

Teacher Guide

Matter I: Its Particulate Nature (Matter Is Made of Particles) • one day, 9:30–2:00

One-line goal: Everything is made of tiny jiggling particles far too small to see — and how tightly those particles hold on to each other is what makes a thing solid, liquid, or gas.

Prerequisites: A-2 (solids/liquids/gases, change with temperature) • A-3 (air is a substance; matter takes up space and has weight).

Vocabulary discipline (book p.67 NOTE): say “**particles**” all day — never “atoms” or “molecules.” Those arrive in A-19; here they only cause overload. And never say a particle melts, softens, shrinks, or grows: **particles themselves never change size or shape when matter changes state** — only their grip and their jiggling change.

KEY CONCEPTS (DON'T MISS THESE)

- **Everything is made of particles** — solid, liquid, gas, rock, water, air, people. This is the **third attribute of matter**: matter takes up space (A-3), has weight (A-3), and is made of particles.
- **Particles are far too small to see.** Even the tiniest speck of sawdust is still millions of particles. A bigger lump does not have bigger particles — **just more of them**.
- **Solid, liquid, or gas is decided by the grip** — how strongly the particles **attract** each other: so tight they can't move past each other = solid; loose, slipping and sliding = liquid; no hold at all, each flying its own way = gas.
- **Particles never stop jiggling.** Warmer = faster jiggling; colder = slower. The grip stays the same — **only the jiggling changes with temperature**.
- **Melting and freezing are a tug-of-war:** warm the ice and the jiggling beats the grip (melt); cool the water and the grip beats the jiggling (freeze). Same for every substance — rock↔lava, iron↔molten iron — just at hotter or colder temperatures.
- **Weight does not change when state changes.** Same particles, same count, same grams — frozen or melted. The scale proves it.
- **Jiggling is not the same as moving.** A thrown ball's particles jiggle exactly as much as a resting ball's; flowing water jiggles the same as still water (same temperature). You feel the *ball*, never the jiggle.
- **Reversible vs. not:** freeze/melt can go back and forth forever because **the particles never changed**. Burning cannot go back, because burning **breaks the particles and makes new, different ones** that fly off as smoke.

VOCABULARY

Key terms: particle • attract • jiggle • tiny • melt • freeze • reversible • dissolve

Copywork (binder sheet, printed): particle • attract • tiny • freeze

Kid-sized definitions to use all day: *particle* — a tiny piece far too small to see • *attract* — pulling toward each other • *jiggle* — particles never stop wiggling • *tiny* — very, very small • *melt* — the jiggling wins and the

particles slip loose • *freeze* — the jiggling slows and the particles lock tight • *reversible* — it can go back the way it was • *dissolve* — particles spread out and hide in the water.

A3 · Rock into Paint — Card 4

10:45 · 30 min · card: [experiment-cards/04-rock-into-paint.pdf](#)

A proven big hit: goggles on, each child takes a turn crushing soft rock in the iron mortar (adult hand over small hands for the first grinds). Smear a pinch of powder on white paper — note the fine specks. Lens check: **still too big to be particles**. Stir powder into a spoonful of matte medium: **rock has become paint**. Paint with it — the painting IS crushed rock glued back together in a new shape; the particles never stopped being rock particles.

Say: “Even a ROCK is a crowd of particles. Crush the crowd apart, add glue, and you can build the crowd into something brand new — that’s all paint is.”

Failure modes: hard river rocks won’t crush — sandstone or chalk only (test the day before). Grit flicks up — goggles stay on, mortar low in a tray. Coarse powder clumps in medium — regrind, or enjoy speckled paint.

A4 · Spray and Bubbles — Card 5

11:15 · 20 min · outdoors · card: [experiment-cards/05-spray-and-bubbles.pdf](#)

The liquid case and the gas case back to back. Spray a fine mist at the sky — the bottle **breaks water into tiny flying bits**; spray again and again at one spot on your other hand and the bits **join back into drops**, then a trickle: the same water, re-formed. Then blow gently through a straw into soapy water: big bubbles and **tiny** ones — each bubble a little package of air particles; when it pops, the package opens and its air mixes back in.

