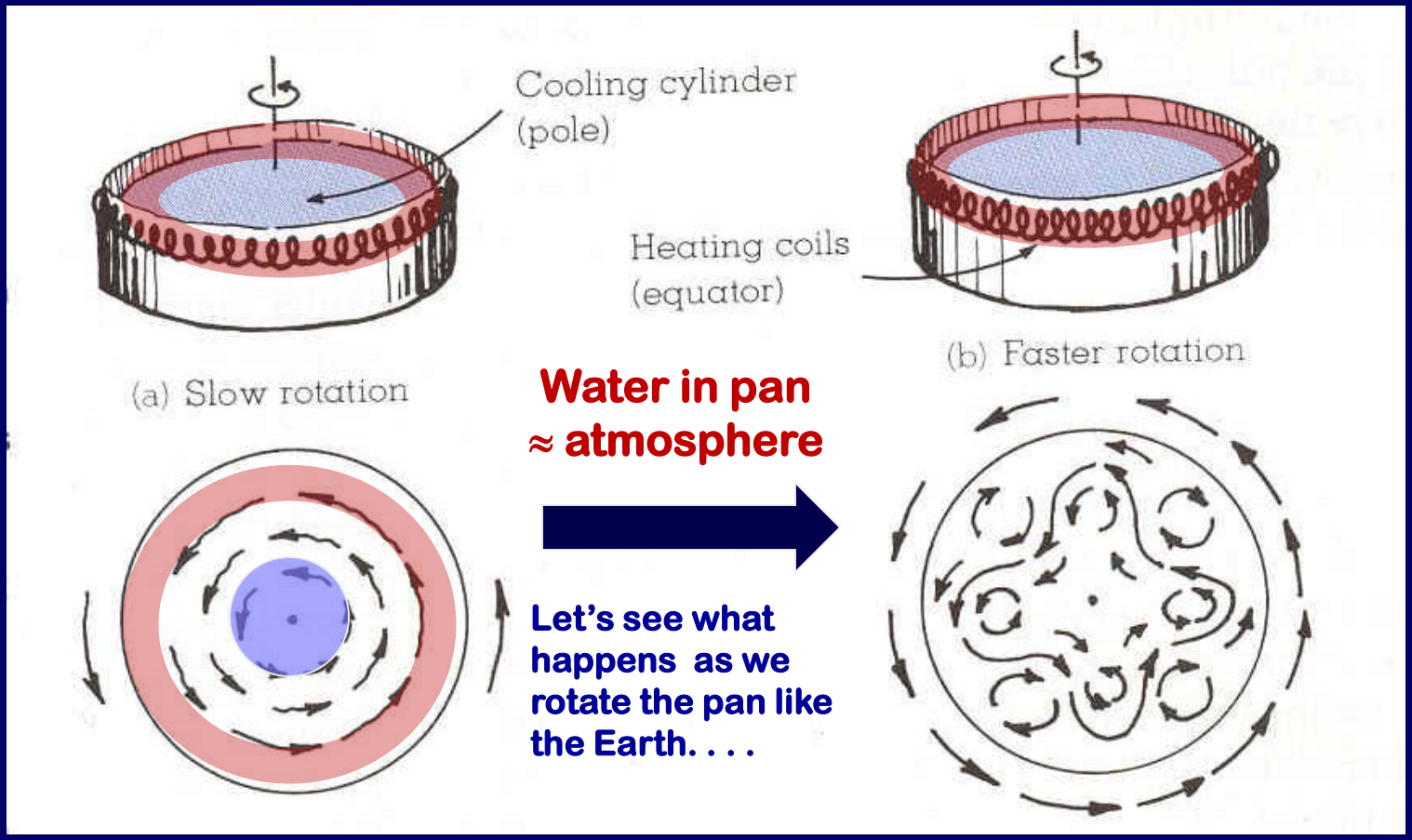
SURPLUS

TO

DEFICIT areas

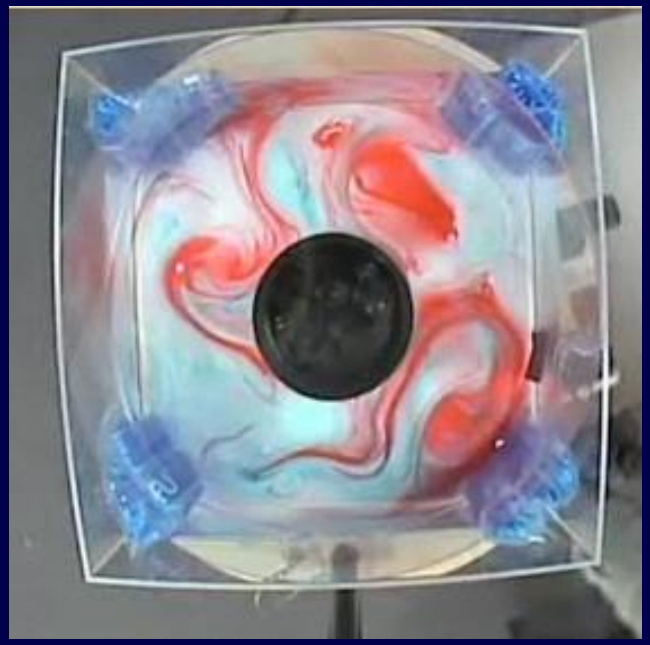
BUT – Hadley cell circulation does not reach high latitudes!

Another way energy gets transported from the hot surplus areas to the cold deficit areas:



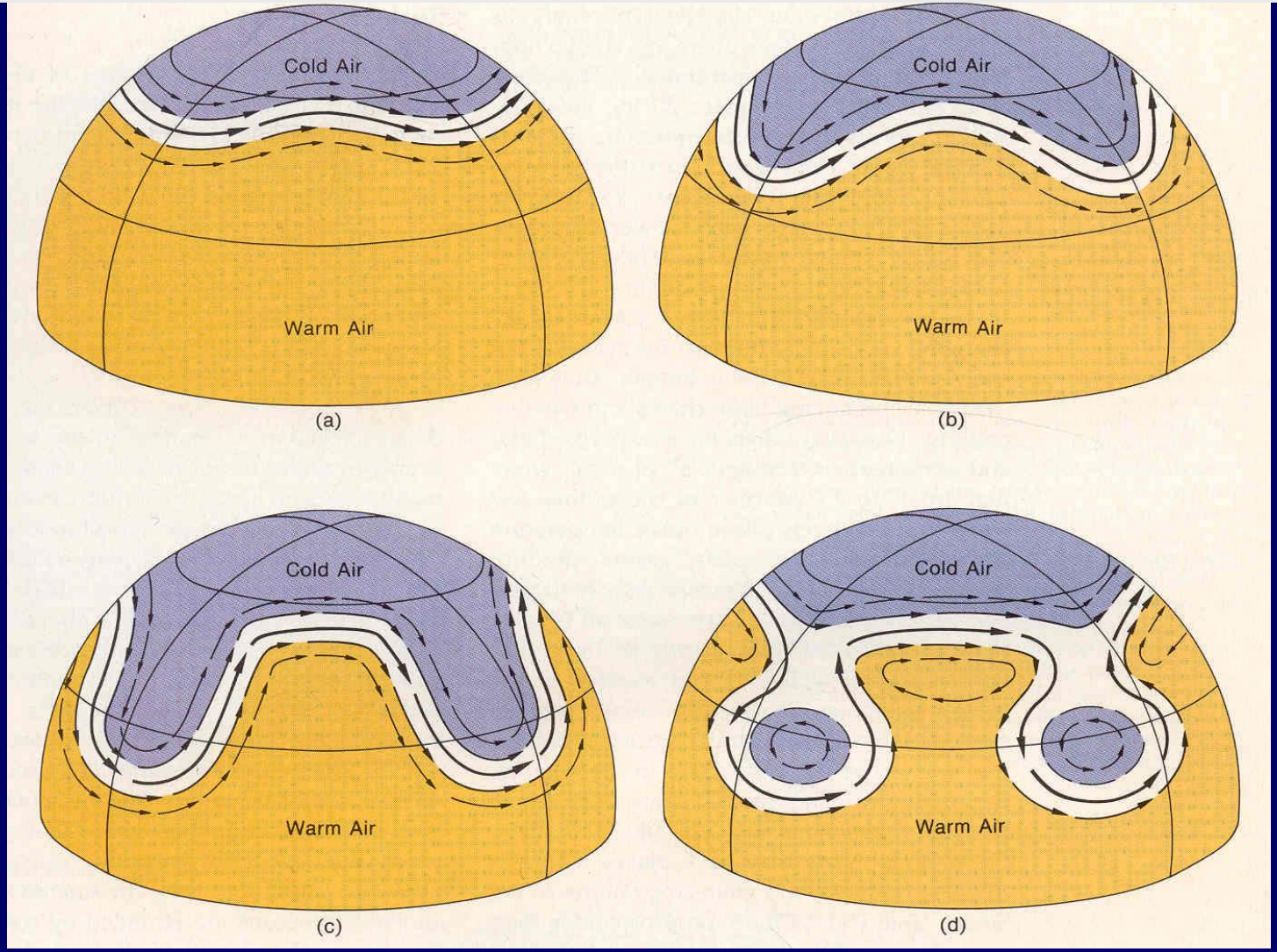
Demo of a simple "dishpan" model of atmospheric circulation

A DEMONSTRATION OF THE DISHPAN

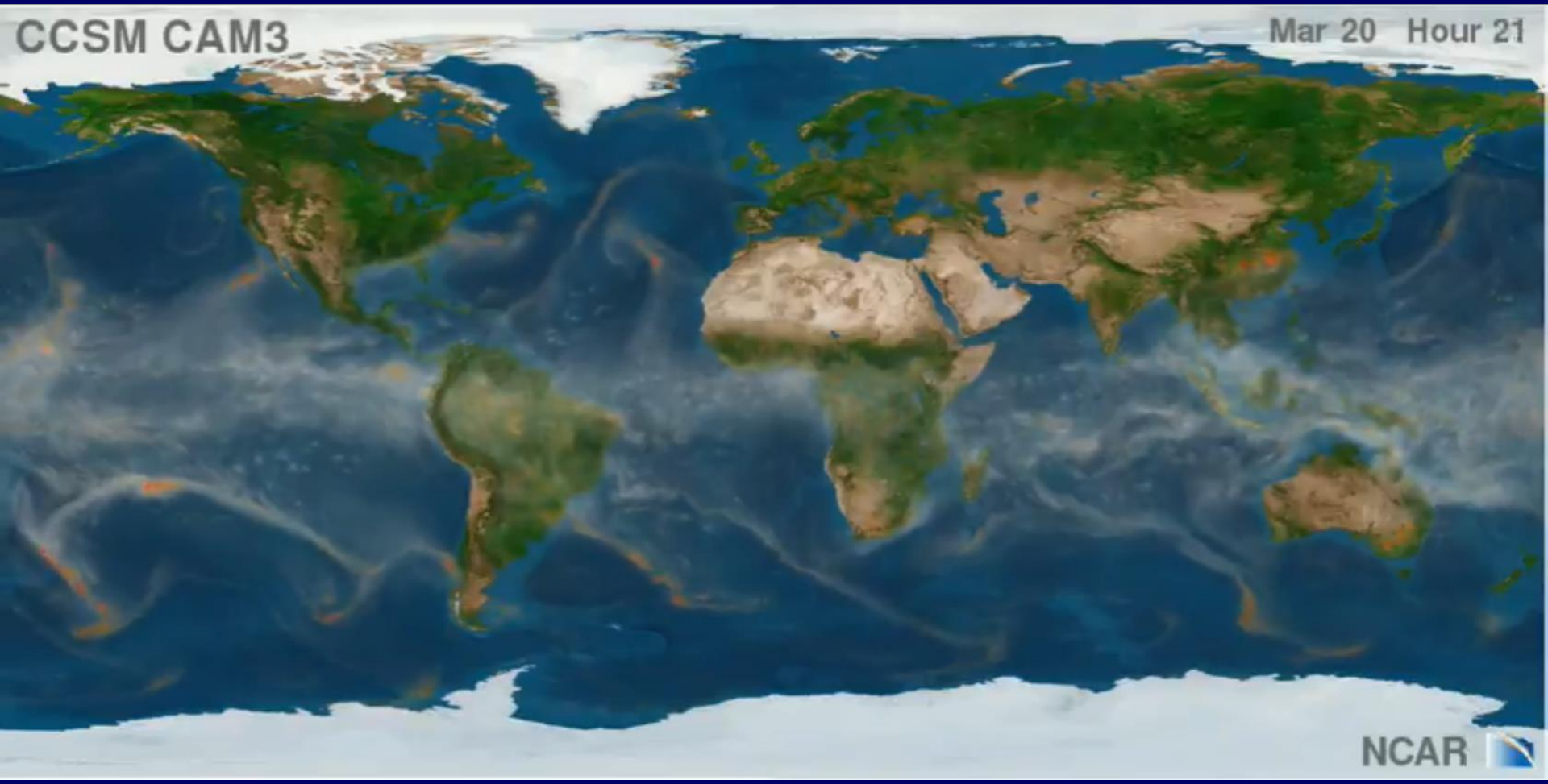


http://www.windows2universe.org/earth/Atmosphere/global_circulation_lsop_video.html

