THE ATMOSPHERE

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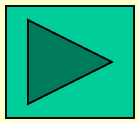
ATMOSPHERIC CIRCULATION

The Three Cell Model
Global Winds
The ITCZ

The purpose of this presentation is to introduce the topic of atmospheric circulation.

Main concepts:

- **atmospheric circulation is a response to differences in insolation between low and high latitudes.**
- **there is a transfer of energy from low to high latitudes**
- **a global pattern of surface winds and pressure belts results from this circulation**
- **there is a seasonal shift of the surface wind and pressure belts**
- **this shift has a pronounced effect on the climate of areas such as sub-saharan Africa**



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THE THREE CELL MODEL

FORMATION OF THE HADLEY CELL (1)

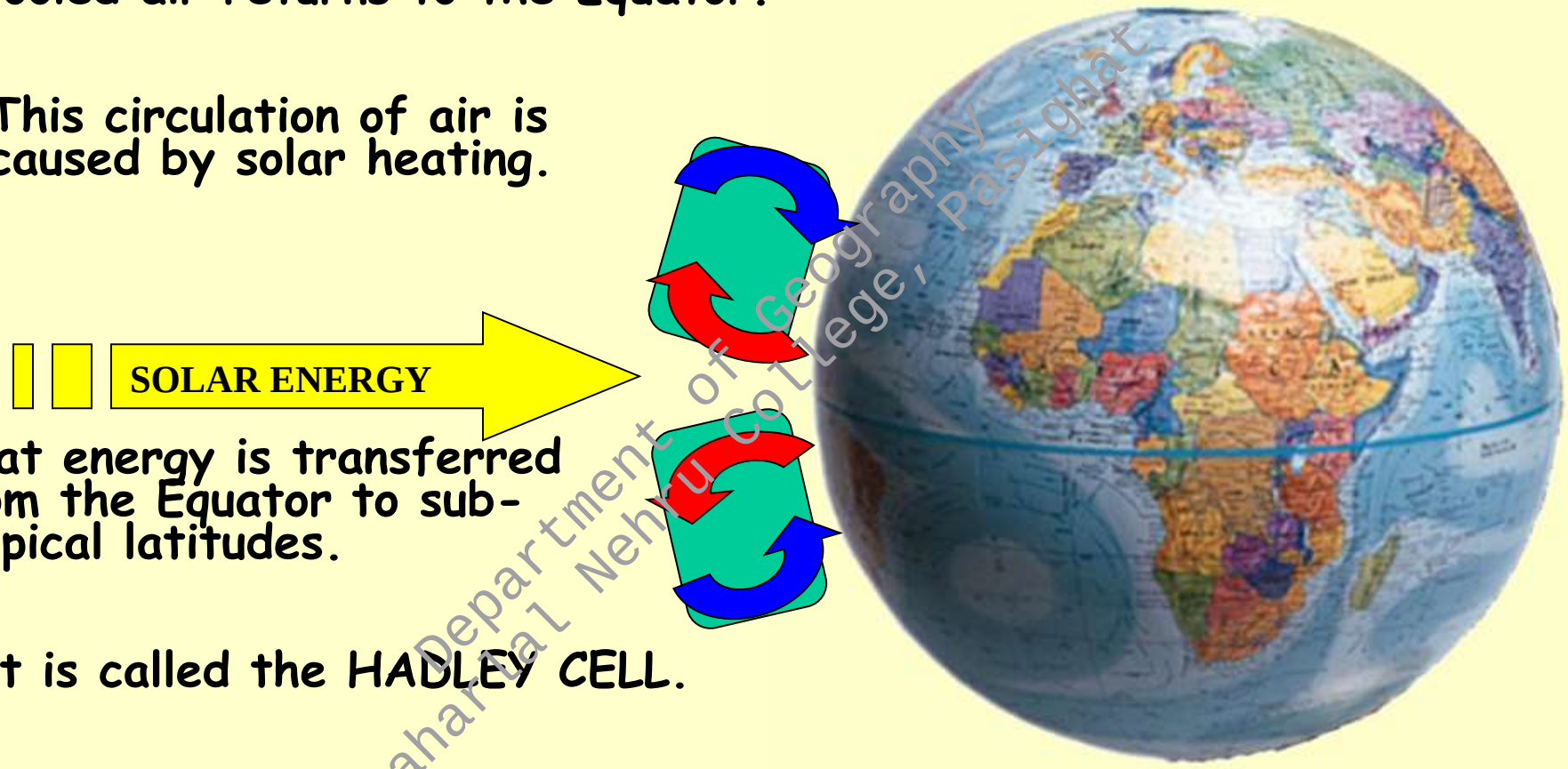
Insolation in tropical areas causes warm air to rise and spread polewards, carrying heat energy.

THE THREE CELL MODEL

FORMATION OF THE HADLEY CELL (2)

Air cools and begins to fall at about 30°N and 30°S of Equator. Cooled air returns to the Equator.

This circulation of air is caused by solar heating.



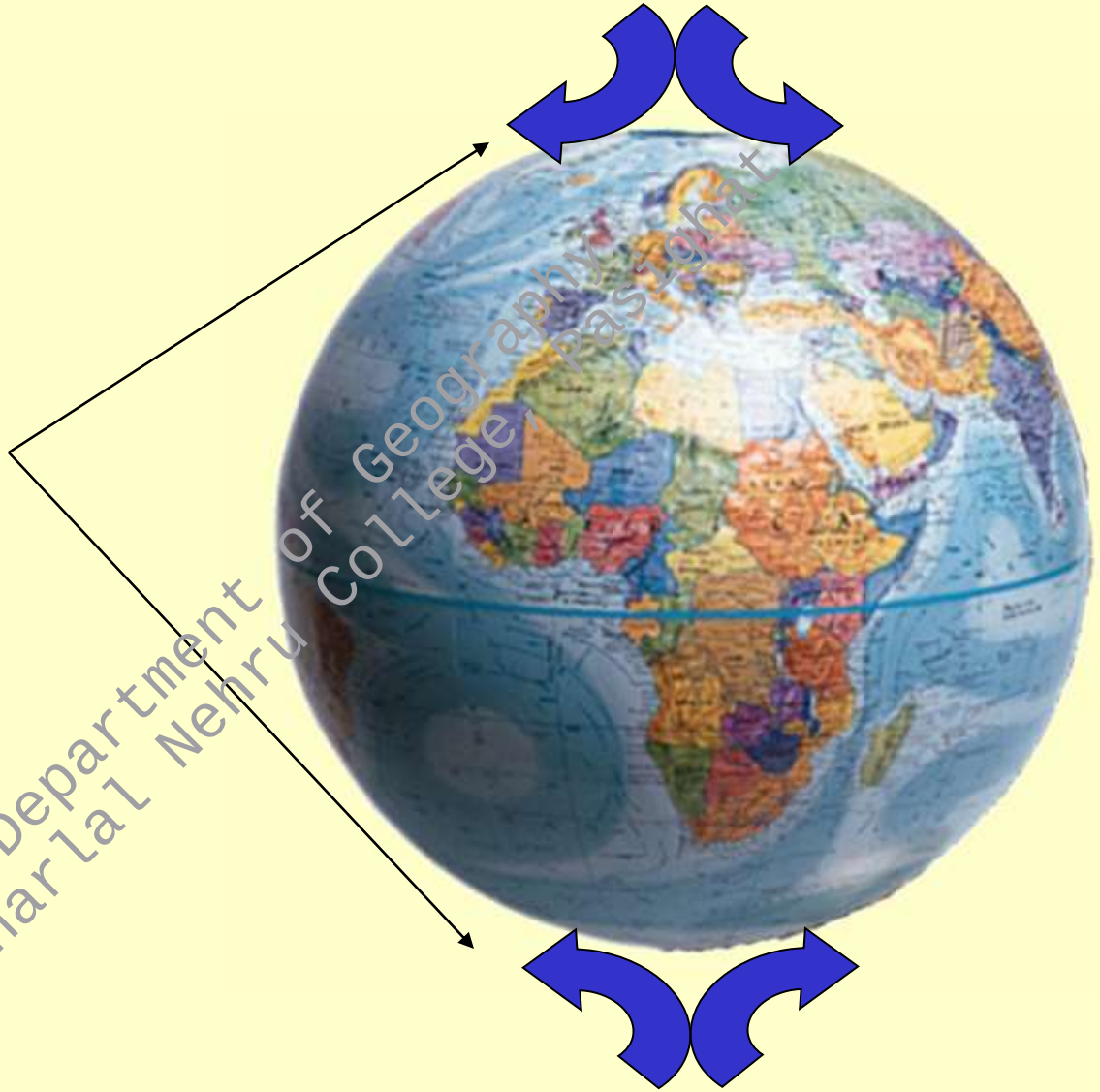
Heat energy is transferred from the Equator to sub-tropical latitudes.

It is called the HADLEY CELL.

THE THREE CELL MODEL

FORMATION OF THE POLAR CELL (1)

Intensely cold, dense air sinks at the poles, then blows as surface winds towards the Equator.



THE THREE CELL MODEL

FORMATION OF THE POLAR CELL (2)

At about 60°N and 60 °S, the cold polar air is warmed in contact with the earth's surface.

This warmed air rises and returns polewards, carrying heat energy.

This circular motion is called the POLAR CELL.

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THE THREE CELL MODEL

FORMATION OF THE FERREL CELL (1)

The Hadley Cell is driven by differences in heat energy at the Equator.

As the air in the Hadley Cell falls at about 30°N and 30°S, it pulls the air beside it down as well due to friction

THE THREE CELL MODEL

FORMATION OF THE FERREL CELL (2)

The Polar Cell is driven by differences in heat energy. Cold polar air falls and spreads towards the Equator.

As the air in the Polar Cell rises at about 60°N and 60°S, it pulls the air beside it up as well, due to friction.

