**2. Concept, Structure and function of various tissues**

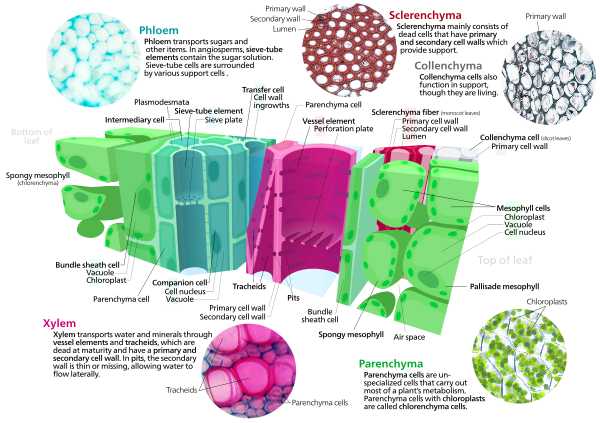
Ground tissue

The **ground tissue** of plants includes all tissues that are neither [dermal](https://en.wikipedia.org/wiki/Epidermis_(botany)) nor [vascular](https://en.wikipedia.org/wiki/Vascular_tissue). It can be divided into three types based on the nature of the cell walls.

1. **Parenchyma** cells have thin [primary walls](https://en.wikipedia.org/wiki/Primary_wall) and usually remain alive after they become mature. Parenchyma forms the "filler" tissue in the soft parts of plants, and is usually present in [cortex](https://en.wikipedia.org/wiki/Cortex_(botany)), [pericycle](https://en.wikipedia.org/wiki/Pericycle" \o "Pericycle), [pith](https://en.wikipedia.org/wiki/Pith), and [medullary rays](https://en.wikipedia.org/wiki/Medullary_ray_(botany)) in primary [stem](https://en.wikipedia.org/wiki/Plant_stem) and [root](https://en.wikipedia.org/wiki/Root).
2. **Collenchyma** cells have thin primary walls with some areas of secondary thickening. Collenchyma provides extra mechanical and structural support, particularly in regions of new growth.
3. **Sclerenchyma** cells have thick [lignified](https://en.wikipedia.org/wiki/Lignin) [secondary walls](https://en.wikipedia.org/wiki/Secondary_cell_wall) and often die when mature. Sclerenchyma provides the main structural support to a plant.[[1]](https://en.wikipedia.org/wiki/Ground_tissue#cite_note-FOOTNOTEMauseth201298%E2%80%93103-1)

Parenchyma

Parenchyma Greek  "visceral flesh" from "to pour in" from *para-*, "beside" and "to pouris a versatile ground tissue that generally constitutes the "filler" tissue in soft parts of plants. It forms, among other things, the [cortex](https://en.wikipedia.org/wiki/Cortex_(botany)) (outer region) and [pith](https://en.wikipedia.org/wiki/Pith) (central region) of stems, the cortex of roots, the [mesophyll](https://en.wikipedia.org/wiki/Leaf#Mesophyll) of leaves, the pulp of fruits, and the [endosperm](https://en.wikipedia.org/wiki/Endosperm) of [seeds](https://en.wikipedia.org/wiki/Seeds). Parenchyma cells are living cells and may remain [meristematic](https://en.wikipedia.org/wiki/Meristematic" \o "Meristematic) at maturity—meaning that they are capable of [cell division](https://en.wikipedia.org/wiki/Cell_division) if stimulated. They have thin and flexible [cellulose](https://en.wikipedia.org/wiki/Cellulose) [cell walls](https://en.wikipedia.org/wiki/Cell_wall), and are generally [polyhedral](https://en.wikipedia.org/wiki/Polyhedron) when close-packed, but can be roughly spherical when isolated from their neighbours. Parenchyma cells are generally large. They have large [central vacuoles](https://en.wikipedia.org/wiki/Central_vacuole), which allow the cells to store and regulate [ions](https://en.wikipedia.org/wiki/Ions), waste products, and [water](https://en.wikipedia.org/wiki/Water). Tissue specialised for food storage is commonly formed of parenchyma cells.

