# Geography

## 1 – Physical Geography

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Introduction

This eGuide is intended as a resource to aid learning and revision for Unit AS1: Physical Geography. The intention is not to provide comprehensive detailed coverage provided elsewhere in textbooks but by breaking the unit down into each element, provide summary of the content focusing on key words and concepts, cases study references and examination questions. It aims to provide illustration with images and web-links to relevant content video, graphics or further information. Throughout and where possible links will be made with GIS where it is relevant to each topic.

Unit overview

In this unit you will......

Have the opportunity to study three key physical themes and related processes. The unit will also involve consideration of human interaction with those processes. These include:

• 1(a) Processes that shape fluvial environments.
• 1(b) Human interaction in fluvial environments.
• 2(a) Global biomes.
• 2(b) Small scale ecosystems.
• 3(a) The processes that shape our weather and climate.
• 3(b) Weather in the British Isles.
• 3(c) Global weather issues.

Assessment Format and Description

Assessment for this Unit 1 will take the form of an external written examination.

The examination is 1 hour and 15 minutes. It is divided into two sections:

Section A: You answer three short structured questions, one on theme.

Section B: In this section there are three questions requiring extended writing, one on each theme. You are required to answer any two questions in this section.

This unit carries a weighting of 40% of AS (Unit 2: Human Geography (40%), Unit 3: Fieldwork Skills and Techniques in Geography (20%)).
Theme 1(a) – Fluvial Environments

1(a) Processes that shape fluvial environments

Introduction:

This is the first theme within the unit and deals with an understanding of rivers and the action of water on the land. It is therefore mainly concerned with an understanding of rivers, processes and landforms. It is broken down into four main sections which are all related and linked:

(i)  The drainage basin
(ii)  Storm hydrographs
(iii) River processes
(iv)  River landforms

On completion of Theme 1(a) you will go on to consider human interaction in fluvial environments (Theme 1(b)).

In each section you will find brief summaries of the content you need to be familiar with and, in particular, key terms and concepts will be highlighted. To aid your understanding, links are provided to web-based video and diagrams that will aid your learning and revision. Key words are highlighted with links to a glossary at the end of the section.

Exam questions are also included at the end of the section.

(i)  The drainage basin as an open system.

In this section you are expected to understand what is meant by a systems approach. You should also understand how a drainage basin can be viewed as an open system. This involves being able to identify what are the Inputs, Outputs, Transfers and Stores.

What is a systems approach?

The drainage basin is the area within the boundaries of the watershed drained by a river and its tributaries. Our understanding and learning about the drainage basin is concerned with the processes that take place within the drainage basin, the development of landforms that result from those processes and how it impacts on human activity and how it is affected by human activity.
The following web link provides some useful definitions and explanations in relation to the drainage basin:
http://www.coolgeography.co.uk/A-level/AQA/Year%202012/Rivers_Floods/Drainage%20basins/Drainage%20basins.htm

Fig. 1.1
The drainage basin is in a constant state of change – the processes, such as *erosion*, are not constant but are affected by energy levels in the river – landforms are continuously evolving – and human activity changes over time. It is useful to view the drainage basin as a system of component parts that play their role in that constant change that occurs within the drainage basin. This is what is referred to as a **systems approach**. It is usually broken down to consider:

- What are the inputs of *energy* and *matter* into the system?
- What are the outputs of energy and matter?
- What are the *stores* of energy and matter?
- What are the *transfers* of energy and matter?

**Store and transfers in a drainage basin:**

Stores: *surface storage*, vegetation storage, soil moisture storage, *groundwater storage* and channel store.


See the following link for more detailed explanation: [https://geographyas.info/rivers/drainage-basins-and-the-hydrological-cycle/](https://geographyas.info/rivers/drainage-basins-and-the-hydrological-cycle/)

Within a drainage basin the primary (matter) input is the water from precipitation. Energy inputs include kinetic energy and potential energy, this is what facilitates movement of water primarily but also the processes of erosion and transportation of material that results in the shaping of the river channel and the formation of landforms.
The outputs are what leaves the system (the drainage basin). Think of what leaves the boundaries of the drainage basin – this might be to the sea or into another larger drainage basin of a bigger river. The most obvious output from the drainage basin is the water that empties into the ocean. Output also includes the sediment that is transported by the water flow that ends up in the sea. Outputs from the system will also include the loss of water through evapotranspiration from land surfaces, vegetation and from open water.

See the following link for a detailed diagram:

To understand the workings of a system it is necessary to understand how and why the inputs, outputs, stores and transfers may vary over time or from one drainage basin to another. These factors will include variations in climate (the amounts and patterns of precipitation); the occurrence of storm events; rock type; altitude and the steepness of slope; soil type and depth, vegetation coverage; human activity (farming patterns, deforestation, water storage management); and the built environment.

From an understanding of drainage basins as an open system it should be clear that the characteristics of drainage basins and, in particular the rivers within them, will vary as a result of variations in the inputs, transfers and stores. You should be aware how drainage basins will respond differently to significant inputs of water through the system due to precipitation or snow melt. The variables outlined above relating to inputs, energy, stores etc. will play a significant part in explaining how similar sized drainage basins might respond differently to a period of intense precipitation due to their different characteristics.

How a drainage basin or river responds to a period of high precipitation can be represented in a storm hydrograph.

(ii) Storm Hydrographs:

Annual hydrographs display variations in a rivers discharge over the course of a typical year. They are based on average flow patterns taken over a number of years observation. These variations will be determined by climatic patterns of precipitation and temperature that will influence variables such as evaporation rates, ground conditions, vegetation cover and snow melt.
Storm Hydrographs are a convenient way of illustrating how rivers respond over time to a period of rainfall. Typically they will highlight how quickly rivers respond to rainfall levels in a storm event in terms of discharge levels. They will show what the lag time is from the period of highest rainfall to highest discharge. They also highlight how quickly discharge levels return to normal or base flow levels.

It is important to be familiar with the key features of a storm hydrograph and understand the key terms used to describe the features. You should be able to accurately quote data from a hydrograph relating to the discharge levels and rainfall levels (on the vertical axes) at different times (on the horizontal axis) usually in hours since the beginning of the storm event.

The key terms and features to be familiar with include:

- **Peak rainfall**;
- **Peak discharge**;
- **Lag Time**;
- **Rising limb**;
- **Falling or Recession Limb**;
- **Storm Flow**; and
- **Base Flow**.

See the following link for descriptions of the storm hydrograph:

http://www.alevelgeography.com/river-discharge-storm-hydrograph/
It is important to be aware of the range of conditions within a drainage basin that may affect a storm hydrograph. These should be the factors you consider when explaining differences when asked to compare contrasting hydrographs.

**Fig. 1.4 Factors influencing storm hydrographs**

**Fig. 1.5 Rapids in the upper course**
(iii) River Processes

This section is concerned with processes that take place within a river. These processes are significant in the development of river features found in and around a river channel as it makes its way from source to mouth, the river may flow into a lake or sea, it may also enter another drainage basin. These processes are erosion, transportation and deposition. You need to be aware of the different ways each of these can take place, the conditions under which they take place. Understanding each of these processes will help understand how various landforms result.

(a) Erosion

You will remember from your GCSE course that erosional processes in a river take place in a number of different ways:

- Abrasion (or Corrasion)
- Hydraulic Action
- Corrosion (or Solution)
- Attrition

See the following video link describing the main erosion processes:
https://www.google.co.uk/

In the link below you will find a description of different types of erosion as well as transportation and deposition. The account also refers to some of the resulting landforms.
https://www.google.co.uk/
You need to be able to:

- distinguish between each of these processes;
- describe them; and
- understand in what way it might affect the river channel and its load.

Erosional processes can impact on a river and its drainage basin in two ways:

- wearing away the river bed and cutting downwards to deepen a valley. This is referred to sometimes as **vertical erosion**.
- wearing away the sides of the river channel, its banks and valley sides. This is referred to sometimes as **horizontal** or **lateral erosion**.

**b) Transportation**

The process of **transportation** refers to the movement of sediment or load in a river. To understand how material is moved or is subject to transportation within the river system it is useful to consider this load in three forms:

- the load that is in **solution**;
- the load that is in **suspension**; and
- the load that rests on the river bed, the **bedload**.

The solution load is material that is dissolved and carried in that form (solution). Limestone for example is dissolved by slightly acidic water. The term **solution** can refer to the process of erosion whereby rock is dissolved by river water. It can also refer to the process of transportation as the dissolved calcium carbonate from limestone is carried downstream by a river.

The suspended load is the fine material carried by the river current that is held up or suspended in mid-channel. This method of transportation is referred to as **suspension**. It is this material that may discolour water giving it a muddy colour.
The bedload is material that is found on the river bed that can be moved either by traction or saltation. Traction describes how larger material as big as boulders can be rolled along the river bed at times of high discharge. Smaller pebbles will bounce along the river bed due to the force of the current. This skipping or bouncing movement along the river bed is referred to as saltation.

The four types of transportation are:

- Solution;
- Suspension;
- Saltation; and
- Traction.

These processes are described in the following link:
http://www.coolgeography.co.uk/GCSE/AQA/Water%20on%20the%20Land/Processes/River%20processes.htm

(c) Deposition

Having learned and understood the processes of erosion and transportation it is important to understand the process of deposition.

You need also to be aware of the features that result from deposition in a river and its drainage basin.

Deposition Process

Your focus here is to understand the conditions in the river channel under which material that has been eroded and moved by the process of transportation comes to rest again. This varies according to the size of the material. There is a relationship between the size of the material and the velocity level at which erosion will take place, transportation takes place and finally deposition takes place. This relationship is described in the Hjulström Curve.
You need to be familiar with this graph, how to read the axes (velocity on the vertical axis and sediment or particle size on the horizontal axis size), you need to understand the two curves:

- the **Pick-up Curve** or **Critical Erosion Velocity Curve**; and
- the **Drop Curve** or **Critical Settling Velocity Curve**.

An explanation of how to interpret the Hjulström Curve can be found at the following link: [https://youtu.be/uoHk4LjIePY](https://youtu.be/uoHk4LjIePY)

**Depositional Features:**

Deposition of a river’s load occurs in situations where there is a loss of energy or put another way, where the river slows down. This can happen where:

- bends in a river channel result in the river changing direction;
- where there are obstructions in the course of a river;
- where river flow loses momentum due to the loss in gradient, e.g. entering a larger mass of water such as the sea or a lake; or
- the water leaves the main channel flow to spill out over adjacent land.

Depositional features are normally associated with the lower course of a river as it reaches the lower end of the drainage basin.

On a river bend, particularly on a meander, deposition tends to occur on the inner
bank. This is where river velocity slows down and is much slower than the outer bend. As it slows down it has less capacity to transport material so load is deposited, very often the largest load first. As it continues to slow down as it goes round the meander bend its ability to carry or transport material decreases so the size of material being transported decreases and the smallest load the suspended load may be deposited at the furthest point round the bend. You might be able to see a grading of material in this depositional feature. At the start of the inside bend the largest material is found and size decreases to the furthest point round the bend where the finer silts are found.

The feature of deposition that results is referred to as a **point bar deposit** or a **slip-off slope** (see photographs Fig.1.9 and Fig 1.10).

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**Fig. 1.9 Deposition on a river bend**
An eyot is a small island formed in a river bed as it nears the mouth of the river. With less energy at this stage the river has less capacity to transport material and some will settle on the river bed forming an eyot.

Braiding
Deposition at this stage in the river may also cause braiding where significant deposition on the river bed causes the river channel to split into a number of channels which flow around the deposition on the river bed.

See the video link below:
https://google.co.uk

Levees
Levees can form naturally in a river’s flood plain as a result of the deposition that occurs when a river overspills the channel and flood waters carrying sediment spill out on to adjacent land. As the flood waters leave the main river channel the velocity and therefore the carrying capacity decreases rapidly as it flows away from the main
river channel. As it does material that was being carried by the river is deposited the largest material first. This creates a ridge of material on the river bank which becomes obvious as the river returns to normal flow levels. This deposited material can help contain the river in its channel.