THE THREE CELL MODEL

FORMATION OF THE FERREL CELL (3)

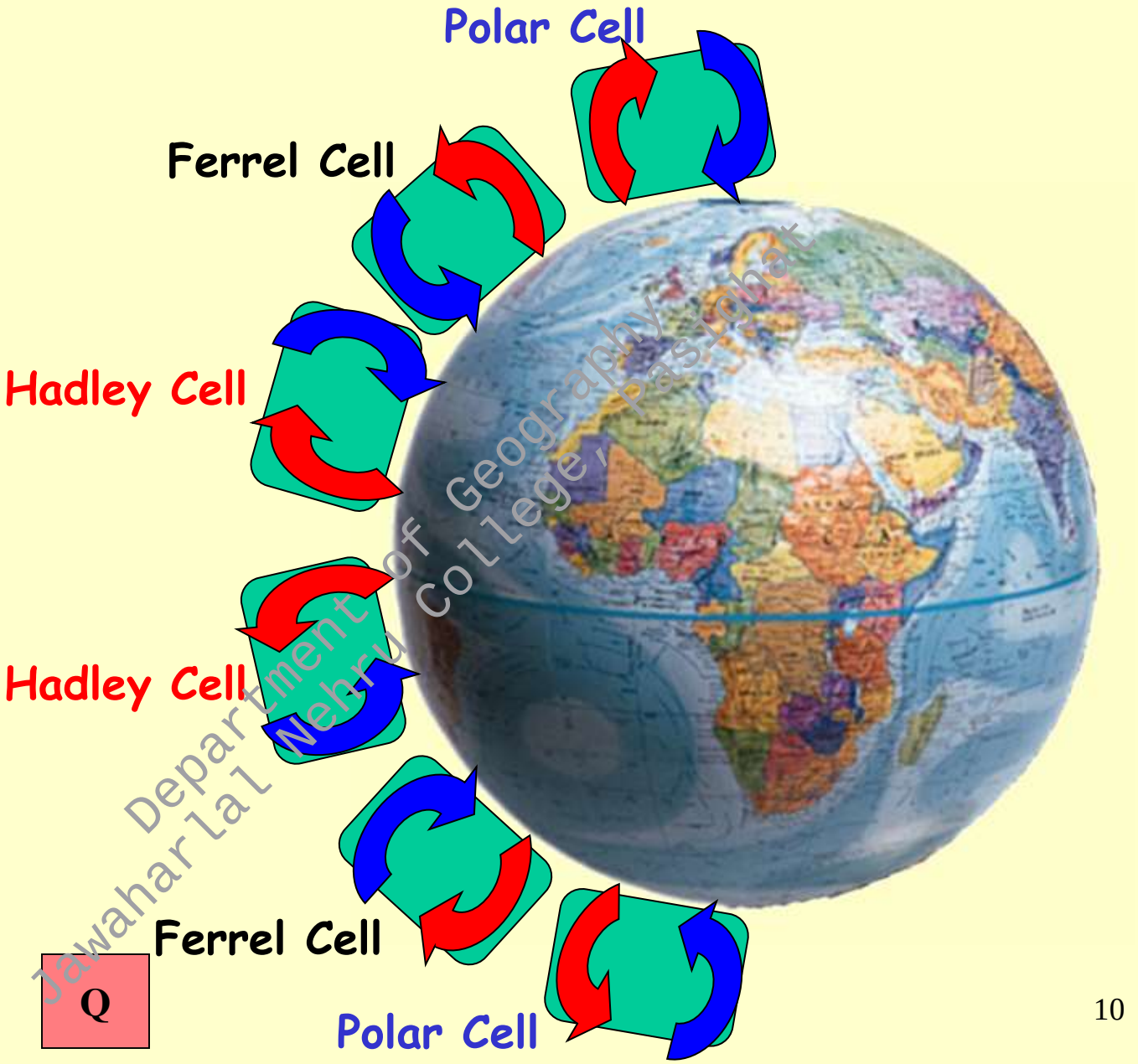
Unlike the Hadley and Polar Cells, the Ferrel Cell is not driven by differences in heat energy.

The Ferrel Cell is caused by friction where air is in contact with the other two cells.

The Hadley Cell drags air down at about 30°N and S.

The Polar Cell causes an uplift at about 60°N and S.

THE THREE CELLS TOGETHER



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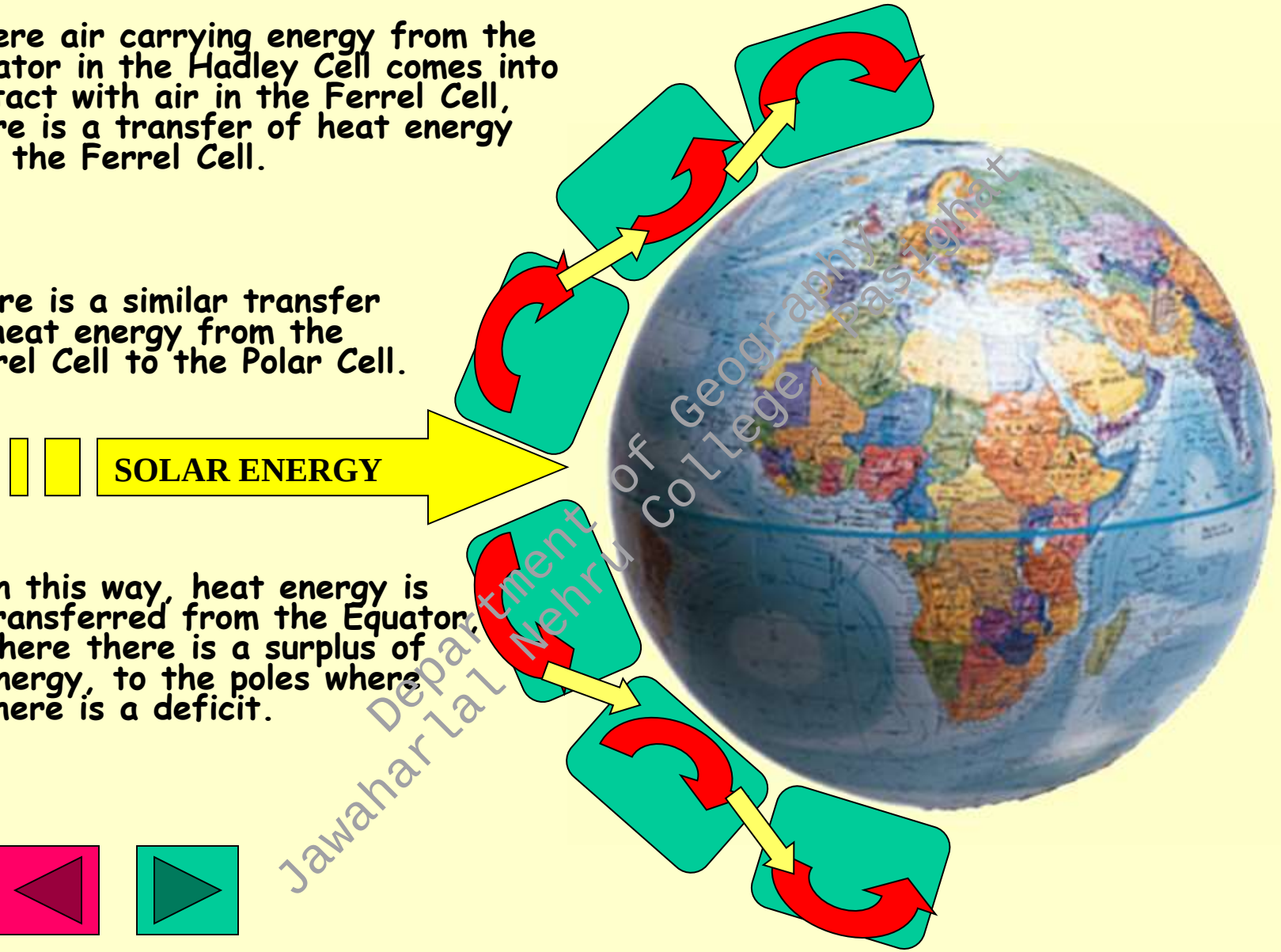
THE TRANSFER OF HEAT ENERGY FROM EQUATORIAL TO POLAR AREAS

Where air carrying energy from the Equator in the Hadley Cell comes into contact with air in the Ferrel Cell, there is a transfer of heat energy into the Ferrel Cell.

There is a similar transfer of heat energy from the Ferrel Cell to the Polar Cell.



In this way, heat energy is transferred from the Equator, where there is a surplus of energy, to the poles where there is a deficit.

THE CORRESPONDING MOVEMENT OF COLDER AIR

In the Polar cell cold air from polar regions flows to mid-latitudes as polar easterly winds

In the Ferrel Cell there is a movement of cold air at high altitude.

In the Hadley Cell, cooler air moves from the sub-tropics to the Equator.

