LIGNUM.
MARIAUD CONSULTING

UNDERSTANDING WOOD

THE TREE

OUR PROGRAM

01 What part of the tree is used?

02 How is quarter-sawn cutting done?

03 Wood Mechanics: Structure, Fibers, Strength

UNDERSTANDING WOOD

01 What part of the tree is used?

🌲 General Tree Structur

A tree is composed of two main zones:

- **Aerial part** (above the ground)
- **Underground part** (in the ground)

🌿 Aerial Part

A. Treetop

- Includes **main branches, twigs, foliage, flowers, fruits** (acorns on oak)
- Function: to capture light, ensure photosynthesis, reproduction
- Terminological details: **the top** (summit), **the branch system** (all branches and foliage), **the terminal branchlets** (small terminal ramifications)

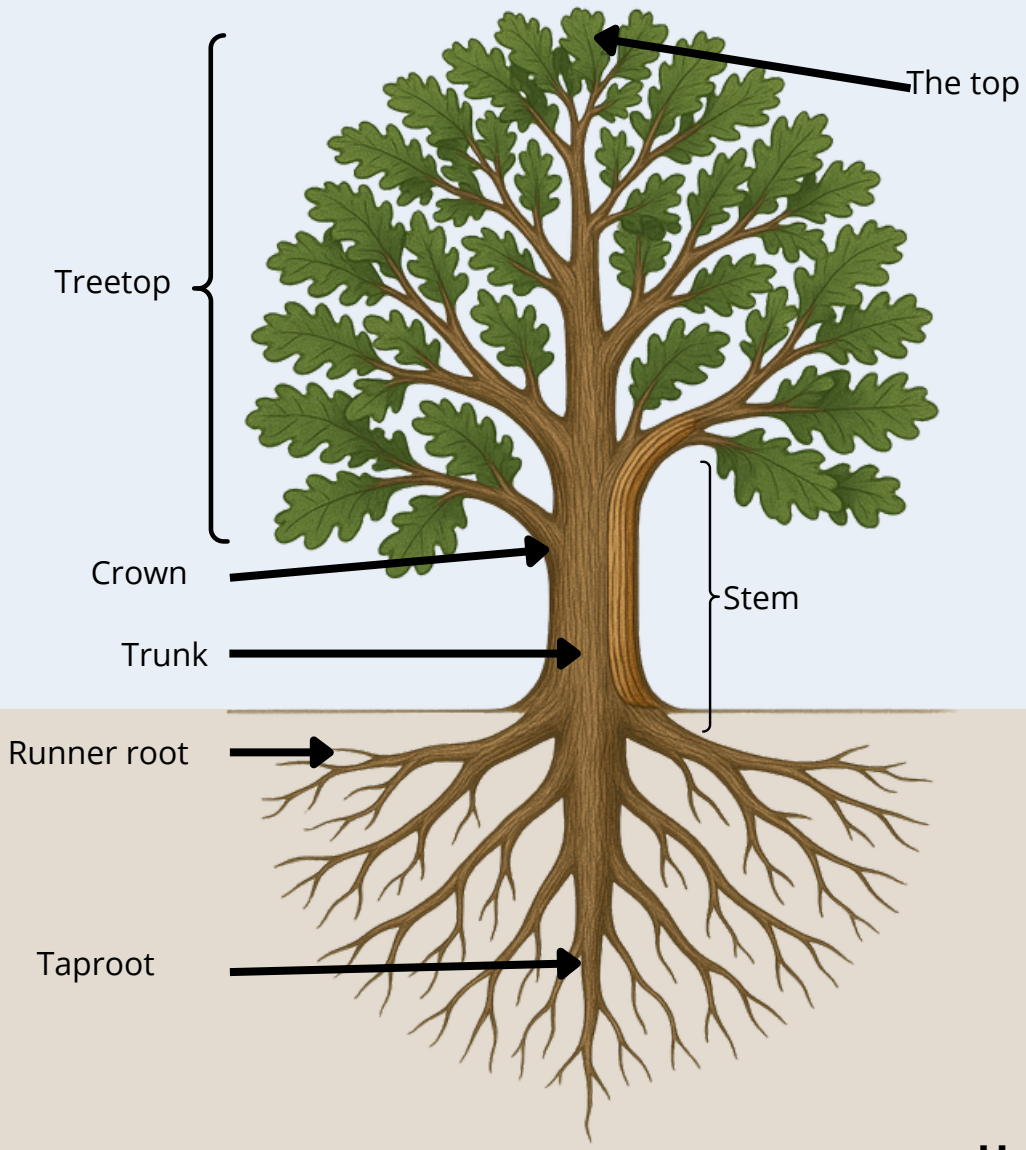
B. Trunk (or stem)