This is described with diagrams in the following link: https://www.youtube.com/watch?v=h_47JRshNkk

(iv) River Landforms

There is a range of river landforms that you should be familiar with. You should be able to recognise them from a photograph or in some cases a map. You should also be able to explain their formation. Explanation will involve referring to the river processes you have learnt in the previous section. A useful way of learning and revising most of these landforms is to practice drawing them as labelled diagrams.

River Landforms:

- Waterfalls.
- Rapids
- Meanders
- Pools and Riffles
- Oxbow lake
- Levees
- Floodplains
- Deltas (arcuate and bird’s foot)

**Waterfalls**

Waterfalls are often formed where rivers flow over horizontally bedded rock. If hard resistant rock (e.g. basalt) overlies softer less resistant rock such as limestone this may result in differing rates of erosion. This can result in an overhanging section of harder rock and the creation of a plunge pool below. The overhanging rock may collapse and the waterfall retreats further back. Over thousands of years this may result in the formation of a gorge.
Meander
Meanders are a feature of the lower course of rivers and, in particular, the flood plain. They may start with the formation of pools and riffles. Rivers rarely follow a straight path because of turbulence and variations in velocity and bedload size within a river channel. The path of the faster moving water tends to swing from side to side. This affects river depth and frictional drag that impacts on patterns of erosion and deposition within the channel. The result is a typical sequence of pools (deep water with smaller bedload material) and riffles (shallow water with larger bedload material). This pattern becomes more marked as the river channel swings from side to side and sinuosity increases. (see Fig. 1.13)

![Fig 1.13 Pools and Riffles](image)

When meanders develop fully a cross section shows the contrasting conditions between the outside of the bend where the faster flow occurs and the flow is directed against the outer bank causing erosion and deepening the channel and creating a river cliff. On the opposite bank there will typically be a gentler slope into shallower water where deposition occurs creating a slip-off slope. (See Fig. 1.14)
Meanders are subject to continuous change as river conditions vary and the processes of erosion and deposition continue to alter the channel. As a result, over time, a meander may migrate downstream. They may also create a wider floodplain as they migrate from side to side. They can also result in the formation of an oxbow lake.

**Oxbow Lake**

An oxbow lake is the result of a meander loop becoming more and more sinuous until, as a consequence of erosion and deposition, the channel can take a shortcut through the neck of the loop (see Fig. 1.15).
Levees and Floodplain

In the lower course of a river deposition becomes a more significant process that results in the formation of a number of recognisable features. These include levees and floodplains as already referred to above; Fig. 1.16 describes their formation. Levees and floodplains are very often the focus of river management strategies. Levees can provide important flooding protection for the low lying land of the floodplain. This becomes particularly crucial when the floodplains provide important agricultural land and the site for significant settlement. In these circumstances levees are often created artificially and maintained as part of downstream river management strategy.

Deltas

Deltas are features of deposition formed where rivers enter the sea or a lake. They are the result of the sudden decrease in velocity of the river as it enters the sea or lake. This loss of energy results in a dramatic decrease in the river's carrying capacity and therefore, if it is carrying a significant load of suspended material, this will be deposited on the river and sea bed.

Fig. 1.16 Levees and floodplain

Fig 1.17 River Delta Satellite Image
The formation of deltas is also aided by the process of **floculation**. This process is the coagulation of finer clay and silt particles with the salt which cause them to sink faster to the bed of the channel or sea bed. As this accumulates the delta will be formed. Fig. 1.18 highlights the key points of the delta formation process.

**Fig. 1.18  Delta Formation**

Deposition is therefore encouraged as the hydraulic radius drops and the river becomes less efficient with the biggest sediment dropping first and the finest sediment dropping further away.

Layers of sediment build the delta out into the sea, as top set, foreset and bottom set beds.

This causes islands or bars of sediment to build up in the middle of the main channel.

The river spreads out and slows down as it a nears the sea.

The river splits into distributaries.

Simple definitions and case study references on rivers:
http://www.3dgeography.co.uk/river-floods
http://www.coolgeography.co.uk

Meanders:
http://www.bbc.co.uk/education/clips/z9cxpv4
https://www.google.co.uk

Waterfalls:
http://www.bbc.co.uk/education/clips/zjdnvcw
Theme 1(b)
Human interaction in fluvial environments

This section of the specification is concerned with management and human interaction with rivers and their drainage basins. This includes understanding the causes and effects of flooding in both LEDCs and MEDCs. You are required to study a flooding case study from both.

1. Channelisation; realignment, re-sectioning and dredging.
2. Sustainable management strategies.
3. Causes and effects of flooding

Rivers are significant features of our landscape. They have also had a significant influence on settlement patterns both here in Northern Ireland and across the world. This is due to their importance as a source of water and food, their role in transport, trade and communications, and the suitability of flood plains as fertile farmland and flat land for settlement building.

Rivers are however dynamic features due to the ongoing processes of erosion, transportation and deposition, as well as the fluctuating water levels within each drainage basin. Change can be gradual and slow over time, but can also be dramatic and sudden. Because of the close interaction and relationship between people (activities and settlements) and the fluvial environments, strategies have been developed to manage rivers and that change. This section is concerned with the different ways in which rivers are managed and the impact of that interaction. It also looks at the causes and effects of flooding.

(i) Channelisation
One of the ways by which rivers are managed is by modifying or adjusting the channel itself through which the water flows. You need to be aware of the different reasons or
motivations for doing this, the different methods of doing this and the effects of each of these methods.

Why modify river channels?

- To prevent flooding of farmland or settlements.
- To protect banks and the land on either side from erosion.
- To improve drainage.
- To maintain navigation channels.

Channelisation refers to any measure taken to modify the river channel. It includes methods such as; **re-alignment, levee construction, re-sectioning** and **dredging**. Carrying out engineering works such as these on a river can be very expensive. When the decision is made to modify a river channel it is usually because the cost is considered less than the cost of any potential flood damage.

![Fig. 1.20 Channelisation of River Clare in County Galway](image)

When considering the option of river channelisation there are both benefits and disadvantages to consider:

**Advantages:**

- Flood prevention – protection of home, industry, businesses, transport links, protection of lives and communities, protection of farmland (social, economic, infrastructural consideration)
- Maintain river transport links (economic, social, communication infrastructure)

**Disadvantages:**

- Relocation of flooding problem
- Cost (immediate and long term)
- Aesthetics – less attractive
- Ecology – damaging to wildlife – river food-chain (invertebrates, fish, mammals and birds)

(ii) **Hard and Soft engineering methods in river management**

Hard engineering refers to methods that involve structural engineering solutions such as those methods of channelization referred to earlier. Soft engineering techniques
are characterised by working with the natural river processes and interfering less with the channel and the ecosystem.

You need to be able to distinguish between these approaches.

Sustainable management refers to approaches to river management, whether that be safeguarding against flooding in built up areas or ensuring rivers do not silt up to cause navigation problems, which do not exacerbate the flooding risks elsewhere, do not impact upon the river ecology or do not result in recurring investment. Sustainable management approaches involve taking account of natural river processes and adapting to them to minimise flood risks. The approach involves a minimum of intervention with the river channel through structural engineering. It is based therefore on a soft engineering approach.

Examples include:

- Strategic planting of trees within a river catchment area, particularly the upper course
- Land use planning that minimises housing development in the flood plain, retains a corridor of land on either side of the river channel to act as a buffer between flood risk areas and the built environment – housing or industry
- Designation of flood prone areas to facilitate river overspill and reduce risk of flooding further downstream in built up areas or more valuable and productive farmland.

A useful resource that describes issues associated with river management and the strategies commonly used can be found at:

(iii) Causes and effects of flooding

In this unit you will have studied the dynamics of a river drainage basin – the fluvial environment – and how river processes, and variations in the physical characteristics of each drainage basin result in different river characteristics and how rivers respond to variations in the inputs of water. You have also considered how human activity can affect river behaviour whether by design through management of the channel, or indirectly due to human activity within the drainage basin. To understand and explain the causes and effects of flooding you will need to refer to those processes that shape fluvial activity. It is useful to think of factors that can influence the likelihood of flooding and divide these into both natural and human.

When considering the effects it is worth dividing these into:

- impacts on people;
- impacts on property; and
- impacts on the land (environment).

The spatial context requirement requirement for this section of the specification is a case study of flooding from either a MEDC or a LEDC. The following provides a summary of two flood events that occurred one in a MEDC – Somerset (2014) and the other in a LEDC – Pakistan (2010). It is broken down to consider causes both physical and human as well as the impact on people, property and land.
## Flood Event Case Studies

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<th>Pakistan 2010 (LEDG)</th>
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<td>The Somerset Levels are found in the southwest of England. It is a low lying coastal plain across which the lower course of a number of rivers (River Axe, River Brue, River Parrett and River Tone) flow before entering the Atlantic. As a low lying coastal flood plain it has a long history of habitation and farming. It is also vulnerable to flooding despite management practices to facilitate drainage. There are several villages in the area but population density is generally low.</td>
<td>The physical geography of Pakistan is varied with high mountainous regions on its border with Afghanistan and the low-lying plains of the Punjab and Sind in the south. The drainage pattern that includes the Indus valley and its numerous tributaries is a significant feature of this vast flood plain. Seasonal monsoon rains area significant feature of the climate. Pakistan's population is predominantly rural and agriculture dependent. Population density is very high (220/sq km)</td>
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<td><strong>Causes - Physical</strong></td>
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| • Prolonged rain through January 2014 with totals of 183.8mm in Southern England – the wettest since records began.  
• Saturated Ground - no capacity to absorb further rainfall resulted in significant run-off.  
• Low lying ground - increases likelihood of flooding and makes drainage difficult  
• High tides and storm surges - the Bristol Channel is often subject to storm surges as a result of the passage of low pressure Atlantic storms. | • An intense five-day period of unprecedented rainfall levels occurred in northern Pakistan in July 2010. This resulted in significant flooding as the Indus was inundated by floodwaters from its tributaries. This travelled southwards along its long course. This rainfall event was followed by normal monsoon rains which added to and prolonged the flooding impact.  
• Low lying land that is susceptible to flooding |
| **Causes - Human**            | **Causes - Human**     |
| Ineffective drainage management is blamed for the limited capacity of the river drainage system to deal with water levels. This was blamed on lack of investment in dredging schemes to maintain channels and prevent them from silting up. This was linked to a conflict of interests between maintaining wetland habitats that depend on flooding and the economic interests of agriculture requiring efficient drainage systems. Changes in farming practices also meant that more of the land is used for more intensive arable farming increasing surface runoff. | • Recent widespread deforestation in Khyber Pakhtunkhwa (northern Pakistan).  
• River management – levees constructed in Sind contained the river channel until flooding but raised it above the height of the surrounding land.  
• River banks could not be maintained because of the prolonged flooding |
Impact - People

There was no loss of life but many families were evacuated from their flooded properties; in total, 600 homes were flooded. Some families were unable to return for months (120 families in Moorland village), and some choosing not to return at all. Some villages were completely cut off and could only be accessed by boat (Muchelney and Thorney).

600 people lost their lives.
Estimates of between 14–20 million people were affected by the flooding. With a largely rural, agriculture dependent population most of those affected lost their homes, farmland and livestock. This resulted in a significant number of homeless refugees requiring relief aid.

Impact - Property

Homes were flooded and badly damaged by flooding. Businesses and farms were also badly affected. Farms were particularly affected by the temporary loss of access to land for livestock which had to be transported elsewhere. Much of farmland lay underwater for months which also affected cultivation.

Millions of people became homeless as houses were destroyed. Infrastructure in the form of roads, railways and bridges were also badly affected hampering transport in the region. Farmland was severely affected and important crops were lost. Farm related property such as animal sheds, seed stores and machinery was destroyed.

Impact - Land

Whilst the productivity of the land was badly affected by flooding, it recovered quickly. Older established grasslands were quick to recover but more recently improved planted grasslands and cultivated land was slower to recover.

