

AUTUMN INVESTIGATION · GRADES 2–8 · AN HOUR AT THE STOVE, THEN A NIGHT UNDER A BOOK

The leaf skeleton

Take away everything soft, and keep the pipes that fed the leaf

Dear fellow scientist,

Hold a leaf up to the window. Behind the green you will see lines: one thick line down the middle, branches leaving it, and between the branches a mesh so fine it looks like lace. Those lines are the leaf's pipes. All summer they carried water up from the roots and carried sugar, made in the leaf, back down to feed the tree.

Today you are going to take the soft green flesh of a leaf away and keep only the pipes. What is left is a skeleton — so delicate you can see through it, and yet tough enough to keep for years. On the forest floor, fungi and bacteria do exactly this, slowly, over a whole winter. You will do it in an afternoon, with a pot of hot water and a spoonful of something from the laundry shelf.

*Fresh, large leaves are the best subjects.*

What you need

- Four to six large, *fresh* leaves — maple, oak, poplar, cottonwood, lilac, or magnolia if you can find one. Green or autumn-coloured, straight from the tree or just fallen. Not dry, brown, curled ones.
- **Washing soda** (sodium carbonate) — sold in the laundry aisle as “super washing soda”. It is *not* baking soda. No box in the house? See the chemist’s trick on the next page: you can make it in the oven from baking soda.
- An old pot that may get stained — steel or enamel, **not aluminium** — and a stove
- A measuring spoon, water, a slotted spoon or tongs, a plate or shallow dish
- A soft old toothbrush or a small paintbrush
- Rubber gloves, paper towels, and a heavy book
- A sheet of dark paper for showing off the result
- An adult, for the stove and the washing soda

What to do

1. **Choose your leaves.** Pick big, flat, undamaged leaves. Before anything else, hold each one against the light and look at its veins — draw the pattern in the record on the last page. This is the “before” photo. You are about to see whether you drew it right.
2. **Make the bath.** Put half a litre of water (a little over two cups) in the pot and stir in $4\frac{1}{4}$ teaspoons of washing soda — about 20 grams — until it dissolves. Doubling both for more leaves is fine. Put your gloves on: the water is now slippery to the touch, and that slipperiness is the washing soda at work.
3. **Heat.** An adult brings the bath almost to the boil, then turns the stove down to the gentlest simmer — a few lazy bubbles, no rolling boil. Slide the leaves in and push them under; a spoon laid on top keeps them down.
4. **Simmer and wait.** Leave the leaves for 30 minutes. The water will go brown and then darker — that is the leaf leaving. After 30 minutes, lift one leaf out onto the plate and stroke it once with the brush. If the green flesh slides off and shows the veins, the batch is ready. If it clings, back into the pot for another 15 minutes, and check again. Tough leaves — oak, maple, magnolia — often want an hour or more. Top up with hot water if the bath runs low.



The bath turns brown as the soft parts of the leaf dissolve.

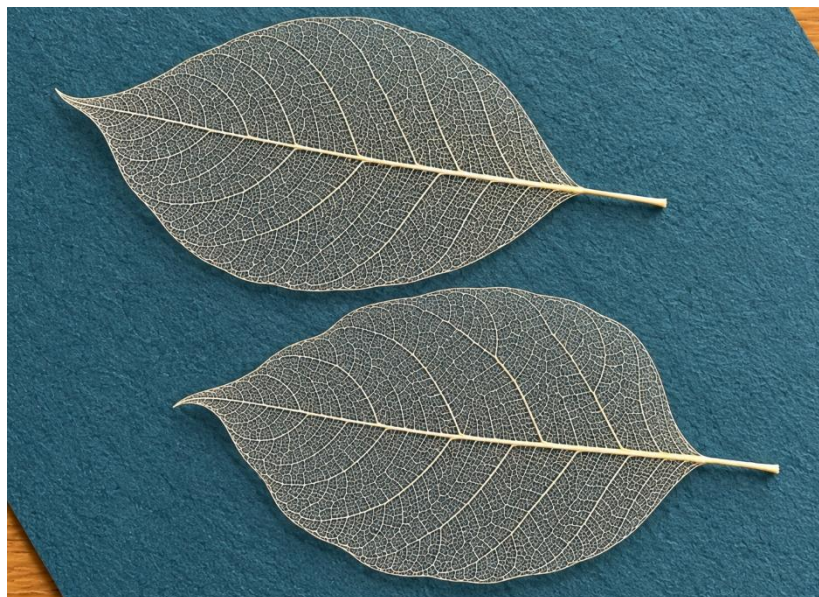
5. **Rinse.** Lift each leaf out with tongs or the slotted spoon — it is soft now, so support it flat — and lay it on the plate. Run cool water over it gently.
6. **Brush.** Hold the leaf under a trickle of cool water, or lay it in a shallow dish of water, and tap and stroke it with the brush, always from the middle vein outward. The flesh comes away in little slimy clouds; the veins stay. Go slowly and take turns — this is the part that needs patient hands, and it is oddly satisfying. If a patch will not come off, return the leaf to the pot for a while rather than scrubbing harder.



The brush lifts the green away and the pipes appear.

7. **Press and dry.** Lay each skeleton flat between two paper towels, put the heavy book on top, and leave it overnight. In the morning it will be flat, dry, and surprisingly strong. It comes out a natural tan or brown — beautiful just as it is.

- 8. Show it off.** Lay the skeleton on dark paper, or tape it to a window. Every vein you drew in step 1 is there — and thousands you did not. Finish the record, and keep the skeleton in your notebook: it will last for years.