[](https://en.wikipedia.org/wiki/File:Plant_cell_types.svg)

Cross section of a leaf showing various ground tissue types

Parenchyma cells have a variety of functions:

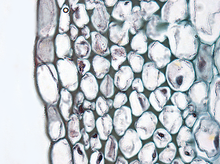
* In [leaves](https://en.wikipedia.org/wiki/Leaf), they form two layers of [mesophyll](https://en.wikipedia.org/wiki/Leaf#Mesophyll) cells immediately beneath the epidermis of the leaf, that are responsible for [photosynthesis](https://en.wikipedia.org/wiki/Photosynthesis) and the exchange of gases.[[5]](https://en.wikipedia.org/wiki/Ground_tissue#cite_note-Leaves-5) These layers are called the palisade parenchyma and spongy mesophyll. Palisade parenchyma cells can be either cuboidal or elongated. Parenchyma cells in the [mesophyll](https://en.wikipedia.org/wiki/Leaf#Mesophyll) of leaves are specialised parenchyma cells called chlorenchyma cells (parenchyma cells with chloroplasts). Chlorenchyma cells are also found in other parts of the plant.
* Storage of starch, protein, fats, oils and water in roots, tubers (e.g. [potatoes](https://en.wikipedia.org/wiki/Potatoes)), seed [endosperm](https://en.wikipedia.org/wiki/Endosperm) (e.g. [cereals](https://en.wikipedia.org/wiki/Cereal)) and [cotyledons](https://en.wikipedia.org/wiki/Cotyledon) (e.g. [pulses](https://en.wikipedia.org/wiki/Pulses) and [peanuts](https://en.wikipedia.org/wiki/Peanut))
* [Secretion](https://en.wikipedia.org/wiki/Secretion) (e.g. the parenchyma cells lining the inside of resin ducts)
* Wound repairand the potential for renewed [meristematic](https://en.wikipedia.org/wiki/Meristematic" \o "Meristematic) activity
* Other specialised functions such as [aeration](https://en.wikipedia.org/wiki/Aeration) ([aerenchyma](https://en.wikipedia.org/wiki/Aerenchyma" \o "Aerenchyma)) provides buoyancy and helps aquatic plants float.
* Chlorenchyma cells carry out photosynthesis and manufacture food.

The shape of parenchyma cells varies with their function. In the spongy [mesophyll](https://en.wikipedia.org/wiki/Leaf#Mesophyll) of a leaf, parenchyma cells range from near-spherical and loosely arranged with large intercellular spaces to branched or [stellate](https://en.wikipedia.org/wiki/Stellate_cell), mutually interconnected with their neighbours at the ends of their arms to form a three-dimensional network, like in the red kidney bean *[Phaseolus vulgaris](https://en.wikipedia.org/wiki/Phaseolus_vulgaris" \o "Phaseolus vulgaris)* and other [mesophytes](https://en.wikipedia.org/wiki/Mesophyte" \o "Mesophyte). These cells, along with the [epidermal](https://en.wikipedia.org/wiki/Epidermis_(botany)) [guard cells](https://en.wikipedia.org/wiki/Guard_cell) of the [stoma](https://en.wikipedia.org/wiki/Stoma), form a system of air spaces and chambers that regulate the exchange of gases. In some works, the cells of the leaf epidermis are regarded as specialised parenchymal cells but the modern preference has long been to classify the epidermis as [plant dermal tissue](https://en.wikipedia.org/wiki/Epidermis_(botany)), and parenchyma as ground tissues

Shapes of parenchyma:

* Polyhedral (found in pallisade tissue of the leaf)
* Spherical
* Stellate (found in stem of plants and have well developed air spaces between them)
* Elongated (also found in pallisade tissue of leaf)
* Lobed (found in spongy and pallisade mesophyll tissue of some plants)

Collenchyma

[](https://en.wikipedia.org/wiki/File:Plant_cell_type_collenchyma.png)