Newly planted forests were destroyed. River systems became heavily polluted and affected by significant inputs of sediment from mudslides. This impacted on water quality and resulted in land contamination. Wildlife was also severely affected by loss of habitat.

The links below provide useful Case Study resource material when considering both the causes and consequences of flooding in these different areas of the world:

**LEDC – Pakistan (2010)**
Geographical Association Case Study: Pakistan Floods
https://www.geography.org.uk/Pakistan-Floods-2010

Geofile online:

**MEDC – Somerset Levels (2014)**
Geoactive – Flooding in the Somerset Levels:

Geographical Association – 2014 UK Floods case study

The Guardian Newspaper report on 2014 winter flooding:
http://www.theguardian.com/uk-news/2014/feb/01/january-uk-wettest-winter-month-250-years
Map links

Geographical information Systems (GIS) are important tools that have been developed within the subject of Geography to enhance understanding of complex issues that affect the areas being studied. These are particularly useful when there are different sets of spatial data that, when combined, can help arrive at a conclusion about an issue for different locations. Government agencies often use GIS for planning purposes. The Rivers Agency is a government agency responsible for the management of our river systems. An important issue for the Rivers Agency is predicting and management of flood risk areas.

You can access Flood Maps for any area in Northern Ireland using the following link.

Rivers Agency Flood Maps:

You can zoom in on any area and, using the Layer List, select the information or layer that you would like displayed such as Present Day Flood Plain Rivers or Significant Flood Risk Areas.

Fig. 1.2.1 Screen shot from Rivers Agency Flood Map showing the layer list
Source: https://www.nidirect.gov.uk/articles/check-the-risk-of-flooding-in-your-area

Fig. 1.22 Screen shot (2) from Rivers Agency Flood Map
In Fig. 1.22, you can see the various layers that have been highlighted which, for example, show on the map SFRA – Significant Flood Risk Areas across Northern Ireland.

Fig. 1.23 focuses on Omagh and shows flood risk areas highlighted in the centre of the town along the course of the River Strule. Flood defences are also shown. The small red arrows on the map provide links to photographs of historical flood events.

The weblink below provides access to an article which gives an account of how GIS, using various spatial data sets is used to predict areas liable to potential flash floods in Saudi Arabia.

http://www.sciencedirect.com
Sample Exam Questions

Extracts [http://www.rewardinglearning.org.uk/microsites/geography/gce/past_papers/](http://www.rewardinglearning.org.uk/microsites/geography/gce/past_papers/)

**Fluvial Environments**  
**Jan 2011**

2 (a) Study Resource 2 which shows pools and riffles.

![Diagram of Fluvial Environments](image)
Jan 2013

(b) Describe one factor which may influence the rate at which a river erodes.
(b) Select one factor from the list below and explain how it influences the storage and transfer of water within the drainage basin.

- Geology
- Soil Type
- Relief

__________________________

__________________________

__________________________

__________________________

__________________________

[4]
2. (a) Study Resource 2A, which shows land-use change in Little Eagle Creek drainage basin in central Indiana (between 1973 and 1991) and Resource 2B, which illustrates the surface runoff in this drainage basin for the same period.

Resource 2A

![Graph showing land use变迁](image)

Resource 2B

![Graph showing surface runoff](image)

Adapted from © URISA Journal Vol. 18, No. 2 (2006)
Using information from Resources 2A and 2B, describe and explain the effects of land-use change on surface runoff within this drainage basin.
2 (a) Study Resource 2A which shows two similarly sized drainage basins with contrasting relief.

With reference to Resource 2A, describe and explain how relief could affect runoff and the shape of the storm hydrograph.

[4]
(b) In the box below draw an annotated cross-section diagram (or diagrams) of a natural river levee and use it to help you explain the formation of this river feature.
Jan 2103

(ii) With reference to your case study of a large scale drainage basin, or its delta, describe one beneficial effect of flooding on people.

[2]

Fluvial Processes Essay Questions
Jan 2011

5. “The causes of flooding, although complex, are related predominantly to climatic factors.” To what extent do you agree that this statement is valid for the large scale drainage basin or delta you have studied? [12]

Jan 2012

5. Describe the processes and the conditions under which rivers erode and deposit sediment. Explain the importance of these processes in the formation of a river meander. [12]
Geography

Glossary of Key Terms

**Abrasion** – An erosional process - the wearing away of the river bed and banks by the movement of material. Smaller material can have a sandpaper effect on rock surfaces. (Sometimes referred to as Corrasion.)

**Arcuate Delta** – A fan shaped delta such as the Nile Delta. It has a curved outer edge as the action of longshore drift maintains the smoother outer edge compared to the Bird’s foot Delta.

**Attrition** – An erosional process affecting the bedload material. It is caused by the action of material striking against other material. This reduces the size of the material and increases roundness.

**Base flow** – the steady and continuous background discharge levels referred to in storm hydrographs. A storm event will result in storm flow where discharge levels rise dramatically above base flow levels.

**Bird’s foot Delta** – a delta which takes the form of a bird’s foot as the distributaries spreading out to sea result in sediment deposits along their course but not continuously between different channels like the Arcuate Delta. e.g. Mississippi Delta.

**Channelisation** – the modification of a river channel usually as part of a flood management strategy. It may take a number of forms – realignment, resectioning or dredging.

**Corrasion** – See Abrasion.

**Corrosion** – An erosional process that refers to the dissolving action of, slightly acidic, river water on rocks. It is sometimes referred to as Solution.

**Delta** – the fan shaped pattern of accumulated alluvial deposition found at the mouth of a river in the sea or a lake. It is formed when the rate of deposition exceeds the rate at which it is removed by tidal currents.

**Deposition** – the laying down of material that has been transported by river or sea.

**Discharge** – The volume of water moving within the river channel past a given point per second. It is measured in Cumecs (Cubic Metres Per Second).

**Drainage Basin** – the area drained by a river and its tributaries.

**Drainage density** – a measurement of the proportion of drainage channel length to the area of a drainage basin.

**Dredging** - A channelisation strategy involving the removal of material from the river bed and banks. This may be accumulated sediment, bedload or larger obstacles such as boulders, storm debris or weeds. The net effect is to increase efficiency of the river flow.

**Erosion** – the process by which land or rocks are worn away by the action of moving water, ice or wind.

**Falling limb/Recession limb** – a feature of the storm hydrograph. This refers to the decrease in discharge levels from peak discharge to base flow levels.

**Flooding** – where river levels exceed bankfull levels and spill out on to adjoining land.

**Floodplains** - the area of low lying land surrounding a river in the lower course. It is composed to a large extent from alluvial materials deposited in previous flood events. This deposition often has the effect of raising the height of the land.

**Groundwater** – rainwater that has penetrated the ground and is stored in the pores and crevices of rocks. This water may eventually make its way to the river channel through groundwater flow.
Hjulström curve – a graph to illustrate the relationship between river velocity and particle size and how this affects the potential for erosion, transport and deposition.

Hydraulic Action – An erosional process that results from the force of the water against the river banks causing them to loosen and break up. Hydraulic action may result in rocks breaking as air is forced into air pockets by the force of the moving water.

Hydrographs (storm and annual) – a graph used to show a river's changing discharge levels during the course of a storm event or over the course of a year.

Infiltration – the process of water sinking into the ground.

Inputs – In a systems approach to geographical understanding, inputs are referred to as the material or energy that enters the system. E.g. looking at drainage basin in this way the inputs are the water, sediment and energy.

Lag time – on a storm hydrograph the time between the peak rainfall and peak discharge is referred to as the lag time.

Levees – the raised banks that form in a flood plain on either side of the river channel as a result of deposition. Artificial levees may also be built as part of a flood management strategy.

Meanders – the curve of a river that often forms wide loops as the river flows across flatter land often in the flood plain.

Open System – in a systems approach to explaining geographical phenomena, they may be described as open, closed or isolated. In the open systems there are both inputs and outputs of energy and matter.

Outputs – In a systems approach to geographical understanding, outputs are referred to as the material or energy that leaves the system.

Oxbow Lakes – the crescent shaped lakes that may be formed as a result of erosional processes and deposition severing through the neck of a meander loop as the channel takes a more direct course.

Peak discharge – in a storm hydrograph the point of highest discharge is referred to as the peak discharge.

Peak rainfall – in a storm hydrograph the point of highest rainfall is referred to as the peak rainfall.

Percolation – the penetration of water through soil pores and crevices in rock to the groundwater store.

Point bar – material tends to be deposited on the inside of a river bend. The accumulation of this material results in the formation of a point bar.

Pools – In the lower course of a river a pattern often exists of pools (areas of deeper water and erosion) followed by riffles a section of shallower water where deposition has occurred.

Rapids – in the upper course of a river, particularly in steeper sections, the river may flow across outcrops of rock which cause turbulent water.

Realignment – A channelisation strategy which involves altering the course of a river channel to create a straighter shorter route.

Re-sectioning – A channelisation strategy involving the enlargement of a river channel’s cross-sectional area by increasing the width of the channel or deepening the channel.

Riffles – sections of shallower water where deposition has occurred in the channel immediately following a pool.
**Rising limb** – in a storm hydrograph the period of increasing discharge following the rainfall event is known as the rising limb. Where it stops increasing is referred to as the peak discharge.

**Saltation** – a process of material transportation where particles bounce along a river bed, for example, as they are moved by the current.

**Solution** – referring to sediment transportation in a river, solution occurs when material is dissolved in the water and carried ‘in solution’.

**Stores** – in a system, material or energy may be transferred to or from stores.

**Storm flow** – in a storm hydrograph, the higher level of discharge that results from a period of precipitation is referred to as the storm flow.

**Suspension** – fine sediment in a river, dislodged by river turbulence, may be transported by the river current as it is suspended in the body of water.

**Traction** – larger bedload material may be rolled along the river bed by the force of strong currents.

**Transfers** – this refers to flows of material or energy within a system.

**Transportation** – the movement of material across the earth’s surface due to the action of rivers, sea, wind or ice.

**Tributaries** – a river or stream which flows into a main river channel.

**Waterfalls** – when a river flows over outcrops of rock with differing levels of resistance a waterfall may be formed where underlying soft rock is eroded away resulting in a sudden drop or fall in the water.

**Watershed** – the boundary of a drainage basin is referred to as the watershed.
This is the second theme within the unit; it deals with global biomes.

(i) Global distribution of biomes.
(ii) The climate and soils of the Tundra and Temperate Grassland biomes.
(iii) The actual and potential impacts of climate change on Tundra ecosystems.

In each section you will find brief summaries of the content you need to be familiar with and, in particular, key terms and concepts will be highlighted. To aid your understanding links are provided to web-based video and diagrams that will aid your learning and revision. Key words are highlighted with links to a glossary at the end of the section.

Exam questions are also included at the end of the section.

On completion of Theme 2 (a) you will go on to consider Theme 2 (b) small scale ecosystems:

(i) How ecosystems function
(ii) Plant succession
Biomes
The distribution and nature of animals and plants varies markedly around the world. The characteristics of plant and animal species found in different parts of the world can be grouped into a classification. This is used as a regional description of the distribution of life forms around the globe. The characteristics of the dominant vegetation is often used to describe each of these regions: tundra, coniferous forest (taiga), tropical rainforest, temperate forest (deciduous), temperate grassland, savanna grassland and deserts. These global zones are referred to as biomes.

You need to be able to identify the global distribution of tundra, tropical rainforest, hot desert and temperate grassland biomes.

