HL IB Environmental Systems & Societies (ESS)

Your notes

2.4 Climate & Biomes

Contents

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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

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Biomes

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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:

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- **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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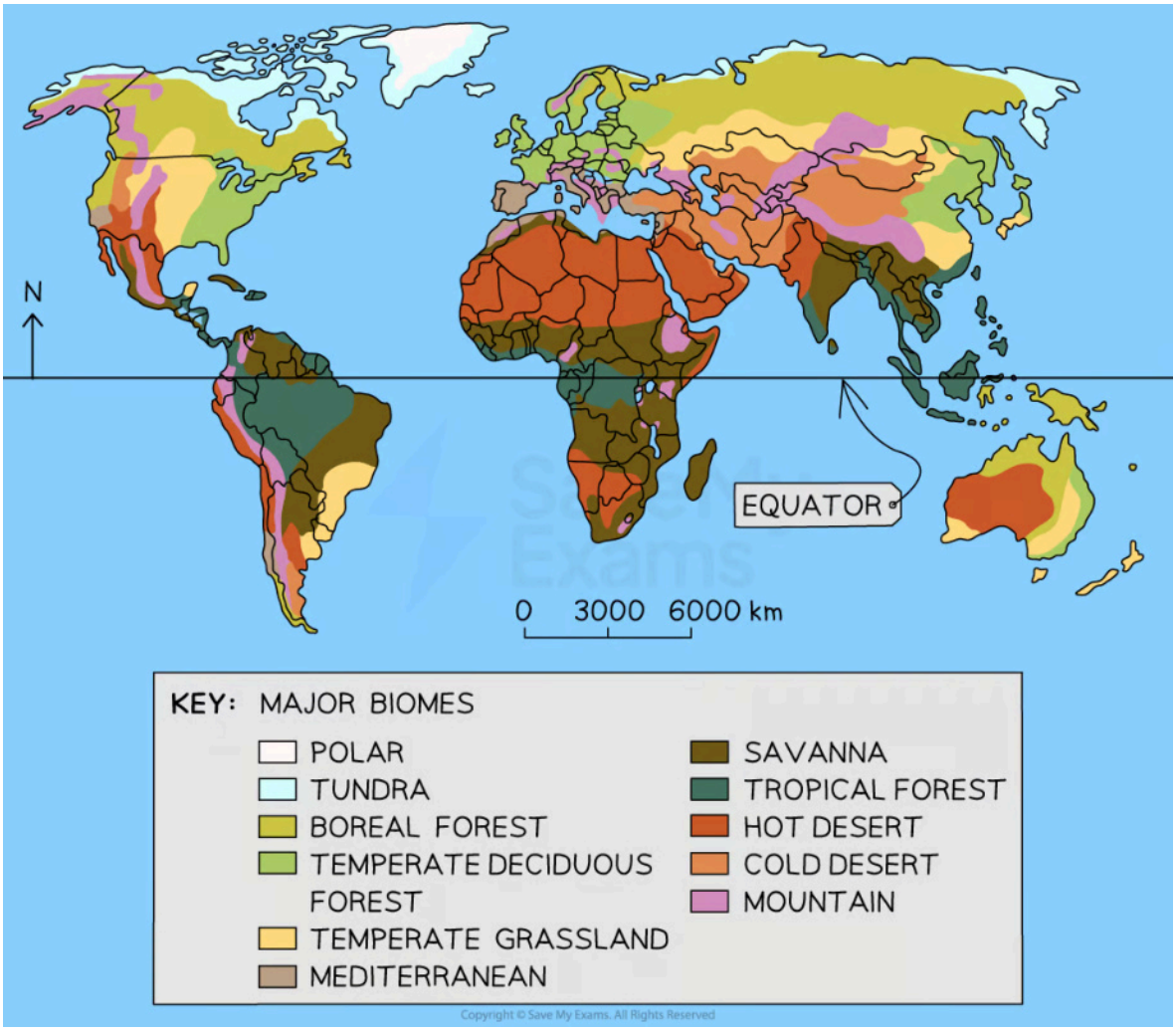