Say: “You just took water apart and put it back together — and it came back exactly the same. Only the grip changed, never the particles.”

Failure modes: pre-set every nozzle to finest mist. Practice straw-blowing on plain water first (sucking soap ends the station). Wind pops bubbles — find a sheltered corner.

A5 · Particle Acting Game — no card (play-act)

11:35 · 15 min · Nebel’s own game, book p.70 · no printed pieces (see [game-components/NO-GAME.md](#))

Everyone is a water particle. Teacher calls: **“SOLID”** — group hug, hold tight, jiggle in place (wiggle shoulders — even solids jiggle!); **“LIQUID”** — handshake distance, making and dropping loose handshakes while drifting over, under, around — a square dance in motion; **“GAS”** — hands clasped behind backs, roam the whole room alone. Call states in random order, then switch to temperature calls: **“FREEZE”** (jiggling slows... grip wins... lock into the hug), **“MELT”** (jiggle harder until the hug breaks into handshakes), **“HOTTER... HOTTER...”** until everyone flies free, then **“COLDER”** back down.

Say: “You never stopped being you. Solid, liquid, gas — same particles every time. Only the holding-on changes.”

Failure modes: it becomes tag — make state-calls freeze-frame moments (“statues first, then move”). Littlest ones do the hug/run poles and skip the square dance.

A6 · Build the Three States — Card 6

11:50 · 15 min · card: [experiment-cards/06-build-the-three-states.pdf](#)

The acting game shrunk onto the tabletop. **Solid:** snap model spheres into a tight rigid grid — try to push one sphere past another without breaking it out; you can’t. **Liquid:** loose clump, touching but unsnapped — slide spheres past each other; the clump flows. **Gas:** scatter spheres across the whole table, none

touching. Point at the spheres: **the balls themselves never changed** — not bigger, not smaller, not softer. Only the arrangement and the grip.

Say: “Show me where the balls got bigger when we made the gas... right — they never do. Particles never change size or shape. Only the grip changes.”

Failure modes: too few spheres = a sad solid — pool the set, rotate builders. Magnetic spheres pinch (table-level hands) and are a swallow hazard for under-3 visitors.

EXPERIMENTS (TEACHER RUNS, KIDS PREDICT → WATCH → EXPLAIN)

E1 • Weigh, Melt, Reweigh — Card 1

9:45 weigh-in · 1:20 finale · card: [experiment-cards/01-weigh-melt-reweigh.pdf](#)

Does melting change how much stuff there is? 9:45 — show the sealed mason jar of ice (frozen overnight), shake it (solid clunks), **weigh it**: a child reads the grams aloud, everyone copies the number into the Number Log. Lid stays ON all day — nothing in, nothing out. **Predict on the worksheet FRONT** (pencil circle): less, the same, or more when melted? Each child writes a guess number in the Log. Park it on the windowsill; peek at lunch (slosh AND clunk). 1:20 — **reweigh**, same scale, same spot; read, write, subtract together. Walk the reasoning (book pp.70–71): weight comes from the particles; melting changed the grip, not the particles; same particles, same count → same weight. Big ✓ on the true worksheet picture.

Say: “The scale can’t see inside the jar. It only counts the stuff. Melting moved the particles apart — it didn’t take a single one away.”

Failure modes: tare with the same empty tray, same draft-free spot, before both weighs. An OPEN cup loses grams to evaporation and “proves” melting lost mass — the sealed lid is non-negotiable. Ice not fully melted by 1:20? Weigh anyway — half-melted weighs the same too, which is itself the point. Wipe the jar DRY at the freezer (condensation film fakes ~0.1–0.3 g).

