DP IB Environmental Systems & Societies (ESS): HL

Your notes

2.4 Climate & Biomes

Contents

Your notes

Weather & Climate

What is the difference between weather and climate?

- Weather refers to the **current state** of the atmosphere at a **specific time and place**
- Weather conditions can **change rapidly** (e.g. over just a few hours)
- This includes **short-term** variations in:
  - Temperature
  - Humidity
  - Cloud cover
  - Precipitation
  - Wind speed
  - Air pressure
  - Other atmospheric conditions
- Climate refers to the **long-term** average of weather conditions in a particular region or location
  - It describes the **overall** patterns, trends and variations in atmospheric factors (temperature, humidity etc.) over relatively long time periods
    - Climate is the average of these conditions over approximately **30 years or more**
  - Climate is influenced by various factors such as solar radiation, atmospheric circulation patterns, ocean currents, land features and greenhouse gas concentrations
- Climate provides a broader perspective on long-term **atmospheric behaviour**
- Whereas, weather is more concerned with immediate atmospheric conditions and forecasts
- Understanding the difference between climate and weather is crucial for:
  - Analysing long-term climate trends
  - Predicting short-term weather events
  - Assessing the impacts of climate change on weather patterns

Biomes

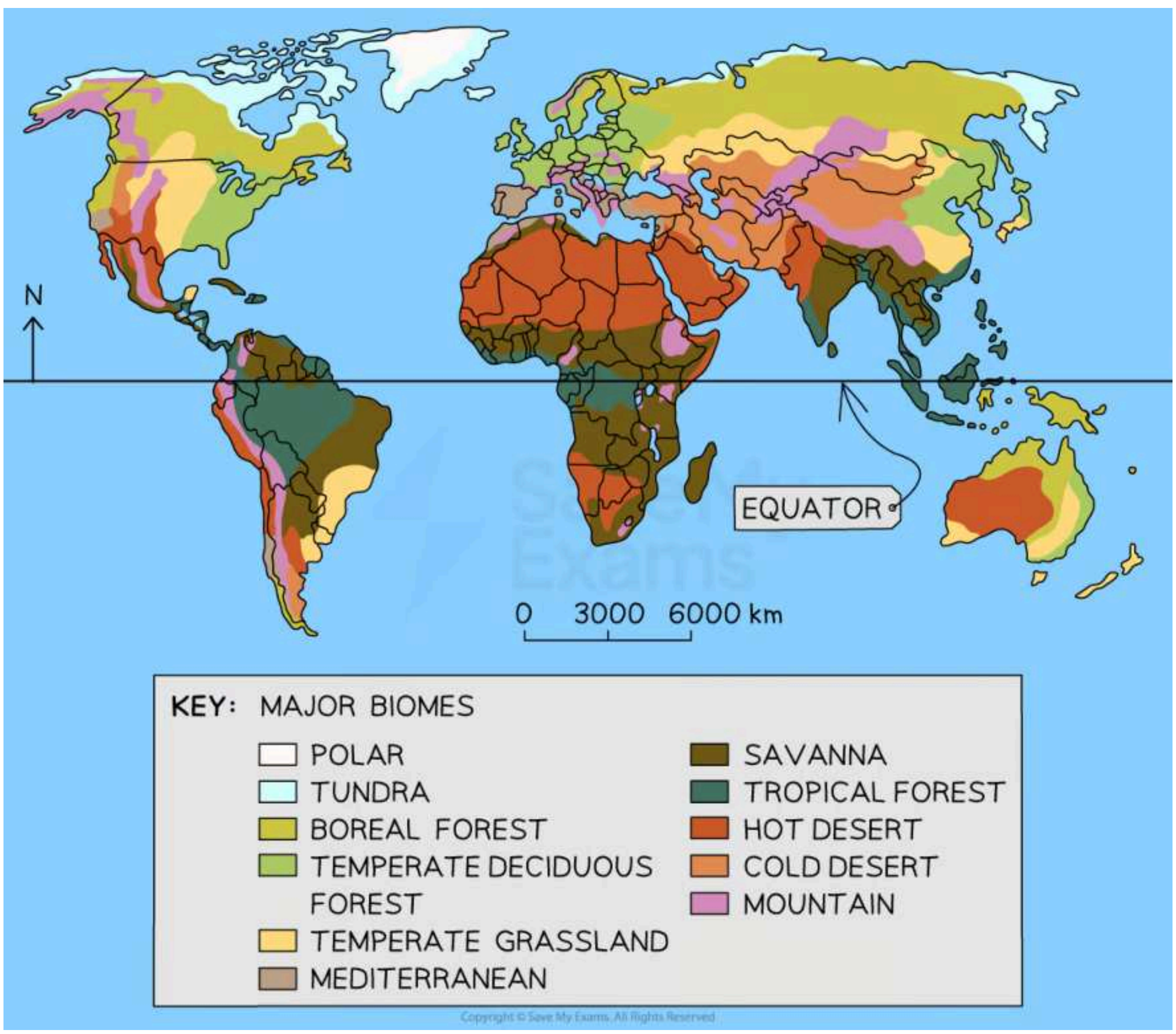
Your notes

Introduction to Biomes

What are biomes?

- A biome is a group of similar ecosystems that have developed in similar climatic conditions
  - Biomes are large-scale ecological communities or ecosystem types
  - They are characterised by their dominant vegetation, climate and other abiotic factors
  - These factors shape their biotic communities
- Biomes cover **large geographic areas**
  - Multiple ecosystems can be found within a single biome
- Biomes can be categorised into groups including:
  - **Freshwater** biomes
  - **Marine** biomes
  - **Forest** biomes
  - **Grassland** biomes
  - **Desert** biomes
  - **Tundra** biomes
- Each of these groups has characteristic abiotic limiting factors, productivity and biodiversity
- These groups can be divided into further categories, for example:
  - Forest biomes are dominated by trees and can be further divided into:
    - **Tropical rainforests**
    - **Temperate forests**
    - **Boreal forests**
  - Grassland biomes are characterised by grasses and herbaceous plants and can be further divided into:
    - **Savannas**
    - **Temperate grasslands**

- Desert biomes are characterised by low rainfall and are dominated by cacti and other drought-resistant plants—they can be further divided into:
  - **Hot deserts**
  - **Cold deserts**
  - **Coastal deserts**
  - **Semi-arid deserts**
- Tundra biomes are found in high latitudes and are characterised by low temperatures and permafrost—they can be further divided:
  - **Arctic tundra**
  - **Alpine tundra**



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Biomes of the world

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- Each biome has characteristic **limiting factors** that affect **productivity** and **biodiversity**
  - For example, in the desert biome, **water** is the limiting factor for plant growth, while in the tundra biome, **low temperatures** and **permafrost** limit plant growth

