Type of Rock	Formation	Example and Characteristics
Igneous	Formed by cooling lava and molten magma where they crystallised.	Granite is very resistant to erosion. Contains crystals of quartz. Older in age.
Sedimentary	Formed by the compaction of sediments on river/sea beds.	Chalk is medium resistance and very porous (liquid can pass through). Younger in age. Some sedimentary rocks can be very weak and erode easily.
Metamorphic	Formed by alteration of existing rocks by heat and pressure, hardening them and making them more resistant.	Slate. Very resistant. Older in age.

Most Metamorphic and igneous rocks are found in the north west of the UK, creating upland (mountainous) landscapes where most sedimentary rocks are found in the south east of the UK creating lowland landscapes.

The development of upland landscapes- Geology and past processes

1. **Tectonic processes:** Rocks were uplifted and are now high above sea-level.
2. **Geology:** Some rocks are more resistant to erosion than others and are eroded much slower than surrounding rocks. Therefore rocks are generally metamorphic and igneous.
3. **Glaciation:** Glaciers calved out the landscape as they moved through river valleys, transforming V-shape valleys into U-shape valleys by making them deeper and wider.

The development of Upland landscapes – Physical Processes

Weathering: The physical, chemical or biological breakdown of solid rock the action of weather or plants.
Freeze-thaw weathering: The breakdown of rock as rainwater gets into cracks during the day. At night, it freezes and expands, widening the crack. This process is repeated until the rock breaks into pieces.

The broken pieces of rock are angular, known as “scree”. They form large piles known as scree slopes.

Slope processes affect the valley sides and scree slopes which are subject to **rock falls** and **landslides** as heavy rain adds weight to the weathered rock so it slides easier.

The development of lowland landscapes – Physical Processes

As rock is sedimentary and less resistant they are affected by **chemical weathering.** This is where rocks in the landscape can be dissolved by acids in the rain.
Biological weathering: Tree roots break up solid rock.
Soil creep: A very slow **slope process** caused by rain dislodging tiny soil particles , relocating them further down the hill. This may happen really slowly, 2cm a year but can cause walls, trees etc. to lean.

Topic 4: The UK’s evolving Physical Landscape – Geology and Rivers

Rivers Keywords

Channel	The beds and banks of the river.
Load	Material carried by a river.
Erosion	Wearing away of the landscape by the action of water.
Transportation	A natural process by which eroded material is carried/transported.
Tributary	A smaller stream/river that joins a main channel.
Discharge	The volume of water flowing in a river measured in cubic metres per second.
Discharge increases as a river flows from source to mouth.	
Velocity	The speed of a river, measured in metres per second.
Alluvium	Sands and clays carried by a river that settles on floodplains after a river floods. Alluvium is very fertile so attracts farmers.
Floodplain	The area of flat land either side of a river that is covered in water during a flood.

Processes of river erosion

Abrasion	Where sediment carried by a river rub against the bed and banks and wear it away through a “sandpaper action”.
Attrition	Where rocks carried by the river collide with each other, breaking down into smaller pieces.
Hydraulic action	The sheer force of the water can get into cracks on the river bank, breaking it down.
Solution	Where rocks are dissolved by acids in the water.

Processes of Transportation

Solution	Minerals dissolve in water and are carried along.
Suspension	Sediment is carried along in the flow of the water.
Saltation	Pebbles that bounce along the sea/river bed.
Traction	Boulders that roll along a river/sea bed by the force of the flowing water.

How does a river change from source to mouth?

Upper Course: The formation of a waterfall

Waterfalls are usually found in the upper course of a river as most erosion in the upper course is vertical (downwards).

Step 1	When a river flows from hard rock, to soft rock, the soft (less resistant) rock erodes (by hydraulic action and abrasion) a lot quicker forming a step or lip.
Step 2	As water flows over the step/lip of hard rock it will undercutting the soft rock underneath.
Step 3	Hydraulic action creates a plunge pool at the bottom of the waterfall.
Step 4	Undercutting leads to the formation of a hard rock ledge. This eventually collapses into the plunge pool underneath due to lack of support.
Step 5	This process repeats itself and the waterfall retreats upstream, forming a steep sided gorge.