E2 • Hot vs. Cold Jiggle Race — Card 7

12:45 · 15 min · card: [experiment-cards/07-hot-vs-cold-jiggle-race.pdf](#)

Jiggling made visible. Fill two identical tall glasses to the same line — one hot from the thermos (adult pours), one fridge-cold; label HOT / COLD. **Kids police the fair test out loud**: same amount, same color, ONE drop each, same moment — only temperature differs (“If I gave the hot one two drops, why would that cheat?”). Predict on the worksheet FRONT. Two kids release one drop each **on the count of three**; no stirring — the water must do it alone. Log the seconds each glass takes to reach full even color (cold may still be swirling at cleanup — log “still going!”). Big ✓ on the true picture.

Say: “Nobody stirred. The water particles did all the pushing — and the HOT particles jiggle faster. Warmer means faster jiggling. Always.”

Failure modes: bumping the table ruins it — glasses on a towel, hands in laps after the drop. Pour the hot glass 2–3 minutes early so it’s calm (fresh-poured swirl exaggerates dishonestly). Hold droppers just above the surface (height plunges the dye deep).

E3 • Reversible or Not — Card 8

1:00 · 20 min · adult-only flame · card: [experiment-cards/08-reversible-or-not.pdf](#)

Two changes side by side. Predict first (worksheet FRONT): melted butter goes to the fridge, a burned match cools on the dish — **which one comes back the way it was?** Melt the butter over gentle heat (“the warm jiggling just beat the grip”) and put it straight in the fridge — it re-hardens during the E1 finale; bring it back out at ~1:30: solid again. **Reversible**. Then the match (adult): strike, burn halfway, onto the fireproof dish; burn the paper scrap too and watch the smoke climb. Cool completely — pass the cold ash. Is it turning back? Dunk it in water even — still ash. **Not reversible**. The why (book p.72): melting only changed the butter particles’ grip; burning **broke the wood’s particles and made new, different particles** — some flew off as smoke — so there is no going back. Big ✓ on the true picture.

Say: "Cooling un-melts butter because the butter particles never changed. Cooling can't un-burn a match — burning made NEW particles, and half of them flew away as smoke."

Failure modes: butter scorches on high heat (browned = a nonreversible change sneaking into your reversible demo!) — lowest heat, pull at first full melt. Matches struck over the fireproof dish, water cup standing by, kids' hands on the table edge. One match + one paper scrap is plenty; crack a window for the smoke alarm.

STRETCH (ranch, adult-run — NOT part of the core day):

- **Liquid Nitrogen Ice Cream** — LN2 from a welding-gas supplier (\$20–40 + dewar): jiggling slowed almost to a stop, cream freezes in seconds while kids stir from a distance; a dipped flower shatters like glass. Adult-only: insulated gloves + face shield, outdoors/ventilated — boil-off displaces breathable air; never in a car or closed room.
- **Microscope Particle Hunt** — stereo microscope (\$100–150), permanent shelf spot: sawdust, rock powder, salt at 40x — the particles STILL hide below view, which is exactly the lesson.
- **Burn-Pile Weigh-In** — weigh a log on the hanging scale, burn it in the fire pit, weigh the ash. Where did the missing weight go? Off into the air as brand-new gas particles. (Scientists have captured and weighed the smoke — nothing was truly lost.)

SUPPLIES TO GATHER

Full list with prices and order-ahead flags: **Supply List.md** in this folder. In brief — **have:** mortar & pestle + soft rocks + goggles · playdoh balls + jars + spoons · white paper · sealed mason jar of ice (freezer, night before) · tape + marker · thermos of hot water · straws + dish soap + spray bottles (A-8 kit) · butter + pan + matches + paper scrap + fireproof dish + tongs + water cup + oven mitt · paintbrushes + heavy paper. **Buy:** 0.1 g pocket scale (skip if owned from A-8) · particle model set · food-coloring droppers + 2 tall glasses · basswood blocks + files ×5 · jumbo hand lenses ×5 · matte medium restock. ~\$80 new spend.