Cross section of collenchyma cells

Collenchyma tissue is composed of elongated cells with irregularly thickened [walls](https://en.wikipedia.org/wiki/Cell_wall). They provide structural support, particularly in growing [shoots](https://en.wikipedia.org/wiki/Shoot) and [leaves](https://en.wikipedia.org/wiki/Leaf). Collenchyma tissue makes up things such as the resilient strands in stalks of [celery](https://en.wikipedia.org/wiki/Celery). Collenchyma cells are usually living, and have only a thick [primary cell wall](https://en.wikipedia.org/wiki/Primary_cell_wall)made up of cellulose and pectin. Cell wall thickness is strongly affected by mechanical stress upon the plant. The walls of collenchyma in shaken plants (to mimic the effects of wind etc.), may be 40–100% thicker than those not shaken.

There are four main types of collenchyma:

* Angular collenchyma (thickened at intercellular contact points)
* Tangential collenchyma (cells arranged into ordered rows and thickened at the tangential face of the cell wall)
* Annular collenchyma (uniformly thickened cell walls)
* Lacunar collenchyma (collenchyma with intercellular spaces)

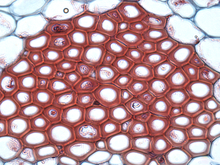
Collenchyma cells are most often found adjacent to outer growing tissues such as the [vascular cambium](https://en.wikipedia.org/wiki/Vascular_cambium) and are known for increasing structural support and integrity.

The first use of "collenchyma" was by [Link](https://en.wikipedia.org/wiki/Johann_Heinrich_Friedrich_Link) (1837) who used it to describe the sticky substance on *[Bletia](https://en.wikipedia.org/wiki/Bletia" \o "Bletia)* (Orchidaceae) pollen. Complaining about Link's excessive nomenclature, [Schleiden](https://en.wikipedia.org/wiki/Matthias_Jakob_Schleiden" \o "Matthias Jakob Schleiden) (1839) stated mockingly that the term "collenchyma" could have more easily been used to describe elongated sub-epidermal cells with unevenly thickened cell walls.

Sclerenchyma

Sclerenchyma is the tissue which makes the plant hard and stiff. Sclerenchyma is the supporting tissue in [plants](https://en.wikipedia.org/wiki/Plant). Two types of sclerenchyma cells exist: fibers and [sclereids](https://en.wikipedia.org/wiki/Sclereid" \o "Sclereid). Their [cell walls](https://en.wikipedia.org/wiki/Cell_wall) consist of [cellulose](https://en.wikipedia.org/wiki/Cellulose), [hemicellulose](https://en.wikipedia.org/wiki/Hemicellulose), and [lignin](https://en.wikipedia.org/wiki/Lignin). Sclerenchyma cells are the principal supporting cells in plant tissues that have ceased elongation. Sclerenchyma fibers are of great economic importance, since they constitute the source material for many fabrics (e.g. [flax] [hemp](https://en.wikipedia.org/wiki/Hemp), [jute](https://en.wikipedia.org/wiki/Jute), and [ramie](https://en.wikipedia.org/wiki/Ramie)).

Unlike the collenchyma, mature sclerenchyma is composed of dead cells with extremely thick cell walls ([secondary walls](https://en.wikipedia.org/wiki/Secondary_cell_wall)) that make up to 90% of the whole cell volume. The term *sclerenchyma* is derived from the Greek σκληρός (*sklērós*), meaning "hard." It is the hard, thick walls that make sclerenchyma cells important strengthening and supporting elements in plant parts that have ceased elongation. The difference between fibers and sclereids is not always clear: transitions do exist, sometimes even within the same plant.