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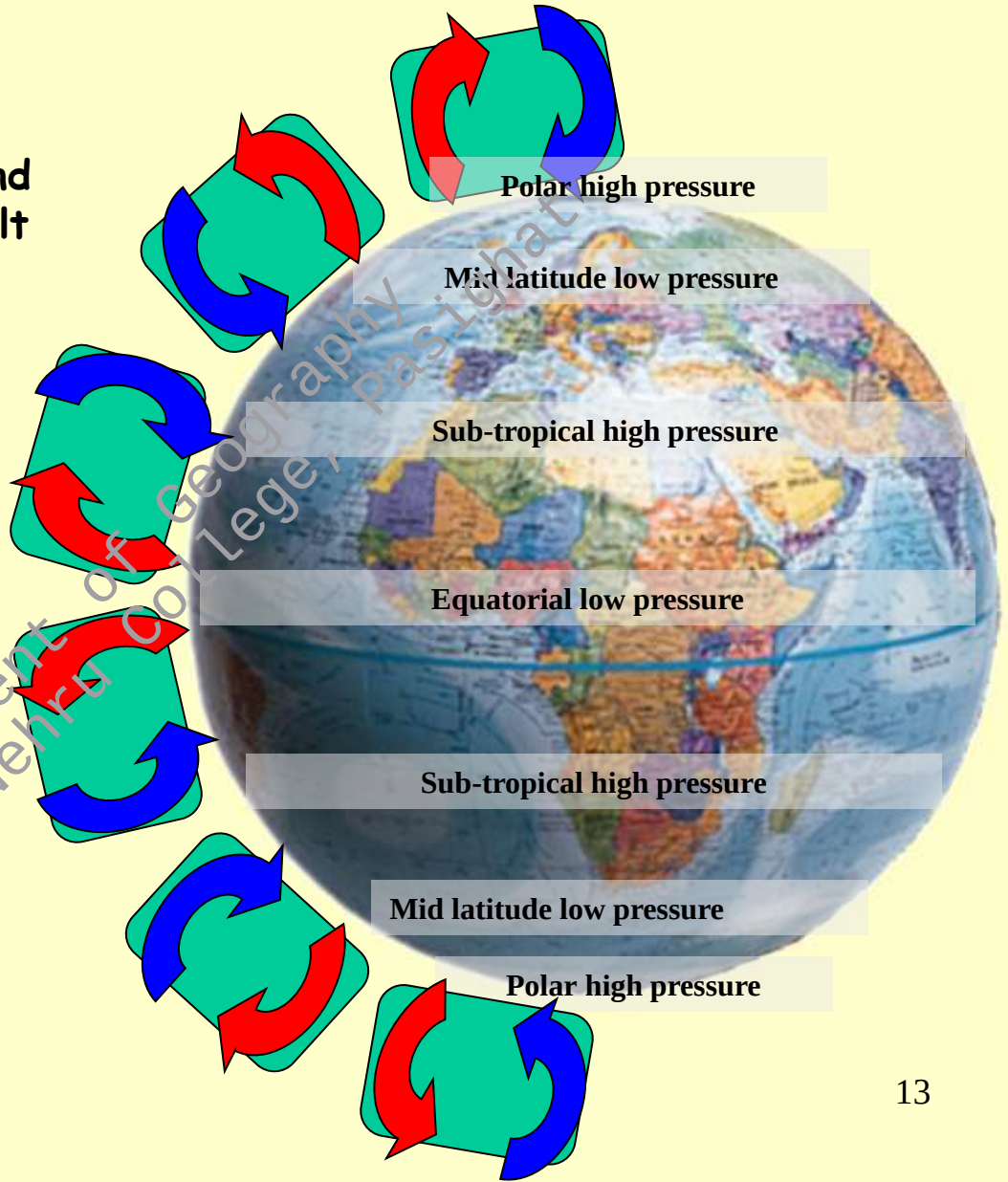
ASSOCIATED PRESSURE BELTS

Rising air at the equator causes the equatorial belt of low pressure

Descending air at about 30°N and 30°S causes the sub-tropical belt of high pressure

Rising air at about 60°N and 60°S causes a mid-latitude belt of low pressure

Descending air at the poles causes the polar high pressure areas



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ASSOCIATED SURFACE WIND PATTERNS

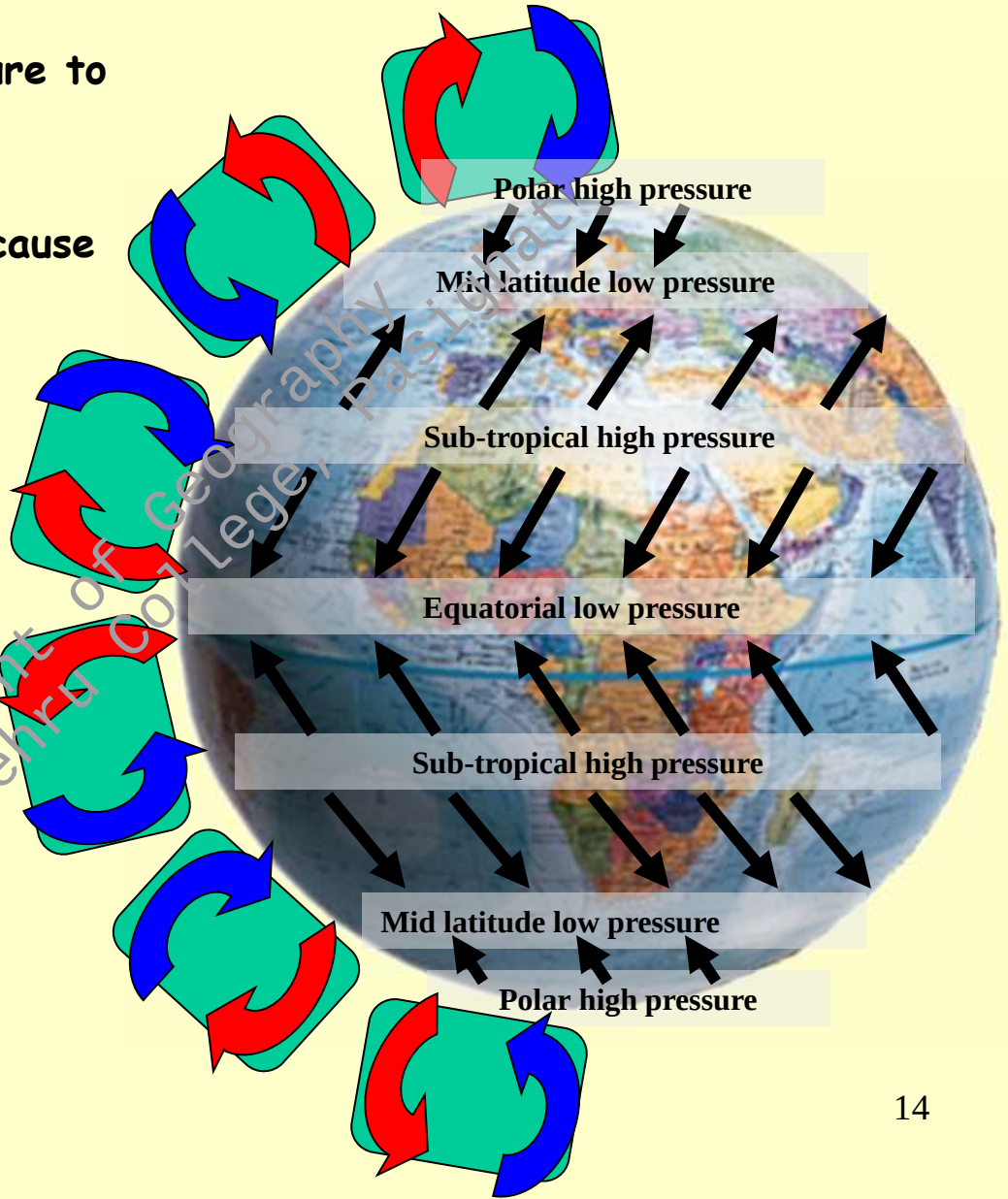
Winds always blow from high pressure to low pressure.

They are deflected because of the Coriolis Force which come about because of the rotation of the earth.

Winds in Northern Hemisphere are deflected to the right.

Winds in the southern hemisphere are deflected to the left.

These wind belts shift seasonally. (See next section)



THE ATMOSPHERE

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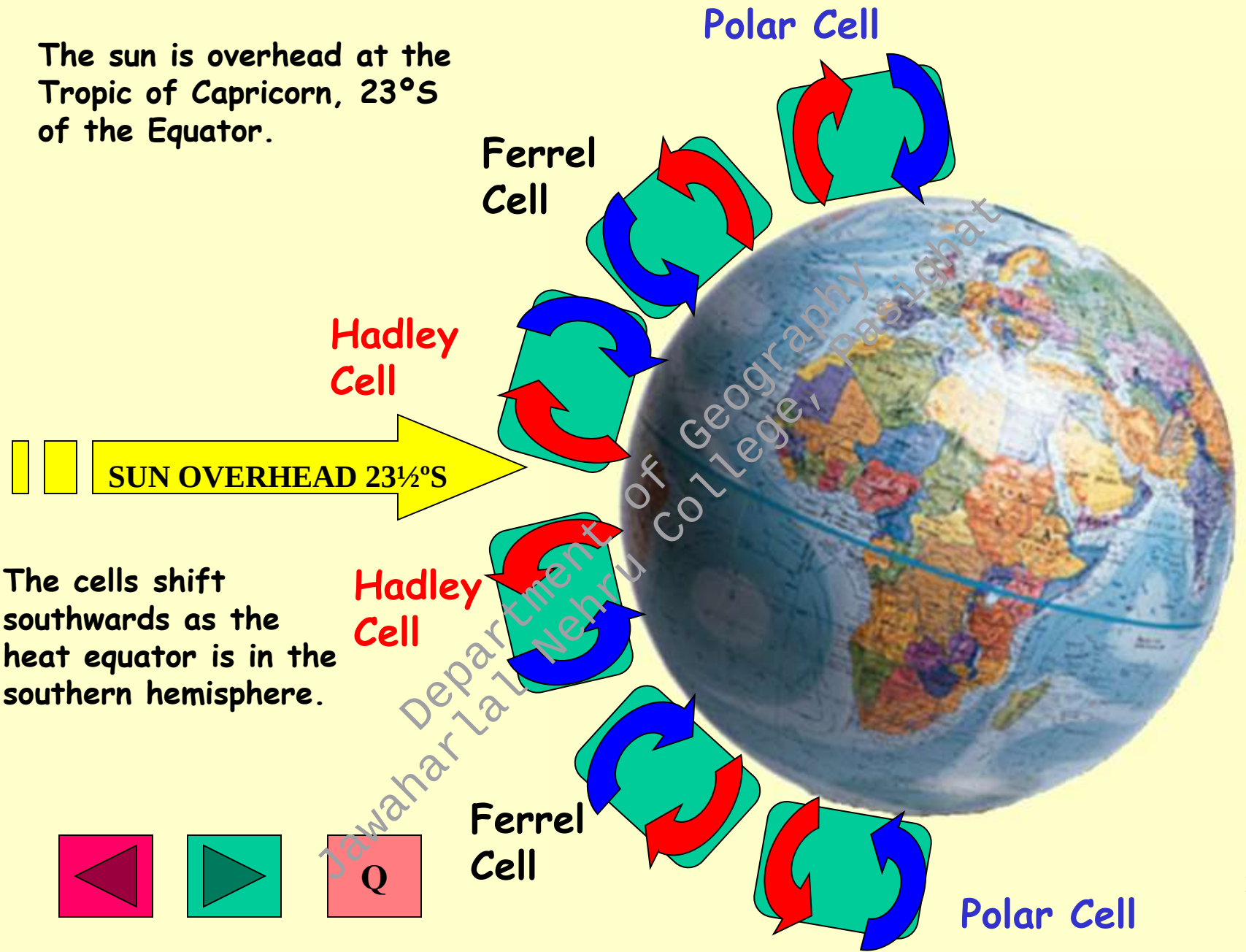
POSITION OF THE THREE CELLS IN DECEMBER

The sun is overhead at the Tropic of Capricorn, 23°S of the Equator.