PROMPTS & QUESTIONS (USE ALL DAY; BOOK PP.72–73)

- What are the **three attributes** of all matter? What's our evidence for each?
- If solids, liquids, and gases are all made of particles, what makes them different?
- Point at a table / a cup of water / the air: *how tightly are the particles holding on in THIS?*
- Why can't you walk through a wall? Why CAN you push through water — but slowly? Why is walking through air so easy?
- What lets a liquid flow?
- Does a big rock have bigger particles than a pebble? (No — just more of them.)
- What happens to the jiggling as things get hotter? Colder?
- What is going on while an ice cube melts? What two things are having a tug-of-war?
- Did the jar weigh less after melting? What's our evidence?
- Is water the only thing that melts and freezes? (Rock↔lava, iron↔molten iron — same tug-of-war, hotter rope.)
- When you catch a ball, are you feeling the particles jiggling? (No — that's the whole ball moving.)
- Why can frozen water come back, but a burned match can't?

WHAT TO WATCH FOR IN DAILY LIFE (SEND HOME WITH PARENTS)

- Around the kitchen and bathroom: pick anything and ask — *solid, liquid, or gas? Is it made of particles? How tightly are they holding on?*
- Sugar stirred into warm tea *vanishes* — where did it go? (Dissolved: its particles spread out and hide between the water particles. Taste proves they're still there.)
- Sawdust where something was cut, crumbs where bread was sliced, shavings where a crayon was sharpened — *what are those little bits?*
- Ice cubes in a drink: *who's winning right now — the jiggle or the grip?*
- Cooking is full of changes: butter melting (reversible!), toast burning (not!). Ask “*could we get it back by cooling it?*” every time.
- Play the Particle Acting Game with friends or family — any child can be the caller.

PREP-AHEAD CHECKLIST

A few days before

- ☐ Order/gather TO-BUY supplies (Supply List): scale (if not owned from A-8), model set, droppers + tall glasses, basswood + files, hand lenses
- ☐ Collect 6+ soft rocks (sandstone/chalk); test-crush one in the mortar
- ☐ Test one playdoh ball in water — confirm it clouds (oil-based clay won't)

The day before

- ☐ Fill the mason jar with ice cubes, lid on, into the freezer (E1)
- ☐ Fridge a bottle of water (E2 cold glass)
- ☐ Fresh battery + tare check on the 0.1 g scale
- ☐ Pre-portion playdoh balls (2 per child); stage a rock in the mortar + one spare
- ☐ Set every spray bottle to fine mist; stage straws, soap, glasses
- ☐ Print student sheets if stock is low (student-binder/ PDFs ×5)

The morning of

- ☐ Fill the thermos with hot water (E2 needs a big hot-cold contrast on cue)
- ☐ Stage per-kid trays: basswood + file + white paper + hand lens
- ☐ Butter, pan, matches, fireproof dish, tongs, water cup by the stove (E3)
- ☐ Scale on a draft-free spot with the tray it will be tared with
- ☐ Mortar + rock in your lap for circle time; spare rock in a pocket

REVIEW HOOKS

- **Back:** A-2 (solid/liquid/gas — today we explain WHY, with the grip) • A-3 (matter takes up space and has weight — today we add attribute #3, and the weight comes from the particles).
- **Forward:** A-5 (different materials = different particles with different properties) • A-6 (air particles push — pressure) • A-8 (the particles FLY — evaporation and condensation; the acting game grows evaporate/condense calls) • A-9 (dissolving in earnest — today's playdoh cloud is the preview) • A-19, years out, finally names the particles: atoms and molecules.

Opening Oration

Matter I: Its Particulate Nature • read aloud, ~3 minutes

Prop: The iron mortar and pestle with one small soft rock (sandstone or chalk) sitting inside it. Keep it in your lap. At the marked moment, crush the rock — slowly, grindingly, so they hear it — then walk the circle letting each child pinch a little of the powder between their fingers. (Prep: test-crush the same rock type the day before; stage a spare rock.)