Forest biomes

Forest Biomes

Characteristics	Tropical rainforest	Temperate forest	Boreal forest
Location	Low **latitudes** Within Tropics: 23.5° north and south of equator E.g. Amazon in South America, New Guinea, Southeast Asia, Zaire Basin	Between 40°–60° north and south of equator E.g. Western Europe, northeast USA, Eastern Asia	Between 50°–60° north and south of equator E.g. Canada, Russia, Scandinavia
Annual precipitation	Over 2000 mm	750–1500 mm (all year round)	300–900 mm (all year round)
Temperature range	26 to 28°C	Over 0° C in winter 20 to 25°C in summer	-30°C in winter Up to 20°C in summer
Seasons	No seasons: hot and wet all year round	Four seasons of equal length	Two main seasons: winter and summer
Growing season	All year round	6–8 months	2–3 months
Soils	Relatively infertile due to leaching and rapid uptake of nutrients by plants	Relatively fertile and nutrient rich due to decomposition of organic matter over autumn and winter	Not very fertile: often acidic, with permafrost Shallow soil with a thick litter layer due to slow decomposition

Biodiversity	Approx. 50% of world's plant and animal species live within the rainforest biome Example **flora**: mahogany, teak trees, lianas, orchids Example **fauna**: Toucans, jaguars, frogs, snakes	Wide range of animals and plants with higher biodiversity than boreal forests Example flora: deciduous trees e.g. beech, oak, birch Example fauna: deer, rabbits, squirrels, bears	Less biodiverse than temperate forests Example flora: coniferous trees Example fauna: squirrels, bears, reindeer, wolves

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Grassland biomes

Grassland Biomes

Characteristics	Savanna	Temperate grasslands
Location	5°–30° north and south of equator North and south of tropical and monsoon forest biomes E.g. central Africa: Tanzania, Kenya	40°–60° north and south of equator E.g." veldts" of South Africa, "pampas" of Argentina, "steppes" of Russia, "plains" of USA
Annual precipitation	800–900 mm	250–750 mm
Temperature range	15–35°C	-40 to 40°C
Seasons	Wet and dry season	Four seasons
Growing season	During wet season (4–5 months)	During summer (dependent on temperature)

Soils	Free draining with thin layer of humus Not very fertile: most nutrients near the surface	Fertile soil
Biodiversity	Wide range of plant and animal species Greatest diversity of hoofed animals Grasses, baobab and acacia trees Zebras, elephants, giraffes	Large numbers of plant and animal species Grasses, sunflowers Bison, antelopes, rabbits

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Desert biomes

Desert Biomes

Characteristics	**Hot desert**
Location	15°–30° north and south of equator North Africa e.g. Sahara, Southern Africa e.g. Kalahari and Namib, Australia, Middle East
Annual precipitation	Below 250 mm
Temperature range	Daytime temperatures can reach 50°C but average around 25°C Night time temperatures below 0°C
Seasons	Summer and winter
Growing season	All year round
Soils	Infertile, dry

Biodiversity	Low biodiversity Cacti, yucca Spiders, scorpions, camels, meerkats

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Tundra biomes

Tundra Biomes

Characteristics	**Tundra**
Location	North of the Arctic Circle and Antarctica
Annual precipitation	Less than 250 mm
Temperature range	Below 0°C for 6–10 months
Seasons	Winter and summer
Growing season	6–10 weeks
Soils	Thin infertile soil Permafrost
Biodiversity	Low biodiversity Small grasses, mosses, lichen Snowy owls, snow bunting, tundra swan Arctic foxes, hares and wolves Polar bears, musk ox and caribou

The distribution of biomes

- Insolation, precipitation and temperature are the main factors that determine where a biomes is located on Earth
  - Insolation refers to the amount of solar radiation that reaches the Earth's surface

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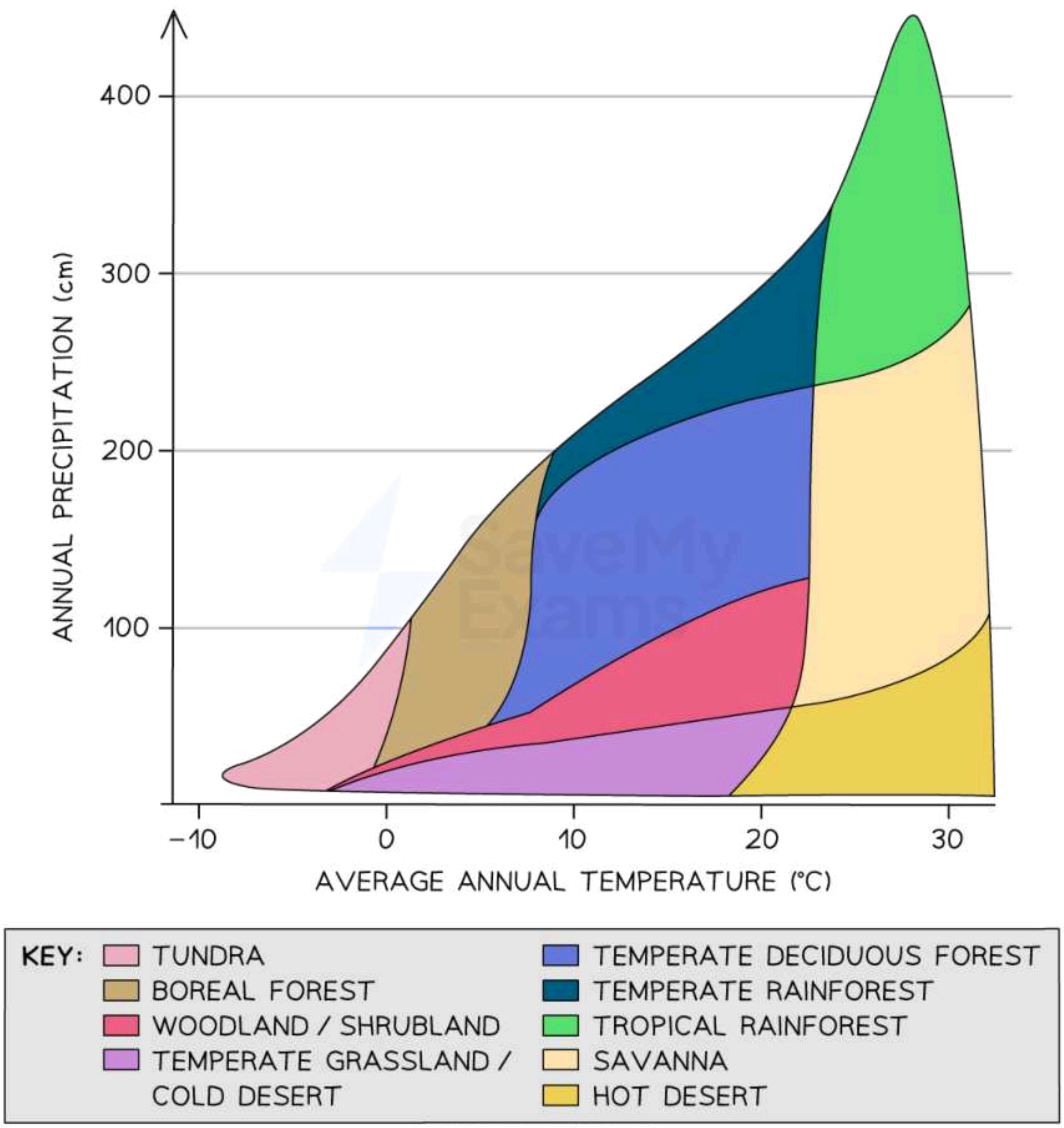
- This affects temperature and the rate of photosynthesis in plants
- Precipitation affects the availability of water
    - This is a key limiting factor for many biomes
- Temperature determines the rate of photosynthesis and respiration in plants
    - It also affects the metabolic rates of animals
- The combination of temperature and precipitation determines the distribution of biomes around the world