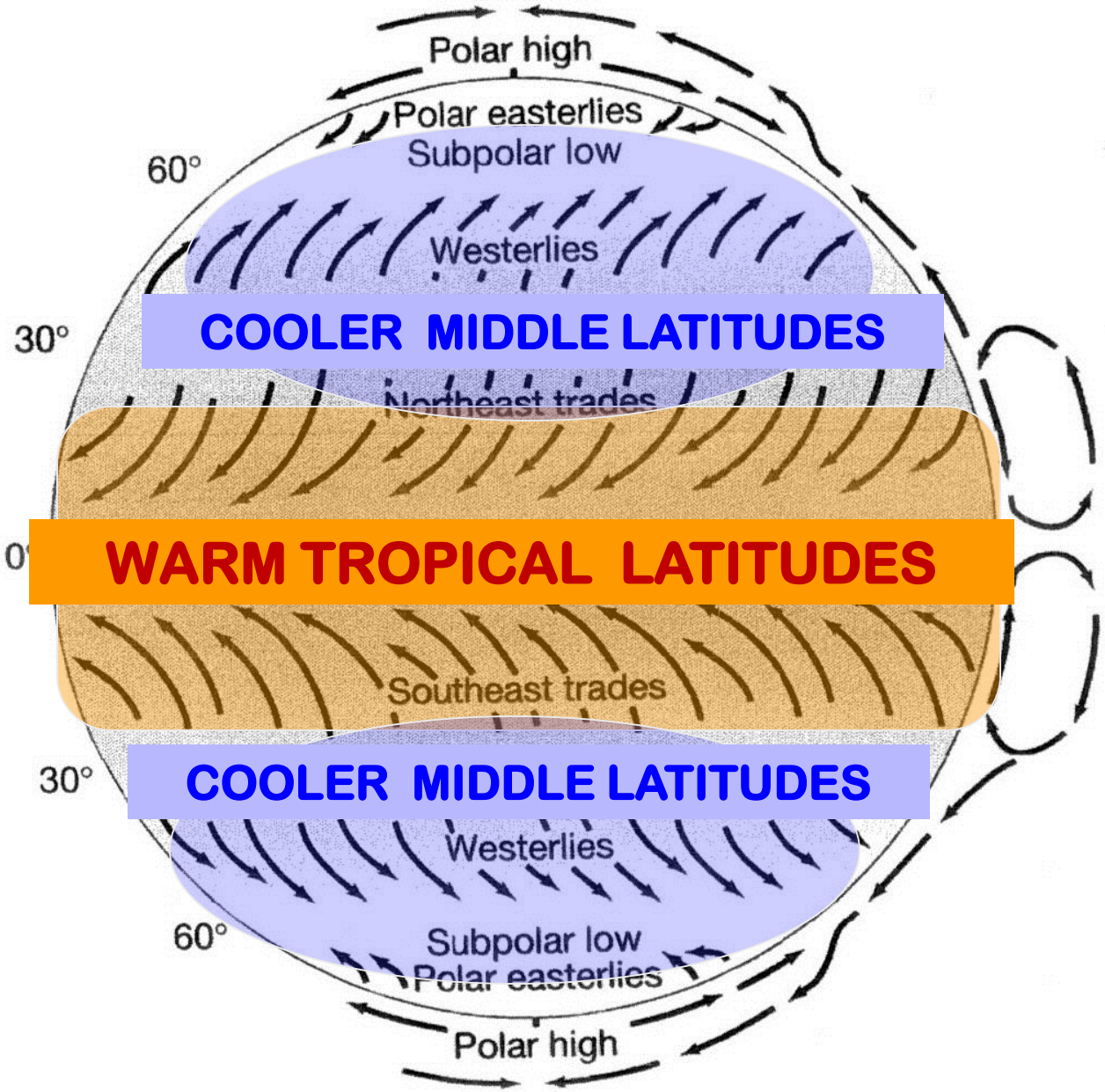
UPPER LEVEL "ROSSBY WAVE" CIRCUMPOLAR WINDS !



"Wave" transport of Energy as SENSIBLE HEAT (in lobes of warm air)!