The cells shift southwards as the heat equator is in the southern hemisphere.

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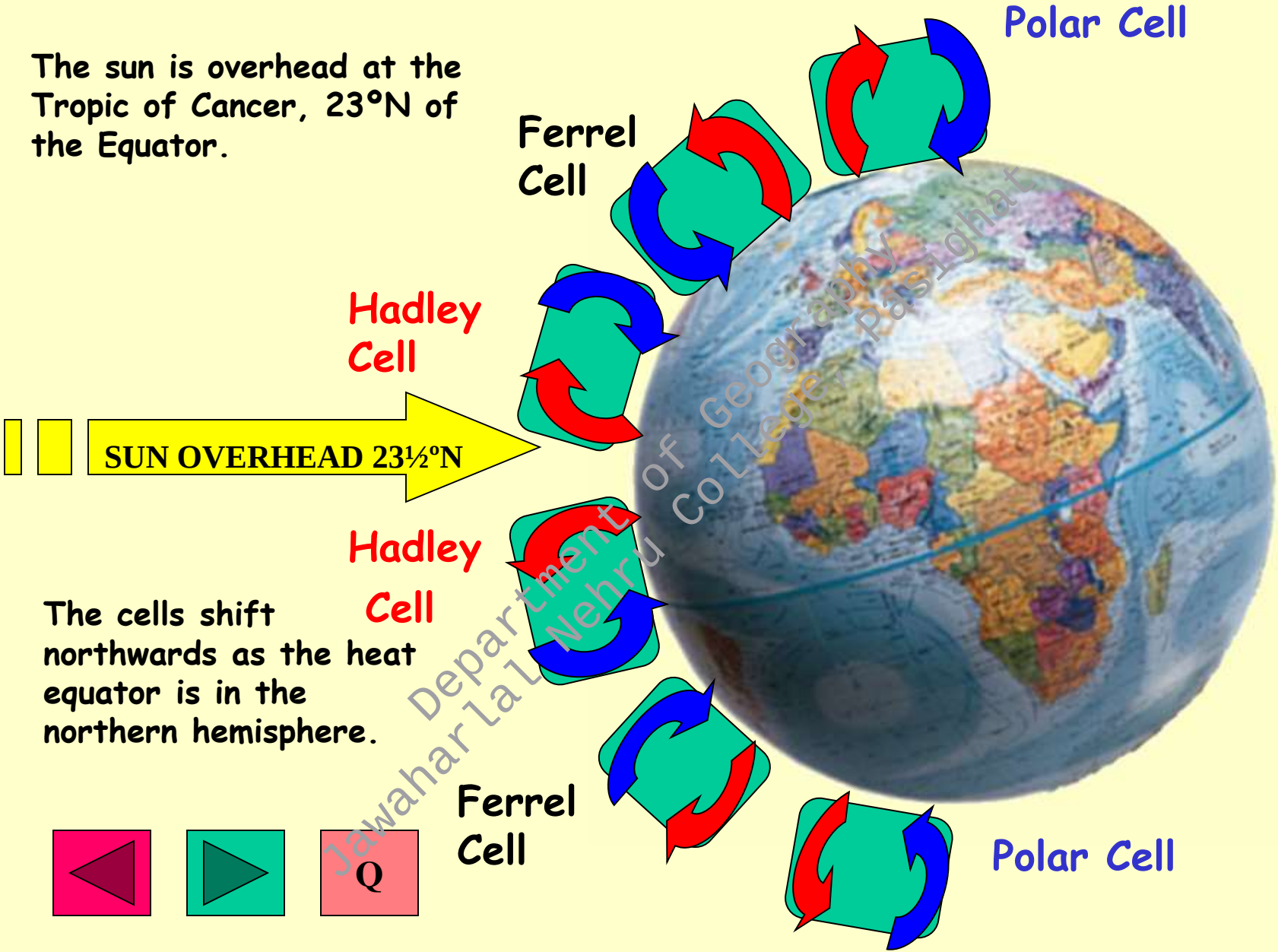
POSITION OF THE THREE CELLS IN JUNE

The sun is overhead at the Tropic of Cancer, 23°N of the Equator.



The cells shift northwards as the heat equator is in the northern hemisphere.

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THE INTER-TROPICAL CONVERGENCE ZONE

IN THE NORTHERN HEMISPHERE:

The winds that blow to the equatorial low pressure belt are called the North East Trade Winds

IN THE SOUTHERN HEMISPHERE:

The winds that blow to the equatorial low pressure belt are called the South East Trade Winds

The line along which they converge (meet) is called the INTER-TROPICAL CONVERGENCE ZONE.

This is often abbreviated to ITCZ

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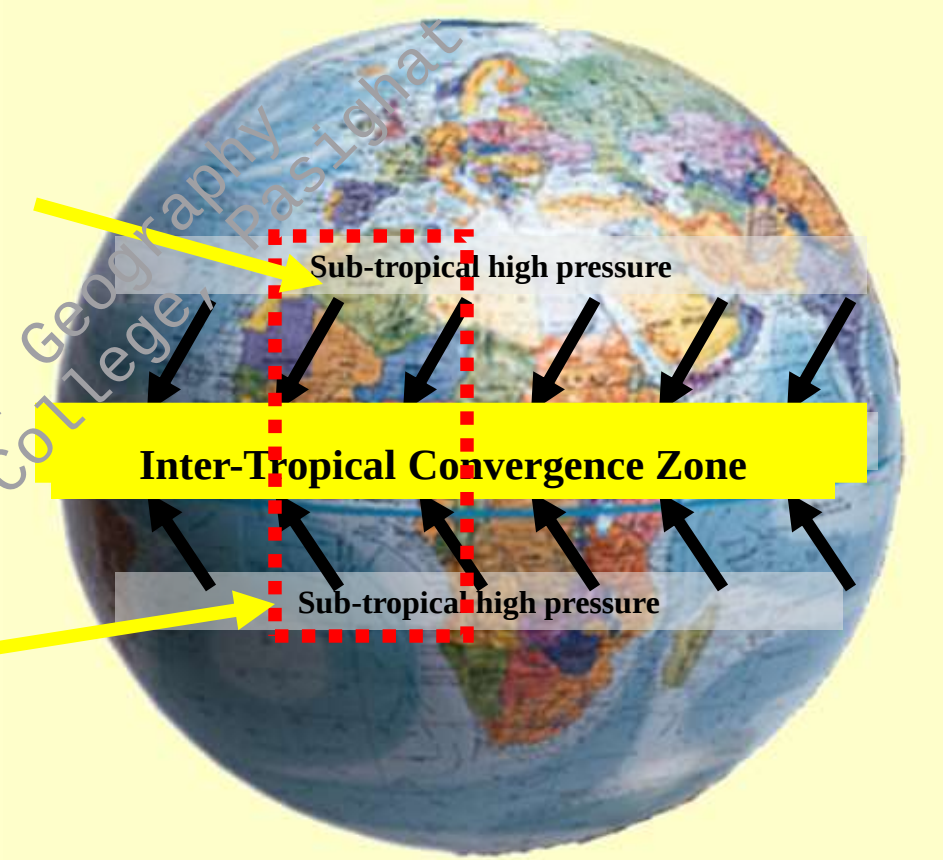
THE INTER-TROPICAL CONVERGENCE ZONE

IN THE NORTHERN HEMISPHERE

OVER WEST AFRICA

The sub-tropical high pressure belt develops over the Sahara so is hot and dry.

This is known as continental Tropical (cT) air.



IN THE SOUTHERN HEMISPHERE

OVER WEST AFRICA

The sub-tropical high pressure belt develops over the Atlantic so is warm and moist.

This is known at maritime Tropical (mT) air.

THE ITCZ IN DECEMBER

In December, the zone of maximum insolation (solar energy) is south of the Equator. This means that the wind belts shift southwards.

This means that winds blow out of the sub-tropical high pressure area over the Sahara, and take dry air from the continental Tropical (cT) air mass across most of West Africa. This causes a dry season.

Moist air from the maritime Tropical (mT) air mass from the Atlantic cannot reach far inland, where there is a dry season.