The finished skeleton against the light: every pipe that fed the leaf.

No washing soda? The chemist's trick

Baking soda turns *into* washing soda when it is heated. Spread a cup of baking soda thinly on a baking tray and bake it at 200 °C (400 °F) for one hour, then let it cool. It looks almost the same, but it is a different substance now — and here is the proof: weigh it before and after. It comes out about one third lighter, because every spoonful gave off water and carbon dioxide gas in the oven. For the older scientists: $2 \text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$, and 168 grams of baking soda become 106 grams of washing soda. Check the fraction.

Why does the soft part go and the veins stay?

A leaf is built from two kinds of material. The green flesh is made of soft cells with thin walls, glued to each other by a natural jelly called pectin — the same pectin that makes jam set. The veins are different: their cells are stiffened with lignin, the hard stuff that makes wood wood. A tree needs its pipes to stay open and stiff, so it builds them tough.

Hot water with washing soda in it is alkaline — the chemical opposite of vinegar — and hot alkaline water dissolves the pectin glue and softens the thin cell walls. The flesh falls apart into mush. Lignin barely notices; it can sit in that bath for hours. So the bath sorts the leaf for you: what is soft leaves, what is hard stays. It is the same reason a stew cooked long enough lets the meat fall from the bones while the bones remain.

Baking soda will not do it. It is only mildly alkaline, and the pectin glue holds. Washing soda is a much stronger base — and that is exactly why the gloves are on.

Words older scientists use

Chemists measure how acidic or alkaline a liquid is on the **pH** scale, from 0 to 14. Pure water sits at 7. Vinegar is about 3 — acidic. Baking soda in water is about 8.5 — a little alkaline. Washing soda in water is about 11 — strongly alkaline, and a whole step of pH is ten times stronger than the one before. That is the difference between a bath that does nothing and a bath that dissolves a leaf.

Think like a scientist

Choose the questions that fit you. There is no wrong place to start.

- **Grades 2–4:** Count the big veins that leave the middle line. Follow one of them with your finger from the stem to the edge of the leaf — does it get thinner on the way? Why does a leaf need pipes at all? Where does the water in them come from?
- **Grades 4–6:** Compare two different kinds of leaf. Is the pattern like a feather (one midrib with branches), like a hand (several big veins from one point), or like a set of parallel lines? Which leaf took longest in the pot? Make a guess about what that says about its veins.
- **Grades 7–8:** Estimate the total length of vein in one leaf. Cut a 1 cm × 1 cm window in a piece of paper, lay it on the skeleton, and measure all the vein you can see inside the window; do this in three places and take the average. Multiply by the area of the leaf (trace it on squared paper and count squares). How many metres did you get? Then: the fine veins form closed loops rather than a tree of dead ends. What is the advantage of loops for a leaf that insects chew holes in?

Did you know?

- Laid end to end, the veins of one large leaf can add up to tens of metres. Botanists measure this as “vein density”, and the leaves of flowering plants have several times more vein per square centimetre than ferns or conifers — one reason they grow so fast.
- The pipes come in two kinds, side by side in every vein: xylem carries water up from the roots, and phloem carries sugar from the leaf to the rest of the tree. Your skeleton is mostly the tough walls of the xylem.
- In parts of Asia, artists have painted on leaf skeletons for centuries, using the leaves of the sacred fig tree. Pressed flat and painted, a skeleton will keep for a very long time.
- Lignin is the second most common material made by plants, after cellulose. It is the reason a fallen branch takes years to rot while a fallen leaf is gone by summer — the branch is nearly all lignin.



Overnight under a heavy book.



Midrib, side veins, and the mesh between them.

Take care

Washing soda is safe to handle with gloves, but it stings on cuts and it must not get into eyes — no splashing, and wash your hands afterwards. An adult runs the stove and lifts the pot. Do not use an aluminium pot: the washing soda attacks it. Some instructions suggest a final dip in diluted bleach to whiten the skeleton; that is an adult-only step, done in a ventilated room, and never mixed with anything else. The natural brown skeleton is lovely as it is — you can skip the bleach entirely.

MY RECORD

Leaf skeleton record

Name: _____ Date: _____ Kind of leaf: _____

1 • Before: the veins I could see

Hold the fresh leaf against the light and draw its vein pattern. Then, on the right, draw the finished skeleton.

Before — the fresh leaf against the light	After — the skeleton

2 • The batch

Leaf (kind)	Length (cm)	Time in the pot	Brushing: easy 1 – hard 5	Result

My leaf's vein pattern is like a: ☐ feather ☐ hand ☐ parallel lines

3 • For grades 7 and up

Vein length inside a 1 cm × 1 cm window, in three places:

_____ cm, _____ cm, _____ cm

Average: _____ cm of vein per cm²

Area of the leaf (squares counted on squared paper): _____ cm²

Total vein length $\approx$ **average** $\times$ **area** = _____ cm = _____ m

If you made your own washing soda in the oven:

before _____ g, after _____ g, lost _____ %

The chemistry predicts a loss of about 37 %. How close were you, and what could explain the difference?

A note from Professor Alexey

You have just used a chemical to sort a living thing into its parts — the soft and the tough — and then looked at what was left and asked what it was for. That is the whole of anatomy in one afternoon. Notice how much more there was than you could draw before you started: nature is always more detailed than our first look. Keep the skeleton. Next time you see a leaf, you will know what is inside it.

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