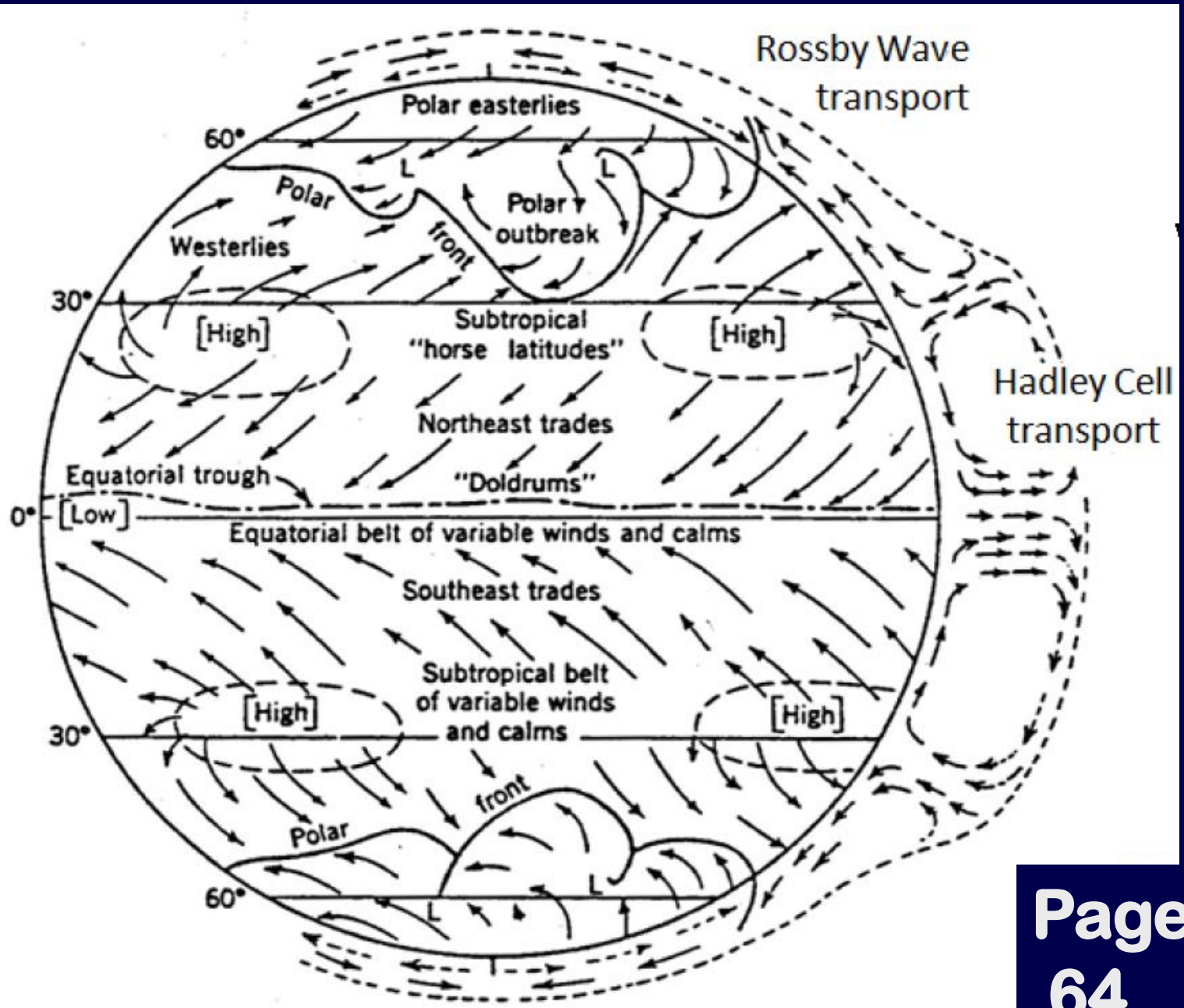


http://www.vets.ucar.edu/vg/T341/index.shtml

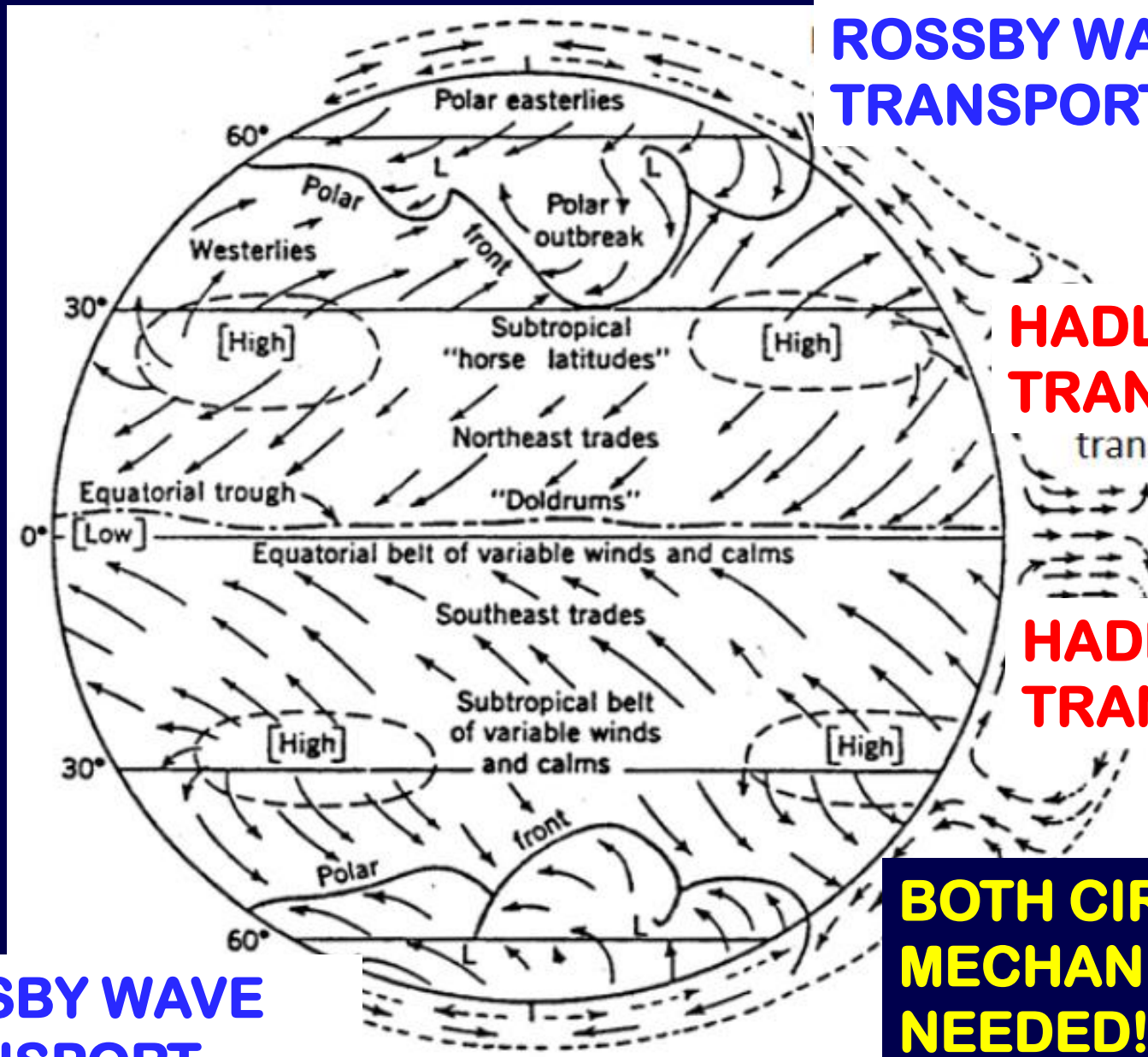


Energy Transfer via Convection Cells

Figure from SGC E-text Chapter 4


Rossby Wave transport
Polar easterlies
60°
L
L
Polar front
Polar outbreak
Westerlies
30°
[High]
Subtropical "horse latitudes"
[High]
Hadley Cell transport
Northeast trades
Equatorial trough
"Doldrums"
0°
[Low]
Equatorial belt of variable winds and calms
Southeast trades
Subtropical belt of variable winds and calms
[High]
[High]
30°
front
Polar
L
60°
L

The "GENERAL CIRCULATION OF THE ATMOSPHERE"



ROSSBY WAVE TRANSPORT

HADLEY CELL TRANSPORT

transport

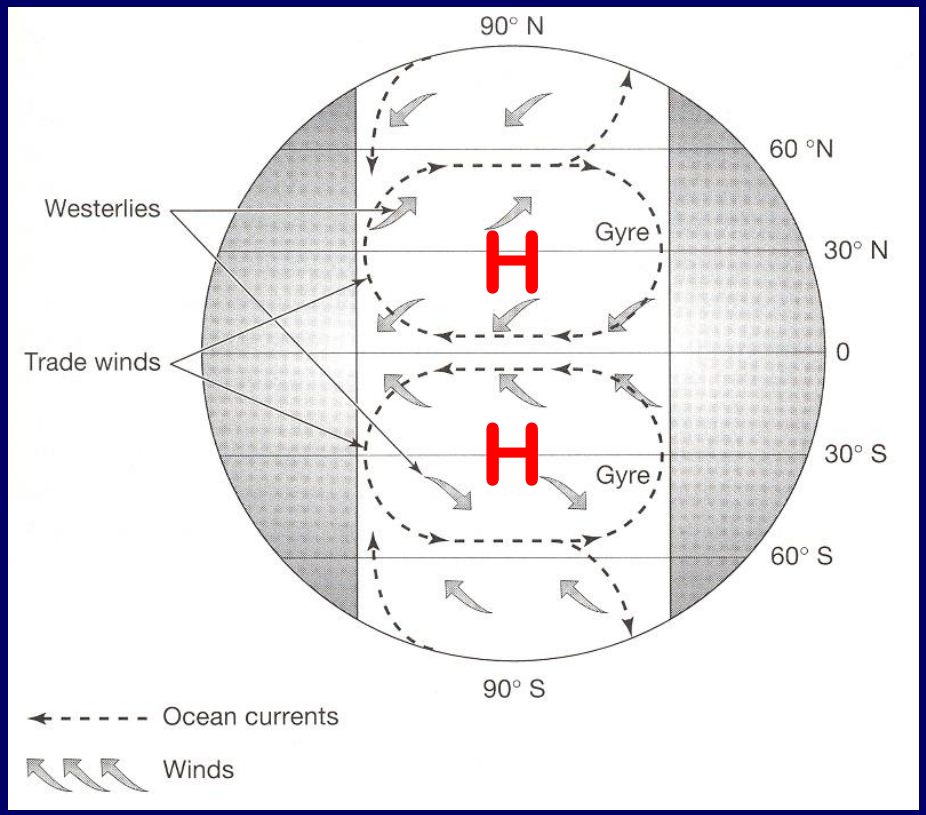
HADLEY CELL TRANSPORT

BOTH CIRCULATION MECHANISMS ARE NEEDED!