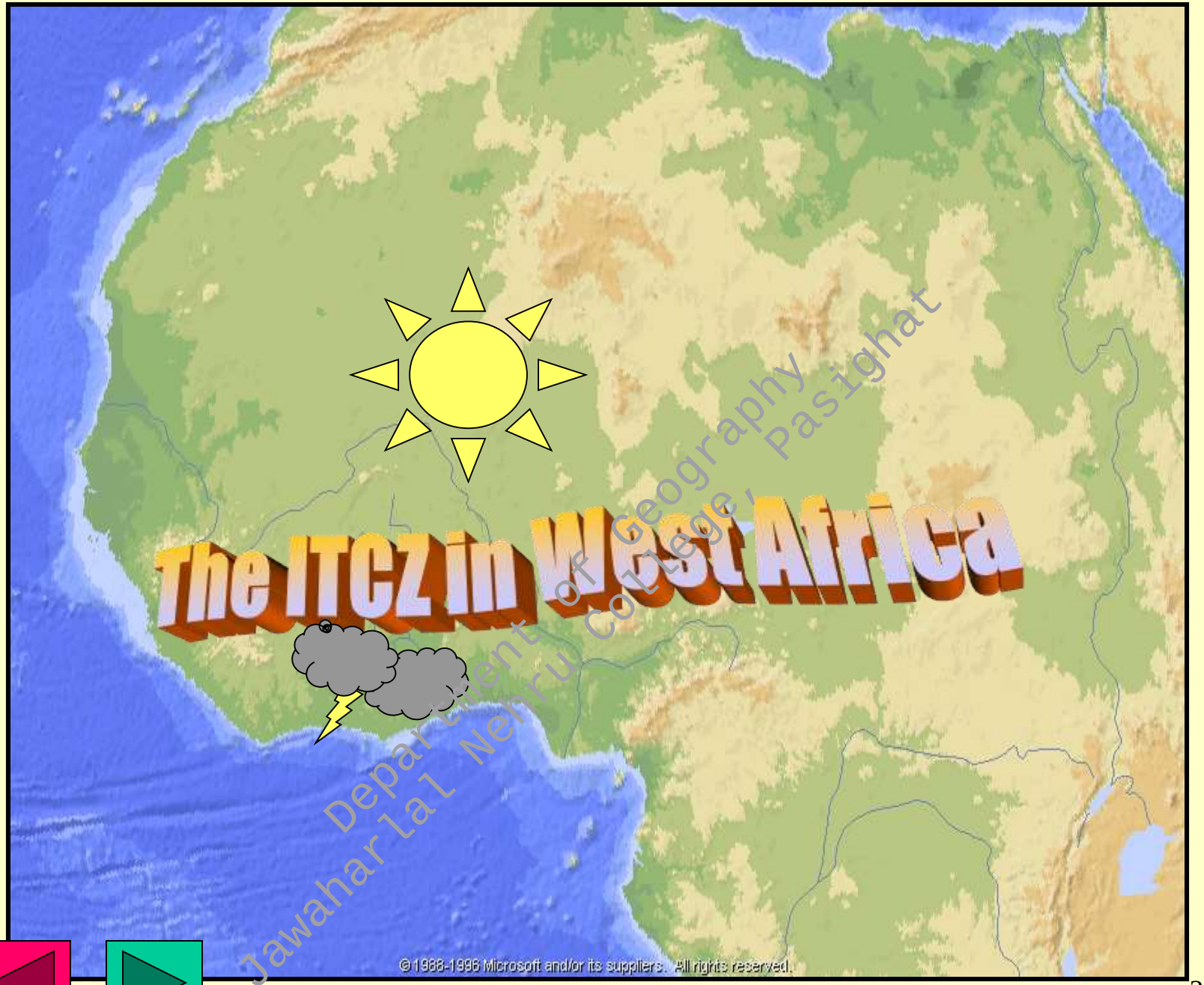
THE ITCZ IN JUNE

By contrast, in June, the zone of maximum insolation is well to the north of the Equator. This means that the wind belts shift northwards.

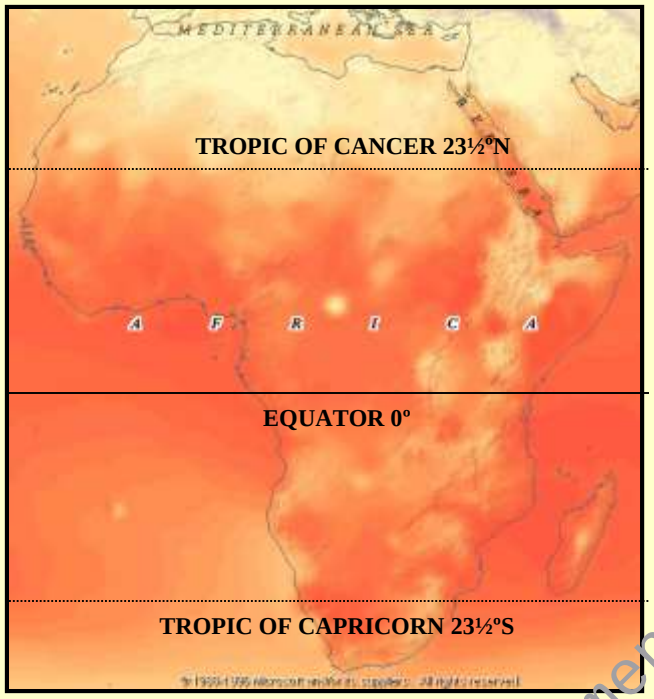
SOLAR ENERGY

Moist maritime Tropical air from the Atlantic now reaches far inland, where there is a rainy season. These winds flow northwards to the ITCZ to replace air that has become unstable and risen.

The winds blow out of the sub-tropical high pressure area over the Sahara, now only affect the northern part of sub-Saharan Africa.

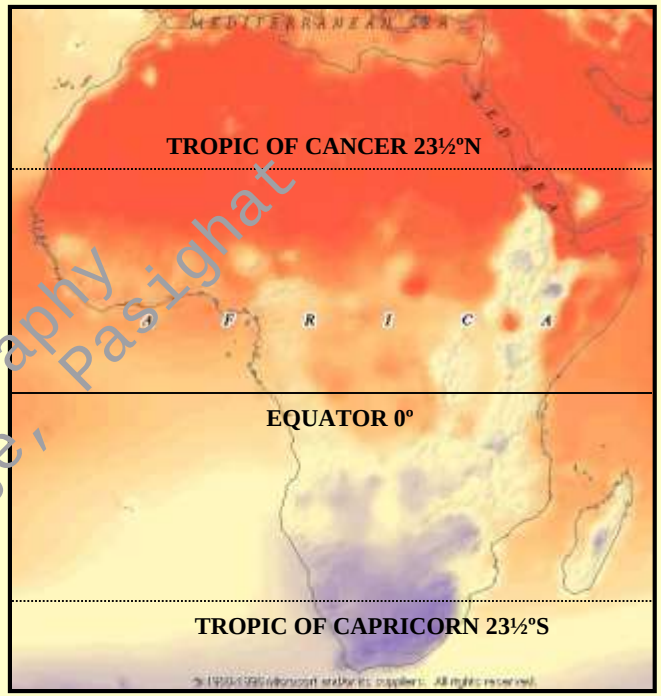


THE EFFECT OF THE SUN'S MIGRATION ON SEASONAL TEMPERATURES AFRICA



AFRICA – TEMPERATURES IN JANUARY

Because the sun is overhead in the southern hemisphere, it is the south that is hottest, (shown by the red areas). The Sahara stands out as a cooler, (lighter coloured), area.



AFRICA – TEMPERATURES IN JULY

In July, with the sun overhead north of the Equator, the Sahara is clearly much hotter than the rest of the continent.

POSITION OF THE ITCZ IN DECEMBER

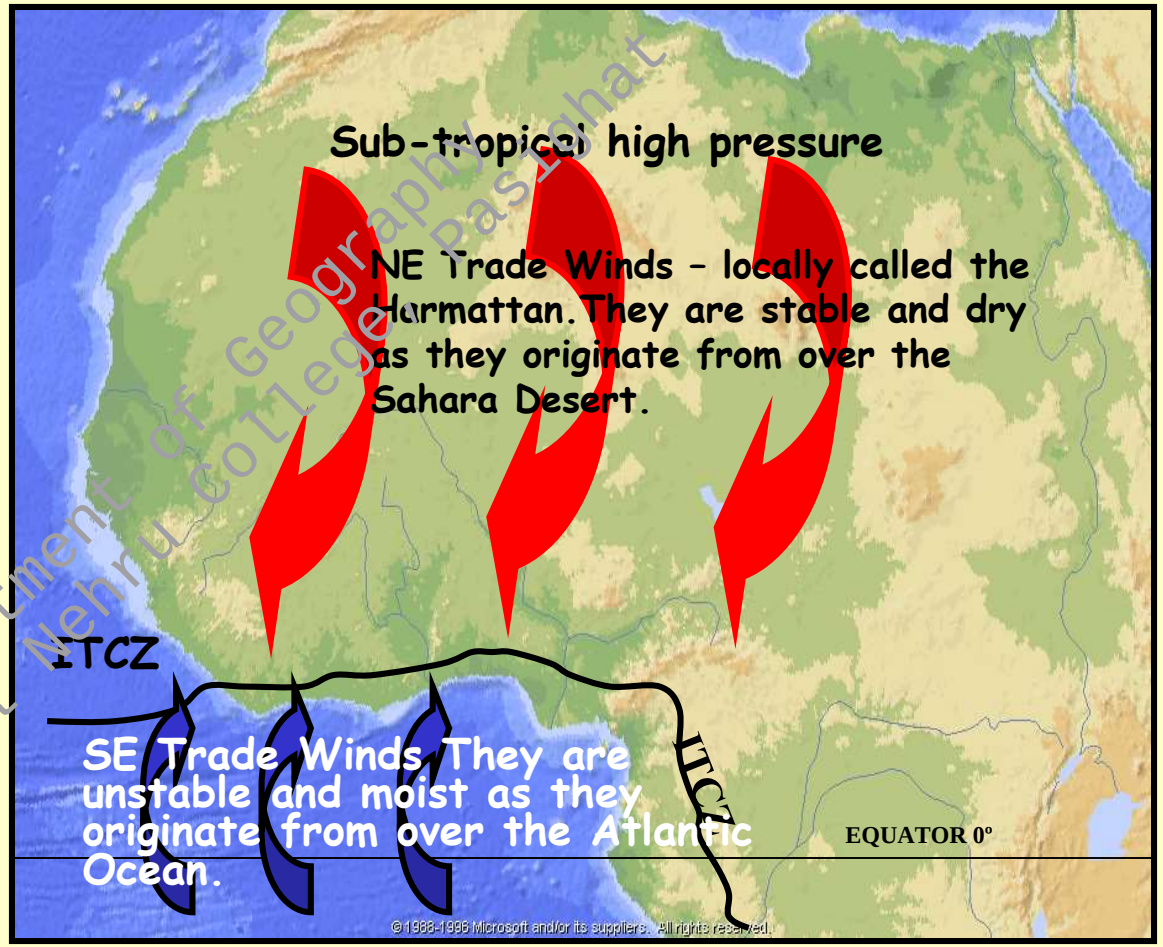
In December the sun is overhead in the southern hemisphere.

The ITCZ is found to the south, where there is maximum insolation.

The sea stays a fairly constant temperature, so the ITCZ runs just along the coast in WAfrica.

Only the coastal fringe receives rain from the unstable mT air at this time of year

Further north, the area is under the influence of the Harmattan, (stable, dry cT air blowing out of the Saharan high pressure area).



