An excerpt from

BOTANY READINGS

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Structure of Plants

An appropriate essay for you to read as you start learning about the basic structure of plants is *How to Spend a Nice Quiet Evening With a Potato* by Edgar Anderson. It is enjoyable yet very informative.

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How To Spend a Nice Quiet Evening With a Potato
by Edgar Anderson
A portion of an essay from: *Bulletin of the Missouri Botanical Garden*, vol. 43, pp. 50-53, 1955

If you're an adult and you want to teach yourself how to find out about plants there is no more convenient way to start. Get a potato, a nice big one, out of the bin, wash it off carefully, and sit down in a comfortable chair with a good light coming over your shoulder. Turn the potato over in your hands. Don't be too terse and earnest. If you can get a friend with kindred interests to join you, so much the better and if you talk about other things now and then it's all to the good. Just try to build up a little intelligent enthusiasm for this starchy sphere which previously you have taken so for granted.

Well, let's look at the potato. Most obviously it has eyes. Nearly everybody knows this much, yet have you really ever looked a potato in the eye? There is something more or less like an arching eyebrow with an eye-hollow within the arch and coming up out of this hollow are little dark buds. Now notice the arching eyebrows. They don't arch any old which way; they are all focused in the same direction. To our surprise we will learn that each potato has a well-defined front end an equally well-defined rear end and that these are very different in appearance. At the front end the eyes are clustered closely together, the buds always frontwards from the arching brow. This brow is really a kind of leaf, or the mark where such a scale leaf was borne and then fell off. Sometimes new potatoes will show delicate little membrane-like scales rising up off the tuber's surface in these arching lines; in the ordinary grocery-store spud the membranaceous scale has usually gone by and only a faintly curving scar is left. Now turn the potato about and look at the other end, then examine the whole region in between. At the other extreme from the active apex with its closely clustered buds you will find either a piece of the little round underground stem on which the potato was formed or the neat little circular scar where this stem was broken off.

A potato, you see, is what botanists call a tuber. It is just the swollen coalesced buds at the end of an underground stem. It is not a root; it is part of a true stem though borne underground. Like all stems, it has joints (the technical word is nodes) at which leaves (or leaf-like scales) are borne and it is in the axils of these scales that all the new branch stems arise when the potato is sprouted. This is how one tells stems from roots in those plants with both underground stems and true roots. Stems have nodes (joints); roots don't. Stems have leaves or scales at the nodes; roots have neither. If you find a root with some little scales on it at fairly regular intervals, it isn't a root. It's an underground stem of some sort. Finally, stems are precise in their pattern of growing; they branch only in the axils of the leaves or scales; roots branch only irregularly.

Our humble potato is therefore a much more precisely organized bit of life than one would have imagined. Like virtually all life it is highly polarized. It has a head end, an apex, at which growth is most active. It has an innate orientation to up and down, to frontwards and backwards. Plant your potato in a bowl of sand or sawdust or vermiculite, keep it well watered and watch its development for a few weeks. See the way the new stems sprout out from the buds near the apex. Plant another potato in the garden and dig it up and wash off the roots after the plant is well developed. You will be able to see for yourself the difference between the true roots and the jointed underground stem on which the potatoes are borne.

So what? Well, you'll have made a beginning at understanding for yourself the world around you. The world looks chaotic; deeper study shows us the order in it; with still deeper and more intensive study we are able to understand enough of the order underneath the apparent chaos so as to work with it rather than against it.

So if plants are beginning to interest you and you wish you knew more about them, no need to sigh for lost opportunities, no need for that magic book which will tell you painlessly the very things you wish you knew. Sit down quietly with a potato, a nice large, clean potato. Relax in your chair. Take a friendly interest in this succulent brown blob which you have previously ignored. Let it become a simple introduction to learning about plants from plants themselves. Take your first step towards botanical insight by spending a nice quiet evening with a potato.

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Basic Structural Plan

This reading describes what we refer to as the basic structure of a "typical plant." What we consider "typical" is only a convenient place to start. The example we use for a typical plant is the type of plant with which you probably are most familiar—a flowering plant.