ROSSBY WAVE TRANSPORT

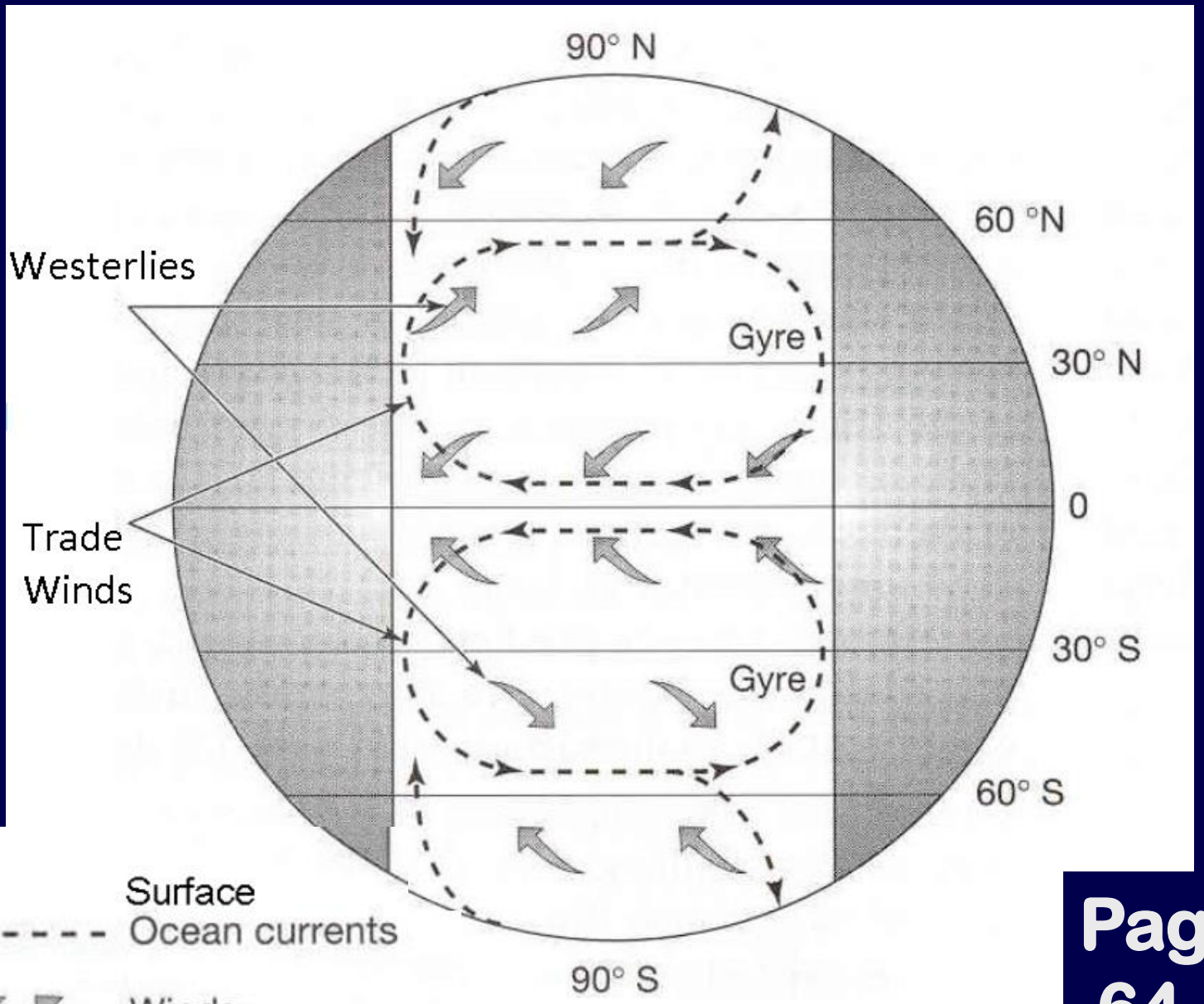
WHAT ABOUT OCEAN CIRCULATION?

➔ Large OCEAN GYRES are driven by Trade Winds & Westerly Winds in Oceanic Subtropical High Pressure Cells