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Precipitation and temperature are the two most important climatic variables that determine the type of biome in a particular location

Effect of Global Warming on Biomes

- As the global climate changes, the distribution of biomes is **shifting**
  - This is leading to significant impacts on ecosystems and the services they provide
  - As climate conditions change, the boundaries of different biomes are moving
  - This is also causing changes in the plant and animal species that live there
- Biome shifts can occur in two ways:
  - **Range shifts**—when species move to new areas to find suitable conditions as their current habitats become less hospitable
  - **Biome type changes** —when a biome transitions to a different type, such as a forest becoming a savanna or a tundra becoming a forest
- The distribution of biomes is primarily determined by **temperature** and **precipitation**
  - As global temperatures rise due to global warming, the boundaries between biomes are shifting:
    - Poleward
    - Upward in elevation (i.e. to higher altitudes)
- This means that the **warmer biomes**, such as tropical rainforests and savannas, are **expanding**, while the **colder biomes**, such as tundra and boreal forests, are **contracting**
- The impacts of biome shifts are significant and far-reaching:
  - As species move to new areas or experience changes in their habitats, they may face new competition, predation, or disease
  - This can lead to **declines** in population numbers and even **extinction** in some cases
  - Biome shifts can also have impacts on the vital **services** that ecosystems provide to living organisms, especially **humans**, such as water regulation, nutrient cycling, and carbon sequestration

Atmospheric Circulation & Ocean Currents

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Tricellular Model of Atmospheric Circulation

Global atmospheric circulation

- Global atmospheric circulation can be described as the worldwide system of winds that move solar **heat energy** from the **equator** to the **poles** to reach a balance in temperature

Wind formation

- Air always moves from areas of **higher pressure** to **lower pressure** and this movement of air generates **wind**
    - Winds are large scale movements of air due to **differences in air pressure**
    - This pressure difference is because the Sun heats the Earth's surface unevenly
    - **Insolation** that reaches the Earth's surface is greater at the equator than at the poles
        - This is due to the Earth's curvature and the angle of the Earth's tilt

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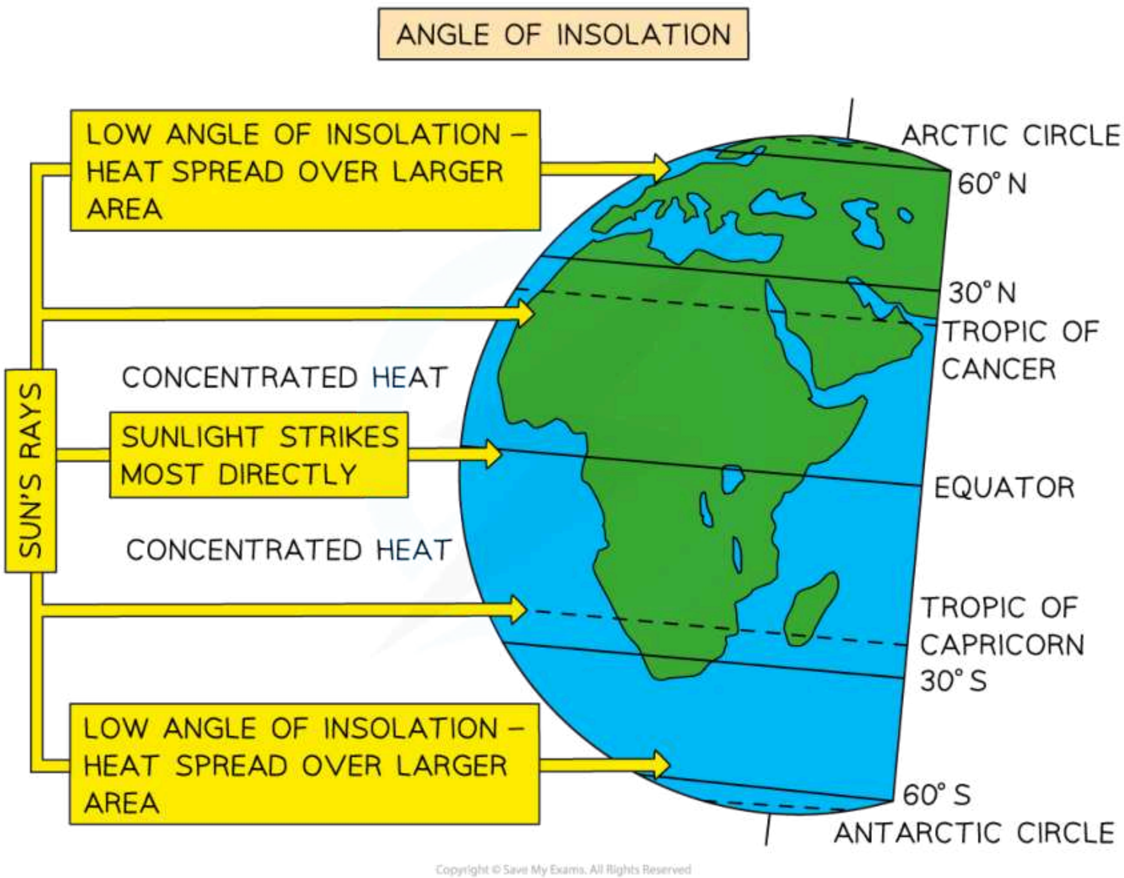

The angle of insolation spreads solar radiation over a wider area at the poles than at the equator

- This **irregular heating** of the Earth's surface creates **pressure cells**
  - In these pressure cells, hot air **rises** and cooler air **sinks** through the process of convection