- Main stem, cylindrical, with no low ramifications
- Connects roots and crown, transports sap, supports the load
- Internal composition (from the outside to the center):
  - **Bark** (or rhytidome): external protection
  - **Phloem** (or inner bark): transports elaborated sap
  - **Cambium**: fine meristematic layer for radial growth
  - **Sapwood**: light-colored wood, living, conducts raw sap
  - **Heartwood** (or duramen): dead wood, dense, resistant, rot-proof
  - **Pith**: center of the heartwood, sometimes split, a zone sometimes discarded
  - **Medullary rays**: radial sap transport/storage paths, visible in cross-section
  - **Growth rings**: annual marks, measure age & quality of growth

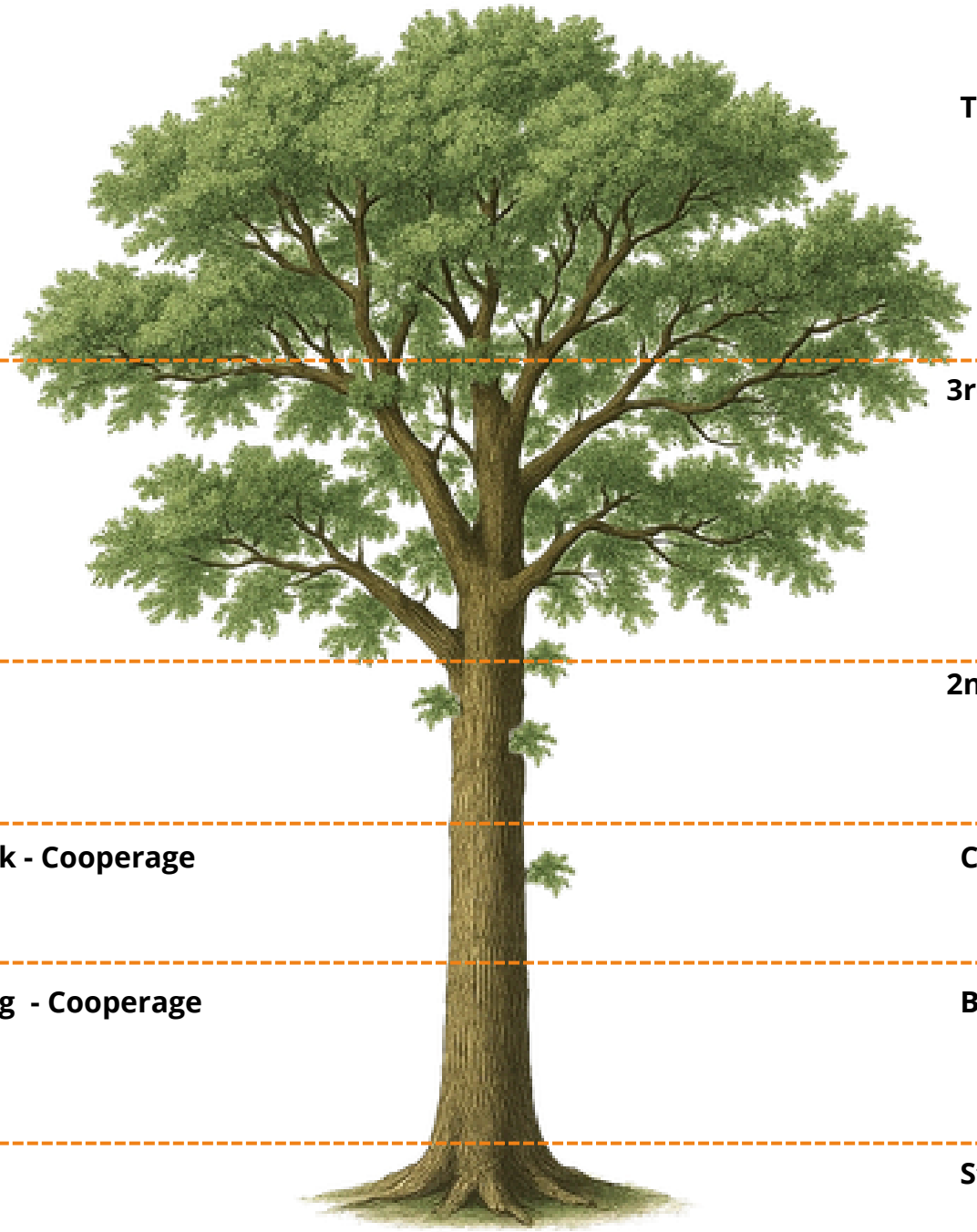
01 What part of the tree is used?

