Topic: Drainage basins as open systems
3.1.1.2 Water and carbon cycles

What you need to know
That the drainage basin is an open system.
That there are different inputs and outputs that make up the drainage basin.
What the water balance is.

Introduction:

A drainage basin is the area of land which is drained by a river and its tributaries. This area of land is known as the catchment area. They can extend from a few tens of square kilometres for a local river, to continental-size drainage basins such as the River Mississippi draining much of central USA.

There are many characteristics in a drainage basin:

- Watershed – the boundary of a drainage basin, usually a mountain range.
- Source – the start of a river within the basin.
- Mouth – where the river meets the sea.
- Tributary – a smaller stream which feeds in to the main river.
- Confluence – the point at which two rivers meet.

A drainage basin is an open system with water being brought to and lost from the area as a result of a variety of processes. Within the river basin there might be a variety of stores regulating the rate of outflow.

Inputs and outputs

There is one primary input to the system – precipitation. This may vary according to quantity, duration, intensity and distribution over the year.

Water is lost from the system (output) in three ways:

- Runoff - rivers entering the sea at the mouth.
- Evaporation – Water warmed up by the sun is transferred from a liquid on the ground to a gas in the atmosphere.
- Transpiration – Water loss from vegetation into the atmosphere.

Evapotranspiration refers to the combination of evaporation and transpiration.

In order for water to eventually leave the system, there are a variety of stores and transfers within the system:

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Stores: surface or underground repositories of significant quantities of water that may regulate the rate at which input feeds through to the output.

- **Lake storage:** water can either travel overland or via the river channel or precipitation can fall directly into a lake where it will be stored. Some water is released via a small outlet from the lake and some can be evaporated into the atmosphere.

- **Interception by vegetation:** the leaves, stems and trunks of vegetation can act as a barrier to precipitation reaching the land's surface and water can be stored temporarily on these growths. The more dense the vegetation the more likely that water won't reach the ground, where it will be stored before being evaporated into the atmosphere.

- **Absorption by vegetation:** vegetation can withdraw water from the soil, river channels or overland flow via their root systems. The largest proportion of a woodland's composition is its store of water. This may eventually be returned to the atmosphere by transpiration.

- **Groundwater:** water is stored within permeable rock underground, entering either through gaps between the grains (porous sandstone) or down joints and cracks in the rock (pervious limestone).

- **Soil storage:** water is stored around and between soil particles in what is called the pedosphere, or soil layer.

- **Channel storage:** the volume of water contained within the banks of a river will operate as a water store between its initial input and ultimate output.

Transfers: flows of water between different stores

- **Surface runoff :** this is the movement of water over the Earth's surface. It is divided into sub-categories:
    - **Channel flow** – water flowing in a river channel.
    - **Overland flow** – water flowing across the land (sheetwash – across the surface not contained in a channel and rills – in indents in the land)

- **Infiltration:** vertical movement of water from the Earth's surface into the soil.

- **Percolation:** vertical movement through rock underground. This movement is much slower than infiltration.

- **Throughflow:** horizontal flow of water through the soil responding to gravity or water-pressure variations.

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- **Groundwater flow:** horizontal flow of water through sub-surface rock responding to gravity or underground water-pressure variations.

- **Stemflow:** water that has been intercepted by vegetation may drip from leaves or flow down stems and trunks to reach the ground.

The water balance

This is the balance between the inputs and outputs of a drainage basin. It is expressed as:

P = Q + E (+/- change in storage)

P = precipitation

Q = run-off

E = evapotranspiration

Rivers will always have a regime which they follow, in that some months the discharge of the river will be higher than others. The water balance looks at how the amount of precipitation compares with the water leaving the system as runoff or as evapotranspiration. This balance will change throughout the year and will be affected by the overall climate of the area near to the river. For example, under 'usual' conditions the precipitation will be matched by run-off and evapotranspiration giving a 'normal' river level. If evapotranspiration becomes greater for a few months in summer while precipitation and run-off remain the same, the river will flow below normal level. Key terms to describe various water balance conditions are:

- **Water Surplus:** there is excess water available to the system. This occurs when precipitation exceeds evapotranspiration and the excess is not being used by plants.

- **Deficiency:** there is a reduction of water available within the system. This occurs when evapotranspiration exceeds precipitation.

- **Recharge:** after a period of deficiency precipitation will occur and replace the lost water in the soil. This needs to occur before a period of surplus can reoccur.

- **Field capacity:** the maximum amount of water that soil can hold before it becomes saturated.

A water surplus can result in wet soils, high river levels and additional run-off whereas a deficit leads to dry soil, falling river levels and possibly a drier micro-climate.