A flowering plant consists of an axis divided into two main systems—the root and shoot. The shoot system is composed of a stem, leaves, and flowers. Roots, stems, leaves, and flowers often are referred to as plant organs.

Growth

Roots and shoots grow at specialized regions. **Apical meristems** occur at the tips of either roots or shoots. Apical meristems account for what is called **primary growth**, the type of growth responsible for the increase in length of a plant. All flowering plants have primary growth. Examples of apical meristems are apical buds of stems, axillary buds of stems, and tips of roots.

Some flowering plants have growth originating from regions termed **lateral** or **secondary meristems**. Growth from lateral meristems is **secondary growth**. Secondary growth accounts for most of the thickening of plants. Trees, for example, have secondary growth that increases the diameter of the stems, or "tree trunks." The secondary meristem responsible for the increase in diameter of stems is called the **vascular cambium**. Vascular cambium also occurs in roots of trees.

Stems

Stems generally occur above ground, and are the structures onto which leaves are attached. This latter point is very important for distinguishing stems from roots since some stems occur below ground.

Leaves attach to stems at **nodes**. The regions between nodes are called **internodes**. Even when leaves are not attached to a stem one can generally recognize the nodes and internodes. On many stems when leaves are not attached a leaf scar is where the leaf was attached. Small buds (**axillary buds**) occur at the nodes near where leaves attach to the stem. This is another way of recognizing a node if a leaf is not present.


Primary growth of stems occurs at apical meristems. The apical meristems of stems differ from those of roots: apical meristems of stems are enclosed in an apical bud. In longitudinal view the apical bud contains young leaves (leaf primordia) attached at nodes. The leaf primordia enclose the apical meristem. In winter buds of trees the leaves that will burst out in bright green in the spring are protected by bud scales on the outside.

Further back from the bud, cells differentiate. The differentiated tissues in a young stem are best described when the stem is viewed in cross section. There are two basic patterns of differentiated tissues in stems of flowering plants. We look at other reasons for making distinctions between two types of flowering plants later in the course. For now, however, we just have to know that one type is called **monocots**, the other **dicots**.

Dicot stems The epidermis is on the outside of the stem. Toward the interior of the stem just underneath the epidermis is the cortex. The most interior region of the stem is the pith. In the region between the pith and the cortex are several to many vascular bundles arranged in a ring. The phloem is on the side of the bundle facing toward the cortex; the xylem on the side toward the pith.

In plants that increase in diameter as they get older, e.g., trees, the increase in diameter is due to **secondary growth**. Secondary growth is produced by a lateral or secondary meristem, the **vascular cambium**. Vascular cambium originates from a group of cells between the xylem and phloem. As the vascular cambium produces new cells, thus new secondary growth, xylem cells are formed to the interior of the vascular cambium, phloem cells are formed to the exterior of the vascular cambium. The xylem is commonly called **wood**. The **bark** is everything to the exterior of the vascular cambium; major components of bark include phloem and cork.

Primary Growth   Secondary Growth
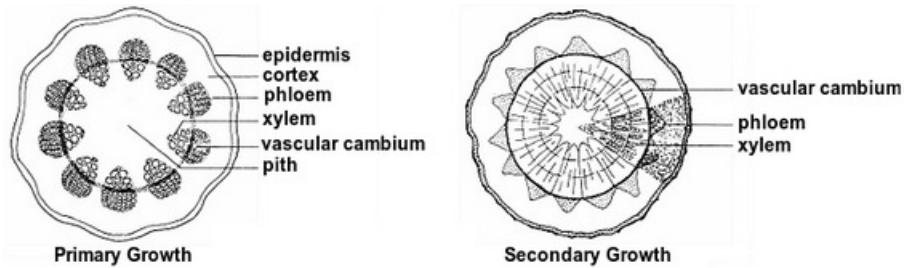
Monocot stems In monocot stems viewed in cross section, the vascular bundles are scattered throughout the stem. Thus, there is no clear separation of tissues around the vascular bundles into cortex and pith. In the vascular bundles of monocots, the phloem is on the side facing toward the epidermis, the xylem toward the center of the stem. Most monocots do not have secondary growth.
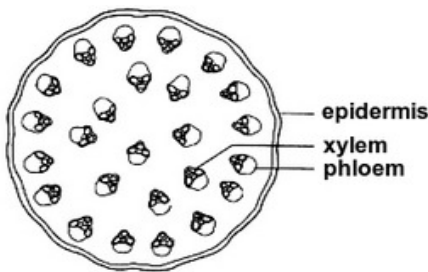