Global distribution of Biomes
You will find it helpful to familiarise yourself with a map showing global distribution of the main biomes. A world map showing the global distribution of the main biomes can be found at http://www.bio.miami.edu/dana/pix/biomes.jpg. You will find some variation in the names used depending on the source. You should be able to describe each biome in terms of location, place name examples, dominant vegetation, climate, latitude and altitude.
The table below provides a summary:

<table>
<thead>
<tr>
<th>Biome:</th>
<th>Tundra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location and place name examples</strong></td>
<td>Northern Hemisphere between 55° and 70° North. Northern Alaska, Northern Canada, Northern Russia and Northern Scandinavia</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Extreme low temperatures. Winter temperatures - 25°C. In the warmest season average temperatures range between 0°–10°. Sub-soil temperatures remain permanently below zero. Precipitation levels are very low 130 – 250mm. Strong winds.</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
<td>Mosses and lichens survive better than most plants. Frozen soil, harsh winds, limited sunlight and low levels of moisture are limiting conditions. Low lying surface plants dominate – sedges, liverworts, bilberry and crowberry. Very limited range of plant species. Animal species also limited – mammals migrate or hibernate.</td>
</tr>
<tr>
<td><strong>Other relevant factors</strong></td>
<td>Latitude – Winters are very dark and sun barely rises. Summers are short but daylight persists for 24hrs. Summer thaw provides source of moisture.</td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td>Global warming - affecting extent of tundra. Significant changes observed at southern fringes – spread of both plants and animals into the tundra. Species such as Arctic fox affected by more limited extent of snow cover and competition with other predators</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biome:</th>
<th>Temperate Grassland</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location and place name examples</strong></td>
<td>Between 30° and 50° North. Found in the interior of large continental land masses, e.g. prairies of US, Canada, and in Asia, e.g. Southern Russia, Mongolia. Less extensive areas of southern hemisphere 30°–40°S; e.g. Africa, South-east Australia and Pampas in Argentina.</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Climate is characterised by extremes of temperature between a hot summer (over 20°C) and a cold winter (-10°C) and low annual rainfall. This large temperature range is due to the continental nature of the location and the distance from the moderating influence of the sea on temperature.</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
<td>Due to the climate (extremes of temperature and limited rainfall) and grazing regime of large herbivores, there is a lack of taller, more established vegetation such as trees and shrubs. It is dominated by a range of grasses and grassland plant species. The height of the dominant grass species is determined by local climatic conditions most notably rainfall levels.</td>
</tr>
<tr>
<td><strong>Other relevant factors</strong></td>
<td>During the cold winter the conditions prevent plant growth and grasses die back and become dormant in the sod layer a mat of roots, bulbs and rhizomes in the top soil. The die back of vegetation in the onset of winter adds considerable organic matter to the soil and its decomposition adds significantly to nutrient levels. This makes a very fertile soil. It is referred to as a mollisol or chernozem.</td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td>Changes in farming practices from grazing to cultivation resulted in considerable damage to the soil structure and its increasing vulnerability to soil erosion.</td>
</tr>
</tbody>
</table>
### Tropical Rainforest

**Location and place name examples**

Between 10° north and south of the equator. The Amazon rainforest (which covers a significant area of Brazil), the Congo Basin and south-east Asia.

<table>
<thead>
<tr>
<th>Climate</th>
<th>Vegetation</th>
<th>Other relevant factors</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>A hot and humid climate. Little seasonal variation in temperature due to equatorial location. Rainfall levels are high. Although there may be some seasonal variation in rainfall levels typically rain fall is experienced every day.</td>
<td>The hot and humid climate facilitates efficient nutrient recycling. The ecosystem supports the most diverse range of plant and animal species found in any of the global biomes</td>
<td>As remote areas of rainforest are explored new species of plant and animal life are discovered. This exploration and discovery is taking place while significant areas of rainforest are being lost to deforestation and exploitation of natural resources.</td>
<td>Forest clearance, settlement expansion and mineral exploitation.</td>
</tr>
</tbody>
</table>

### Hot Desert

**Location and place name examples**


<table>
<thead>
<tr>
<th>Climate</th>
<th>Vegetation</th>
<th>Other relevant factors</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely arid (dry) environment (less than 250mm per year). High temperatures sustained over long periods due to the clear skies, long days and high angle of the sun.</td>
<td>Vegetation is very limited due to the hostile conditions. Scrub with long roots and few leaves. Succulents can store water in leaves.</td>
<td>Soil is very poor as the lack of vegetation results in low organic content and moisture storage is minimal.</td>
<td>Vegetation clearance on desert margins can result in the spread of desert areas.</td>
</tr>
</tbody>
</table>

**Web Link** - An interactive and more detailed GIS map can be found using the following link. As the definition of these regions is based on a range of factors – climate, soil vegetation, that vary spatially we can see how GIS is an appropriate means of delimiting the area of each biome. Location of world Biomes ESRI GIS: https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=c742a4b7fbf44a9081e35496a626f0e4
**Tundra Description**

**Climate**

The climate is notable for the extreme cold temperature. For most of the year, temperatures are below 0°C. Average temperatures may be as low as -25 °C. It is only for a brief 3–4 month summer period when temperatures may rise above freezing.

This climate results in the sub surface soil freezing permanently. It is only in the summer that the top 2 or 3 cms of the soil will thaw. This surface layer often becomes waterlogged as the permafrost prevents effective drainage. Precipitation levels are low at around 250mm. Strong cold winds are a further climatic feature that result in a very hostile climate for both plants and animals.

**Soils**

Due to the permafrost conditions soils are thin and poorly developed. The low temperatures and waterlogged conditions result in limited decomposition of accumulating organic matter. This results in an infertile, peaty soil and acidic conditions. The permafrost also inhibits drainage. There is a lack of any distinct horizons.

**Vegetation**

Due to the thin soils, short growing season, poor soils, low temperatures and strong winds vegetation is very limited. There is a lack of trees and plant life tends to be limited to coarse grass, mosses, lichen and herbs. Roots are shallow and they are tolerant of the acidic conditions and low temperatures. Due to the short season, some plants adapt reproduction to alternating pollination and flowering in one year and germinating in another. Biomass is low.

**Animals**

It is no surprise that the lack of vegetation and harsh environment results in a limited
range of animal species on the Tundra. Land mammals include shrews, hares, rodents, wolves, foxes, bears and deer. There are huge herds of caribou in North America (known as reindeer in Eurasia) which feed on lichens and plants. There are also smaller herds of musk-oxen. Wolves, wolverines, arctic foxes, and polar bears are the predators of the tundra. Smaller mammals include snowshoe rabbits and lemmings. There are only a few species of insects in the tundra including black flies, deer flies and mosquitoes. Thick insulating fur or feathers are key features often with suitable seasonal pigmentation to blend in with a treeless, often snow-covered, landscape. Migration to food sources is also a key to survival.

**Human Impact: Threats and change**

The harsh and hostile climate and the limited range of plant and animal species found in areas of the Tundra such as northern Alaska combine to create a very vulnerable ecosystem. It is sensitive to change and requires a long recovery period from any damage suffered. Exploration and extraction of minerals has become a recent threat to the fragile nature of the habitat. The associated development of transport links and settlement adds further to the impact. Tourism can also pose a threat to the ecosystem.

Climate change is more evident in the higher latitudes where the Tundra regions are found. There is greater evidence to suggest the warming of temperatures and this is having measurable impacts on the environment.

You need to be aware of both the **actual** and **potential** impacts of climate change on a tundra region.

**Actual:**
- Alaskan temperatures have risen by 2°C in the last 50 years.
- Melting permafrost. Summer thaw penetrates deeper resulting in softer soil which poses a considerable threat to the stability of built structures.
- More precipitation falling as rain rather than snow.
- Rising sea levels due to melting mountain glaciers.
- Deterioration of water quality due to the release of chemical pollutants from thawing ice and eroding coastlines.
- Changing habitat, particularly the loss of sea ice, poses a threat to mammals such as polar bears, walruses and some seal species.

**Potential**
- Areas of permafrost will decrease significantly in areas such as Alaska.
- Increase in size and area of lakeland.
- Threat of extinction of some animal species such as polar bears and ringed seals.
- Increase in population of some bird species such as black brant geese.

**Web Link** – the following links provide descriptions of the Tundra and issues associated with this biome:

- [https://www.youtube.com/watch?v=A_NbfphqB1M](https://www.youtube.com/watch?v=A_NbfphqB1M)
- [https://www.youtube.com/watch?v=b5Jbf_T00-c](https://www.youtube.com/watch?v=b5Jbf_T00-c)
- [http://www.blueplanetbiomes.org/tundra.htm](http://www.blueplanetbiomes.org/tundra.htm)
Temperate Grassland: the North American Prairies

Climate:
The climate of the Temperate Grassland is characterised by low annual precipitation and a temperature range of extremes.

The hot summers with temperatures up to 30°C contrast with cold winter temperatures of -20°C

Precipitation levels are low (250–750mm) falling as snow, which accumulates in winter and rain in the summer months. The high summer temperatures result in high evaporation levels. In the US, it is wetter towards the east.

Soils:
The typical prairie or temperate grassland soil is a Chernozem or Mollisol which is sometimes referred to as a Black Earth. These soil characteristics are a consequence of:

• the vegetation, primarily grasses;
• the parent rock rich in calcium;
• the climatic extremes; and
• soil processes of capillary action and leaching.

It is a fertile, deep soil that is characterised by a pronounced dark A-horizon formed of decomposing grass vegetation. This is a crumbly, fertile soil that is rich in humus. The annual die back of vegetation in the harsh winter climate results in the thick layer of roots, bulbs and decaying grass. The low annual precipitation results in low moisture levels and as a consequence the grass species, such as Big Bluestem and Switchgrass, have long roots penetrating deep into the soil.

Some leaching of nutrients from the upper layers of the soil occurs in early spring as the winter accumulations of snow melt.

In the summer, the moisture deficit in the upper layers of soil results in water being drawn upwards through the soil by capillary action. This process results in the deposition of nodules of calcium carbonate in the sub-soil.

Temperate Grassland description:
Web Link –
http://www.blueplanetbiomes.org/prairie.htm
http://www.nationalgeographic.com/environment/habitats/grasslands/
2 (b) Small scale ecosystems

(i) How do ecosystems function?

If we think of the different habitats we find in our neighbourhood, region, country or continent, their characteristics vary hugely. The variety is found not just in the plants and animals we find but also the rock type, the soil and the climate. Understanding the relationship between each of those elements gives us a better understanding of the variation between habitats as well as their vulnerability. In any habitat, large or small, there is a complex relationship between the various parts, living and non-living. We refer to this as an Ecosystem.

![Diagram of ecosystem components](image-url)

**Fig. 2.2 Components of an ecosystem**

In understanding how an ecosystem works you need to be familiar with a range of concepts and processes:

- The **biotic** and **abiotic** components;
- The ecosystem as an open system with **inputs**, **outputs** and **transfers**;
- The **trophic structure**;
- **Nutrient cycling**.

As mentioned above any ecosystem is made up of various components. These can be divided into the **biotic** or living components, and the **abiotic** or non-living components.

**Living (biotic) parts of the ecosystem**

![Diagram of living components](image-url)

**Non-living (Abiotic) parts of the ecosystem**

![Diagram of non-living components](image-url)

**Fig. 2.3 Biotic and abiotic components of an ecosystem**
The biotic elements of an ecosystem can be divided into **Autotrophs** and **Heterotrophs**. Autotrophs are sometimes referred to as **producers**. These are the organisms capable of harnessing the sun’s energy in the creation of food energy. Green plants for example use sunlight, carbon dioxide and water to produce carbohydrates in the process referred to as photosynthesis. This group also includes plankton.

Heterotrophs on the other hand are consumers that feed on other organisms. They may be **herbivores**, **carnivores**, **omnivores** or **detrivores**.

The flow of energy is a key process in any ecosystem and the sun provides the source of energy which is initially harnessed by the autotrophs. Energy will subsequently transfer through the ecosystem along the food chain. Plants will be eaten by herbivores, herbivores will be consumed by carnivores and the smaller carnivores may be eaten by larger carnivore; e.g:

![Fig. 2.4 Basic food chain](image)

At each stage along the food chain, starting with the autotrophs, energy is transferred. There are typically four stages in the chain or four energy levels. These levels are referred to as trophic levels.