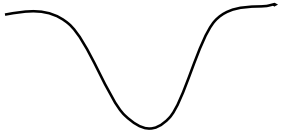
Middle Course: The formation of a meander (river bend)

Helicoidal Flow	How water flows in a corkscrew motion.

1. Helicoidal flow sends the rivers energy and fastest current (**thalweg**) from side to side, promoting lateral erosion.
2. Helicoidal flow causes the water to erode and undercut the river bank on the outside of a river bend. This erodes sediment away, forming a river cliff.
3. This sediment is carried across the channel and deposited by the slower currents on the inside of the next bend.

Point bar	A river beach formed on the inside of a meander from the deposition of sediment eroded upstream.

Overtime the neck of land between two meanders can narrow until the two sides join. The river will now flow straight across instead of around this meander, creating an oxbow lake.

	Upper course	Middle course	Lower course
Long profile			
Cross profile			
Gradient	Steep gradient	More gentle gradient	Flat gradient
Velocity	Low velocity, turbulence and friction	Faster velocity, less friction and increased discharge	Greatest velocity, little friction and highest discharge
Features	Water falls, gorges, V shaped valley, pot holes rapids, large rocks and boulders, the source, interlocking spurs.	Meanders, ox bow lakes, floodplains, smaller pebbles and suspended particles of rock	Floodplains, deltas, estuaries, the mouth, suspended sand particles
Channel	Narrow, shallow channel and uneven, rough surfaces	Wider, deeper and smoother channel	Widest, deepest and smoothest channel
Main Processes	Vertical Erosion	Lateral Erosion and Transport	Deposition

Lower Course Landforms

Estuary	Where the river meets the sea. River water is flowing outwards but twice a day tidal water flows inwards. Saltmarshes form with plants that can survive with both fresh and salt water.
Levee	Natural embankments that form beside the river channel than have built up through the deposition of alluvium/sediment during floods when water is at **bankful** (full to the top of the banks, before it spills onto the floodplain). Can also be artificial.
Delta	An area at the mouth of a river made of deposited sediment that stretches beyond the coastline into the water.

Processes in the water cycle

Infiltration	When water soaks into the soil
Surface Runoff	Water flows over the surface of the soil. It happens if the soil is saturated (can't hold anymore water) and infiltration cannot occur.
Surface runoff is common on soils that are impermeable (don't let water pass through them). This is a much faster process than infiltration/throughflow and can lead to flooding.	
Interception	When branches and leaves of plants intercept and store rainfall before it reaches ground.
Antecedent rainfall	How much rainfall has fallen recently.
Transpiration	The evaporation of moisture from vegetation through pores in leaves.
Throughflow	The movement of water horizontally through the soil, back to the river channel.
Groundwater flow	The movement of water horizontally through rock below the soil.
Storm hydrograph	A graph that shows how a river changes as a result of rainfall. It shows rainfall and discharge.
Rain takes time to reach the river as most lands on the valley sides and must travel via through flow or surface runoff. Discharge will then rise from what is normal (base flow) to a peak discharge (maximum volume of water)	
Lag time	The difference in time between peak rainfall and peak discharge.

How Human activities alter storm hydrographs

- Lag time will be short where the water cycle is sped up (surface run off occurs quickly) e.g. where humans have changed the land use of an area. Ground which was previously permeable can be made impermeable such as in towns and cities or an area has been deforested so there is no interception and the ground is saturated quickly. This creates a steep rising limb on the graph.
- Lag time will be longer where the water cycle is slowed down through permeable grounds, interception by forests. This creates a gentle rising limb on the graph.

How did physical and human processes cause flooding of a named river?