Biomes of the world

- 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

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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


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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)

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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

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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

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- 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
    - 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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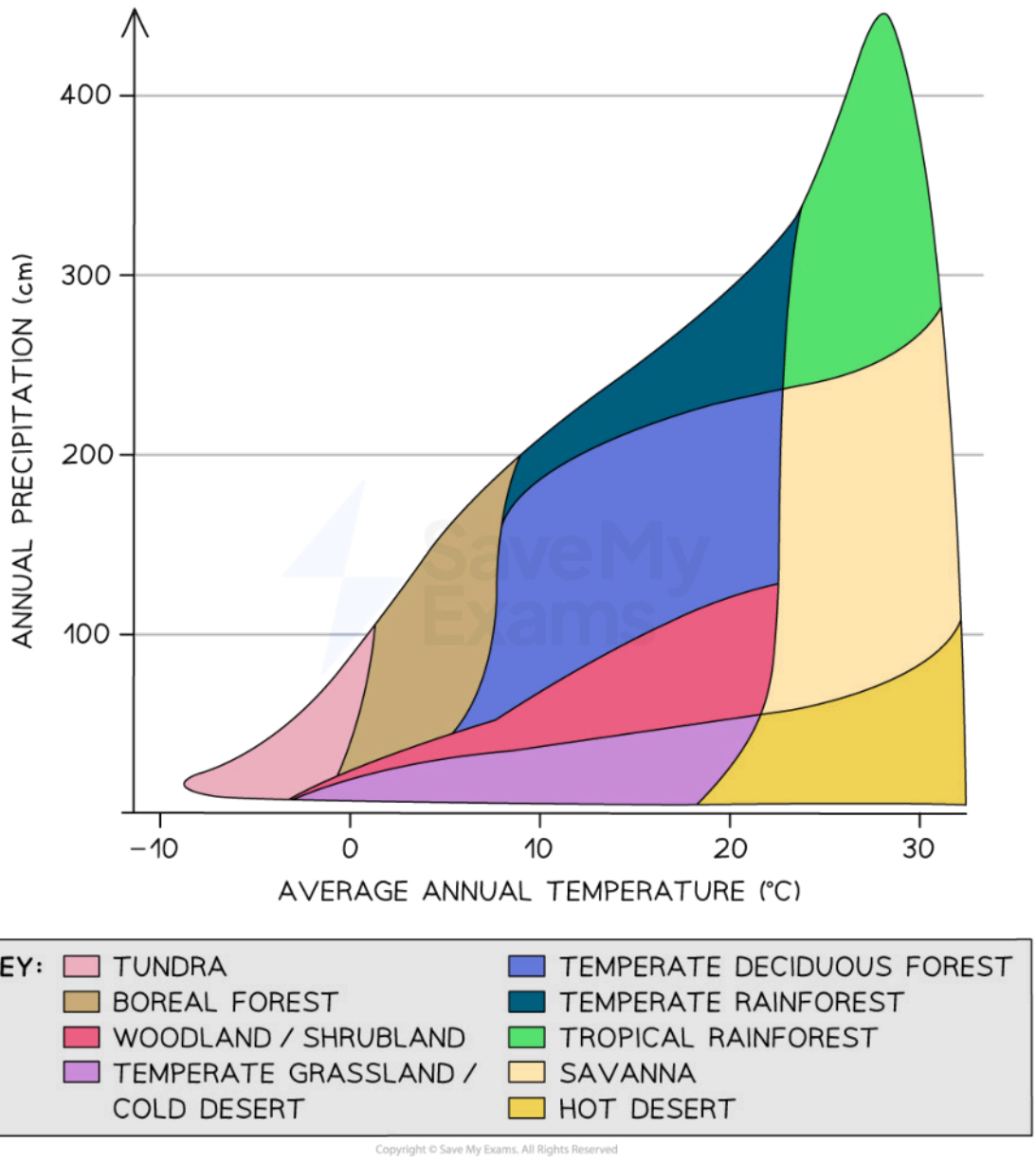