![Fig. 2.5 Trophic levels in a food chain](image)

A key point to remember about the transfer of energy between each trophic level is that it is not 100% efficient. In other words, considerable amount is energy is lost at each trophic level through processes such as respiration, movement, reproduction and growth. Energy is also lost through death and decay and excretion. This loss of energy through the levels means that as energy levels decrease so too does the number of organisms that can exist at each level. What we find in an ecosystem therefore is that the number of organisms decreases significantly at each level. This decrease in numbers is reflected in the **trophic pyramid**. The number or amount of living organisms is sometimes quantified as the **biomass** (the total mass of living matter.) The trophic pyramid is not simply a reflection of a decrease in numbers of organisms but takes into account the size or mass of the organisms.
It is important to remember that as well as the autotrophs or producers and the heterotrophs or consumers (herbivores, carnivores and omnivores) found at different trophic levels, detritivores and decomposers also operate at each level. The detritivores include woodlice, worms and slugs. The decomposers include fungi and bacteria. They are all responsible for the breakdown of organic matter and play an important role in the recycling of material.

**Nutrient cycling**

The survival of any ecosystem requires the cycling of nutrients through the growth death and decay cycle that affects all organisms. Nutrients are the essential chemical compounds required for the lifecycle. They include carbon, nitrogen, potassium and calcium based compounds. Understanding how the cycling of nutrients takes place within an ecosystem requires you to understand the key stores of nutrients, how the transfer works between stores and what are the main inputs and outputs of nutrients into and out of an ecosystem. The Nutrient Cycling Model is used to show these key elements of the nutrient cycling process and how they vary between different ecosystems. You need to be familiar with this diagram and understand how it will differ between biomes, for example between a prairie grassland and a tropical forest.
**Small scale ecosystem case study: Breen Wood**

Breen Wood provides a useful case study and illustration of a small scale woodland ecosystem where local abiotic conditions impact on the biotic elements of the habitat. You should familiarise yourself with those abiotic conditions and how they have an impact on the plant and animal life that is found there.
**Breen Wood, Co Antrim**

<table>
<thead>
<tr>
<th>Location:</th>
<th>Six miles south of Ballycastle in north Co. Antrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Description</td>
<td>A remnant of ancient deciduous woodland dominated by native oak species. It is found on a north facing slope between 130 and 190 metres above sea level.</td>
</tr>
<tr>
<td>Rock Type:</td>
<td>Basalt – low in nutrient value – acidic.</td>
</tr>
<tr>
<td>Soils</td>
<td>Thin acidic soils due to steep slope and basalt parent rock. High rainfall results in leaching of nutrients. Podsol development</td>
</tr>
<tr>
<td>Climate</td>
<td>Rainfall: high 1,600mm/year</td>
</tr>
<tr>
<td></td>
<td>Temperature range: 4°–16°C</td>
</tr>
<tr>
<td></td>
<td>Winter frosts common. Low levels of sunlight</td>
</tr>
</tbody>
</table>

The poor soils and difficult climate are limiting factors on growing conditions and the range of plant and animal species found

<table>
<thead>
<tr>
<th>Plant life</th>
<th>Ground</th>
<th>Shrub</th>
<th>Canopy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wood rush, bracken, moss, fern, bilberry, bramble</td>
<td>Holly, blackthorn, willow, rowan, hazel</td>
<td>Oak and downy birch</td>
</tr>
<tr>
<td></td>
<td>Spring Bluebell, anemone, cuckoo pint, lesser celandine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fungus</th>
<th>Bracket fungus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invertebrates</td>
<td>Worms, millipede, woodlice, spider, beetles, caterpillar</td>
</tr>
<tr>
<td>Birds</td>
<td>Blue tit, Great Tit, Goldcrest, Tree Creeper, Sparrowhawk, Buzzard</td>
</tr>
<tr>
<td>Mammals</td>
<td>Shrew, Fieldmice, Squirrel, Pinemartin, Badger, Fox</td>
</tr>
</tbody>
</table>

Fig. 2.10  Breen Wood Case Study Summary
Fig. 2.11 Breen Wood

1 & 5 Bluebells, celandines and 8 wood anemones grow in early spring before light levels are affected by the late spring development of the oak canopy. 4 Oak trees dominate but are small in size due to the limited soil. 3 Bracket fungus 6 Cuckoo pint growing on the forest floor. 7 Bird boxes provide nesting opportunities for the numerous insect feeding birds such as the blue tit, great tit, longtailed tit and tree creepers. 9 There is a wide range of butterflies and moths in the woodland. Their larvae – the caterpillars – provide an important food source for nesting birds.

Web Link – Breen Wood case study information:
http://www.geographyinaction.co.uk/Landscapes/Landscapes_Breen.html
http://www.bbc.co.uk/northernireland/landscapes/lev2_ecosystems_breen_script.shtml

Joint Nature Conservation Council site description:
http://jncc.defra.gov.uk/ProtectedSites/SACselection/sac.asp?EUCode=UK0030097

Flash cards memory game
(ii) Plant succession
Succession describes the process of change in the plant community within an ecosystem over time. It is a process that typically goes through a number of recognisable stages from when an area of ground is initially colonised by plants until the vegetation community becomes stable and is characterised by dominating mature trees.

The process of succession is affected by the prevailing abiotic conditions and as each stage of the succession develops the micro environment will in turn be affected and have an impact on the development of the next stage.

The different stages in the succession process are referred to as seral stages. There are a number of situations where succession may take place. This may be on bare rock (lithosere), accumulating sand dunes (psammosere), an infilling pond or lake (hydrosere), salt marshes (halosere). It is also a process which affects any area of disturbed ground which may due to natural phenomenon such as tectonic activity, fire, flood, drought or landslide, or human activity – deforestation, cultivation or abandoned farmland.

Web Link – video describing succession:
Lithosere: https://youtu.be/k03vxRYsJ4Y
Hydrosere: https://youtu.be/UsiEcapJ3KU

There are a number of key terms and concepts that you need to be familiar with. You should also be able to describe both the biotic and abiotic changes that take place within the ecosystem with reference to a specific case study. These changes include soil conditions such as pH, moisture content and organic matter; microclimate conditions such as wind and temperature, light conditions; vegetation including diversity of species, vegetation height and plant adaptations. You should be familiar with the example of succession on a sand dune system to understand the processes of change that take place over time. This change is evident with distance inland as the age of the dunes tend to increase as you go inland. It is therefore possible to see the different stages in the succession process, or the seral stages, as they are found as the journey in distance inland corresponds to the journey in time from the youngest stage of development to the oldest. This is best illustrated by looking at the example of the Umbra sand dunes.

The Umbra Sand Dunes

The Umbra is part of the Magilligan Sand Dune System in the north west of Northern Ireland. It is within Binevenagh Area of Outstanding Natural Beauty (AONB) and the sand dunes are notable because of their extensive and unmodified nature. It is because of this and the diverse range of plant and animal species that it supports, that it is designated an Area of Special Scientific Interest (ASSI), a Special Area of Conservation (SAC) and a Special Protection Area (SPA). The Umbra itself is a nature reserve managed by the Ulster Wildlife Trust with restricted access.

It is 450 m from the beach, where the embryo dunes are found, to the oldest dunes where climax vegetation is evident. A journey across the dunes takes you over about 15 identifiable dune ridges or crests. The vegetation you find at each of these dunes reflects the abiotic conditions and the age of the dune or the length of time since vegetation became established. Moving inland conditions become less harsh and
more suitable for successful plant colonisation and growth. The key changes in conditions that take place over time and with distance inland are:

- exposure and the level of shelter;
- moisture availability;
- stability of the sandy environment;
- exposure to salt water and spray;
- nutrient level in the soil; and
- light levels.

Figs. 2.12 and 2.13(a)-(e) illustrate five key seral stages across the dunes in the Umbra Nature Reserve and describe the differing conditions found.

Fig. 2.12 A simplified cross-section of the sand dunes to show key seral stages
1. Embryo Dunes
Sand Couch colonising accumulated sand at the top of the beach
Shell fragments in the sand mean it is rich in calcium and therefore the pH is high.
Moisture content is low and there is a lack of dead organic matter
Sand couch is salt tolerant. Rapidly growing rhizomes enable this plant to survive in the unstable shifting sands.

Fig. 2.13(a) Embryo Dunes

2. Foredunes (yellow dunes)
Sand Couch has been replaced by Marram grass as the dominant species.
There is little visual evidence of DOM but some accumulation has taken place to allow the sparse vegetation to derive nutrients. Soil pH is still quite high with little moisture present.
Marram is the dominant plant species but other plant species are also beginning to colonise – fescue, bird's foot trefoil and catsear.

Fig. 2.13(b) Foredunes (yellow dunes)
3. Fixed Dunes (Grey dunes)

Vegetation becomes more established. There is no longer any exposed sand and the dunes are more stable.

There is increasing evidence of the accumulation of DOM in the soil profile as you move inland. This is important for the provision of nutrients to support a wider range of plant species. The DOM also serves to retain moisture. Soil pH levels decrease further.

The dominance of Marram decreases inland as other plant species successfully colonise and compete for nutrients and light as soil becomes more developed and the microclimate becomes more favourable.

![Fig. 2.13(c) Fixed Dunes (Grey Dunes)](image)

4. Mature Dunes (Grey dunes)

These are found some 150 metres inland. It is a more sheltered part of the dunes. It is beyond the influence of wind-blown salty spray from the sea or sand from the beach.

The dominance of Marram further decreases. Fescue and meadow grass are also prevalent along with a significant range of annual and perennial plants. Moss is found in abundance in more shaded areas. Dune slacks develop in hollows between dunes.

The soil profile has further developed with a significant humus layer now present. The soil is now able to support a more complex range of vegetation types including woody spiny shrubs.

![Fig. 2.13(d) Mature Dunes (Grey Dunes)](image)
5. Oldest Dunes (Climatic climax)
These are found some 400 m inland. A soil core from these dunes shows the influence of the deciduous woodland. There is a substantial DOM layer. Leaf litter forms a significant element of this. Sand is still evident in the lower part of a soil profile.
The scrub vegetation which covered much of the ground prior to this, now gives way to taller deciduous trees that dominate the ecosystem. Due to their height and the extent of their canopy, light levels are more limited at ground level. Ground level vegetation is therefore more limited to shade tolerant species such as ivy, ferns and bracken.

Fig. 2.13(e) Oldest Dunes (Climatic Climax)
Fig. 2.14 illustrates in more detail the key changes in soil conditions described in the Umbra case study.

Fig. 2.14 Key changes in soil conditions across the Umbra Sand Dunes

Web Link - Useful resources may be found at the following sites:

Sand dune development: [https://youtu.be/XBofnaGQQCo](https://youtu.be/XBofnaGQQCo)


Geography in Action: [http://www.geographyinaction.co.uk/Magilligan/Mag_intro.html](http://www.geographyinaction.co.uk/Magilligan/Mag_intro.html)

[http://www.ulsterwildlife.org/reserves/umbra](http://www.ulsterwildlife.org/reserves/umbra)

[http://wt360s.wildlifetrusts.com/umbra/umbra.html](http://wt360s.wildlifetrusts.com/umbra/umbra.html) (UWT virtual tour of the Umbra)
Sample Exam Questions

Ecosystems
Jan 2011

6. Explain the processes of environmental change which have produced all the stages in a vegetation succession you have studied at a small or regional scale. [12]

Jan 2012

3. Select any two characteristics from Resource 3A, which shows some of the typical ecosystem changes between early and late seral stages of vegetation succession.

<table>
<thead>
<tr>
<th>Ecosystem Characteristic</th>
<th>Early Seral Stage</th>
<th>Late Seral Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Plant Biomass</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>B Plant Canopy Structure</td>
<td>Multi-Layered</td>
<td>Mono-Layered</td>
</tr>
<tr>
<td>C Longevity (Growth Duration)</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>D Species Diversity</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>E Microclimatic Environment</td>
<td>Extreme</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Adapted from: ©www.physicalgeography.net/fundamentals/9i.html Reproduced with kind permission.

Jan 2012

(a) (i) With reference to your named plant succession study, describe the two changes you have selected from Resource 3A.
Jan 2012

(ii) Explain one soil change which would be expected between the early and late seral stages of a succession.

Answer:

______________________________
______________________________
______________________________
______________________________

[2]

Jan 2011

(b) Describe how nutrients are cycled within a small scale ecosystem you have studied.