Underground Part

- **Taproot**: main vertical root, deep anchorage
- **Lateral roots** (oblique, superficial): water/nutrient absorption, soil stabilization
- **Rootlets**: fine ends, active in absorption



01 What part of the tree is used?



Fuelwood

Treetop

Stave wood
Crosspiece

3rd cross-section

Joinery

2nd cross-section

Fine woodwork - Cooperage

Cross-section

Cabinetmaking - Cooperage

Butt log

Firewood

Stump

01 What part of the tree is used?

In cooperage, only **the trunk** is used for **technical, mechanical, and organoleptic reasons.**

✅Wood quality

🔸 **Straight and Regular Wood**

The trunk, particularly the butt log (lower part), is the straightest, knot-free, with regular growth.

→ This makes it possible to produce staves that are solid, watertight, and uniform.

🔸 **Ideal Internal Structure**

The trunk provides a good wood grain, which is necessary for splitting, bending, and mechanical resistance.

→ The fibers are continuous, so the wood does not break when heated.

✅ Material yield

The staves are long (around 90 to 100 cm for a standard barrel).

→ Only the trunk can produce pieces of this size.

The **branches**, **twigs**, or **roots**:

- are too small or irregular
- often contain knots or fiber deviations
- do not allow for proper quarter-sawn cutting

✅ Organoleptic Cleanliness

- The trunk, especially the central part called the heartwood, is low in sap and rich in **stable tannins, lactones, and gentle aromas** (vanilla, spices).
- The other parts of the tree (sapwood, twigs, roots) have:
    - too much sap
    - unstable compounds
    - risks of off-flavors

→ Only the trunk offers **neutral or noble wood, predictable** for aging.

01 What part of the tree is used?

🌿The two types of sap

Type of sap	Composition	Circulation	Main role
Crude sap	Water + mineral salts	Roots → leaves (upward flow)	Nourish the leaves
Elaborated sap	Water + sugars (photosynthesis)	Leaves → trunk, roots (downward flow)	Nourish the whole tree

🪵 Where does the sap circulate in the oak tree?

🔹 **Sap circulates only in the living zones:**
- **Crude sap:** circulates in the sapwood (young, light wood)
- **Elaborated sap:** circulates in the phloem, just under the bark

🔸 **The heartwood** is **dead:**
❌ It no longer contains sap
✅ This is the part used in cooperage

Criterion	Sapwood	Heartwood (wood used)
Contains sap	✅ Yes	❌ No
Durability	❌ Poor	✅ Excellent
Mechanical strength	❌ Weak	✅ Very good
Aromatic compounds	❌ Few	✅ Rich

01 What part of the tree is used?

🔍 What to know about sapwood:

- It is the **light-colored area** between the heartwood and the bark.
- It is **alive**: it transports **crude sap**.
- It still contains **a lot of water**, nutrients, and sometimes even sugars.
- Its cells are **not fully lignified**, so:
  - It is **less dense**
  - It is **softer**
  - It is **very susceptible to fungi, insects, and moisture**

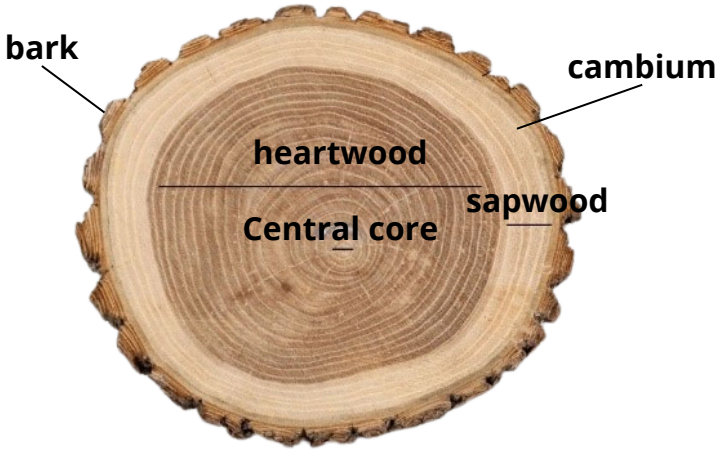
⚠️ Why it crumbles or rots over time:

- It does not resist long-term drying well.
- It reacts very poorly to humidity / dryness cycles.
- Without chemical treatment, it quickly becomes brittle, especially outdoors.
- In a barrel: it would **give off-flavor**s (musty, vegetal, dry).

🧠 Key Takeaways

Sapwood contains sap AND crumbles.

It is precisely for **these two reasons** that it is rejected in cooperage.



01 What part of the tree is used?

🧠 Key Takeaways

Part of the Tree	Description	Use in Cooperage	Estimated Volume (%)
Roots	Underground system, tortuous fiber, knotty wood	❌ No	~15 %
Crown + twigs	Fine, knotty, irregular branches	❌ No	~15–20 %
Usable log (trunk)	Straight part of the trunk without branches, of sufficient quality for stavewood	✅ Yes	~30–35 %
Unusable log	Top of the trunk, too small, too many knots	❌ No	~10–15 %
Bark	External, rough layer	❌ No	~10 %
Sapwood	Young wood under the bark, wet, porous	❌ No	~10–15 % (of the log)
Central core	Area often split, unstable	❌ No	~5–10 % (of the log)
Usable heartwood	Healthy, dense heartwood, split into staves	✅ Yes	**~8–10 % of the total tree**

✅ Conclusion

🔹 **On the scale of the entire tree** (roots, branches, trunk...):
👉 **90 to 92% of the total volume** of the tree is discarded for stave production.
👉 **Only 8 to 10% of the entire tree** actually ends up as usable stavewood.

🔹 **On the scale of the trunk only** (the log):
👉**The trunk represents about 30 to 35%** of the total tree volume.
👉 Out of this volume, **only 20 to 25% is kept** for making staves.
👉 This means that around **75 to 80% of the trunk is lost** or **used for other purposes** (bark, sapwood, heartwood, scraps).

02 How is quarter-sawn cutting done?

🌲Felling & Selection

- Oak trees are felled during **the dormant season,** often in winter, to limit moisture and biological attack.
- Only **straight logs, without knots, with a diameter of ≥ 40 cm,** and with a fine grain are selected.

✅ Log Selection

First of all, you need **a cooperage log**:

- **Straight log, without knots** or curvature
- Usable length: **1.5 m to 2.5 m**
- Diameter after debarking: **≥ 40 cm**
- Mature wood (tree age: 100–150 years)

🔍 We discard:

- logs with a cracked heart
- those with a deviated grain
- logs with growth that is too fast (rings that are too wide)

02 How is quarter-sawn cutting done?

📏 In Practice:

- The minimum diameter after debarking for a log to be accepted in cooperage is generally at least **40 cm at the small end.**
- Some high-end cooperages and stave mills even require **45 cm to 50 cm** to ensure:
  - long quarters (staves ≥ 90 cm)
  - a good depth of heartwood
  - a better yield

📉 Why this minimum?

Below 40 cm:

- The **yield drops sharply**
- The **heartwood takes up too much space**, so there is little usable wood
- The staves are too short, too narrow, or unstable

🔨Sawing into logs

- The logs are cut **into sections of 1.2 to 1.5 m** (up to 2.5 m depending on the needs).
- Each log is **marked** to guide the operator during splitting.

02 How is quarter-sawn cutting done?

🪵 Quarter Splitting

📌 Objective: Respect the wood grain

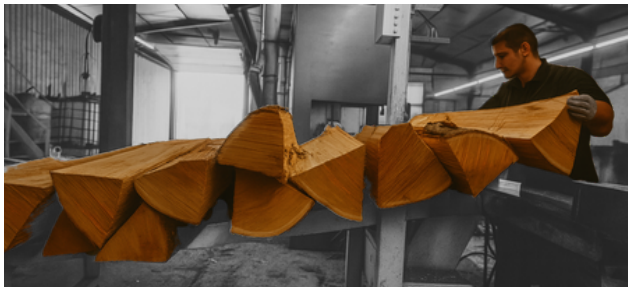
French oak is split (not sawn) to preserve:

- the natural fiber orientation
- the mechanical strength
- the watertightness of the staves

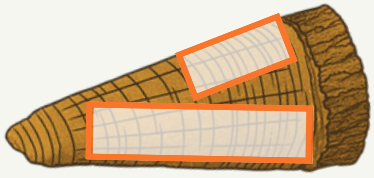
🔧 Steps:

1. **Splitting into 2 → 4 → 8 → 16 quarters**
   ➜We work like a pie, following the center of the heartwood.
2. **Squaring the quarters**
   ➜ Each quarter is squared to obtain a rough cuboid shape.
3. **Final splitting / Sawing into staves**
   ➜ Each quarter is split along the grain to create pieces with a:
   - **Length:** 90 to 100 cm
   - **Width:** 8 to 12 cm
   - **Thickness:** 25 to 30 mm

🛠️ By hand (wedge and mallet) or with a hydraulic splitter (machine)

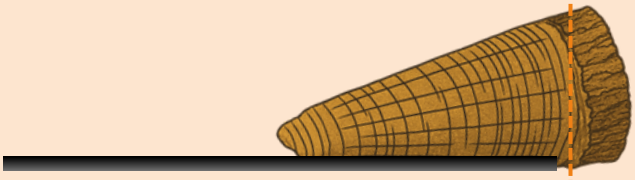


02 How is quarter-sawn cutting done?



Our objective is to be able **to get two pieces from a single quarter**, in order to optimize the material while respecting the wood grain.

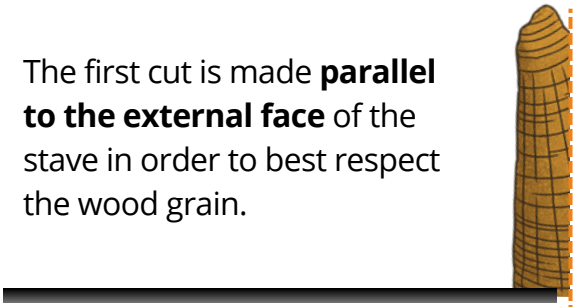
1



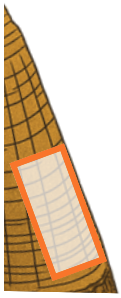
T**he bark** is systematically removed, as well as a **maximum amount of sapwood**. However, a small amount may remain, as other machining operations are planned later that **will remove any residual traces**.

2

The first cut is made **parallel to the external face** of the stave in order to best respect the wood grain.



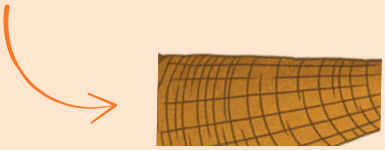
When possible, **a smaller piece** can also be extracted from the second part of the quarter, **thus optimizing the available material.**



3

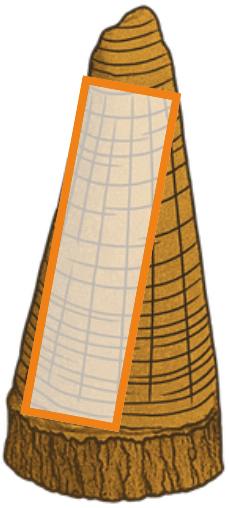
Finally, **the heartwood is removed** in order to keep only the most stable part, which is the most suitable for manufacturing

Here is the **finished piece**, ready to be used for the next processing steps.

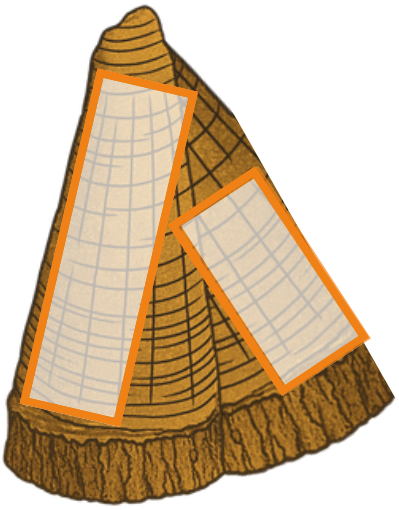


Each piece must have **a radiant face oriented toward the heart**, and **a second face parallel to the first,** in order to ensure respect for the grain and the stability of the stave.