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Precipitation and temperature are the two most important climatic variables that determine the type of biome in a particular location

Effect of Global Warming on Biomes

- As the global climate changes, the distribution of biomes is **shifting**

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- 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

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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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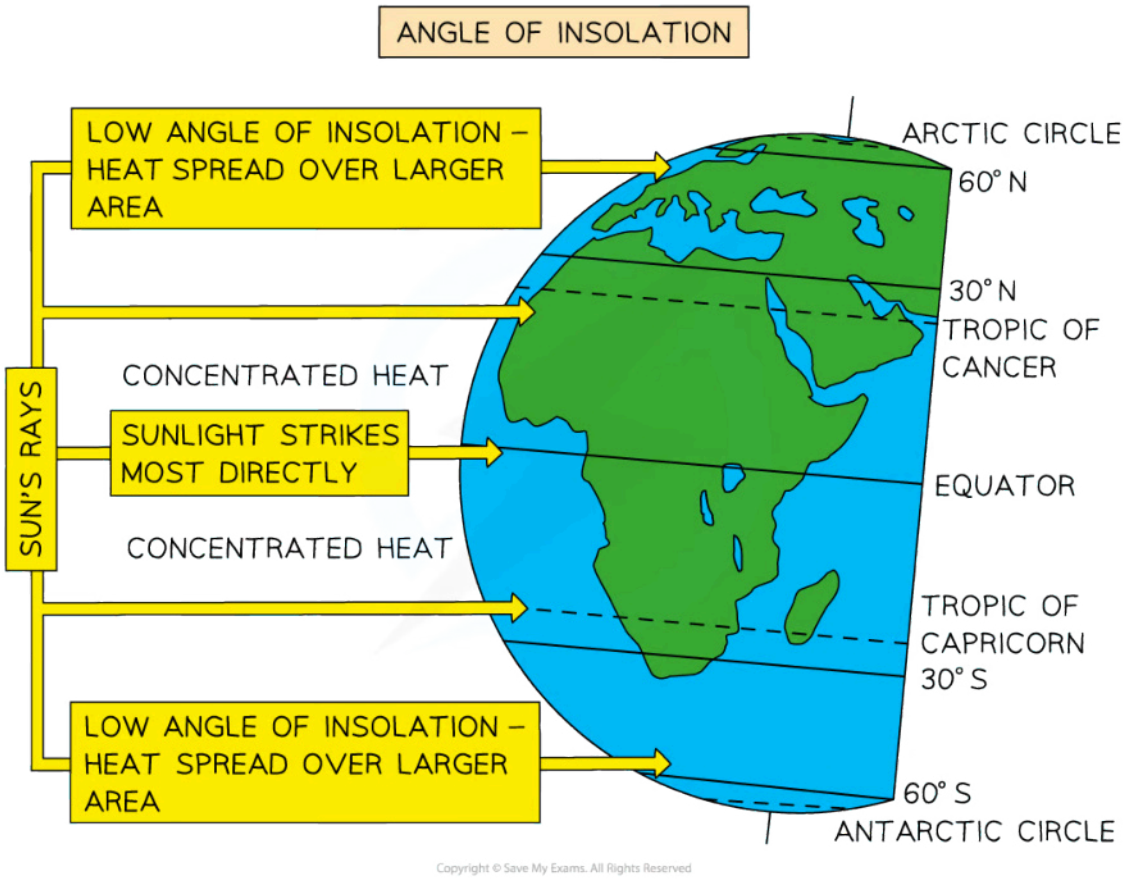