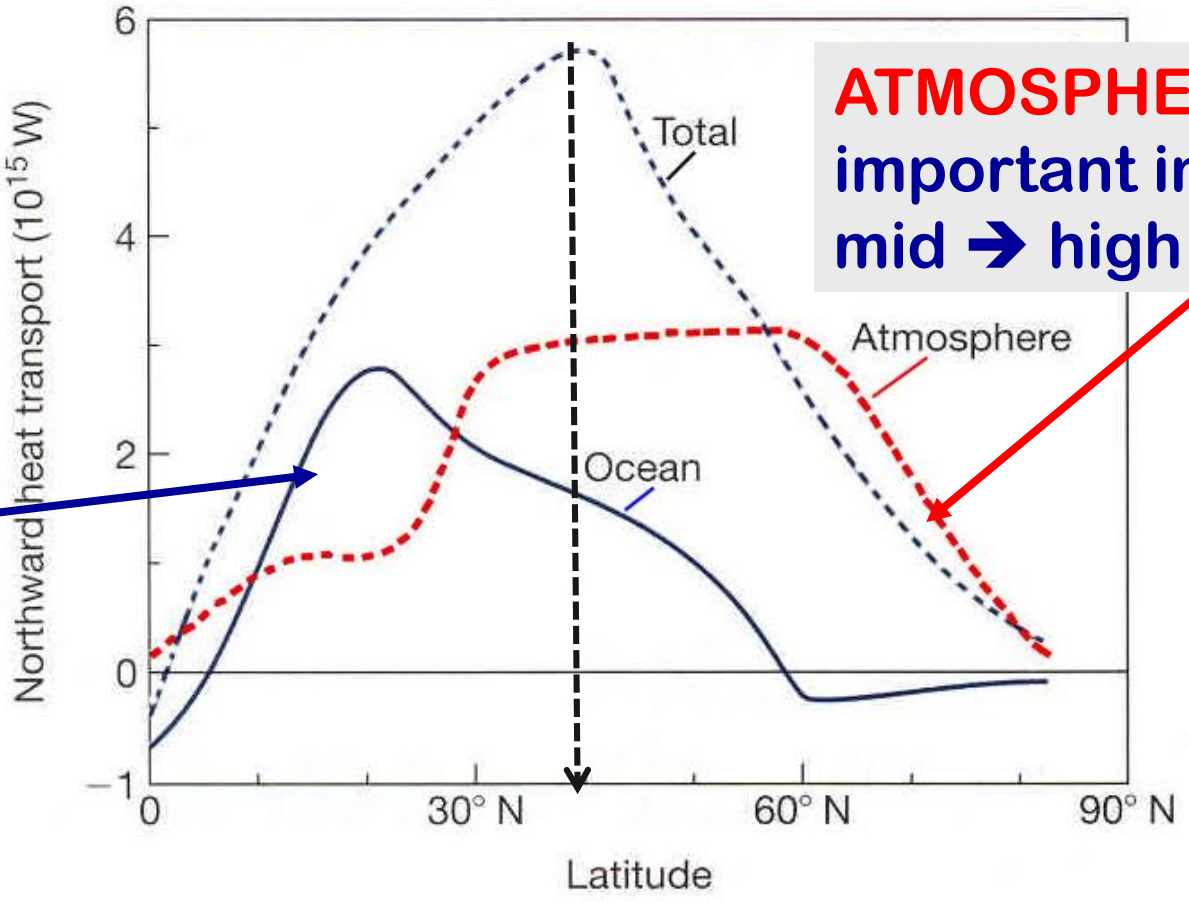


Leads to <u>SURFACE</u> ocean currents

OCEAN CIRCULATION - SIMPLIFIED



Both ATMOSPHERE & OCEAN play important roles in BALANCING OUT ENERGY SURPLUS & DEFICIT AREAS:



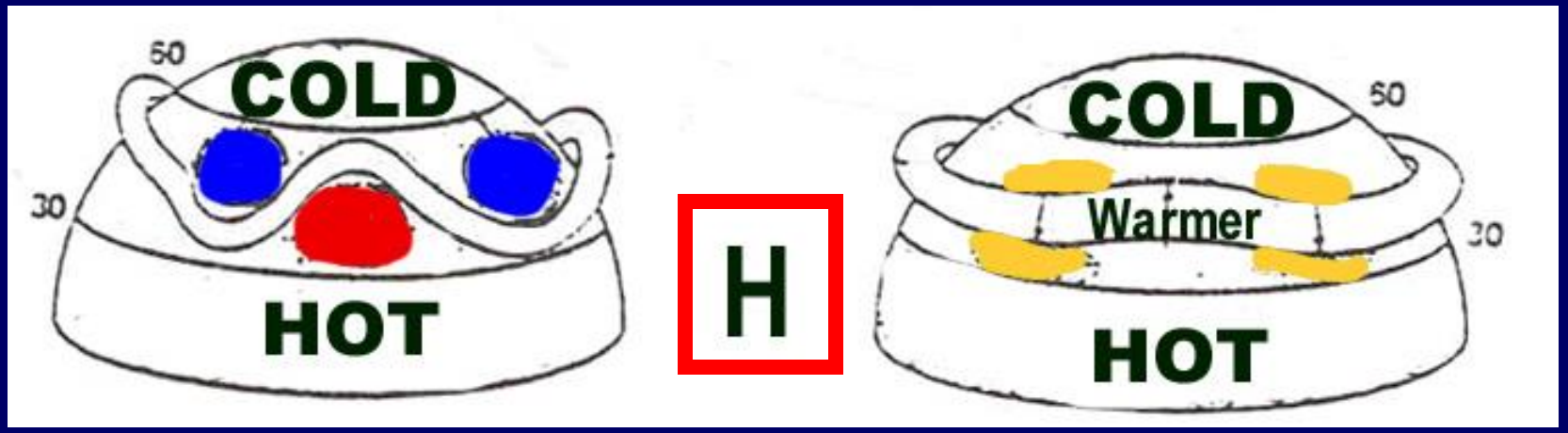
ATMOSPHERE more important in mid ➔ high latitudes

OCEAN transports MOST of the energy in LOW ➔ subtropical latitudes

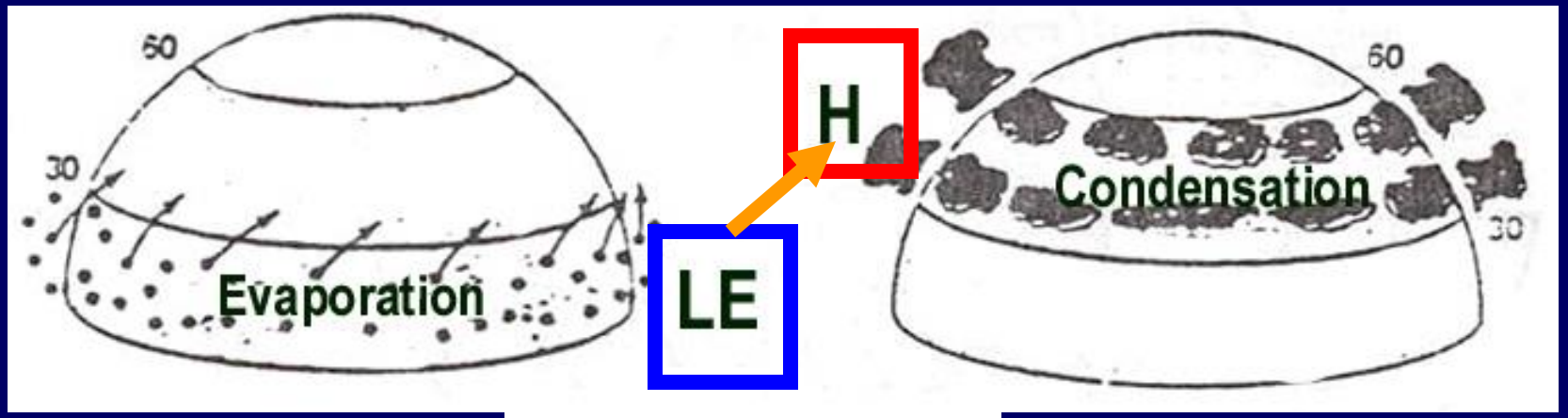
Poleward transport of energy in N.H.