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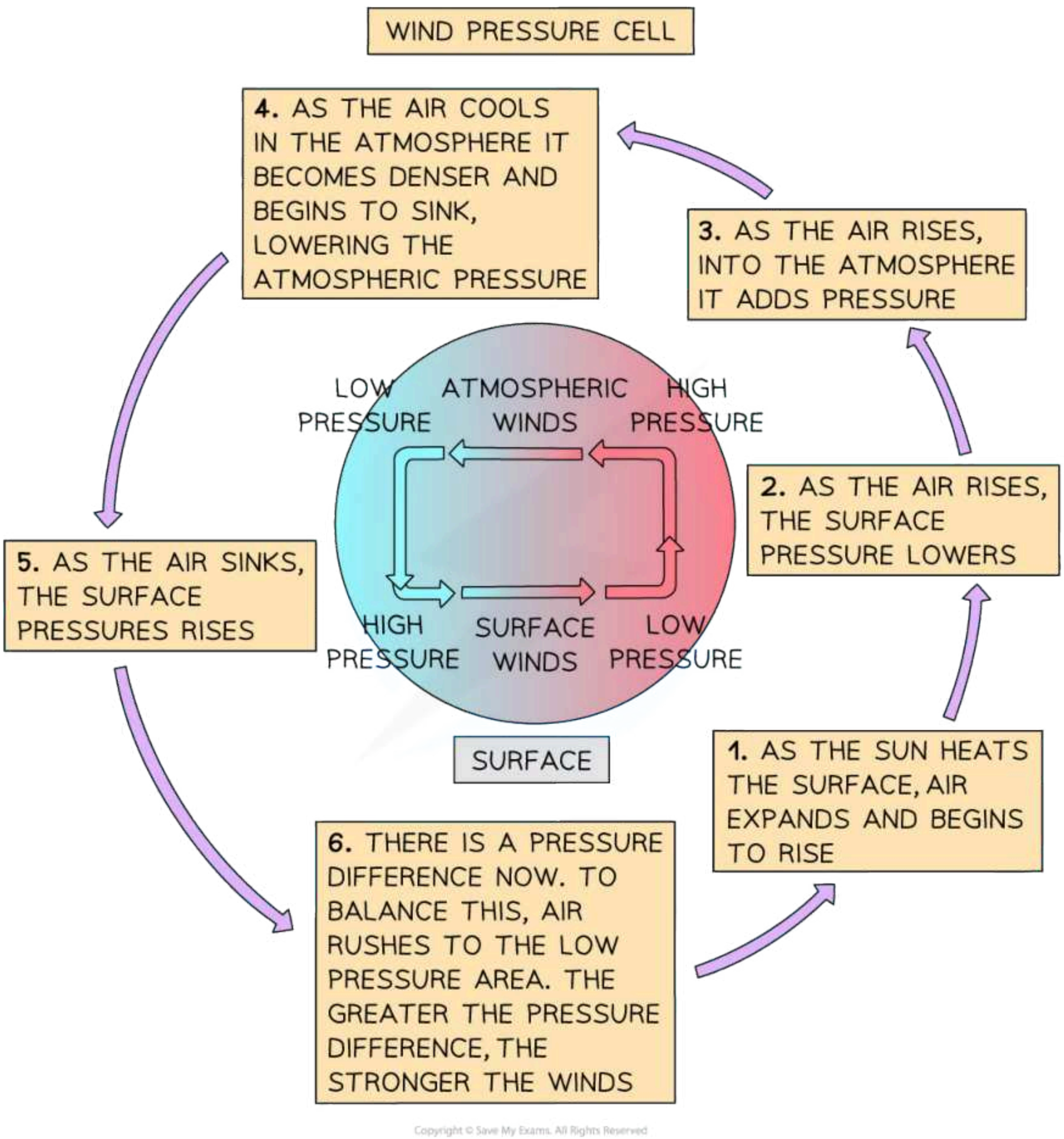

A typical wind pressure cell system showing the distribution of pressure at Earth's surface and upper atmosphere

- Air movement within the cell is **roughly circular** and moves surplus heat from equatorial regions to other parts of the Earth

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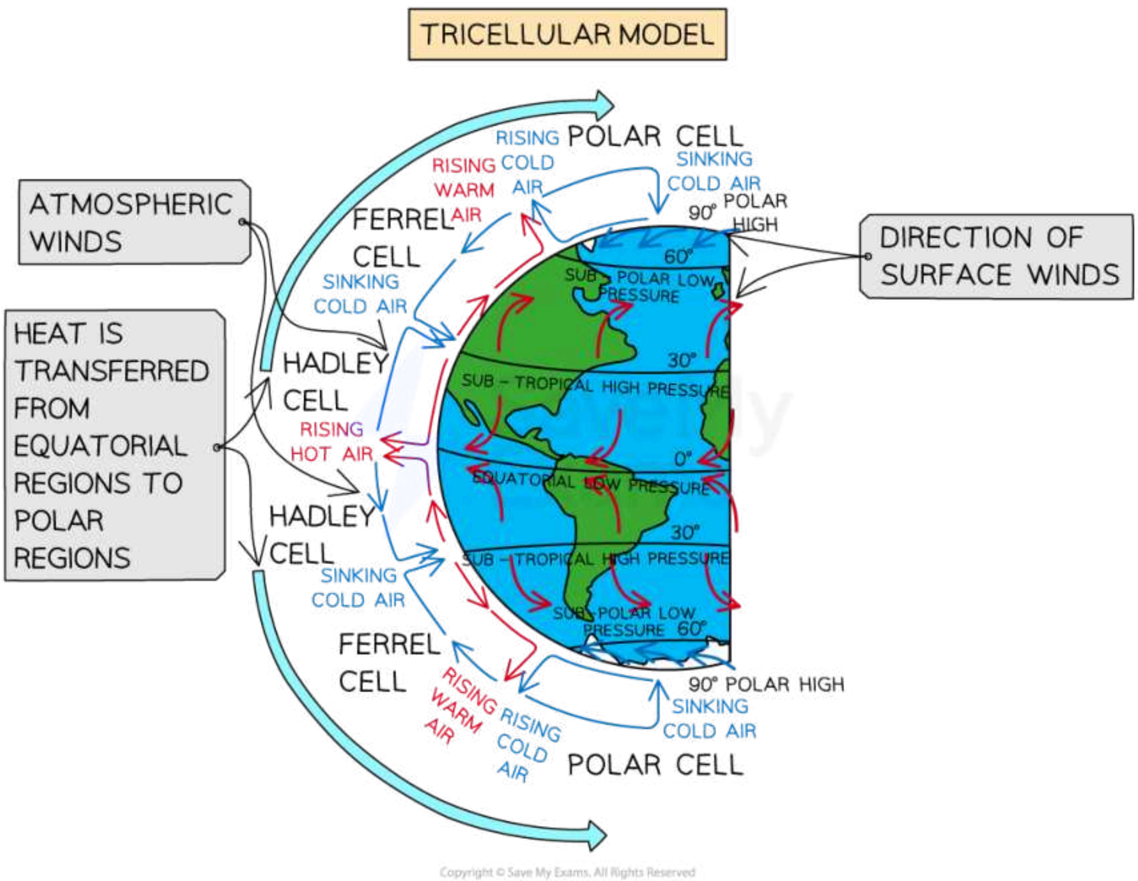
- In both hemispheres (the Northern hemisphere and the Southern hemisphere), heat energy transfer occurs where different atmospheric circulation cells **meet**
  - There are **three** types of cell
  - Each cell generates **different weather patterns**
- These are the **Hadley**, **Ferrel** and **Polar cells**
  - Together, these three cells make up the tricellular model of atmospheric circulation:



Heat energy flow and surface winds can be explained using the tricellular model of atmospheric circulation