- Boscastle is a village in Cornwall, south west England that flooded in 2004.
- The river Jordan flows through Boscastle

Human Causes	Physical Causes
Importance of location: Boscastle has been built on a floodplain creating impermeable surfaces.	**Importance of location:** The surrounding area had impermeable underlying geology .
Importance of location: Boscastle is located on a confluence of the River Jordan and Valency.	**Importance of location:** The surrounding area was very steep.
A bridge within Boscastle acted as a dam when it debris got caught underneath it.	The soils surrounding Boscastle were saturated before the storm event due to antecedent rainfall.
	Heavy, localised rainfall (89mm/two weeks worth) in one hour.

What are the costs and benefits of managing flood risk?

Hard engineering: Structures are built to defend areas from floodwater.	**Soft engineering:** The area is adapted allowing natural processes to deal with rainwater.

Hard Engineering

Method	Cost	Benefit
Flood walls: Build a high wall alongside a river to increase its capacity to prevent flooding.	Depends on the material used. Can be very expensive. Will increase flood risk downstream.	Allows people to use land near river without fear of flooding.

Soft Engineering – More sustainable

Method	Cost	Benefit
Flood plain retention: The level of floodplains is lowered and surfaces restored to/planted with shrubs and grassland.	Expensive: £1.2 million for a 2km stretch.	Increased ability for that area to store water which slows down the water cycle.
River channel restoration: Remove any hard engineering and replace with planted trees. Restore any meanders that have been cut off**.** Both slow down the water cycle and reduce the risk of flooding.		People prefer natural look and improvement in number of plants and animals. People choose where the river floods by lowering the banks near les valuable land.

Topic 4: The UK's Evolving Physical Landscape: Coasts

Coasts Keywords	
Discordant	Coastlines which are made of two or more different types of rock facing the sea.
These erode at different rates and result in the formation of bays where the softer, less resistant rock erodes quickly and headlands where the harder, more resistant rock erodes slower.	
Concordant	Coastlines where only one rock type is facing the sea.
Headland	An area of harder rock that juts out into the sea. These erode through a series of landforms from a cave, arch, stack and stump.
Erosion	The wearing away of the land by water. There are four types.
Hydraulic action	The sheer force of the water and air that is forced into cracks in cliff faces breaks off fragments of rock.
Corrosion	Sea water is corrosive. Acids in the water dissolve coastal rocks.
Abrasion	Pebbles and sand wear away the cliff as they are hurled at the cliffs, carried by the waves (sand blast effect)
Attrition	Particles (pebbles/sand) become increasingly rounder and smaller through repeated collision with each other.
Transport	The movement of material along a beach due to the action of waves.
Deposition	The dumping down of material.
Swash	The movement of waves up a beach. This deposits sediment.
Backwash	The movement of waves down a beach. The rip current erodes sediment by dragging it back down the beach.
Destructive wave	Powerful and tall waves with a plunging motion. Backwash is greater than swash which erodes the beach, resulting in steep beach profiles.
Constructive wave	Smaller waves with a spilling motion. Swash is greater than backwash which deposits sediment, resulting in flat and wide beaches.
Fetch	The length of water over which the wind has blown, affecting the size and strength of waves. The longer the fetch, the bigger the waves.
Mass Movement	The movement of materials downslope such as rock falls, landslides or cliff collapse.

Formation of a spit

A spit is a ridge of sand that extends out from the coastline into the sea. They are formed through deposition and are known as depositional landforms.

Step 1	**Prevailing wind** (most common direction) causes constructive waves to come in (generally from a south west direction).
Step 2	As the swash moves up the beach at an angle it picks up sediment. Under gravity, the wave moves back down the beach an a **right angle** to the cliffs. This process is repeated, transporting sediment from west to east and is called **longshore drift.**
Step 3	A change in the direction of coastline is needed for the sand to be deposited and extend out forming a spit. They do not form across river estuaries as the current would wash the deposited sediment away. Often behind spits a salt marsh forms.
Step 4	The end of the spit can become hooked or **"recurved"** due to the action of the tide.