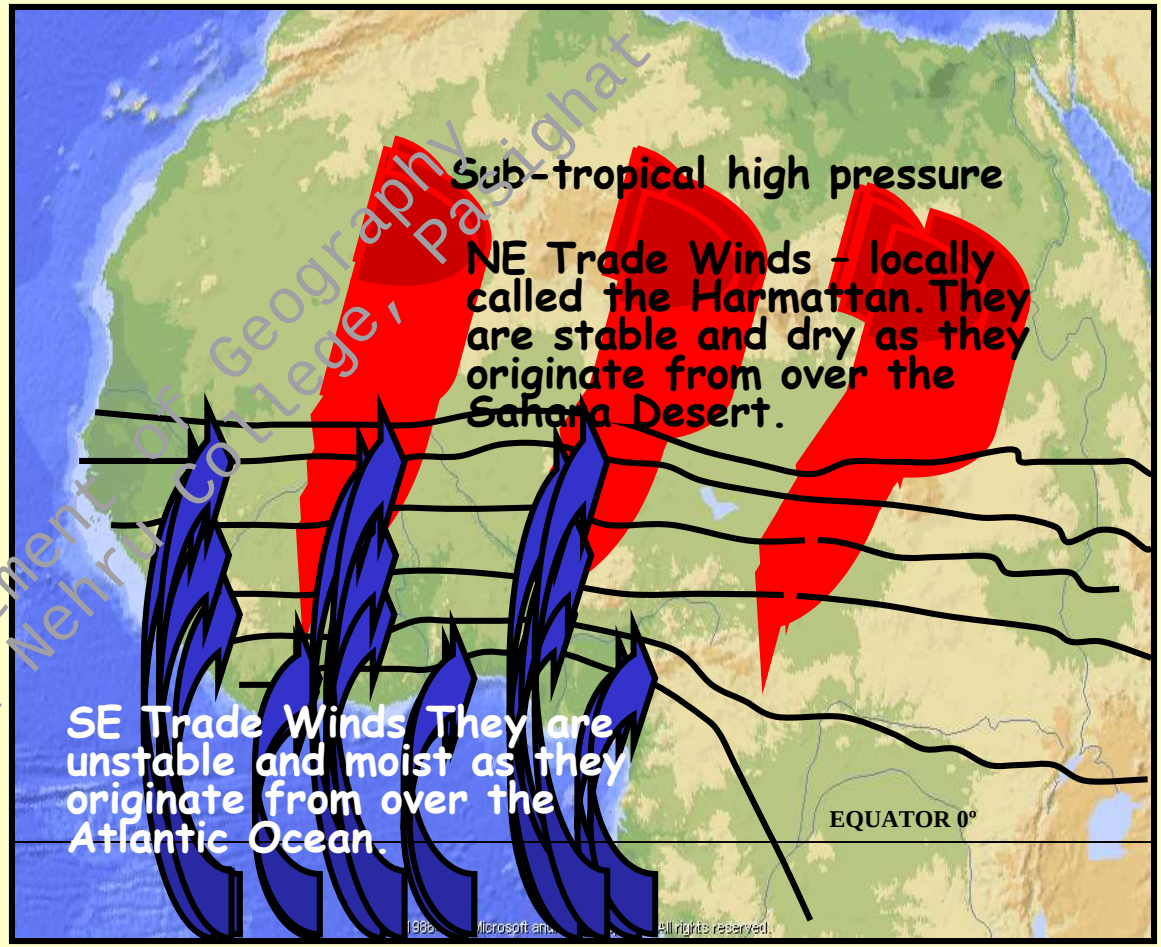
Click here to find out about stable air

Click here to find out about unstable air

MIGRATION OF THE ITCZ FROM DECEMBER TO JUNE

Between December and June, progress through the Earth's orbit causes the sun to migrate northwards.

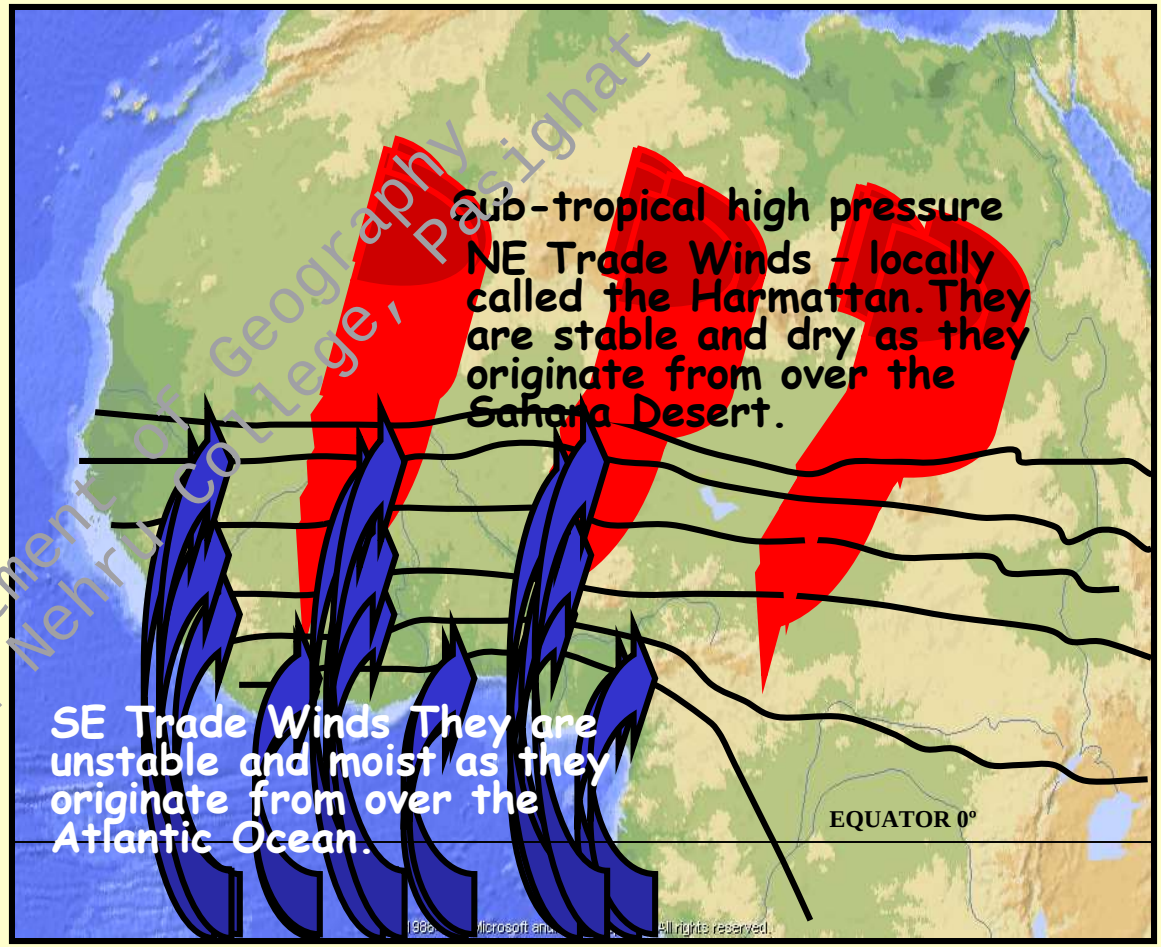
As it does so, the ITCZ also moves further north, allowing moist mT air to reach progressively further inland, brining the rainy season to West Africa.



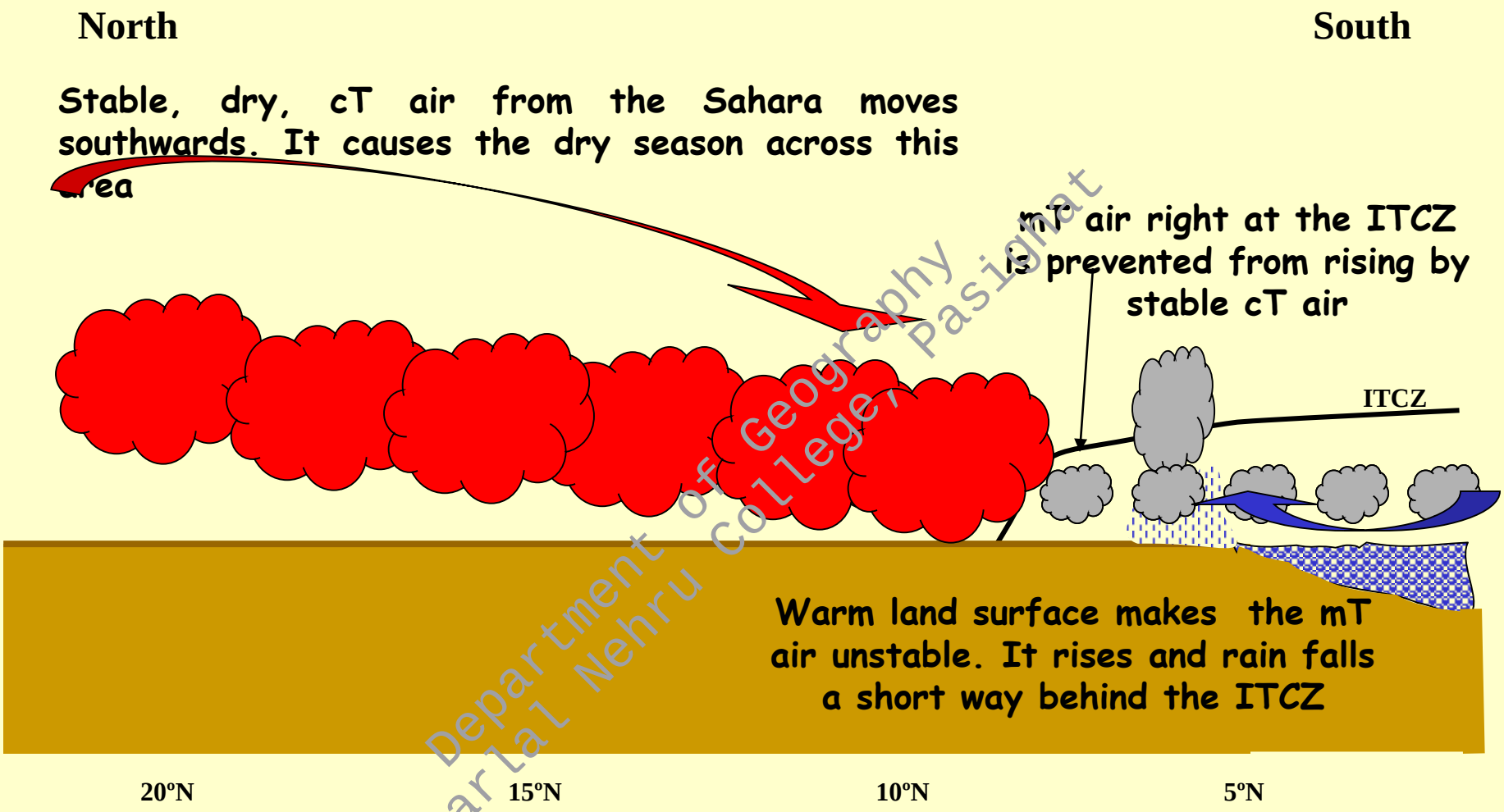
MIGRATION OF THE ITCZ FROM JUNE TO DECEMBER

By late June, the sun begins to migrate southwards, and so does the ITCZ, following the zone of maximum insolation.