The tricellular atmospheric wind model

- **Each hemisphere** has **three cells** (the Hadley cell, Ferrel cell and Polar cell) that circulate air from the surface, through the atmosphere, and back to the Earth's surface again

- The **Hadley cell** is the **largest cell** and extends from the equator to between 30° and 40° north and south
  - Trade winds blow from the tropical regions to the equator and travel in an easterly direction
  - Near the equator, the trade winds meet, and the hot air rises and forms thunderstorms (tropical rainstorms)
  - From the top of these storms, air flows towards higher latitudes, where it becomes cooler and sinks over subtropical regions
  - This brings dry, cloudless air, which is warmed by the Sun as it descends: the climate is warm and dry (hot deserts are usually found here)
- The **Ferrel cell** is the **middle cell**, and generally occurs from the edge of the Hadley cell to between 60° and 70° north and south of the equator
  - This is the most complicated cell as it moves in the opposite direction from the Hadley and Polar cells; similar to a cog in a machine
  - Air in this cell joins the sinking air of the Hadley cell and travels at low heights to mid-latitudes where it rises along the border with the cold air of the Polar cell
  - This occurs around the mid-latitudes and accounts for frequent unsettled weather
- The **Polar cell** is the **smallest** and **weakest** of the atmospheric cells. It extends from the edge of the Ferrel cell to the poles at 90° north and south
  - Air in these cells is cold and sinks creating high pressure over the highest latitudes
  - The cold air flows out towards the lower latitudes at the surface, where it is slightly warmed and rises to return at altitude to the poles

Influence on terrestrial biomes

- The tricellular model influences the distribution of **precipitation** and **temperature** across latitudes
- Near the equator, rising warm air leads to high rainfall and high temperatures
  - This creates **tropical rainforests** and **savannas**
  - Tropical rainforests thrive in regions of high precipitation and warmth within the **Hadley cell**
- Mid-latitudes experience variable weather due to interactions between warm and cold air masses, resulting in temperate climates with moderate precipitation
  - This creates **temperate forests** and **grasslands**
  - These biomes occur in areas within the **Ferrel cell**, with moderate precipitation and temperatures
- High latitudes, influenced by descending cold air, have low temperatures and limited precipitation

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- This creates **polar deserts** and **tundra**
  - These biomes occur due to the cold, dry conditions within the **Polar cell**
- These climatic factors, in turn, influence the structure and productivity of terrestrial biomes by affecting plant growth, water availability and average temperatures
- The tricellular model therefore helps us to:
  - Understand the **global distribution** of biomes
  - Understand the **ecological characteristics** of biomes
  - **Predict biome shifts** due to climate change and global warming

Ocean Currents

Solar radiation absorption

- Oceans act as vast **heat reservoirs**
  - This is because they absorb the solar radiation that penetrates their **surface layers**
  - Solar energy is absorbed primarily in the top layer of the ocean
    - Here, it warms the water and results in **thermal energy** being **stored**

Ocean currents and heat distribution

- Ocean currents play an important role in distributing the heat absorbed by the oceans **around the world**
  - Surface ocean currents, **driven by winds** and Earth's rotation, transport **warm water** from the equator **towards the poles** and **cold water** from the poles **towards the equator**
  - These currents redistribute heat horizontally across the ocean surface
    - This movement of heat affects regional climates and weather patterns

Impact on climate and ecosystems

- The redistribution of heat by ocean currents helps **regulate global climate**
  - This is because it helps to **moderate temperature extremes**
- Warm ocean currents can bring milder, warmer weather conditions to coastal regions, while cold currents cool down coastal regions
- Oceanic heat transport also affects marine ecosystems

- They affect patterns of ocean productivity, distributions of marine species and levels of marine biodiversity

Your notes

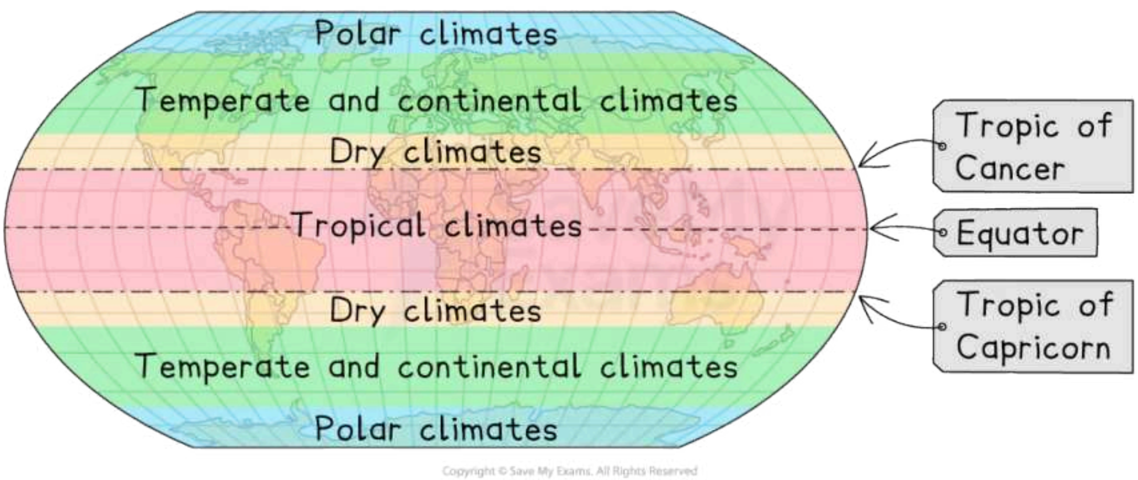
Your notes

Climate Types (HL)

Climate Types

Tropical, temperate and polar climate types

- There are three general patterns of climate types that relate to specific biome types
- These general climate types are:
  - **Tropical**
  - **Temperate**
  - **Polar**
- Each type has distinct characteristics based on **temperature** and **rainfall**



Distribution of tropical, temperate and polar climates

Tropical climate types

- Tropical climates:
  - Closer to the equator
  - Between the Tropics of Cancer and Capricorn
  - High temperatures and rainfall
  - Most regions have two seasons (wet and dry)

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- Tropical climates can be further divided into two subtypes:
  - **Seasonal**
  - **Equatorial**
- **Seasonal tropical climates**:
  - Distinct wet and dry seasons
  - During the wet season, rainfall is abundant (averaging more than 1000 mm per year)
  - Support **savannas**, which are grasslands scattered with trees
  - Examples:
    - Forests of the Congo in Africa
    - Central American tropical forests in Panama and Nicaragua
    - Seasonal forests on the Indian subcontinent, Indochina, and in northern Australia (Queensland)
- **Equatorial tropical climates**:
  - High temperatures and high humidity year-round
  - Consistent rainfall (monthly precipitation greater than 60 mm, annual precipitation greater than 2000 mm)
  - Support **tropical rainforests**, which are rich in biodiversity and contain dense vegetation
  - Examples:
    - Amazon rainforest
    - Southeast Asian rainforest
- The main **biomes** found in tropical climates include tropical rainforests and savannas, each adapted to their specific seasonal patterns