Spits can extend across bays, joining two headlands. This is known as a **bar** and they create a lagoon behind the bar.

Processes Acting on Cliffs

The **foot** of cliffs (bottom) are attacked by waves causing hydraulic action which creates rock fragments which are used in abrasion. This continual process results in **cliff retreat** as they cut out **wave cut notches** at the bottom of the cliff, causing the face (front of cliff) to collapse due to lack of support.

Weathering	Attacks the face of the cliff. This is where rocks are worn away without the action of waves. There are three types.
Biological/plant weathering: roots grow into cracks forcing them wider. This will be through Animals burrowing/nesting also have a similar effect.	**Freeze-thaw weathering:** cracks fill up with water, which in turn freezes when the temperature drops forcing the crack wider which in turn can cause fragments of rock to break off.
Sub-aerial Processes	Mass movement and erosion which are the causes of cliff face erosion.

Joints, cracks and **faults** speed up the rate of erosion at the cliff foot or headland as the surface area of the rock in contact with water is increased.

Wave-cut Platform	The flat rocky area left behind when waves erode a cliff away.

How can Humans Defend the Coastline from Erosion?

When choosing whether or not to protect a coast the UK government has 4 options. These are known as **shoreline management plans (SMP's).**

1. Hold The Line	This is where hard engineering, coastal defences are installed on the coast line to slow erosion significantly. This is done if the benefits are greater than the costs of protecting a certain area.
2. Advance The Line	This is where hard engineering, coastal defences are installed in front of the coastline, in the water, to break the waves before they reach the coast.
3. Do Nothing	Install no defences as the costs outweigh the benefits.
4. Strategic Realignment	This is where an area that previously has been protected, have their defences removed and allows the sea to "reclaim"/flood the land behind forming a salt marsh. People and businesses are moved away from the area and people are compensated.

Keywords

Stakeholder	Anyone with an interest or involvement in the coastal area that would be affected (positively or negatively) by any change e.g. choosing to install, remove or stop maintaining coastal defences.

Some examples include local residents, Tourists, Business owners/employees, Environmentalists. The decision to protect the coast or not can lead to conflict between the stakeholders.

Cost-Benefit Analysis	They weigh up whether the cost of installing coastal defences in a certain location outweigh the benefits (value of land and infrastructure saved from erosion). If the benefits are greater, they will protect this stretch of coastline. If the costs are greater, they won't install coastal defences.
Integrated Coastal Zone Management (ICZM)	The government now take into account long stretches of coastline, rather than towns in isolation, when choosing whether of not to install coastal defences. This is due to negative effects experienced by some locations due to the installation of coastal defences further up the coast e.g. the shrinking of beaches as they are starved of sediment, normally supplied through longshore drift and trapped by groynes. This minimises conflict between stakeholders.
Hard Engineering	Taking the most **drastic measures** to **slow** erosion with **expensive, man-made, visually intrusive** concrete/steel barriers which aim to reduce **(dissipate)** the amount of wave energy hitting the beaches and cliffs.
Soft Engineering	No physical structures are built and involves using natural processes to protect the coast. These methods maintain the beach, ensuring there is plenty of sand/sediment which in turn will absorb the energy of the waves. Not visually intrusive. Looks more natural and is much cheaper.

If the geology of the area is soft/weak then soft engineering may not be an option as erosion rates will be high. Hard engineering ill be the only solution to significantly slow erosion rates.

Costs and Benefits of Coastal Defences

Hard Engineering

	Cost	Benefit
Groynes: These are wooden or concrete barriers placed on the beach at right angles to the cliff.	They minimise longshore drift by trapping sediment that would normally be transported. This acts as a natural defence to erosion, absorbing the impact of the waves.	their lifespan is relatively short and have to be replaced fairly often. They can also reduce tourism by being an eyesore, further making them economically unsustainable.
Sea Walls: Concrete barriers placed at the foot of cliffs to absorb the power of waves.	Can make accessing the beach difficult. Can look ugly/be visually intrusive and drive away tourists. The local economy may suffer as a result. Very expensive and overtime will need replacing due to erosion.	Reflects waves back out to sea and significantly reduces erosion. Protects the base of the cliff.