As the ITCZ moves further south, the Harmattan carries dry, stable cT air further south, bringing the dry season across more and more of West Africa.

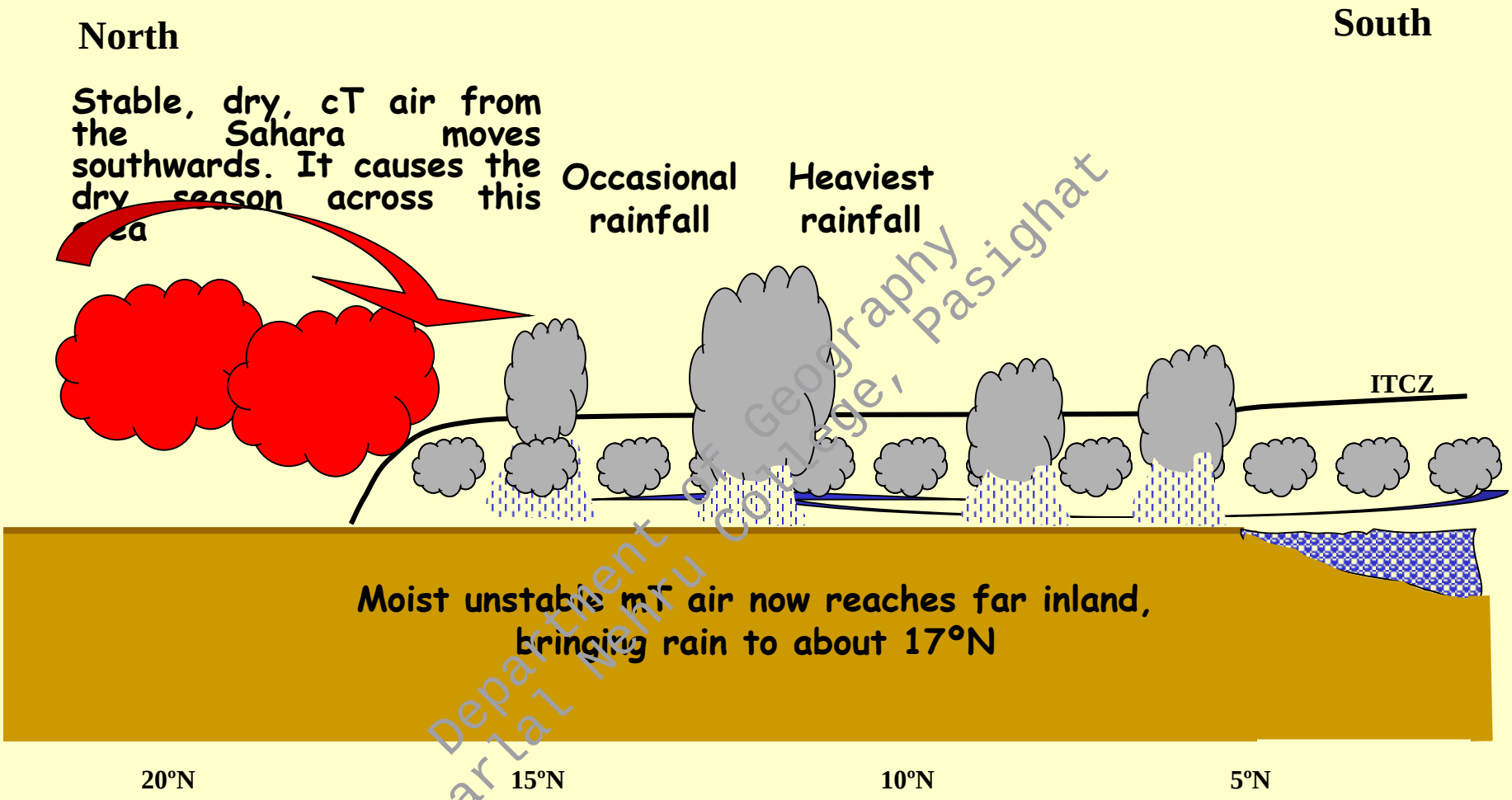


THE ITCZ AND PRECIPITATION IN WINTER



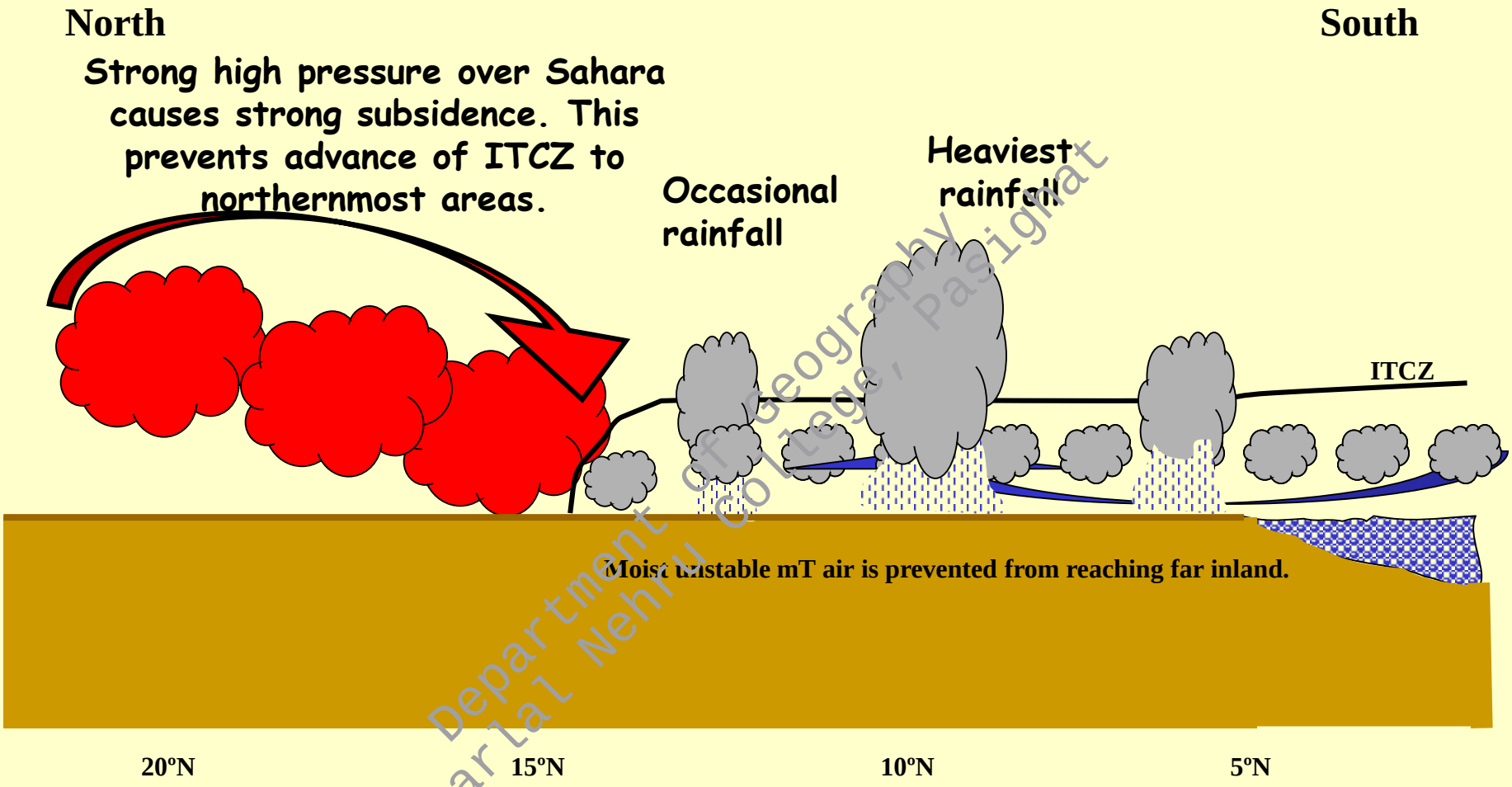
Based on a diagram from "Core Themes in Geography", by Broadley & Cunningham

