What you need to know:
How wind creates waves.
How tides are created.
How ocean currents work.
Where the sources of sediment originate from in a coastal system.
How a sediment cell and budget work.

Introduction:

The processes and subsequent landforms that are created in a coastal landscape originate from two main causes. Sources of **energy** are required to bring about change and be able to modify the coastal landscape, and **sediment** plays a role in certain processes of erosion and cycles around a system to form stores of deposition.

The key energy sources to be considered are energy from the wind, energy from the gravitational pull of the moon and sun as well as ocean currents. **Biogenic sediments** from decaying sea creatures, together with **clastic sediments** transferred into the coastal system by mass movement of weathered and eroded rock are equally as important to the system.

Energy sources:

Wind:

- The primary cause of erosion along a coastline is by wave action. Marine processes increase with high energy waves. These waves are **destructive waves** which are high frequency waves (occurring 10-15 times per minute) and they are tall, which means that they crash onto the beach and scour away at the land, removing material out to sea.
  Their swash up the beach is less powerful than their backwash, causing a net beach loss.

  They cause erosion, primarily by abrasion, whereby material is thrown at cliff faces and wears it away. The primary cause of deposition is also to do with the wave action. Low energy waves known as **constructive waves** are less frequent (6-9 times per minute) and roll onto the beach. They lose energy when rolling up the beach so deposit any material that they are carrying.

  Their forward swash is more powerful than their backwash leading to net beach gain.

- Waves are formed by the wind blowing across the surface of the water. Initially, the blowing wind will create ripples and these will then turn into waves. As waves reach the coast the lower part of the wave will slow down due to friction. The upper part of the wave then falls forward and breaks onto the beach. What makes the difference between a destructive and a constructive wave is wind strength, which is affected by local weather systems and the fetch. The fetch is the distance of the sea, over which the wind has travelled. For example, if the wind blows over an area of sea which is several thousand miles long, destructive waves will form as they have had the time to generate greater energy. Whereas, a shorter fetch will result in smaller, constructive waves.

- The Coriolis effect also affects the impact of wind on waves. This force is where the earth's rotation affects the way that winds travel over the earth. In the northern hemisphere, winds are deflected clockwise and counter clockwise in the southern hemisphere. This has an impact as some coastlines depending on their orientation as they will have water deflected at them in a much more direct head-on way than others as a result of this force.

Tides:

- Tides are caused by the gravitational pull of the moon and the sun. Tides are long-period waves that appear to move through the oceans due to the gravitational forces exerted by the moon and sun. Their apparent movement towards the coast creates a rise of the sea surface, though due to the earth's rotation it is the coast rolling into a deeper bulge of ocean that creates the effect. Where the sea surface rises to its highest point, this is known as high tide and at the lowest point it is known as low tide. The difference between the high and low tide is called the tidal range.

- Coastal areas experience two high and two low tides every lunar day (approx. 24 hours & 50 minutes)

- As well as high and low tides, when the moon, earth and sun are in alignment this causes the gravitational pull to increase more than usual and creates a high **spring tide**. However, **neap tides** are lower than normal tides and they occur when the sun and moon are at right angles to the earth so the gravitational pull from both has a reduced impact. There are two spring tides each lunar month – at full moon and new moon when the sun, earth and moon are in a line, and two neap tides at quarter and three-quarter moons.

- Tides increase the rate of coastal erosion. Where tidal range is low, for example, in the Mediterranean, wave energy is less and many cliff faces are unaffected by marine processes. However, in other places, such as the UK, where the tidal range is greater, this leads to an increase in erosion and can create landforms such as wave cut notches and platforms.

Ocean currents:

- Ocean currents are located at both the ocean surface (surface currents) and in deep water below 300 metres (deep currents). They move water both horizontally and vertically and occur at both local and global scales. The ocean is an interconnected system powered by the forces of wind, tides, Coriolis force, the sun, and water density differences. The topography and shape of ocean basins and nearby land also influences ocean currents. These forces and physical characteristics of both land and ocean affects the size, shape, speed, and direction of ocean currents

- Surface ocean currents are typically wind-driven, resulting in both horizontal and vertical water movement. Horizontal surface currents that are local and typically short term include rip currents, longshore currents, and tidal currents. In upwelling currents, vertical water movement and mixing brings cold water towards the surface while pulling warmer, less dense water downward, where it condenses and sinks. This creates a cycle of upwelling and downwelling.

- Deep ocean currents are density-driven and differ from surface currents as they are slower moving.

- The global conveyor belt includes both surface and deep ocean currents that circulate the globe in a 1,000-year cycle. The global conveyor belt's circulation is the result of two processes: warm surface currents carrying less dense water away from the equator toward the poles, and cold deep ocean currents carrying denser water away from the poles toward the equator. The ocean's global circulation system plays a key role in distributing heat, regulating weather and climate, and cycling nutrients and gases around the earth.

Sediment cells & budgets:

Sediment sources:

- Sediment is brought into the coastal system in many ways. Rivers can bring clastic sediments (weathered rock) into the coastal system. **Subaerial processes** such as freeze thaw **weathering** at the river's source will have added material to the river channel and over time due to attrition and solution within the river the material reduces in size and is finally deposited when the river reaches the mouth. This sediment can then be moved by littoral (longshore) drift along the coast and is integral in the formation of depositional coastal landforms.

- Sediment also comes from mass movement of the cliffs along the coastline. At high tide, wave energy may attack the cliffs, **eroding** material, noticeably by the processes of abrasion, hydraulic action and quarrying and this material may then be moved into the marine current zone by wave backwash across beaches to be carried away and deposited elsewhere.

- Sediment can also be carried towards the coastline by onshore currents excavating sea floor stores of sediment under high energy conditions and moving it towards a shoreline.

Sediment cells:

Sediment cells are areas along the coastline and in the nearshore area where the movement of material is largely self-contained. They can be considered as a **closed coastal sub-system** as far as sediment is concerned. They are often determined by the topography and shape of the coastline which directs the movement of the sediment within the cell. It is for this reason that they are therefore thought to be closed systems: sediment is largely recycled within them rather than having significant new inputs or outputs. The boundaries of the sediment cells tend to be headlands and peninsulas which act as natural barriers to stop the further movement of the sediment.

Despite the fact that the majority of sediment stays in the cell, changes in wind direction and movements of ocean currents can affect some of the sediment under high-energy conditions and cause some sediment to move offshore into long-term ocean floor stores of sediment. Within each sediment cell, there can be smaller sub cells. For example, there are 11 large sediment cells in England and Wales but these can then be further sub-divided into smaller cells.

The defining of sediment cells helps consideration of coastal process as a system and assists coastal management plans by illustrating the links between inputs, components, stores, transfers and outputs. Human intervention in a coastal system, in the form of coastal defences for example, is likely to have repercussions elsewhere in the system.

Sediment budgets:

A sediment budget is the balance between changes in the volume of sediment held within the system and the volume of sediment entering or leaving the system. A positive budget is when there are more inputs than outputs to the system and a negative budget is when outputs are higher than inputs. The budget can alter according to the following factors:

- Input changes: volume of fluvial material being deposited into the coastal system and the impact that human intervention can have on that, e.g. damming a river. Coastal defences can impact upon the inputs too with reduced cliff face erosion taking place. Sea level rise may add more sediment with increased coastal erosion.
- Output changes: human intervention, such as removing large amounts of sand from an area for industrial or coastal protection use. Also, sea level rise can increase the likelihood of changing ocean currents and material being removed from sediment cells.