Temperate climate types

- Temperate climates:
  - Moderate mean annual temperatures (average temperature greater than 10° C in warmest months and greater than -3° C in coldest months)
  - Most regions have four seasons
- Temperate climates can be further divided into two subtypes:
  - **Maritime**

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  - **Continental**
- **Maritime temperate climates**:
  - Influenced by large bodies of water, leading to mild, wet winters and cool, dry summers
    - Often linked to weather patterns caused by prevailing winds
    - Oceans store heat energy, which moderates temperate regions near the sea (giving more consistent temperatures)
  - Often found on the western coast of continents (the prevailing winds bring in wetter weather at certain times of the year)
  - Receive consistent rainfall throughout the year
  - Support **temperate forests** with diverse tree species
  - Examples:
    - Western Europe: countries like the UK, Ireland, and the coastal areas of France, Spain, and Portugal experience a maritime climate due to the Atlantic Ocean's influence
    - Pacific Northwest (North America): The Pacific Ocean has an impact on Canada's coastal regions of Washington, Oregon, and British Columbia, resulting in mild, wet winters and cool summers
- **Continental temperate climates**:
  - Have greater temperature extremes than maritime temperate climates, with hot summers and cold winters
  - Mostly found in the interior of continents away from the influence of oceans
  - Support **grasslands** or **deciduous forests**, which have trees that lose their leaves in winter
  - Examples:
    - Eurasia (mainly Russia)
    - North America (mainly Canada, some areas in northern USA)
- The main **biomes** found in temperate climates include temperate forests, grasslands, and scrublands

Polar climate types

- **Polar climates** are characterised by:
  - Very low temperatures (average temperature less than 10° C in all months)
  - Limited precipitation, primarily as snow
  - Often windy

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- Examples:
  - Arctic and Antarctic regions (average temperature less than 0° C in all months)
  - Areas of northern Canada, Russia and Greenland
- These climates support **tundra biomes**, which have short growing seasons and vegetation that includes mosses, lichens, and low shrubs
- Polar regions often have **ice caps** and glaciers, with very few organisms able to survive the extreme conditions

Influences on biomes

- The biome predicted by any given temperature and rainfall pattern may not develop in an area due to:
  - **Secondary influences**
  - **Human interventions**
- Secondary influences are factors that affect the development of a biome beyond just temperature and rainfall
- These can include:
  - **Soil quality**: Poor soil may limit plant growth, even in areas with suitable climate
  - **Topography**: Mountains, valleys, or slopes can alter water drainage, sunlight exposure, and temperature, impacting local ecosystems
  - **Fire and natural disturbances**: Frequent fires or storms can change the types of vegetation and animals in an area
- **Human activities** such as urban development, agriculture, and deforestation can prevent natural biomes from forming. For example:
  - A region that would naturally develop into a temperate forest may instead become a city or agricultural land
  - Agricultural practices can change the natural vegetation and soil quality, further impacting the local biome
  - Urban development alters local climate conditions, leading to a phenomenon known as the **urban heat island effect**, with:
    - increased temperatures
    - changes in rainfall patterns
- All these influences can prevent the expected biome from developing in a given climate zone

Examiner Tips and Tricks

Make sure you are clear on the differences between climate types and biomes—they are not the same thing. You need to recall how temperature and rainfall patterns (in different climate types) correlate with specific biomes.

Your notes

Your notes

El Niño Southern Oscillation (HL)

El Niño Southern Oscillation (ENSO)

- The El Niño Southern Oscillation (**ENSO**) is a **natural climate phenomenon**
- It is characterised by fluctuations in wind patterns and sea surface temperatures across the tropical Pacific Ocean
- ENSO cycles consist of **two extreme phases**:
  - **El Niño** (a **warming** phase)
  - **La Niña** (a **cooling** phase)
    - Neutral or transitional conditions occur between these two extremes
- These changes in the Pacific Ocean can influence weather and climate patterns not only locally in the Pacific region but also **across the globe**
- ENSO events are **irregular** and **difficult to predict** in terms of frequency and intensity
  - They usually occur every 2–7 years
- During normal conditions, **trade winds** blow in a **westerly** direction:
  - Normally, these winds push warm surface water toward the western Pacific (near Asia and Australia)
  - This normally causes colder water to rise to the top of the ocean near the coast of South America to replace this warm water
    - This cooler, nutrient-rich water rises through **upwelling**
- El Niño and La Niña **interrupt** these normal conditions

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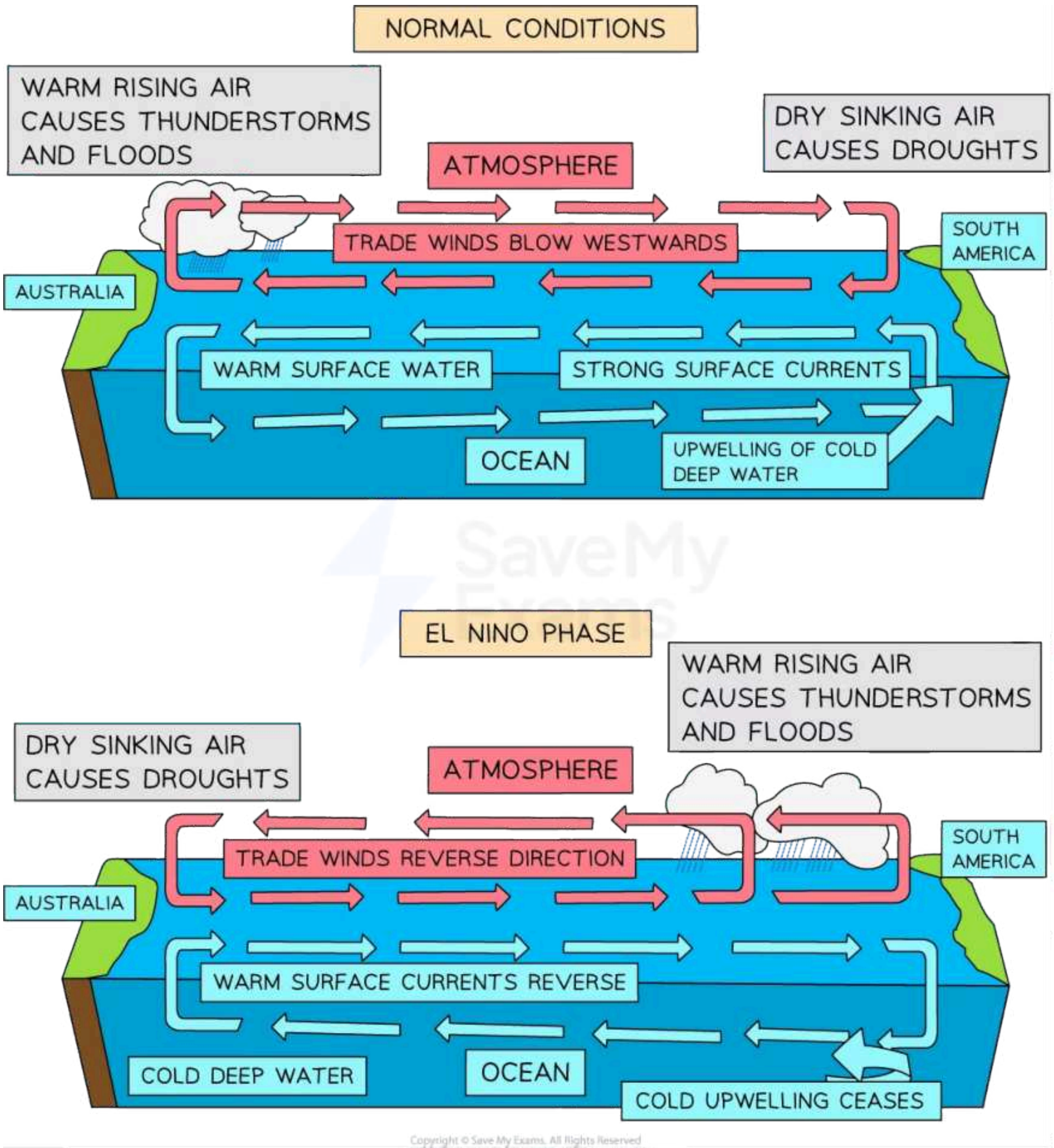