Stem modification Stems of different plants may be in forms other than what we encounter in a "typical" plant. If a stem is underground and horizontal it is called a **rhizome**. An above ground horizontal stem is a **runner**, which also is known as a **stolon**. A swollen tip of an underground stem is a **tuber**. A vertical underground shoot that is mostly stem tissue is a **corm**. A vertical underground shoot that is mostly leaf tissue is a **bulb**. The important part for you to remember here is that if a structure looks like it could be either a stem or a root, look for nodes. **Stems have nodes; roots do not!**


Rhizome

Tuber

Bulb (mostly leaf tissue)

Runner

Corm (mostly stem tissue)
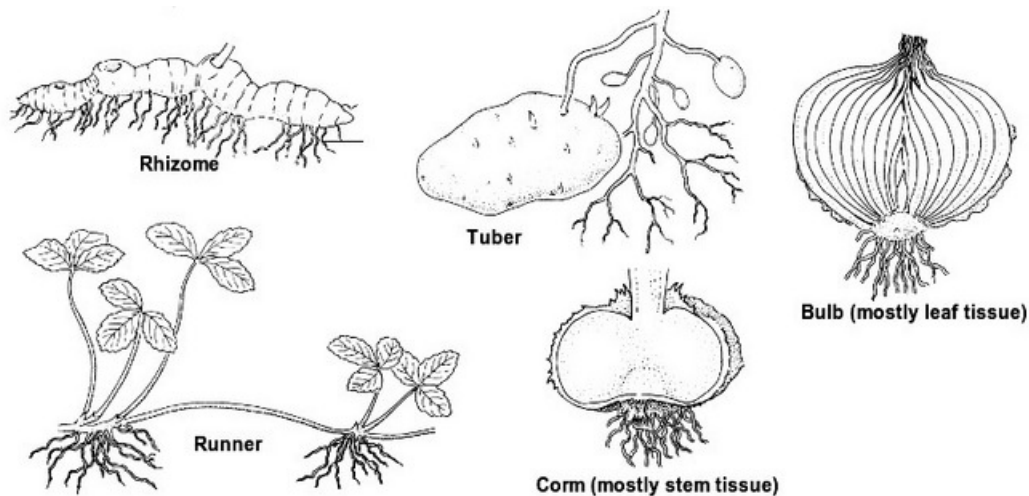
Roots

Roots generally grow underground and anchor the plant into the soil. The major function of roots is absorption of water and minerals from the soil. There are two basic types of roots. 1) **Taproot** has a main, large root that has branch roots coming off of it. A carrot is an example of a taproot. 2) **Fibrous roots** have many roots, none of which is more prominent than the others. Roots of grasses are examples of fibrous roots.

Taproot   Fibrous Root
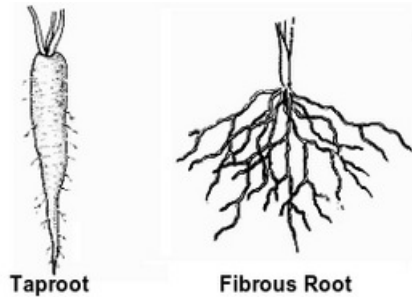
Primary growth of roots occurs at the root apical meristem. In longitudinal view, a root apical meristem has a region of dividing cells, with elongating cells behind them and a root cap in front of them. The root cap is constantly being worn down as the root tip is pushed through the soil by the elongating cells. New root cap cells come from the region of dividing cells. New elongating cells also come from the region of dividing cells.