Answer:

______________________________
______________________________
______________________________
______________________________
______________________________

[5]

June 2013
(b) Study Resource 3B which shows the proportion of energy stored within the trophic levels of a food chain.

Resource 3B

Producers 97,000 kJ

Primary consumer 7,000 kJ
Secondary consumer 600 kJ
Tertiary consumer 50 kJ

Describe the transfer of energy in this food chain and explain how energy is lost from the system.
Glossary of Key Terms

**Abiotic components** – Any ecosystem has various components which will shape its characteristics. These may be divided into abiotic and biotic components. The abiotic components are the non-living parts that include the climate, soil, rock, sediment and water.

**Autotrophs** – the organisms within an ecosystem that harness the energy from the sun (photosynthesis) and convert it to food energy. Also referred to as producers.

**Biomes** – a large scale global ecosystem that is usually described by the dominant type of vegetation.

**Biotic Components** – in an ecosystem the biotic components refer to the living parts of the ecosystem such as plants and animals.

**Climatic Climax vegetation** – the vegetation that is best adapted to the environmental conditions. It is the final stage in the succession of seres.

**Decomposers** – this important group of organisms includes the detrivores which break down dead organic matter and make nutrients available again.

**Ecosystems** – a systems approach used to describe the relationships between plants, animals and their environment in a habitat.

**Heterotrophs** – the trophic structure of an ecosystem involves autotrophs or producers at the base of the pyramid. All subsequent levels are occupied by consumers or heterotrophs.

**Inputs** – applying the systems approach to nutrient cycling in ecosystems the inputs are the original source of nutrients namely the atmosphere and the underlying rock.

**Nutrient Cycling** – this refers to how nutrients are retained within an ecosystem and recycled between three stores; biomass, litter and soil.

**Outputs** – in the nutrient cycling model, outputs refer to nutrients that are lost through, for example, run-off and leaching.

**Plagioclimax vegetation** – when a vegetation community is prevented from reaching its climatic climax through human activity such as grazing or burning.

**Seral Stages** – The process of succession involves a sequence of changing plant communities until the climatic climax is reached. The seral stages or seres are the distinctive stages in that sequence.

**Stores** – Within the nutrient cycling model of an ecosystem, stores refer to biomass, litter and soil between which nutrients are transferred as part of the recycling process.

**Succession** – The sequence of vegetation change that is experienced over time from initial colonisation by pioneer species until it reaches an equilibrium between the plant community and the environmental conditions, the climatic climax.

**Transfers** – In the recycling model the movement of nutrients into the system (inputs), between stores, and out of the system (outputs) are referred to as transfers.

**Trophic Structure** – the different stages in the food chain relate to energy levels and how they are transfers form the producers at level 1 through the consumers levels 2 – 4. The trophic structure describes this flow of energy through the food chain and the numbers of organisms which decreases at each level.
3(a) – The processes that shape our weather and climate

This section is concerned with understanding the factors that influence variations in weather and climate around the globe. It requires an understanding of key processes that influence the spatial and seasonal variations that are experienced in the weather conditions from place to place.

Section Contents:
(i) The global energy balance
(ii) General circulation of the atmosphere
(iii) Factors that influence air temperature
(i) The Global Energy Balance

The global energy balance describes the inputs and outputs of energy from the sun to the earth and the atmosphere. The storage and transfer of energy within this ‘system’ is a key factor in determining global weather patterns and climatic conditions.

The sun is the earth’s main source of incoming energy referred to as insolation in the form of heat and light. This incoming energy (short wave solar radiation) is absorbed by both the atmosphere (18%) and the earth’s surface (50%). A significant proportion is reflected back by clouds (21%), gas and dust (5%) and the surface of the earth (6%). This is a general picture of incoming energy and reflected energy and variations occur from place to place due to different conditions.

Web Link - The following links provide some useful video presentations that help explain these concepts:

The Earth’s Energy Balance and the Greenhouse effect: https://youtu.be/t0izmfTLzU8

Heat budget explanation: https://youtu.be/FYheqR5R3QI

The heat budget shows us that some areas of the globe have a heat surplus and other areas have a heat deficit. The balancing mechanism between the two areas, the poles and the equator, are the heat transfers – vertical and horizontal.

Vertical heat transfer refers to transfer of heat or energy from the earth’s surface into the atmosphere. This can take place through:

- radiation – heat is radiated back into the atmosphere from the earth’s surface by long wave radiation;
- conduction – heat is transferred by contact;
- convection – heat rises into the atmosphere as a convection current. As the warm air rises it is replaced by incoming cooler air at the earth’s surface.

Web Link - To help you understand and explain each of these processes the following video provides a useful illustration and explanation:

Energy Transfer in the Atmosphere: a video explaining vertical heat transfer – Radiation, Conduction and Convection https://www.youtube.com/watch?v=Y3kZVX6ZCsY

Horizontal Heat Transfer

Winds and ocean currents are important mechanisms in balancing the difference in heat between areas of surplus and deficit. They are therefore hugely influential on global weather patterns. Winds are the most important in terms of transferring heat from warm to cold areas.

Ocean Currents

Ocean currents, whilst not as significant as wind as a means of horizontal heat transfer, do play an important role in modifying climate in different parts of the world. Our own climate is influenced significantly by the North Atlantic Drift ocean current and the prevailing mild and moisture laden winds from the Atlantic.
Web Link - The following links provide an insight into the role of ocean currents in shaping climatic patterns:

The Oceans: A Driving Force for Weather and Climate. General description of how the oceans and currents can influence our climate (NASA).  [https://youtu.be/6vgyTeuoDWY](https://youtu.be/6vgyTeuoDWY)

The Role of Ocean Currents in Climate – a general account of how ocean currents can affect climate in different parts of the world. [https://youtu.be/6Rz8MRxV4sq](https://youtu.be/6Rz8MRxV4sq)

Ocean currents explained. [https://youtu.be/1ifoCIFKYXQ](https://youtu.be/1ifoCIFKYXQ)


Important Ocean Currents - a description of the main ocean currents of the world. [https://youtu.be/PrO7ejaVdzs](https://youtu.be/PrO7ejaVdzs)

Wind

Wind patterns, like ocean currents, are an important mechanism of horizontal heat transfer. Winds transfer heat from the tropics to cooler areas north and south. The air is warmed by the surface of the land or ocean and the heat energy is transferred as the air moves further away from the tropics. The warm air may also be carrying water vapour. This is latent heat which is transferred by the wind. This latent heat is released if the water vapour condenses in cooler conditions further north.

Wind speed and direction are influenced by a number of key factors:

The pressure gradient – this is the difference in air pressure between two areas. Wind generally blows from areas of high pressure to areas of low pressure.

The Coriolis Force – this is the influence of the earth’s rotation on the movement of air. It causes winds to deflect to the right in the northern hemisphere and to the left in the southern hemisphere.

Friction – the drag caused by surface contact slows winds down and limits the impact of the Coriolis force. This influence is limited to winds in the lower atmosphere.

(ii) General Circulation of the Atmosphere

The flow of air in the atmosphere plays an important role in influencing patterns of global wind and air pressure. It has a significant impact on the redistribution of heat energy concentrated on the equator and in the tropics. In one model it is described as being made up of three cells of circulating air which are found in the northern and the southern hemisphere. These cells are known as the Hadley cell found in the tropics between the equator and 30°N and 30°S, the Polar cell which sits over each polar region, and the Ferrel cell which lies in between the two. This model is referred to as the Tri-cellular model.

You need to be aware of and be able to describe the tri-cellular model of air circulation. This has important links to global patterns of air pressure and precipitation.
Web Link - An explanation and description can be found on the following links:


Geography Classics - Global Atmospheric Circulation describes and explains the tri-cellular model of air circulation: the Hadley Cell, the Polar Cell and the Ferrel Cell. https://youtu.be/GZzGO5r3_7U

Jet Streams are strong westerly winds in the upper atmosphere between 7 and 15 km above sea level moving at speeds of around 200km/h. They play an important role as they affect the position of both high and low pressure systems in mid-latitude areas. They may affect the pattern or path of depressions moving across the north Atlantic towards the British Isles. Seasonal variations in the path of the jet stream affect the frequency with which we can experience anticyclonic conditions or depressions.

Web Link – See the link below for an illustration and explanation of the Jet Stream:

What is the Jet Stream and how does it work? (Met Office) https://youtu.be/huweohIh_Bw

(iii) Temperature Variations

You should be aware of the main factors that influence temperature around the world. These factors are:

- latitude;
- distance from the sea/continentality;
- altitude;
- ocean currents; and
- seasonality.

These factors are explained in the following video clip: https://youtu.be/u8y1J1eDrhU

Latitude

Areas closer to the equator are warmer than areas closer to the poles. This is explained by:

- The greater concentration of incoming solar radiation at the equator compared to greater dispersal at the poles due to the angle of the sun’s rays.
- Insolation pass through a greater depth of atmosphere at the poles so there is a greater likelihood of it being reflected out to space.

Distance from the Sea/Continenteality

Proximity to the coast is a factor influencing temperatures due to differences between land and sea in rates of heat absorption and loss. The sea warms up slowly but retains heat and only slowly loses heat. By contrast land surfaces absorb heat relatively quickly but lose heat quickly also. This is most obvious in the variations experienced between night and day; land may experience a much more extreme
range over the course of 24 hours. Ocean temperatures, on the other hand, will warm slowly over summer months and cool slowly during the autumn and winter but will show negligible day-to-day change. Continental interiors are therefore prone to more extreme temperature ranges. Coastal locations tend to be less extreme as they are moderated by the influence of the sea.

**Altitude**
Temperature is affected negatively by an increase in altitude. Every increase of 100m above sea level results on average in a drop of 1°C.

**Ocean Currents**
Each of the world’s oceans has a circular pattern of ocean currents. Ocean currents that flow from equatorial regions are warm currents. One of the best known is the North Atlantic Drift which flows in a north-easterly direction from the Gulf of Mexico towards N.W. Europe. This ocean current keeps the British Isles warmer than areas in North America at a similar latitude.

Currents that flow towards the equator carry cooler water towards the tropics and so are referred to as cold currents. The California current brings cold water southwards along the west coast of the U.S.A. This current keeps San Francisco relatively cool and is responsible for the fog that often obscures the Golden Gate Bridge particularly in summer.

**Seasonality**
Seasonality is brought about by the migration of the overhead sun between the Tropic of Cancer (21st June) and the Tropic of Capricorn (21st December). As this happens, variations in insolation are experienced between the northern and southern hemisphere due to the angle of the sun and the changing length of day.

Maps showing the variation in global air temperatures for January and July can be viewed at the following web links:

http://www.physicalgeography.net/fundamentals/images/jan_temp.gif
http://www.physicalgeography.net/fundamentals/images/july_temp.gif


![Fig. 3.1 Global variations in precipitation levels](https://www.climate-charts.com/World-Climate-Maps.html)
The following video shows how the major wind and pressure belts of the earth shift according to the seasons: https://youtu.be/v7CaZOTXCSo.

The following link provides a useful summary with diagrams and video clips to describe and explain the redistribution of energy by the atmosphere and oceanic circulation: https://www.bbc.co.uk/education.guides/zym77ty/revison
3 (b) Weather in the British Isles

This section is concerned with the weather systems that affect the British Isles. You should be able to distinguish between anticyclones and depressions from surface pressure charts and satellite imagery, explain their formation and the weather conditions associated with them. You are expected to be able to explain the formation of different types of precipitation – relief (orographic), frontal and convectional.

Section Contents:

- Understanding precipitation
- Mid-latitude weather systems
- Interpreting weather from surface pressure charts

Precipitation

Precipitation is a significant feature of our weather that affects our daily lives. You are expected to understand the process that results in the formation of rainfall (or other sorts of precipitation) and the different conditions or circumstances that can prompt that process.

There are three main types of rainfall experienced in the British Isles. The formation of rainfall is the result of a set of conditions and processes – expanding air, adiabatic cooling and increasing humidity that exceeds dew point. This results in condensation taking place. The causes or circumstances in which this happens differ resulting in the three types of rainfall.