Normal (neutral) conditions and El Niño conditions

El Niño phase

- **El Niño** occurs when the east-to-west trade winds **weaken** or **reverse**
  - This is due to a weakening or reversal of the Walker circulation

- During El Niño, **warmer-than-usual sea surface temperatures** develop in the central and eastern tropical Pacific
- This results in **reduced upwelling** of cold, nutrient-rich water off the coast of north-western South America
    - This particularly affects **Peru** and **Ecuador**
    - Reduced upwelling **decreases marine productivity** in these regions
    - This negatively impacts local fisheries and food chains

Effects of El Niño

- **Global weather impacts**: El Niño can cause extreme weather events around the world
    - **Drier conditions** in **Australia** and **Southeast Asia**, leading to droughts and wildfires
    - **Heavy rainfall** and **flooding** in the **western coast of the Americas**, particularly **Peru** and parts of the **USA**
    - **Warmer winter temperatures** in **Canada** and the **northern USA**
    - **Decreased monsoon rains** in **India** and parts of Southeast Asia

La Niña phase

- **La Niña** is the opposite phase of El Niño and occurs when the **Walker circulation** (the east-west atmospheric circulation) **strengthens**
    - **Stronger trade winds** push warm water even further west
    - This causes cooler water to dominate the eastern and central Pacific
    - This leads to **increased upwelling** of cold, nutrient-rich water off South America
    - This **increases marine productivity** in these areas

Effects of La Niña

- **Global weather impacts**: La Niña also affects weather patterns globally, but generally in the opposite way to El Niño
    - **Increased rainfall** in **Australia** and **Southeast Asia**, leading to floods
    - **Drier conditions** in **South America** and parts of the **USA**
    - **Harsher winter conditions** in **Canada** and the northern USA

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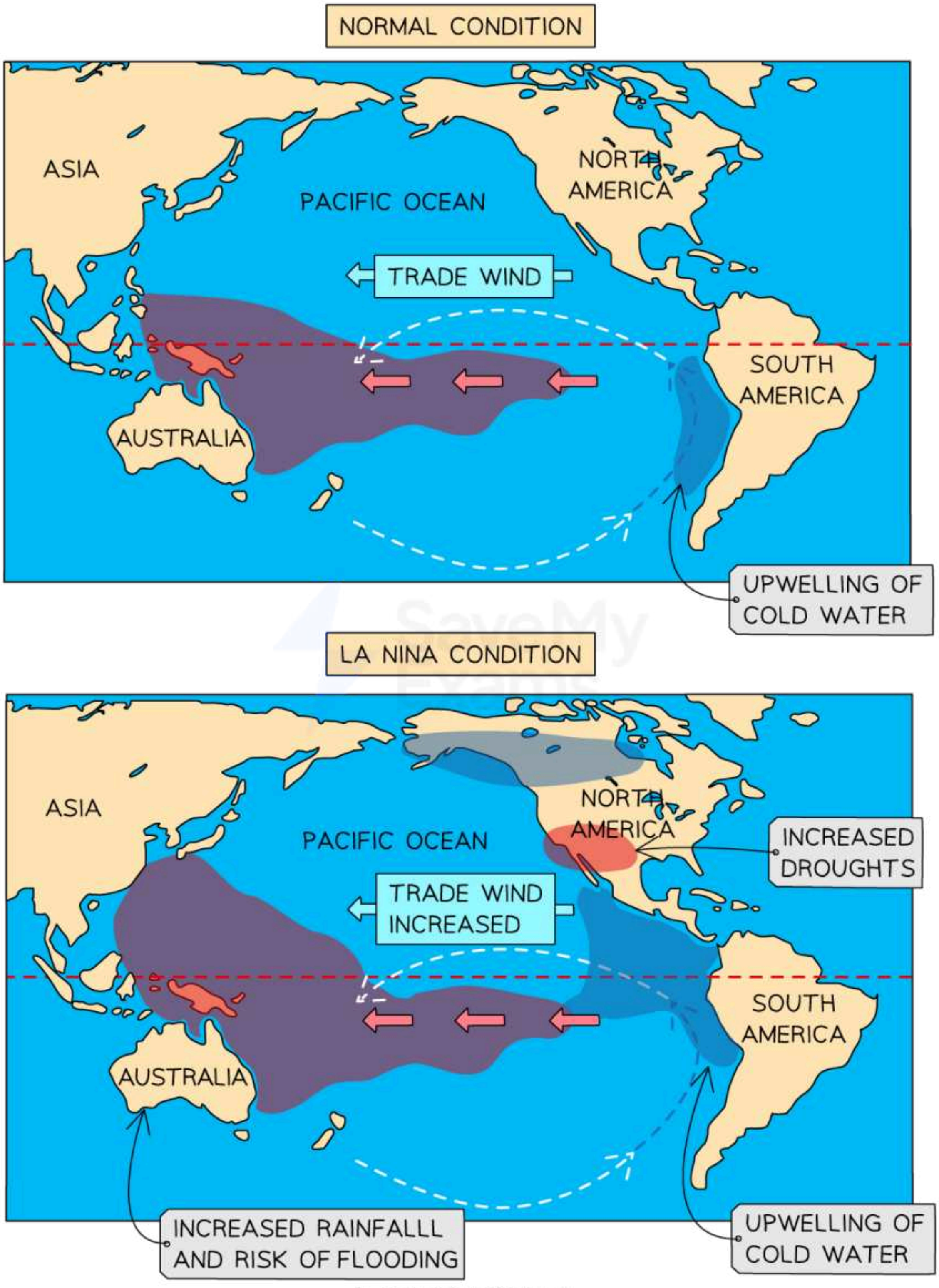
NORMAL CONDITION
ASIA
PACIFIC OCEAN
NORTH AMERICA
TRADE WIND
SOUTH AMERICA
AUSTRALIA
UPWELLING OF COLD WATER
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ASIA
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NORTH AMERICA
INCREASED DROUGHTS
TRADE WIND INCREASED
SOUTH AMERICA
AUSTRALIA
INCREASED RAINFALLL AND RISK OF FLOODING
UPWELLING OF COLD WATER
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Normal (neutral) conditions and La Niña conditions