ENERGY is transported from areas of surplus to deficit via

Warm Air transport : H (sensible heat)



& LE (Latent Energy) transport

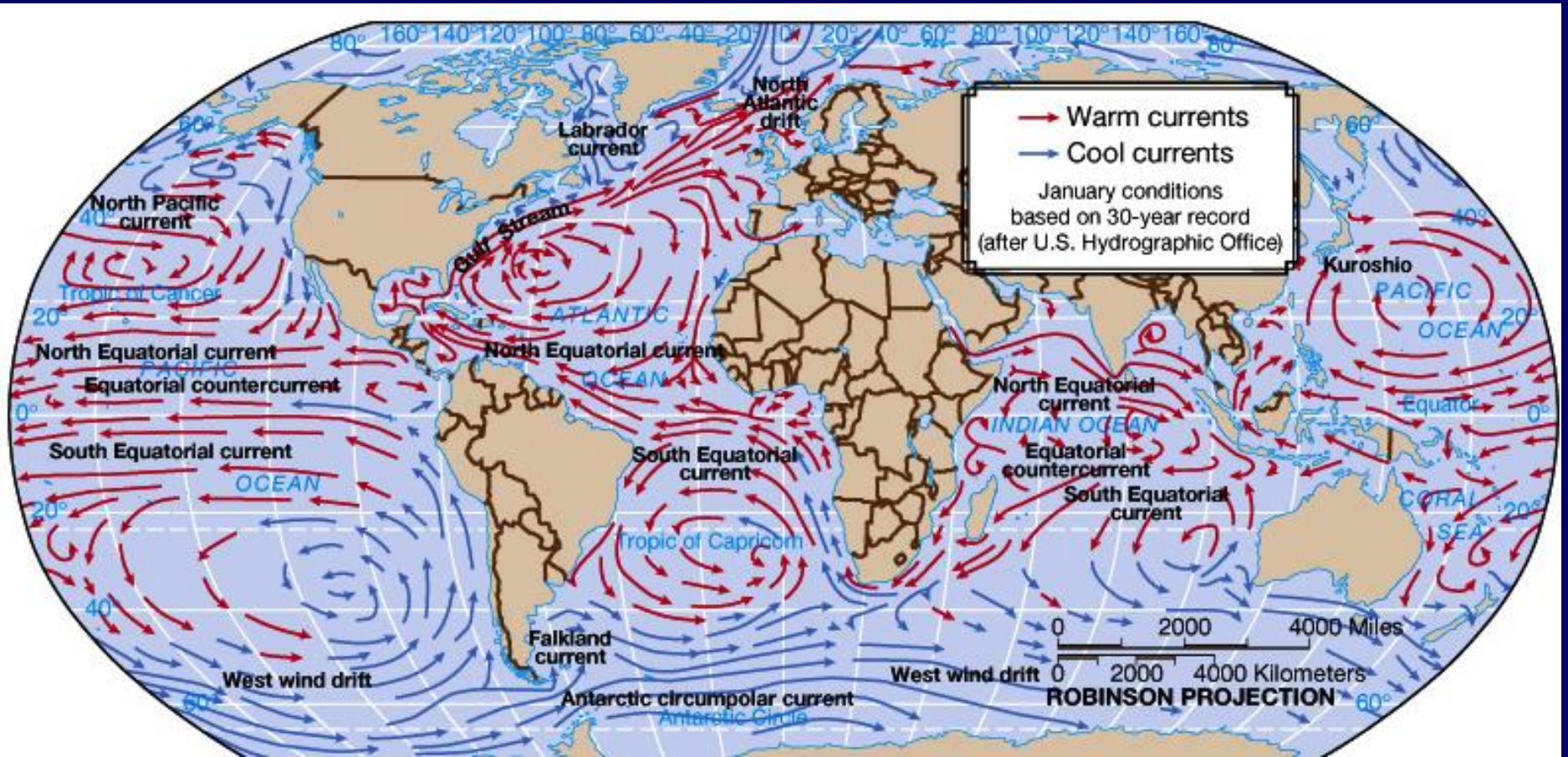


H + LE

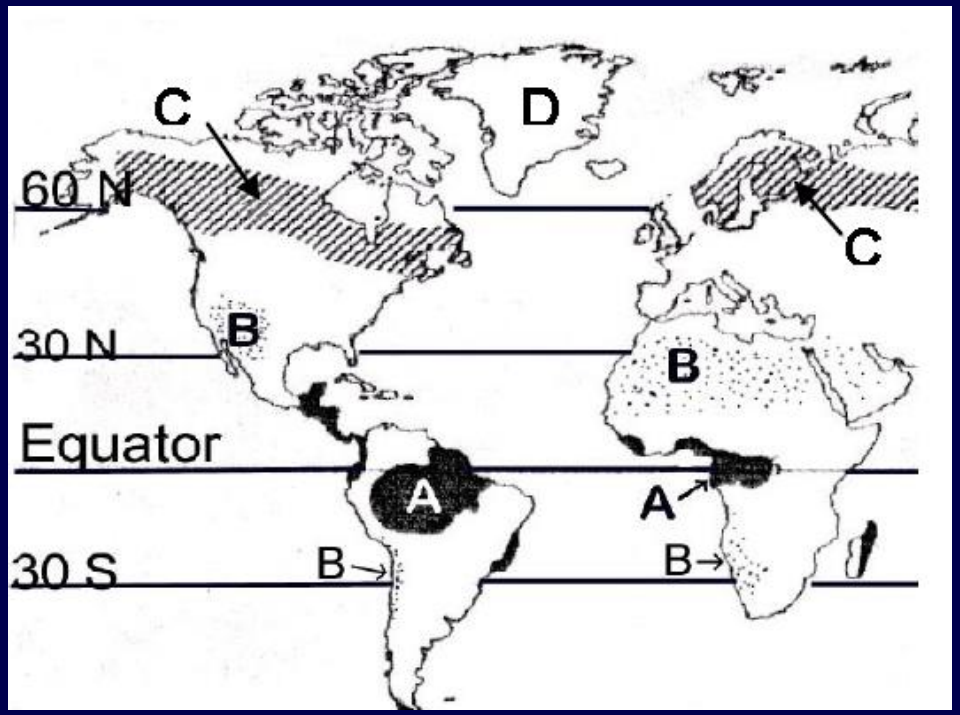
ENERGY TRANSFER IN THE OCEAN

H + LE + G

Energy stored in the OCEAN (as **G**) , can later be transported via ocean currents as **H** !



