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VITAL

ROOTS

Like tall buildings, trees need solid foundations to keep them in place. They also need to collect water and nutrients from the soil. Both these tasks are carried out by roots, which fan out through the ground. Roots grow in step with the rest of the tree. At first, they are small, delicate and very easy to break. But, by the time a tree reaches maturity, its biggest roots are as strong as a ship's cables, helping it to ride out storms. Laid end to end, a tree's entire root system may be thousands of kilometres long.



Turning into trunks
Banyan trees grow roots that hang down in the air. When these roots reach the ground, they turn into extra trunks. Some of the oldest banyan trees have over a hundred trunks that cover an area bigger than a tennis court.

SURVIVING IN SWAMPS

TREES LIVE in many different habitats, including areas that flood for part of the year. Only a few kinds of trees can survive being in water all year round because waterlogged ground makes a bad anchorage. Also, water contains less oxygen than soil, which makes it hard for roots to grow. To get around this problem, swamp-dwelling trees have specialised roots that prop them up and collect oxygen from the air.



SWAMP CYPRESSES *These grow in the southern USA. They have buttress roots and knobbly "knees" (pneumatophores) just above the water's surface.*



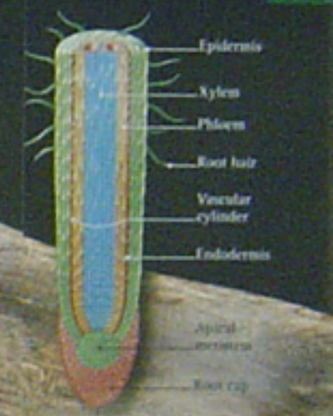
MANGROVES *In warm parts of the world, mangroves grow along shallow coasts. Prop roots anchor them in the tidal mud.*



Many from one
In North America, aspens often spread underground, sprouting new trees from their roots. Over many years, this creates giant clumps of connected trees. Some of these clumps started growing more than 10,000 years ago, when the last Ice Age was drawing to a close.

LIVING BUTTRESSES

In rainforests, many trees have giant roots that snake their way across the ground. Known as buttress roots, they prop up trees in habitats where the soil is thin. Some of the tallest buttress roots are grown by the kapok or silk cotton tree. Buttress roots can be more than 3 metres (10 ft) high where they join the tree's trunk.



Going for growth
Root tips are covered by a tough root cap, which pushes its way between particles of soil. Behind this is the apical meristem – the part of the root where cells divide rapidly, making the root tip grow.



Digging deep
In temperate forests, cooler climate means that dead leaves and wood take longer to rot. As a result, the soil is often richer than in tropical rainforests and tree roots grow deeper down.

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UNDERGROUND ROOTS

Hidden away beneath the soil's surface, tree roots make up a secret world with its own wildlife. Some of the animals stay below ground and never see daylight in their lives. Others – including many insects – grow up inside rotting wood or shuttle between the surface and the soil. These mini-animals help to break down dead remains, recycling nutrients that trees need to grow.

Giant anteater

Leaf-cutter ants

Subterranean termites

Giant centipede

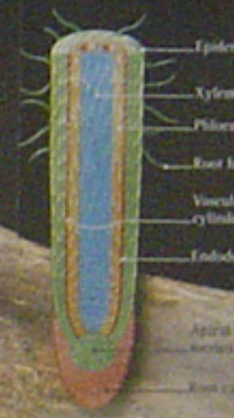
Leaf litter is the carpet of dead leaves on the forest floor.

Humus contains small pieces of dead leaves and particles of rotting wood.

Topsoil contains humus mixed with particles of bedrock.

Bedrock is the deepest layer, with only a few living things.

Slice through the soil
The ground beneath a forest has four different layers: leaf litter, humus, topsoil and bedrock. In tropical rainforests, the top three layers are often thin, so tree roots stay close to the surface, instead of growing further down.



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BENEFICIAL BUGS

TREES DO NOT NEED FOOD but they do need simple substances called nutrients, which they collect with their roots. Most plant nutrients originally come from soil and rock but one of the most important – nitrogen – comes from the atmosphere. Strangely, trees cannot gather nitrogen from the air. Instead, they rely on soil bacteria to collect it. These "nitrogen-fixing" bacteria then turn it into a form that roots can absorb.

NODULES
Some trees have special growths on their roots that shelter nitrogen-fixing bacteria.

INSIDE ROOTS

In warm weather, a big tree can suck up more than 1,000 litres (220 gal) of water a day. All this water travels from the soil and up a tree's roots. At the same time, roots carry sap in the other direction, giving root tips the energy they need to grow. This two-way transport works through special pipelines, which connect the roots with every other part of the tree.

Roots revealed

Roots contain two different kinds of pipelines: xylem (pronounced *zy-lem*) and phloem (*flo-em*). Xylem carries water, while phloem carries sap. Each root absorbs water through thousands of microscopic hairs, which look like a fuzzy beard.

Root pipelines

Xylem pipelines are hollow tubes that run all the way up the tree. Water travels up these pipelines and into the leaves. Phloem pipelines are made of living cells. These cells can pump sap in either direction, sending it where it is needed.

Underground partners

Most tree roots are covered by a network of microscopic thread-shaped fungi that reach out through the soil and help the roots to collect nutrients. In return, the roots give the fungus sugary food. These partnerships between roots and fungi are called "mycorrhizae".

Root hairs

As a root grows, it sprouts thousands of microscopic hairs, each just one cell thick. Together, the hairs have a very big surface area, ideal for absorbing water from the soil. In colder regions, root hairs die in autumn and are regrown in spring.

Epidermis
Xylem
Phloem
Root hair
Vascular cylinder
Endodermis
Apical meristem
Root cap

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