[](https://en.wikipedia.org/wiki/File:Plant_cell_type_sclerenchyma_fibers.png)

Cross section of sclerenchyma fibers

Fibers or [bast](https://en.wikipedia.org/wiki/Bast_(biology)" \o "Bast (biology)) are generally long, slender, so-called prosenchymatous cells, usually occurring in strands or bundles. Such bundles or the totality of a stem's bundles are colloquially called fibers. Their high load-bearing capacity and the ease with which they can be processed has since antiquity made them the source material for a number of things, like [ropes](https://en.wikipedia.org/wiki/Rope), [fabrics](https://en.wikipedia.org/wiki/Textile) and [mattresses](https://en.wikipedia.org/wiki/Mattress). The fibers of [flax](https://en.wikipedia.org/wiki/Flax) (*Linum usitatissimum*) have been known in [Europe](https://en.wikipedia.org/wiki/Europe) and [Egypt](https://en.wikipedia.org/wiki/Egypt) for more than 3,000 years, those of [hemp](https://en.wikipedia.org/wiki/Hemp) (*Cannabis sativa*) in [China](https://en.wikipedia.org/wiki/China) for just as long. These fibers, and those of [jute](https://en.wikipedia.org/wiki/Jute) (*Corchorus capsularis*) and [ramie](https://en.wikipedia.org/wiki/Ramie) (*Boehmeria nivea*, a [nettle](https://en.wikipedia.org/wiki/Urticaceae)), are extremely soft and elastic and are especially well suited for the processing to [textiles](https://en.wikipedia.org/wiki/Textile). Their principal cell wall material is [cellulose](https://en.wikipedia.org/wiki/Cellulose).

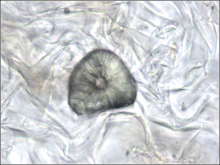
Contrasting are hard fibers that are mostly found in [monocots](https://en.wikipedia.org/wiki/Monocot). Typical examples are the fiber of many [grasses](https://en.wikipedia.org/wiki/Poaceae), *Agave sisalana* ([sisal](https://en.wikipedia.org/wiki/Sisal)), [*Yucca*](https://en.wikipedia.org/wiki/Yucca) or *[Phormium tenax](https://en.wikipedia.org/wiki/Phormium_tenax" \o "Phormium tenax)*, [*Musa textilis*](https://en.wikipedia.org/wiki/Musa_textilis) and others. Their cell walls contain, besides cellulose, a high proportion of [lignin](https://en.wikipedia.org/wiki/Lignin). The load-bearing capacity of *Phormium tenax* is as high as 20–25 kg/mm², the same as that of good [steel](https://en.wikipedia.org/wiki/Steel) wire (25 kg/ mm²), but the fibre tears as soon as too great a strain is placed upon it, while the wire distorts and does not tear before a strain of 80 kg/mm². The thickening of a cell wall has been studied Starting at the centre of the fiber, the thickening layers of the secondary wall are deposited one after the other. Growth at both tips of the cell leads to simultaneous elongation. During development the layers of secondary material seem like tubes, of which the outer one is always longer and older than the next. After completion of growth, the missing parts are supplemented, so that the wall is evenly thickened up to the tips of the fibers.

Fibers usually originate from [meristematic](https://en.wikipedia.org/wiki/Meristematic" \o "Meristematic) tissues. [Cambium](https://en.wikipedia.org/wiki/Cambium_(botany)) and [procambium](https://en.wikipedia.org/wiki/Procambium" \o "Procambium) are their main centers of production. They are usually associated with the [xylem](https://en.wikipedia.org/wiki/Xylem) and [phloem](https://en.wikipedia.org/wiki/Phloem) of the vascular bundles. The fibers of the xylem are always [lignified](https://en.wikipedia.org/wiki/Lignified), while those of the phloem are [cellulosic](https://en.wikipedia.org/wiki/Cellulosic). Reliable evidence for the fibre cells' evolutionary origin from [tracheids](https://en.wikipedia.org/wiki/Tracheid" \o "Tracheid) exists. During evolution the strength of the tracheid cell walls was enhanced, the ability to conduct water was lost and the size of the pits was reduced. Fibers that do not belong to the xylem are bast (outside the ring of cambium) and such fibers that are arranged in characteristic patterns at different sites of the shoot. The term "sclerenchyma" (originally *Sclerenchyma*) was introduced by [Mettenius](https://en.wikipedia.org/wiki/Mettenius" \o "Mettenius) in 1865.