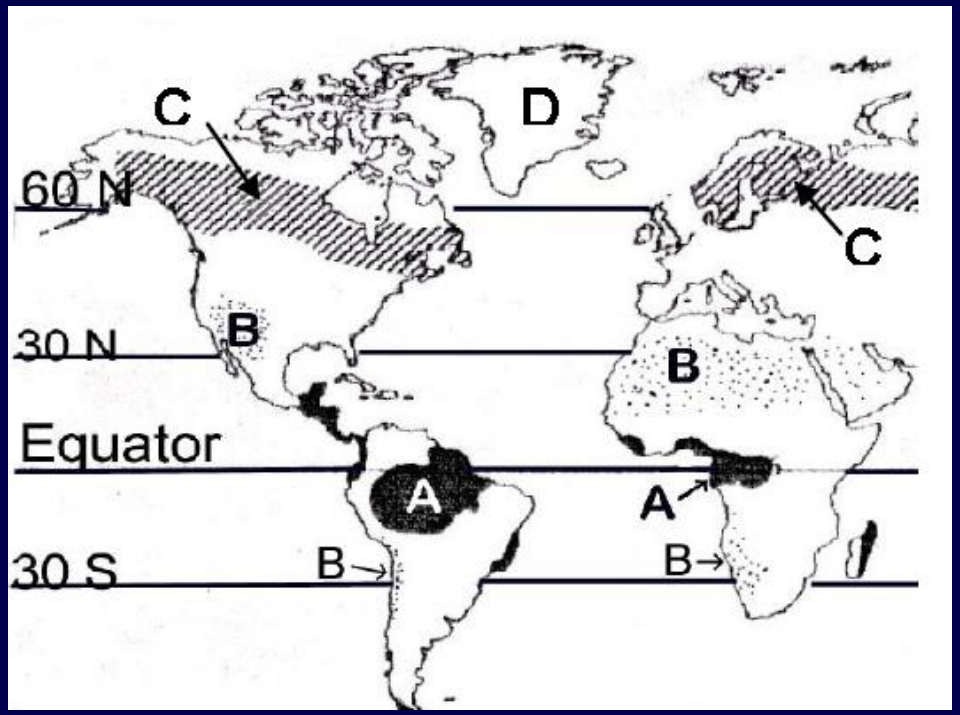
Q's. What kind of climate and vegetation will you find in the areas marked A, B , C, & D ?



Area A= ____
Area B = ____
Area C = ____
Area D = ____

1-Tropical Forest
2 -Conifer Forest
3- Warm Desert vegetation
4 -No vegetation: snow and ice

Q's. What kind of climate and vegetation will you find in the areas marked A, B , C, & D ?

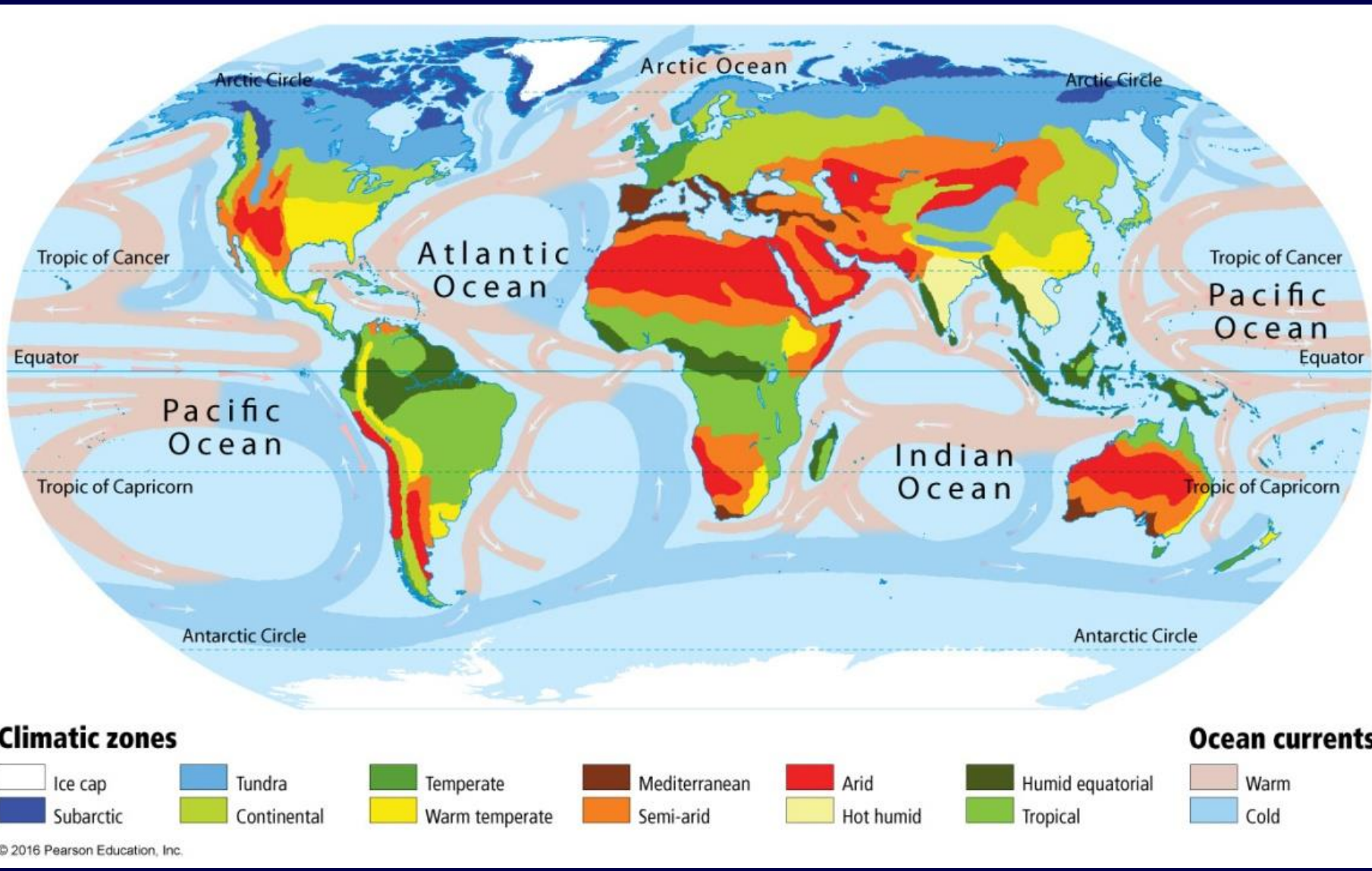


ANSWERS:

Area A = 1
Area B = 3
Area C = 2
Area D = 4

1-Tropical Forest
2 -Conifer Forest
3- Warm Desert vegetation
4 -No vegetation: snow and ice

WORLD OUTLINE MAP



WORLD OUTLINE MAP

EXAM COMMENTS

Midterm Exam Points Recovery Opportunity Directions

Here's how you may recover up to HALF of the points you lost on your Midterm Exam in up to **THREE (3) questions**:

1. **Select up to 3 questions** (multiple choice or write-in) that you got wrong and that you still don't understand very well.

2. For <u>each question</u> explain:

   a) Why you answered as you did
   b) Why your answer(s) were wrong
   c) What the correct answer is, and
   d) Why it is correct (explain in your own words)

3. **For Write-in Questions # 26 -34,** do (a) through (d) described above. Note, however, that the point recovery **maximum for any one of the Write-In Questions will be a maximum of 3 points.**

4. Your paper must be **TYPED, with your NAME & GROUP # on it, and submitted in hard copy WITH YOUR MIDTERM EXAM** to Dr H no later than class time on Mon Nov 9th.

No late or emailed papers accepted – must be submitted IN PERSON **with a COPY OF YOUR EXAM.**

[Note that the recovery of half of the points you missed is not "automatic." The number of additional points assigned will be based on how well you demonstrate a thorough understanding of the material in your write-up.]