The angle of insolation spreads solar radiation over a wider area at the poles than at the equator

- 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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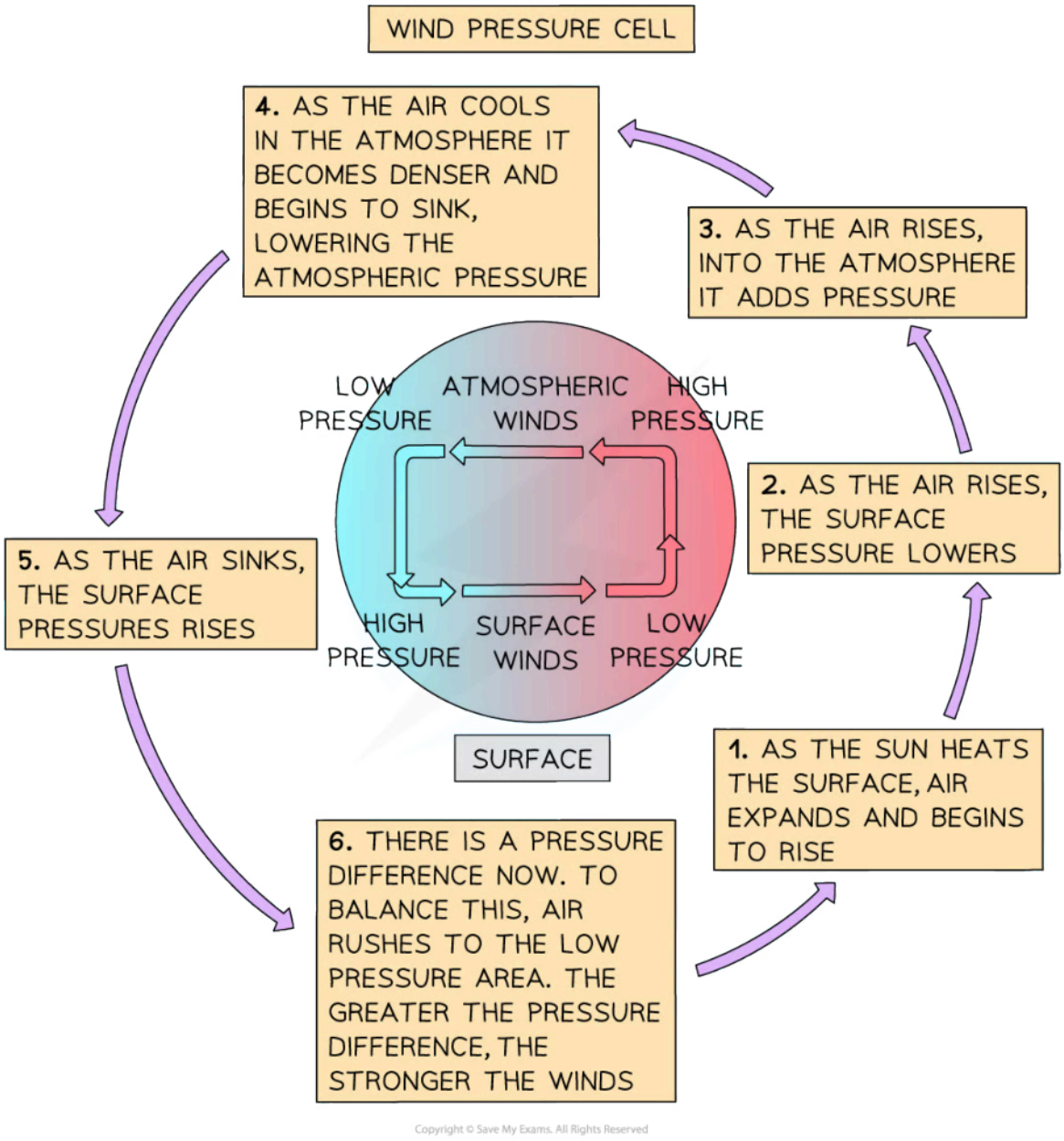