**Sclereids**[[edit](https://en.wikipedia.org/w/index.php?title=Ground_tissue&action=edit&section=4)]

|  |  |
| --- | --- |
| [https://upload.wikimedia.org/wikipedia/en/thumb/9/99/Question_book-new.svg/50px-Question_book-new.svg.png](https://en.wikipedia.org/wiki/File:Question_book-new.svg) | This section **does not**[**cite**](https://en.wikipedia.org/wiki/Wikipedia:Citing_sources)**any**[**sources**](https://en.wikipedia.org/wiki/Wikipedia:Verifiability). Please help [improve this section](https://en.wikipedia.org/w/index.php?title=Ground_tissue&action=edit) by [adding citations to reliable sources](https://en.wikipedia.org/wiki/Help:Introduction_to_referencing_with_Wiki_Markup/1). Unsourced material may be challenged and [removed](https://en.wikipedia.org/wiki/Wikipedia:Verifiability#Burden_of_evidence). *Find sources:* ["Ground tissue"](https://www.google.com/search?as_eq=wikipedia&q=%22Ground+tissue%22) – [news](https://www.google.com/search?tbm=nws&q=%22Ground+tissue%22+-wikipedia) **·** [newspapers](https://www.google.com/search?&q=%22Ground+tissue%22+site:news.google.com/newspapers&source=newspapers) **·** [books](https://www.google.com/search?tbs=bks:1&q=%22Ground+tissue%22+-wikipedia) **·** [scholar](https://scholar.google.com/scholar?q=%22Ground+tissue%22) **·** [JSTOR](https://www.jstor.org/action/doBasicSearch?Query=%22Ground+tissue%22&acc=on&wc=on) *(September 2015) (*[*Learn how and when to remove this template message*](https://en.wikipedia.org/wiki/Help:Maintenance_template_removal)*)* |

*Main article: [Sclereid](https://en.wikipedia.org/wiki/Sclereid" \o "Sclereid)*

[](https://en.wikipedia.org/wiki/File:Plant_cell_type_sclerenchyma_sclereid.png)

Fresh mount of a sclereid

[](https://en.wikipedia.org/wiki/File:Dionysia_kossinskyi_sclereids.TIF)

Long, tapered sclereids supporting a leaf edge in *Dionysia kossinskyi*

Sclereids are the reduced form of sclerenchyma cells with highly thickened, lignified walls.

They are small bundles of sclerenchyma tissue in [plants](https://en.wikipedia.org/wiki/Plant) that form durable layers, such as the cores of [apples](https://en.wikipedia.org/wiki/Apple) and the gritty texture of [pears](https://en.wikipedia.org/wiki/Pear) (*Pyrus communis*). Sclereids are variable in shape. The cells can be isodiametric, prosenchymatic, forked or elaborately branched. They can be grouped into bundles, can form complete tubes located at the periphery or can occur as single cells or small groups of cells within [parenchyma](https://en.wikipedia.org/wiki/Parenchyma) tissues. But compared with most fibres, sclereids are relatively short. Characteristic examples are [brachysclereids](https://en.wikipedia.org/w/index.php?title=Brachysclereid&action=edit&redlink=1" \o "Brachysclereid (page does not exist)) or the stone cells (called stone cells because of their hardness) of pears and [quinces](https://en.wikipedia.org/wiki/Quince) (*Cydonia oblonga*) and those of the shoot of the [wax plant](https://en.wikipedia.org/wiki/Hoya_carnosa) (*Hoya carnosa*). The cell walls fill nearly all the cell's volume. A layering of the walls and the existence of branched pits is clearly visible. Branched pits such as these are called ramiform pits. The shell of many seeds like those of nuts as well as the stones of [drupes](https://en.wikipedia.org/wiki/Drupe) like [cherries](https://en.wikipedia.org/wiki/Cherry) and [plums](https://en.wikipedia.org/wiki/Plum) are made up from sclereids.

These structures are used to protect other cells.