Root Apical Meristem
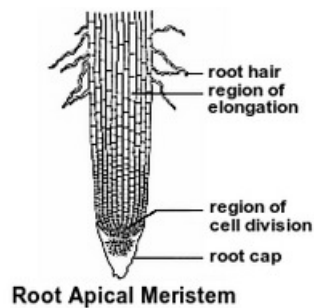
As cells elongate they also begin to differentiate. Some epidermal cells become modified into root hairs, cells that absorb water and minerals from the soil. Cells in the interior of the root differentiate into cells specialized for water and mineral transport (**xylem** cells); others become specialized into cells that transport sugars. The latter transport cells are termed **phloem** cells. Xylem and phloem, form a cylinder in the interior of the root known as the **stele**. The **cortex** separates the vascular cylinder from the epidermis. As with stems, the patterns of xylem and phloem differ in cross sections of roots of monocots and dicots.

Root Primary Growth   Root Secondary Growth
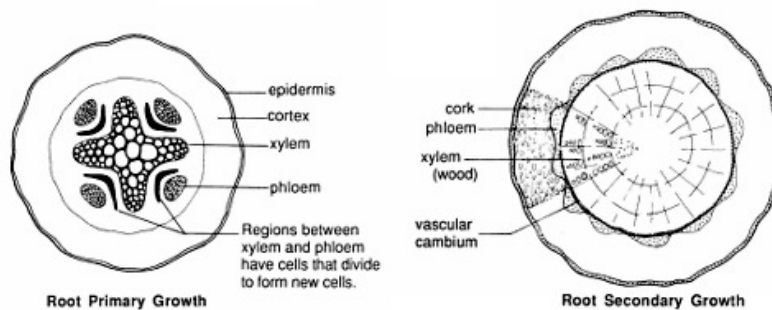
Roots branch. In fibrous systems there are many branch roots, all of which remain about the same size. In taproot systems the main root, the taproot, has smaller roots branched off from it. In either system, however, there is no predictable pattern for the branch roots.

In some plants, e.g., trees, roots increase in diameter and become woody. The growth that increases the diameter of the root is secondary growth. Secondary growth originates at the **vascular cambium**, a ring of special cells that start dividing between the phloem and xylem. As the vascular cambium produces new cells, cells to the interior of the root differentiate into xylem. Cells to the exterior mostly differentiate into phloem. A mature, woody root is mostly xylem when seen in cross section. The material to the outside of the vascular cambium is the **bark**.

Leaves

Leaves are attached to stems at **nodes**. Leaves generally are green because the cells of leaves contain **chloroplasts**. Chloroplasts are green because of the presence of the green pigment **chlorophyll**. Chlorophyll is the molecule that converts light energy into chemical energy in the process of **photosynthesis**.

A leaf is divided into two regions; 1) **blade** or **lamina**, and 2) **petiole**. The petiole is the thin, stick-like structure between the blade and the attachment site at the node. Sometimes at the base of the petiole is a small leaf-like structure called the **stipule**. If there is no petiole, the leaf is said to be **sessile**.

Vascular tissue (xylem and phloem) is continuous from the stem, through the petiole, into the blade. Vascular tissue in the blade is seen as so-called **veins**. The continuation of the vascular tissue from the petiole into the blade is the **midrib** of the leaf blade. The pattern of the veins is the venation of the leaf. Leaves may have either **netted** or **parallel venation**. Leaves of most dicots have netted venation; leaves of most monocots have parallel venation.

Monocot vs. dicot leaves: left is daylily, a monocot; right is mint, a dicot.

The edge of a leaf blade is the **margin**. Several common variations of margins include smooth (also termed entire), dentate (shaped like teeth), serrate, or lobed.