Soft Engineering

	Cost	Benefit
Beach Replenishment: Artificially replacing sediment that has been lost from beaches by longshore drift. Also known as beach nourishment.	This requires regular maintenance which costs money as sediment is easily removed by longshore drift.	The sand acts as a natural defence absorbing the power of the waves. The natural appearance attracts tourists which boosts the local economy. This is a relatively cheap process.
Slope Stabilisation: The cliff is made more stable by planting vegetation and installing drainage pipes.	Difficult to install drainage pipes.	Water now drains from the cliff easily. This means it doesn't become saturated and heavy. Mass movement is prevented.

The Impact of Climate Change on Coastal Erosion and Flooding	
Storms	Storms may become more frequent and powerful due to warmer oceans creating larger storm surges and greater coastal flooding. Rates of coastal erosion and cliff retreat will increase, especially in areas of softer rock.
Rising sea level	Causes by thermal expansion and melting ice caps. People living in low-lying coastal areas are at risk.
Calculating the Rate of Erosion	A map showing where the coastline used to be and where it is today with a clear scale to allow the distance between the two coastlines to be measured. The dates of the coastline are also important to show the retreat of the coastline over a specific timescale.

How Human Activities Affect the Coastal Landscape	
Coastal Management	Concrete/man-made and intrusive structures are installed along the coastline in order to slow erosion rates.
Industry	Piping gas onshore to gas terminals is not popular with tourists but essential to the UK.
Development	Housing is in high demand due to the coast being a popular retirement destination and for Londoners who can't afford to buy in London. Companies are also relocating to some coastal areas due to the high cost of land in London. Other infrastructure such as roads, railways and oil refineries have developed the coastline.
Agriculture	Pressure has increased on coastal farmland (e.g. saltmarshes) for grazing pastures for cattle which puts pressure on animal habitats due to rising cost of land. Land that is farmland has lower economic value and therefore is not protected. It is being lost to the sea due to erosion.

How the Interaction of Physical and Human Processes is Causing Change in Lyme Regis	
Significance of Location	Lyme Regis is on the Jurassic Coast in South West England. This means it is exposed to a powerful destructive waves due to the large fetch. This stretch of coast is a natural World Heritage Site and is internationally important for its rocks and fossils. Installing coastal defences and interfering with the natural process of erosion prevents any fossils from being exposed. At the peak of summer the population of the town swells from a resident population of 5,000 to 15,000 as tourists arrive. Tourism is the main source of income to the town. Lyme Regis receives 16.5 million tourists each year providing £830 million in business. Protecting the town is therefore economically important.
Human Actions	The approach taken directly in front of Lyme Regis is hold the line. They have installed hard engineering with a sea wall and groynes. They have also created a sandy-beach through beach nourishment to attract tourists which they have sheltered from waves by extending the Cobb. They have stabilised the slopes behind the beach front by installing drainage facilities and 1000 pins securing the top layer of rock to the bottom layer. Away from the town there is a mix of 'holding the line' and 'do nothing' on the stretch of land between Monmouth Beach and Ware cliffs as the land is undeveloped and has low economic development
Natural Processes	Coastal erosion and mass movement. The town is built on a layer of strong limestone which is very solid. On top of that layer there are slippery muds, clays and sands which slide over the limestone layer to form the landslides. The sea is rising and eroding the foot of the cliffs, causing even more landslides. Properties have been lost to sea throughout history.

Impacts of Erosion on the Local Community
• **Homeowners lose their homes to the sea.** • House values fall. • **Homeowners struggle to obtain home insurance.** • **Roads and infrastructure is destroyed.**