Web Link - How does it rain? (Met Office video) https://youtu.be/dQJsJRNJOFI

Key terms to include in an explanation of rainfall:

- **Evaporation**: change in state of water from liquid to a gas.
- **Humidity**: a measure of the amount of water vapour in the air.
- **Relative Humidity**: a measure of the amount of water vapour in the air as a percentage of the maximum the air could hold at that temperature.
- **Saturated air**: If air has a Relative Humidity of 100% it has reached maximum humidity and is said to be saturated.
- **Dewpoint Temperature**: when air cools the potential of the air to hold water vapour will decrease i.e. it will become saturated. The temperature at which that happens is called the Dewpoint Temperature.
- **Condensation**: at dewpoint temperature water vapour will start to condense. In other words it changes in state from gas to liquid in the form of tiny droplets of water. This process will be aided by tiny particles of dust, salt or ash in the atmosphere which will act as condensation nuclei providing a surface on which tiny droplets can form.

**Orographic or relief rainfall**

Air cools and expands as it is forced to rise over higher ground, usually having been blown inland from the sea. Relative humidity increases until it reaches dew point at 100% humidity.
Frontal rainfall
When warm and cold air meet at a front the warm air is forced to rise over the denser cold air. As it rises it cools and expands. This results in an increase in humidity and when dew point is reached precipitation occurs.

Convectional Rainfall
This is the result of rising air caused by the heating of the land in warmer summer conditions. The rising air cools, expands and results in an increasing humidity levels.
Mid-latitude weather systems: 
This term includes the weather we experience in the British Isles. It is governed to a large extent by the complex mixing of a number of air masses, with contrasting characteristics, which results in very changeable weather conditions.

Air masses and their characteristics: 
Air masses and their characteristics are an important part of the explanation for the weather we experience. An air mass is a large body of air that has been positioned over an area of land or sea for a period of time. The air mass adopts characteristics due to the nature of the land or sea over which they have become settled or formed. The most significant of these characteristics relate to temperature and moisture levels. The temperature of a land mass is affected by latitude (Polar - cooler, Tropical – warmer) and also whether it has formed over land or sea (continental - warmer, maritime – cooler). Moisture levels are affected by formation over land or sea (maritime – moist air, continental – dry air). Much of the explanation for our weather is based on the consequences of the mixing of cooler polar air from the north mixing with warmer tropical air from the south.

Web Link - https://www.metoffice.gov.uk/learning/learn-about-the-weather/how-weather-works/air-masses/types
Weather systems
The mixing of these air masses is affected by the upper westerlies, strong winds found in the upper troposphere. The path and speed of these winds varies and affects the mixing of the cooler polar air to the north and warmer tropical air to the south. The mixing of these air masses takes place at the boundary between the two air masses and results in the formation of the two key weather systems – high pressure anticyclone systems and low pressure (cyclone) systems.

For each of these you are expected to be able to recognise the weather systems on a synoptic chart, understand their formation and be able to describe the weather or sequence of weather associated with them in the British Isles.

Low pressure systems
These are referred to as mid-latitude depressions or cyclones. They tend to have a more frequent influence on the weather we experience in Northern Ireland than anticyclones. They are also responsible for the very changeable and sometimes dramatic weather we experience. They can result in periods of high winds and heavy rainfall. When these depressions result in storms they are given names by forecasters. e.g. Storm Brian which we experienced in October 2017.

Web Link – This link to a met office news release provides a useful insight into anticipated weather and associated dangers. There is a useful video clip that illustrates the path taken by the depression, wind strength and direction: https://www.metoffice.gov.uk/news/releases/2017/storm-brian-to-arrive-this-weekend

As they progress over the British Isles, usually from south-west to north-east there is a typical sequence of weather associated with their passing.
**Formation**

Low pressure systems are the result of the meeting of cold polar air from the north and warmer tropical air from the south. The polar front is the boundary between these air masses. As these air masses converge along the front differences in air temperature result in a wedge of cold air from the north undercutting the rising warmer air from the south, see Fig 3.6. This results in a recognisable and predictable sequence of weather.

This dynamic weather system is characterised by rapidly changing conditions as it moves across the British Isles. You should be familiar with the typical sequence and in particular be able to describe and explain the changes in air temperature, air pressure, cloud levels, precipitation, wind direction and strength.

The significant temperature differences between polar and tropical air masses results in strong westerly winds that circulate in the upper troposphere in the mid-latitudes. The Polar Front Jet Stream is one of these strong air flows which has an influence on the formation of depressions (and anticyclones). As they speed up the rising air results in a low pressure system. Where they slow down, falling air results in the high pressure which may form an anticyclone.

**Web Link** – The video clip should give you a further insight into the formation and nature of weather fronts:

*Warm and Cold Fronts (Met Office)*  [https://youtu.be/G7Ewqm0YHUI](https://youtu.be/G7Ewqm0YHUI)

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Fig 3.6 Development of a low pressure system

Fig 3.7 shows a typical diagram describing how weather changes in a cross section through a depression. It is important to remember that this cross-section will move from left to right (moving eastwards) across Northern Ireland and as it does the changes in the sequence of weather will be experienced at ground level. Fig 3.8 summarises how conditions change through the different phases of a passing depression.
Fig. 3.7 Cross section through a depression and the associated conditions

**Web Link** – It is important to be familiar with the typical sequence associated with the passing of a depression. The following clip should prove useful:
Explanation of depression formation and sequence of weather: [https://youtu.be/jsuWK9S7W4I](https://youtu.be/jsuWK9S7W4I)

A detailed diagram of a cross-section through a typical depression can be viewed at:
### Depression characteristics and sequence

The following table summarises the sequence of weather conditions associated with the passage of a low pressure weather system.

<table>
<thead>
<tr>
<th>Time Sequence</th>
<th>Depression has passed</th>
<th>Passage of the depression</th>
<th>Approaching depression</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Position in Cross-section</strong></td>
<td>Cold Sector</td>
<td>Warm Sector</td>
<td>Ahead of warm front</td>
</tr>
<tr>
<td>Passage of cold front</td>
<td>Low stratus clouds – may thin and break to clear skies</td>
<td>Lower and thicker clouds. nimbo-status</td>
<td>Thickening clouds – cirrus and alto-stratus</td>
</tr>
<tr>
<td><strong>Cloud Cover</strong></td>
<td>Thinning clouds - cumulus</td>
<td>Thickening clouds often forming large cumulonimbus</td>
<td></td>
</tr>
<tr>
<td><strong>Precipitation</strong></td>
<td>Clearing showers</td>
<td>Heavy rainfall – may experience hail or sleet</td>
<td>Rain eases to drizzle and becomes relatively dry</td>
</tr>
<tr>
<td><strong>Wind Speed and Direction</strong></td>
<td>N or NW winds decreasing in strength</td>
<td>Increase to strong winds, may be gale force, veering to North</td>
<td>Calm conditions light or moderate westerly winds</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>Cold conditions</td>
<td>Sudden drop in temperature</td>
<td>Milder conditions</td>
</tr>
<tr>
<td><strong>Air Pressure</strong></td>
<td>Rising Air pressure</td>
<td>Rising air pressure</td>
<td>Steady</td>
</tr>
</tbody>
</table>

Fig. 3.8 Table summarising the sequence of weather conditions associated with the passage of a depression

**Web Link** – You are not required to study the potential impact of depressions; however, should you wish to explore the impacts of depressions then the following links are useful:

Storm Desmond on 5th-6th December resulted in serious flooding in Cumbria. This is described along with meteorological detail and statistics. [https://www.metoffice.gov.uk/climate/uk/interesting/december2015](https://www.metoffice.gov.uk/climate/uk/interesting/december2015)

During the winter of 2014 the UK experienced a succession of severe storms which resulted in flooding and severe winds particularly in SW England. This link provides a useful description of the impacts of the storms and descriptions of the weather experienced including meteorological detail. [https://www.metoffice.gov.uk/climate/uk/interesting/2014-janwind](https://www.metoffice.gov.uk/climate/uk/interesting/2014-janwind)

**High Pressure Systems**

High Pressure systems are also referred to as anticyclones. Anticyclones differ from cyclones or depressions in a number of key areas:

- They are areas of descending air.
- Anticyclones cover a greater area.
• They are formed from a single air mass and there is little variation in weather experienced.
• They are slow moving and have a settling influence on weather patterns.
• There is a significant contrast in the weather associated with a winter anticyclone and a summer anticyclone in the British Isles.

Formation
The formation of an anticyclone weather system in the mid-latitudes is the result of a large area of descending air. This results from the slowing down of the Polar Front Jet Stream which causes air to subside or descend.

Characteristics and sequence
Anticyclones are areas of subsiding air. This means that air pressure tends to be high at the surface. Winds tend to blow outwards from the centre of a high pressure system in a clockwise pattern. This is in contrast to a low pressure system where winds tend to blow towards the centre of the depression in an anticlockwise direction. Isobars in an anticyclone tend to be further apart so winds are lighter than would be typical in a depression where isobars tend to be closer together.

Summer Anticyclone
When high pressure systems settle over the British Isles in the summer months they tend to result in a settled period of low winds, clear skies and warm temperatures. When they become established they may last for several days. The clear skies may result in dewy conditions and low night time temperatures due to the lack of cloud cover. Early morning fog or mist may be experienced in coastal areas but will not persist in the high temperatures. High temperatures may persist for several days resulting in ‘heat wave’ conditions.

Web Link – For a case study of a summer anticyclone including a description of the conditions experienced and the impacts see the link below:

Winter Anticyclone
A winter anticyclone brings contrasting weather temperatures due to the position of the sun in the sky, the shorter daylight hours and the lower temperatures. Winter anticyclones are typified by longer periods of settled cold weather. The lack of cloud cover results in particularly cold night-time temperatures. This often results in frost and icy conditions. Fog often develops and may persist throughout the day as there is insufficient heat from the low sun to raise temperatures. Such conditions are often referred to as ‘anticyclonic gloom’. Low temperatures may persist for several days and cause disruption to transport by road, rail or air, as well as to other aspects of everyday life.

Web Link – For a case study of the winter anticyclone experienced over the UK in 2010 that includes a description of the conditions experienced and the impacts see the link below:
https://www.metoffice.gov.uk/climate/uk/interesting/jan2010

Weather Forecasts and Synoptic Charts
The weather forecasts we watch on television vary in terms of the detail and explanations they provide. In more detailed forecasts, presenters use surface pressure charts or synoptic charts to describe and explain the weather over the British Isles.
They may also use satellite images that highlight cloud patterns from which it is often possible to recognise the prevailing weather system. You need to be able to recognise these charts and understand the symbols used on them. The link below should prove useful.

**Web Link** – Met Office explanation of synoptic charts: [https://youtu.be/wl_FFK_HbjY](https://youtu.be/wl_FFK_HbjY)
3 (c) Global Weather Issues

Section Contents

In this section you need to:

• Know how the El Niño Southern Oscillation (ENSO) and La Niña events affect global wind and rainfall pattern.
• Understand how hurricanes (tropical cyclones or typhoons) form and explain their structure.
• Describe the impacts of a recent hurricane, tropical cyclone or typhoon and evaluate the management strategies that were in place to reduce its impacts on people and property.

El Niño Southern Oscillation

El Niño is a phenomenon that occurs at irregular intervals of between 2 and 10 years. It is the result of changes in sea temperatures in the eastern Pacific which alters ocean patterns, pressure systems and wind direction between Australia and South America. This results in changes to the normal weather experienced in South America, Australia and beyond. These deviations from the normal climatic conditions can sometimes have disastrous consequences.

Fig. 3.9 below describes the normal conditions in the Pacific Ocean which influence weather in South America in the east and Australia and Indonesia in the west. Sinking air on the coast of South America results in high pressure, low rainfall and settled weather. The cold waters on the Pacific coast of South America are driven westwards by prevailing easterly and southeasterly winds. The cold water is warmed by the tropical sun and results in rising air with wet weather and low pressure as a consequence on the coast of Australia. This air then tends to become part of an air circulation travelling eastwards at high altitude. This is referred to as the Walker Circulation.