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Impacts of ENSO on marine ecosystems

- Both El Niño and La Niña events have a significant impact on **marine productivity**
  - During **El Niño**, the lack of nutrient-rich upwelling causes a **decline** in **plankton**, leading to fewer fish and affecting entire marine food chains
  - **La Niña** promotes nutrient upwelling, boosting marine life and improving fisheries
- The cycle can also affect **coral reefs**
  - Warmer waters during **El Niño** leading to **coral bleaching** events
  - This damages ecosystems in places like the **Great Barrier Reef** in Australia

Secondary impacts of ENSO

- **Agriculture**:
  - Crops can be damaged due to droughts (El Niño) or flooding (La Niña), leading to **food shortages**
- **Health**:
  - Changes in climate can increase the **spread of diseases** such as malaria in tropical regions where wetter conditions provide breeding grounds for mosquitoes
- **Economic impacts**:
  - Natural disasters caused by ENSO events can result in **economic losses**, especially in countries that depend heavily on agriculture and fishing

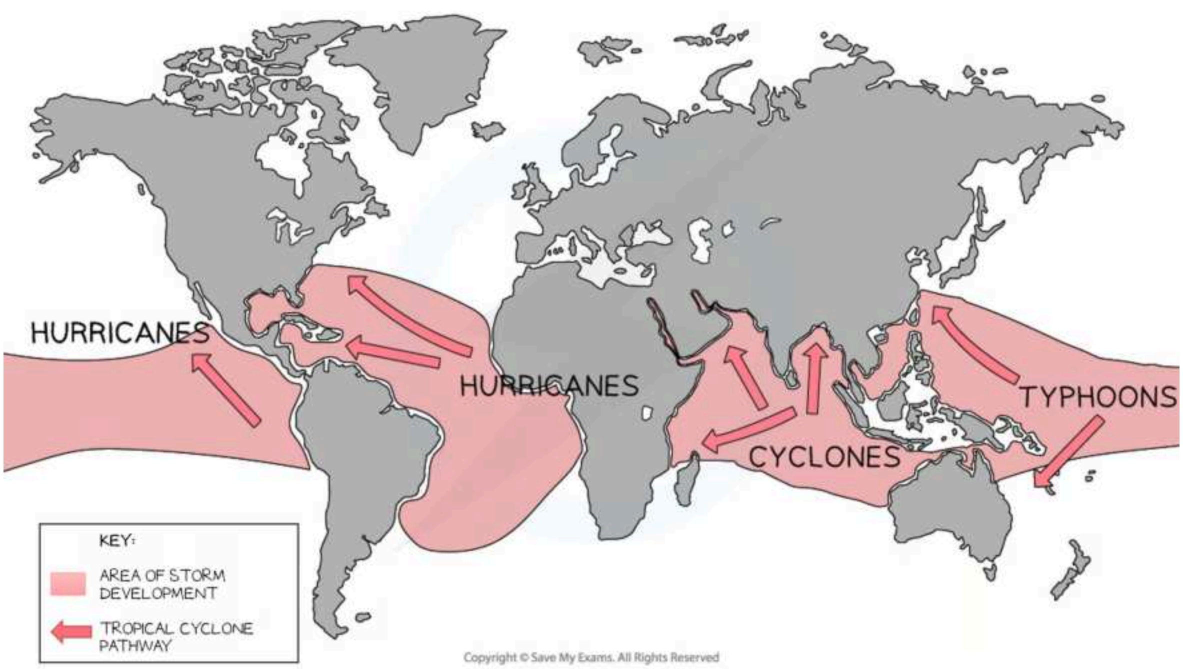
Tropical Cyclones & Climate Change (HL)

Your notes

Tropical Cyclones & Climate Change

What are tropical cyclones?

- Tropical cyclones are large, rapidly rotating storm systems that form over **warm tropical oceans**
- They have a **low-pressure centre** (the 'eye') and are characterised by **strong winds**, **heavy rainfall**, and **thunderstorms**
- Once **sustained wind speeds exceed 119 km/h**, a tropical cyclone is classified as:
  - A **hurricane** (in the Atlantic and eastern Pacific, including the Gulf of Mexico, Caribbean Sea, and west coast of Mexico)
  - A **typhoon** (in the South China Sea and western Pacific)
  - Other regions may call them **cyclones** (Indian Ocean and South Pacific, including the Bay of Bengal and northern Australia)



Map showing the global distribution of tropical storms

How tropical cyclones form

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- Tropical cyclones form over **warm ocean waters** (above 26.5 °C)
- The energy for these storms comes from the **evaporation** of this warm water
  - This fuels the storm as the water vapour in the warm, moist air rises and then condenses into clouds and rain, releasing huge amounts of **latent heat energy**
  - This release of latent heat warms the surrounding air, causing it to rise further, reducing pressure at the surface
  - The low pressure at the centre pulls in more warm, moist air, which continues the cycle of evaporation, condensation, and heat release
  - This continuous cycle of rising warm air and condensation intensifies the storm, leading to the development of a tropical cyclone
- The **Coriolis effect**, due to the Earth's rotation, causes the storm to rotate and develop its characteristic spiral structure

Impact of climate change on tropical cyclones

Ocean warming and increased cyclone intensity

- **Global warming** is causing the oceans to warm, which provides more energy for tropical cyclones
  - Warmer water allows for **greater evaporation**, leading to stronger and more sustained storm systems
- As **sea surface temperatures** rise, the intensity of tropical cyclones increases, leading to:
  - **Stronger winds** that can cause severe damage to infrastructure and ecosystems
  - **Heavier rainfall**, leading to more flooding in coastal and inland areas

Frequency and duration of tropical cyclones

- Some studies suggest that while the total **number** of tropical cyclones may not increase, the **frequency** of the **most intense storms (category 4 and 5)** has **risen**
  - For example, the Atlantic hurricane season has seen an increase in **major hurricanes** in recent decades
- Rising sea levels caused by global warming contribute to **higher storm surges**, worsening coastal flooding during tropical cyclones

Evidence of climate change impacts

- **Typhoon Haiyan (2013)**:

- One of the strongest tropical cyclones ever recorded, with wind speeds exceeding 315 km/h
- Scientists believe the warmer sea temperatures increased its intensity

- **Hurricane Harvey (2017)**:
    - Warmer waters in the Gulf of Mexico caused record rainfall, leading to catastrophic flooding in Texas
- Research indicates a **40% increase** in the likelihood of storms reaching **category 3 or above** since the 1980s

Examiner Tips and Tricks

Be clear on the difference between **hurricanes**, **typhoons**, and **cyclones**—they are the same phenomena but have different names based on location.

Your notes