A typical wind pressure cell system showing the distribution of pressure at Earth's surface and upper atmosphere

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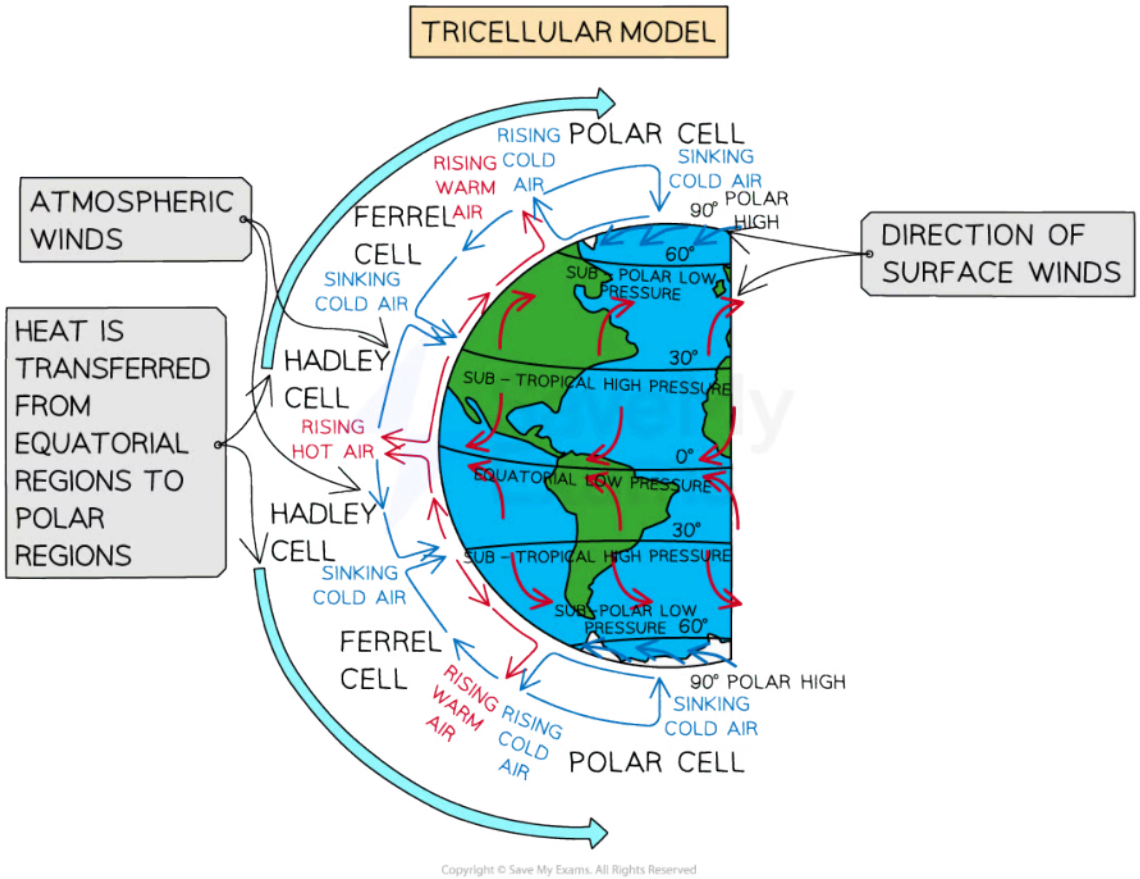
- Air movement within the cell is **roughly circular** and moves surplus heat from equatorial regions to other parts of the Earth
- In both hemispheres (the Northern hemisphere and the Southern hemisphere), heat energy transfer occurs where different atmospheric circulation cells **meet**
  - There are **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

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The tricellular atmospheric wind model


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- **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**

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- 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
  - 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


Your notes

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

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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


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