Fig. 3.9 Normal air and sea conditions in the south Pacific

El Niño

Periodically (every 3 – 7 years) the pattern described in Fig. 3.9 is reversed (see Fig. 3.10). The trade winds are weakened and along with warm ocean currents operate in the opposite direction towards South America as shown in the diagram. This has significant consequences for the weather experienced in South America and Australia. The lack of rainfall can result in drought in Australia and higher than normal precipitation in South America resulting in floods and deeper accumulations
of snowfall on the mountains. These conditions are described in more detail in the web link below. In 2015-2016 a particularly strong El Niño was experienced and is thought to have influenced weather in Europe during that winter when severe storms were experienced in Ireland and the UK.

This variation in the temperature of ocean currents that occurs periodically in the southern Pacific is referred to as the El Niño Southern Oscillation. This oscillation in ocean current sometimes results in a La Niña event where ocean currents are cooler than normal. Whilst this occurs less frequently it can, similarly have global implications for weather patterns. This can result in lower than normal air pressure over the western Pacific and higher than normal pressure over eastern Pacific with implications for rainfall levels in South East Asia and drought conditions in South America. In 1988 it was linked to the severe monsoon that resulted in disastrous flooding in Bangladesh. It may also be linked to increased hurricane activity in the Caribbean.

Web Link – The following websites provide useful illustrations of the causes and consequences of El Niño and La Niña:
https://www.nationalgeographic.org/encyclopedia/el-nino/
https://blog.education.nationalgeographic.org/2015/10/26/what-you-need-to-know-about-el-nino/

Hurricanes

In describing hurricanes you need to be aware of:

(i) The conditions under which hurricanes form
(ii) The sequence of hurricane formation
(iii) The structure of a hurricane
(iv) The impact of hurricanes and how this can be managed.

Hurricane formation

Hurricanes are extreme and violent weather events that are characterised by extreme winds and periods of torrential rainfall. They are intense low pressure systems but do not have the fronts associated with mid-latitude depressions. They are also referred to as tropical cyclones or typhoons.
Hurricanes tend to form within the Tropics as their energy is derived from the warm equatorial waters. Fig 3.11 shows the global distribution of hurricanes, cyclones and typhoons. Certain conditions have been identified which lead to their formation and these help to explain the distribution patterns seen above. It is important to be able to describe these conditions:

- They form over warm water where it is 26°C or more to a depth of 60m. This tends to be from late summer until late Autumn by which time the sea has reached its highest temperature.
- They originate within the tropics but not within 5 degrees north or south of the equator. The Coriolis force is not strong enough close to the equator to result in the spiralling or spinning of the air.
- They tend to form on east ocean basins and move westwards veering away from the equator.
- Hurricanes will die once they lose the source of their energy i.e. away from the warm tropical waters they will move into cooler waters or move over land.

The sequence of hurricane formation
You are expected to be able to describe and explain the sequence outlined below which leads to the formation of a hurricane:

- Moist warm air is drawn upwards from the ocean;
- The Coriolis force cause this rising air to spiral;
- The rising air cools and condensation results in cloud formation in spiral bands;
- The condensation of moist air results in energy release and wind strength increases reaching sustained wind speeds of over 120 km/hr; and
- Over time the characteristic eye of the storm develops in the centre of the bands of clouds. This is an area of calmer conditions and subsiding air.

This process takes place over a wide area and the excessive volume of water that is evaporated from the warm ocean is a significant factor in the extreme nature of the winds and rainfall that characterise hurricanes.
The consequences of hurricanes are felt most severely when hurricanes meet land and are the result of:

- High wind speeds;
- Prolonged and intense periods of rainfall; and
- Storm surges due to the intense low pressure and the force of the onshore winds driving the sea landwards.

An important part of your study of hurricanes should include becoming familiar with the structure of a typical hurricane. You will find a range of diagrams in text books, revision guides and websites that describe this. The diagram in Fig. 3.15 includes reference to the eye, the eye wall, spiralling bands of cloud and rain, rotating winds, and descending or subsiding air.

**Web Link** – The following websites provide useful guides and illustrations to show the structure and formation of hurricanes:
http://wx.db.erau.edu/faculty/mullerb/Wx365/Hurricanes/Hurricane.jpg
https://spaceplace.nasa.gov/hurricanes/en/

The following website explains how disasters are measured including the Saffir-Simpson Hurricane Scale used to measure hurricane strength:
http://greenfieldgeography.wikispaces.com/Measuring+Disasters

You are expected to be familiar with a case study of a hurricane, tropical cyclone or typhoon to illustrate how they form, their structure and impacts. You should also be able to discuss how management strategies or levels of preparedness affected the level of impact. **Hurricane Katrina (2005)** and **Cyclone Haiyan (2013)** are listed in the specification as appropriate case studies. Below you will find links to useful case study material for each of these case studies.

**Hurricane Katrina case study**
Hurricane Katrina provides a useful illustration of the path often taken by such extreme events and how they develop and impact upon an area. The website below provides useful information regarding its formation and impact.

**Web Link** – [http://coolgeography.co.uk/A-level/AQA/Year%2013/Weather%20and%20climate/Hurricanes/Hurricane_Katrina.htm](http://coolgeography.co.uk/A-level/AQA/Year%2013/Weather%20and%20climate/Hurricanes/Hurricane_Katrina.htm)

**Cyclone Haiyan Case Study**
The following website link provides case study information regarding Cyclone Haiyan 2013:
Cyclone Haiyan case study information:

**General information about hurricanes with details of 2017 storms:**
The hurricane season of 2017 was significant because of the number of severe Atlantic hurricanes that occurred. Hurricane Irma provides a useful more up to date case study. The websites below provide a range of sources of information describing these hurricane events and their impacts in Autumn 2017:
Web Link – Hurricane Irma Case study:
https://www.thebalance.com/hurricane-irma-facts-timeline-damage-costs-4150395
https://www.thenational.ae/world/the-americas/what-we-know-about-hurricanes-irma-and-jose-facts-figures-forecast-1.627024
https://www.tropicalweather.net/hurricane-articles.html

Preparedness:
Web Link – The following link is to a web page that discusses the importance of preparedness in minimising loss of life in the 2017 Hurricane Irma:
Sample Exam Questions

Mid-latitude Depressions

2011
Describe and explain, with reference to any four of the elements, the weather associated with the passage of the warm front at 3pm.

Jan 2012

7 Using an annotated diagram, describe the structure of a mid-latitude frontal depression and use your case study material to help you discuss the impact of such a weather system on people.
4 (a) Study Resource 4A which illustrates the same parcel of air at three different temperatures (shown as Boxes A, B and C).

(i) Describe and explain the relationship between air temperature and its saturation level.

________________________________________________________________________________________________________________________________________________________________________

(ii) Explain why clouds and precipitation are most likely to occur in Box C.

________________________________________________________________________________________________________________________________________________________________________

[3]  

[2]  

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Jan 2013

(c) Study Resource 4B, a table illustrating some of the differences between a mid-latitude depression and an anticyclone. Complete the table by adding **three** additional differences between the two weather systems.

<table>
<thead>
<tr>
<th>Depression</th>
<th>Anticyclone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Winds blow anticlockwise.</td>
<td>Winds blow clockwise.</td>
</tr>
<tr>
<td>2 Low pressure at ground surface.</td>
<td>High pressure at ground surface.</td>
</tr>
<tr>
<td>3 Isobars close together on synoptic chart.</td>
<td>Isobars widely spaced on synoptic chart.</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Global Weather Issues
Jan 2011

7 With reference to a hurricane or tropical cyclone you have studied at a national or regional scale, evaluate the protective measures used to reduce the loss of life and damage to property. [12]
Jan 2012

(c) Study Resource 4B which illustrates some of the physical and human factors which can influence the severity of the effects of hurricanes/tropical cyclones.

Resource 4B

**PHYSICAL FACTORS**
- Relief
- Climate
- Drainage
- Geographical Location

**Factors Influencing Severity of Effects**

**HUMAN FACTORS**
- Land Use
- Population Density
- Technology
- Planning Regulations
- Level of Development
- Hazard Management

Select one human and one physical factor and explain how they influenced the effects of a named hurricane/tropical cyclone you have studied.

[6]

Jan 2013

7 With the aid of an annotated diagram, describe the general structure of hurricanes and explain the conditions required for their formation. [12]
Glossary of Key Terms

**Anticyclone** – A system of high pressure. Isobars are generally widely spaced with high pressure at the centre and decreasing towards the outer edges of the system. Winds blow in a clockwise direction and are usually light.

**Atmosphere** – The layer of gas which surrounds the earth. The atmosphere is divided in layers. The troposphere being closest to the surface above which are found the stratosphere, the mesosphere and the thermosphere.

**Continentality** – refers to the influence of large land mass interiors which experience less rainfall due to distance from the ocean and are subject to more extreme ranges of temperature than maritime areas and therefore have a contrastingly different influence on weather and climate.

**Convectional precipitation** – rain caused by the process of convection in the atmosphere. It is associated with equatorial climates.

**Cyclonic precipitation** – rainfall caused by rising air at fronts in a depression.

**Depression** – a low pressure system. Isobars can be very close together and winds, often strong, blow in an anticlockwise direction. Depressions form as a result of the meeting of two air masses creating warm and cold fronts.

**El Niño Southern Oscillation** - the periodic occurrence of changes in oceanic circulation in the southern Pacific which results in variations in weather patterns. The changes may result in an El Niño event or a La Niña event.

**Global Energy Balance** – the balance between incoming solar energy and that which is reflected results in an equilibrium which means the earth is neither heating up nor cooling down.

**Horizontal Heat Transfers** – heat is transferred horizontally from different areas across the globe maintaining a heat balance. This transfer of heat energy is carried out by winds and ocean currents.

**Hurricane** – a tropical storm or cyclone that is characterised by very strong ‘hurricane force’ winds, intense rainfall. Where they make landfall they can have a very destructive impact on settlements.

**Jet streams** – the narrow belt of high altitude westerly winds that occur in the troposphere.

**La Niña** – An extreme of the El Niño Southern Oscillation. In the Southern Pacific La Niña refers to the periodic cooling of the ocean currents off the coast of South America. This results in lower than normal air pressure over the western Pacific and higher than normal pressure over eastern Pacific with implications for rainfall levels in South East Asia and Drought conditions in South America. La Niña events occur less frequently than El Niño.

**Latitude** – a measure of the degree north or south of the equator, in meteorology it has an influence on global temperatures.

**Ocean Currents** – flows of water in the oceans. They represent horizontal heat transfers as they assist in maintaining the global heat balance.

**Orographic precipitation** – precipitation that results from the uplift of air over a land barrier. It is referred to also as relief precipitation.

**Relief precipitation** – See orographic precipitation.
**Satellite imagery** – photographs taken from satellites orbiting the earth. They provide useful images, e.g. of cloud formations, that can help meteorologists in their understanding of weather patterns and forecasting.

**Seasonality** – the weather patterns that are associated with different times of the year as a consequence of variations in the duration and intensity of solar radiation.

**Surface pressure charts** – maps used by meteorologists to display variations in surface pressure. Isobars are used to show these variations as they link up points of equal pressure.

**Synoptic chart** – a weather map used by meteorologists to display weather data compiled at a specific time for a particular location.

**Tri-cellular model** – This model is based on the concept that in each hemisphere, circulation of air occurs within three cells, the Hadley cell, the Ferrel cell and the Polar cell.

**Tropical Cyclone** – severe storm events that develop over tropical oceans. They are referred to as hurricanes in the Atlantic and typhoons where they occur in the pacific.

**Typhoon** – see tropical cyclones and hurricanes.

**Upper westerlies** – westerly winds in the upper troposphere found above the mid and high latitudes.

**Vertical Heat transfers** – in the global heat budget heat is transferred vertically, preventing the earth’s surface from getting increasingly hotter whilst also warming the air above the earth’s surface. The transfer mechanisms are radiation, conduction and convection.