A simple leaf has one blade attached to the petiole. A compound leaf, however, has several to many little leaves, **leaflets (pinnae)**, in place of a single blade. If the leaflets are attached to one point at the end of the petiole the leaf is **palmately compound**. If the leaflets are attached along the extension of the petiole, the **rachis**, in a feather-like arrangement, the leaf is **pinnately compound**.
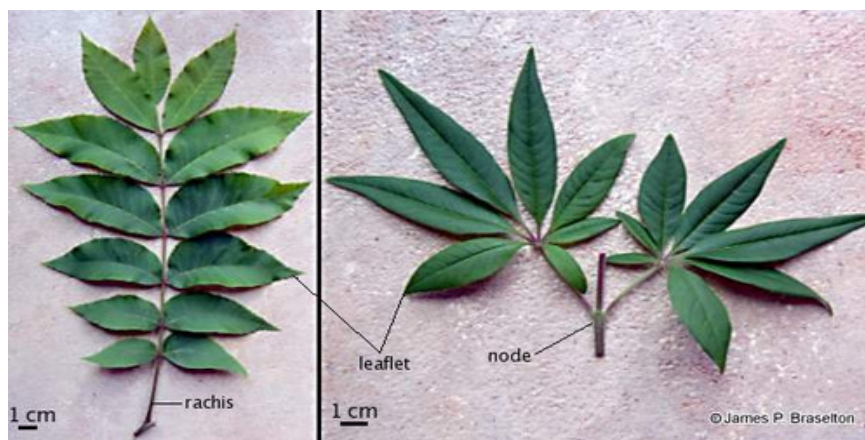
Pinnately compound leaf on left; palmately on right.

Leaves can be arranged at the nodes in one of three basic ways. **Opposite** arrangement is when two leaves are attached at one node on opposite sides of the node. **Alternate** arrangement is when one leaf is attached to a node, and at the next node one leaf is attached on the other side of the stem. **Whorled** arrangement has three or more leaves attached at one node.

Flowers

The portion of stem to which a flower is attached is the **peduncle**. The **receptacle** is the swollen tip of the peduncle to which the other major flower parts are attached. **Sepals** occur in the outermost whorl of leaf-like structures, the **calyx**. The next whorl to the interior is the **corolla**; the individual leaf-like structures are the **petals**. If sepals and petals look the same, they are called **tepals**. To the interior of the petals are the **stamens**, the pollen-producing structures. Each stamen consists of a thin **filament** and sac-like structure, the **anther**, in which **pollen** is produced. The most interior structure of the flower is the **pistil**, which is divided into three parts, the **stigma**, **style** and **ovary**. Seeds are produced in the ovary.

External and cut-away view of flower of *Lilium* sp.

Flowers vary many ways: The most obvious are size and color. Another major variation is the number of parts. In monocots, flower parts occur in threes or multiples of three. For example, there may be three sepals, three petals, six stamens, and one pistil. Dicots generally have flowers with parts in fours or fives, or multiples of four or five.

Monocot vs. dicot flowers: left is spiderwort, a monocot; right is phlox. a dicot.

Symmetry is another major way flowers may vary. Flowers with **radial symmetry** are **actinomorphic**. Flowers with **bilateral symmetry** are **zygomorphic**.

Floral symmetry: left is actinomorphic flower of spreading evening primrose; right is zygomorphic flower of kudzu.

Flowers that contain all major parts (i.e., sepals, petals, stamens, and pistil) are **complete**. If any one of the four major parts is missing, then the flower is **incomplete**. If a flower has both stamens and pistil, that flower is **perfect**. If a flower does not have either stamens or pistil, then that flower is **imperfect**. An imperfect flower with stamens but no pistil is a staminate flower, also called by some a "male" flower. An imperfect flower with a pistil but no stamens is a pistillate flower, also called by some a "female" flower.

Inflorescences

A group of flowers is an **inflorescence**. Common inflorescence types are **solitary**, **spike**, **head** (**capitulum**), **raceme**, **panicle**, **cyme**, and **umbel**.

Solitary Spike Head

Raceme Panicle

Cyme Umbel