02 How is quarter-sawn cutting done?



Simple Quarter



Double Quarter

02 How is quarter-sawn cutting done?

📏 Dimensions and Classification of Staves

Staves are classified into two main categories:

- **Staves**
- **Heads**

💡 **Note**: Some dimensions can be suitable for both uses.
Example: A 50 cm stave can be used for a 28 L barrel stave or for a head for a Bordeaux barrel (225 L).

📐 Standard Thicknesses

The two most common thicknesses are:

- **22 mm** (Bordeaux barrel, 225 L barrel)
- **27 mm** (large vats, thick pieces)

These values correspond **to the thickness of the dry stavewood.**
When the wood is green, they are sawn thicker to compensate for drying:

- **The 22 mm** is sawn to 25/26 mm
- **The 27 mm** is sawn to 31/32 mm

📏Standard Widths

The widths vary according to the specifications, generally between **60 mm and 130 mm**, sometimes a little below 70 mm for fine staves (called trimmings).

02 How is quarter-sawn cutting done?

📦 How the Wood is Measured (Cubage)

Cubage is based on the final dimensions of the dry wood.
For example:
For a Bordeaux barrel, the stavewood is measured on a basis of 22 mm in thickness and 0.95 m in length, even though it is actually delivered as green wood at **25/26 mm thick** and about 1 meter long.

📊Classification of Lengths

Here is a simple table for quickly reading the sawing ranges according to the length classes:

Class	Sawing Range
1.10 m Stavewood	Sawn between 1.105 m and 1.15 m
1.05 m Stavewood	Sawn between 1.055 m and 1.10 m
1.00 m Stavewood	Sawn between 1.005 m and 1.05 m
0.95 m Stavewood	Sawn between 0.955 m and 1.00 m
0.90 m Stavewood	Sawn between 0.905 m and 0.95 m
0.85 m Stavewood	Sawn between 0.855 m and 0.90 m
0.80 m Stavewood	Sawn between 0.805 m and 0.85 m
0.75 m Stavewood	Sawn between 0.755 m and 0.80 m
0.70 m Stavewood	Sawn between 0.705 m and 0.75 m
0.65 m Stavewood	Sawn between 0.655 m and 0.70 m
0.60 m Stavewood	Sawn between 0.605 m and 0.65 m
0.55 m Stavewood	Sawn between 0.555 m and 0.60 m
0.50 m Stavewood	Sawn between 0.505 m and 0.55 m
0.45 m Stavewood	Sawn between 0.455 m and 0.50 m

03 Wood Mechanics: Structure, Fibers, Strength

🌳 One ring = one year

Each year, the tree grows a new layer of wood:
➡️ This is called a ring.

A ring is **composed of two parts:** the **spring wood**, lighter and more porous, formed at the beginning of the season, and **the summer wood**, darker and denser, formed at the end of the season; together, they represent one year of the tree's growth.

🧮 Simple Equation:

Age of the tree = Number of rings

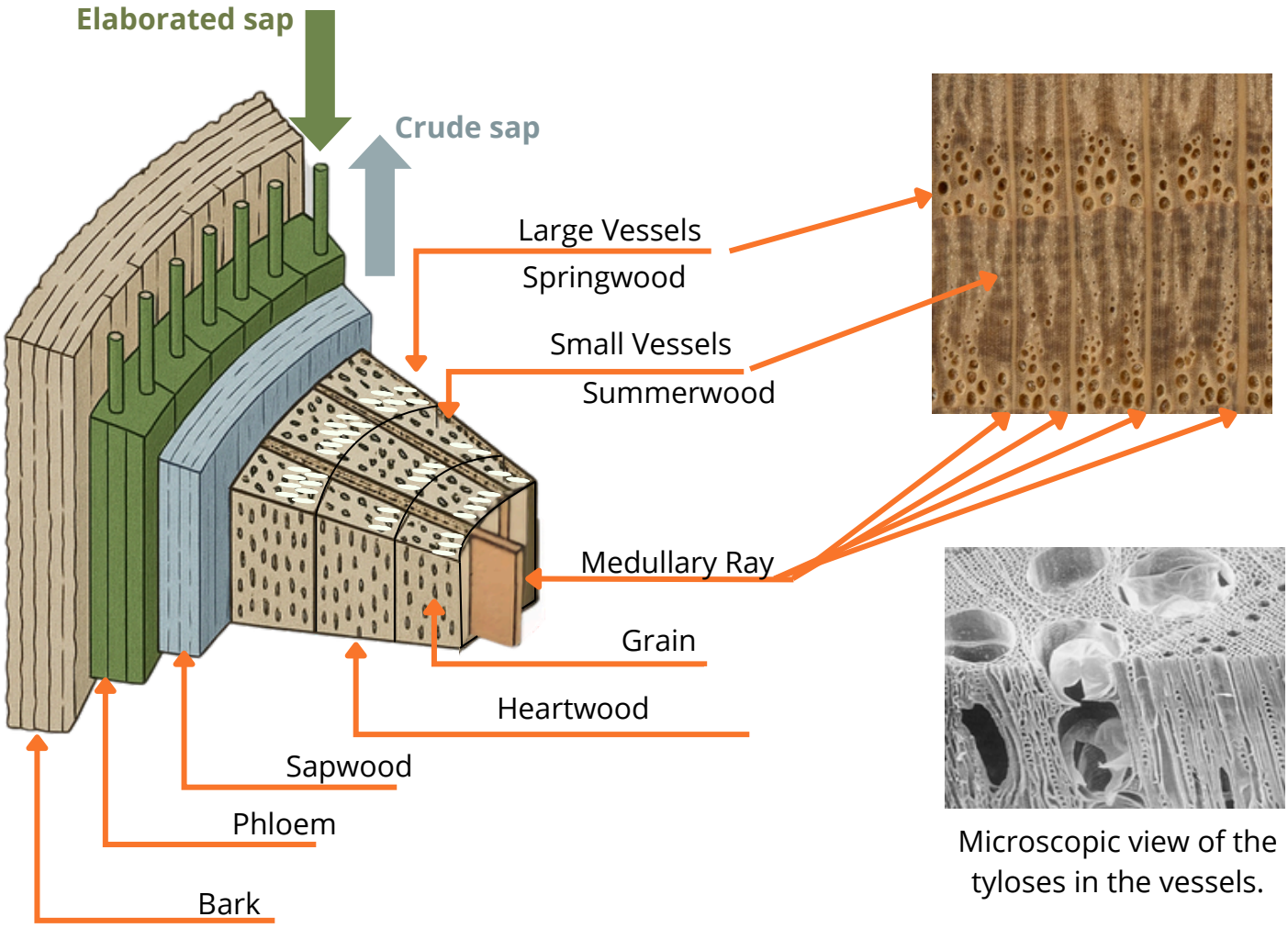
And if you want to know the total thickness of the wood formed since the first year:

Total thickness = Number of rings × Average thickness of one ring

✏️ Example:

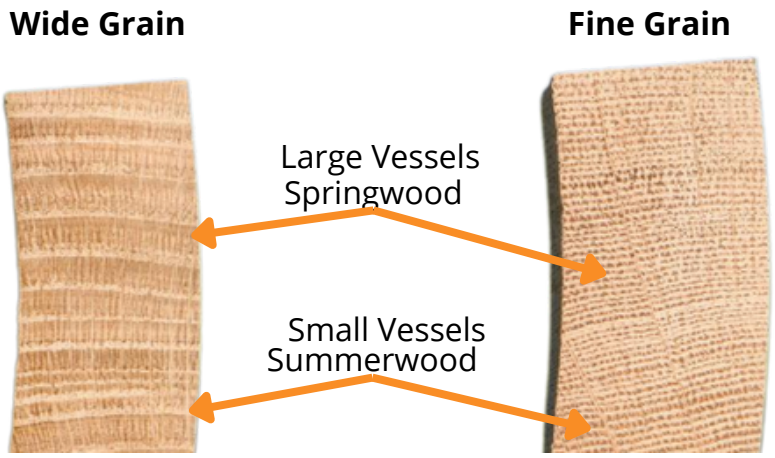
If the tree has **30 rings**
And each ring is, on average, **3 mm thick**:
30 × 3 = 90 mm = **9 cm of wood formed**

03 Wood Mechanics: Structure, Fibers, Strength



Microscopic view of the tyloses in the vessels.

Fine Grain	<2,5 mm
Medium Grain	2,6<Grain>3,5mm
Wide Grain	>3,6 mm



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Wood is a noble material because it comes from a long cycle. It's up to us to respect it.

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