THE ITCZ AND PRECIPITATION IN SUMMER



Based on a diagram from "Core Themes in Geography", by Broadley & Cunningham

THE ITCZ AND PRECIPITATION IN A SUMMER DROUGHT



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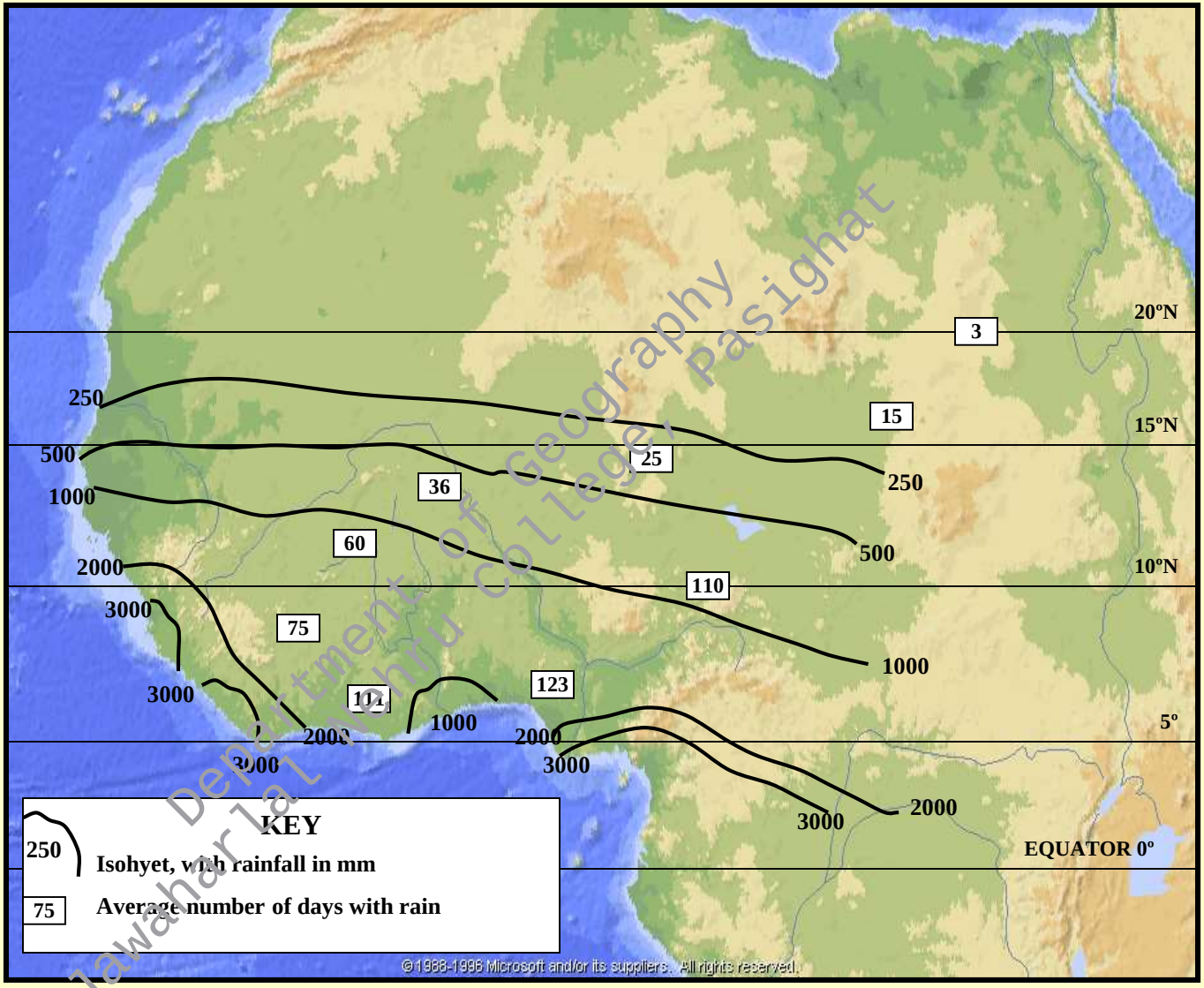
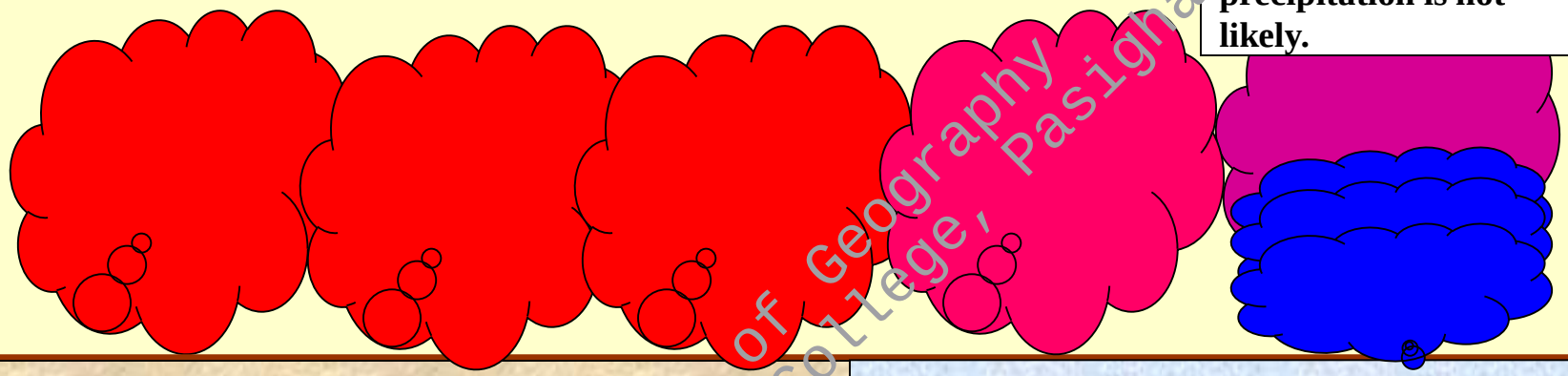
RAINFALL IN WEST AFRICA



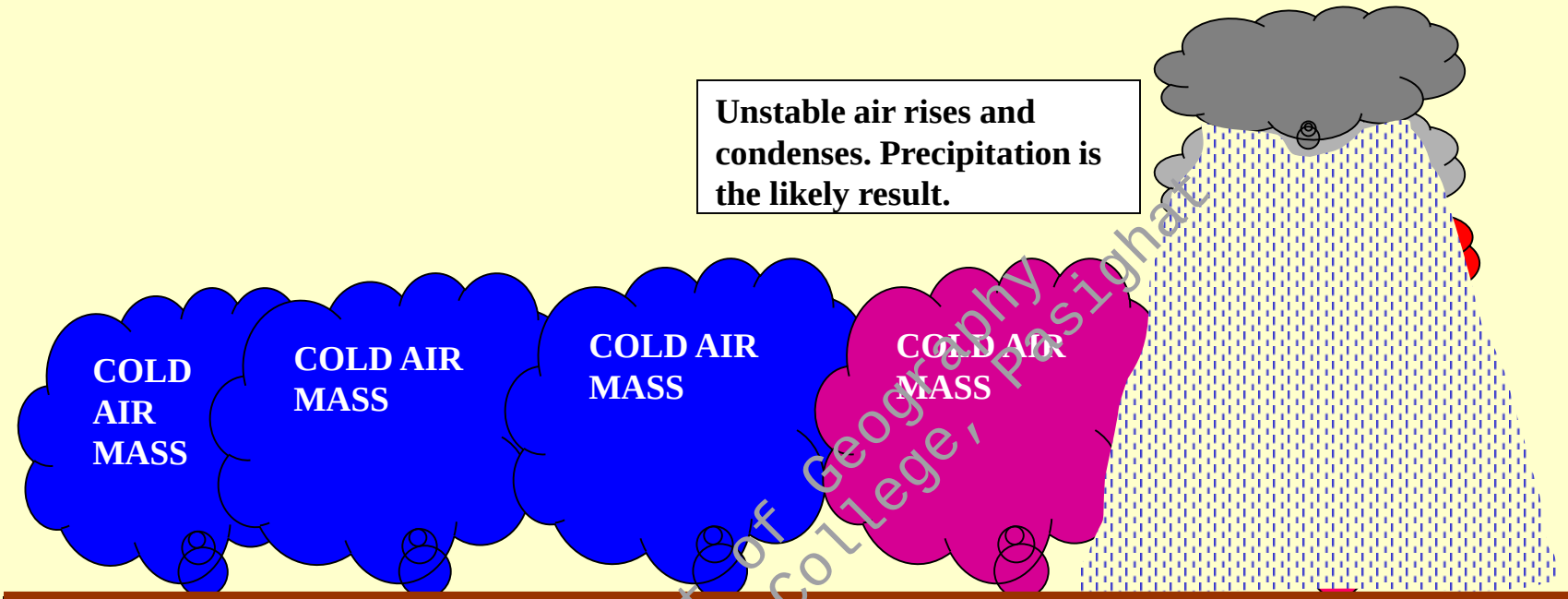
THE FORMATION OF A STABLE AIRMASS



Because no air rises, precipitation is not likely.

WARM SURFACE	COLD SURFACE
A large volume of air develops uniform characteristics of high temperature and humidity.	**The lower layers of the air mass are chilled. They are dense and are not likely to rise.**
This creates a warm air mass	**This air is *stable*.**

THE FORMATION OF AN UNSTABLE AIRMASS



COLD SURFACE

A large volume of air develops uniform characteristics of low temperature and humidity over a cold surface.

This creates a cold air mass.

WARM SURFACE

The lower layers of the air mass are heated and begin to rise. As the air rises, it cools, and any water vapour condenses, giving the potential for precipitation.

This air is *unstable*.

THE THREE CELL MODEL

Describe, in detail, what happens as a result of insolation at the Equator.

What energy is being transferred from where to where?

What is the name of this cell?

A

THE THREE CELL MODEL

Describe, in detail, what happens at the poles.

What is being transferred from where to where?

What is the name of this cell?

A

THE THREE CELL MODEL

Explain how energy is transferred between 30°N or S and 60°N or S.

What is the name of this cell?

A

THE TRANSFER OF HEAT ENERGY

Explain how heat energy is transferred from the zones of surplus to zones of deficit.

SOLAR ENERGY

A

ASSOCIATED PRESSURE BELTS

Describe and explain the pressure belts associated with these cells.

ASSOCIATED SURFACE WIND PATTERNS

From what pressure (high or low) to what pressure does wind blow ?

How and why are winds deflected in the northern hemisphere?

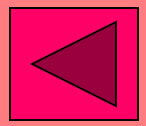
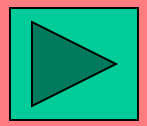
How are winds deflected in the southern hemisphere?

Make a quick sketch of the surface winds

POSITION OF THE THREE CELLS IN DECEMBER

Where is the sun overhead in December?

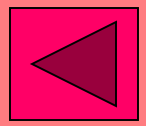
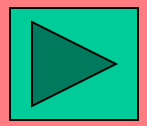
What effect does this have on the cells and pressure belts?


POSITION OF THE THREE CELLS IN JUNE

Where is the sun is overhead in June?

What effect does this have on the cells and pressure belts?

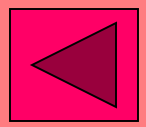
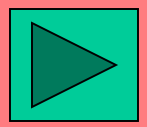

IN THE NORTHERN HEMISPHERE:

What is the name of the winds which blow to the Equator?

IN THE SOUTHERN HEMISPHERE:

What is the name of the winds which blow to the Equator?

What is the full name of where these winds meet?


THE INTER-TROPICAL CONVERGENCE ZONE

What are the characteristics and name of the air mass that develops over the Sahara?

What are the characteristics and name of the air mass that develops over the S. Atlantic?

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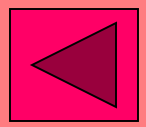
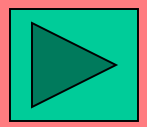
THE ITCZ IN DECEMBER

Which air mass influences most of W.Africa in December?

What conditions does this bring?

What influence does the other air mass have over West Africa?


THE ITCZ IN JUNE

Where is the zone of maximum insolation in June ?

Which air mass has an influence over West Africa ?

What conditions does this cause ?