Hold out your hand and imagine I put one drop of water in it. Just one little drop.

Now imagine you had the tiniest, sharpest scissors in the world — and you cut that drop in half. Cut it in half again. Smaller still. Again. Again. *Again*. A hundred times. A thousand. A **million**.

Here is my question — one of the biggest people have ever asked: **what would you finally hold?** Nothing at all? Or something so small it cannot be cut anymore?

People wondered for thousands of years. Here is the answer: you would finally hold one tiny piece of water — one **particle**, a piece so small that nobody — with any microscope — can see a single one. But everything, *everything*, is made of them. This rock. That table. The water in your cup. The air going in your nose right now. **You**.

You don't believe me? That's good — scientists never just believe. They test. (*Lift the mortar so all can see the rock.*) Look at this rock. Hard, right? One solid piece. You'd never guess it is secretly tiny bits holding on very, very tightly. So let's stop guessing.

(*Crush the rock — slow, loud, grinding. Show the powder.*)

Look what happened. Where did my rock go? It's all still here — a thousand tiny crumbs. Keep grinding, and every crumb would break smaller, and smaller... all the way down to particles far too small to see. The rock was never really *one* thing. It was a crowd — a crowd of tiny particles, holding hands.

Today we are going to break things into tiny bits all day — wood into dust, dough into a cloud, rock into paint. Then, the best question of all: if everything is made of the same tiny jiggling particles, what makes some things hard, some wet, and some air?

(*Walk the circle: each child pinches some rock powder — the crowd, broken apart.*)

A-4 Supply List — Matter Is Made of Particles

Everything for the full 9:30–2 day. Prices are rough. Two items overlap the A-8 kit (scale, spray bottles) — buy once, share across the thread.

ALREADY HAVE (TYPICAL HOUSEHOLD / PROVEN GEAR)

☐	ITEM	USED IN
☐	Iron mortar and pestle	Oration prop • E3-adjacent • Card 4 rock crush
☐	Small soft rocks — sandstone or chalk, 6+ pieces (yard/creek)	Oration, Card 4
☐	Safety goggles (kid-size)	Card 4 rock crush
☐	Playdoh or soft clay — 2 marble-size balls per child	Card 3 dissolve
☐	Clear jars or drinking glasses (one per child + 2 tall for Card 7)	Cards 3, 5, 7
☐	Spoons for stirring	Card 3
☐	White paper (catching sawdust and powder; painting)	Cards 2, 4
☐	Small mason jar with lid	Card 1 (sealed melt jar)
☐	Ice — freeze the jar of ice cubes the night before	Card 1
☐	Masking tape + marker	Cards 1, 7 labels
☐	Thermos of hot water (filled the morning of)	Card 7 hot glass
☐	Drinking straws (one per child)	Card 5 bubbles
☐	Dish soap	Card 5
☐	Spray bottles (5 — bought for the A-8 kit)	Card 5
☐	Butter (one pat) + small pan or heat-safe dish	Card 8
☐	Hot plate or kitchen stove (gentle heat)	Card 8
☐	Fridge (re-hardens the butter; chills Card 7 cold water)	Cards 7, 8
☐	Matches + a scrap of paper	Card 8 burn
☐	Fireproof dish (ramekin/ashtray) + tongs + cup of water	Card 8
☐	Paintbrushes + heavy paper (watercolor or cardstock)	Card 4 paint
☐	Oven mitt	Card 8

TO BUY

☐	ITEM	QTY	~PRICE	WHY	ORDER AHEAD?
☐	Pocket digital scale, 0.1 g precision	1	\$15	Card 1 — makes weigh-melt-reweigh a real measured result, not a hand-wave. Skip if already owned from A-8	Yes
☐	Chunky ball-and-stick or magnetic-sphere particle model set	1	\$20	Card 6 — kids build solid/liquid/gas arrangements on the table	Yes
☐	Food-coloring dropper set + 2 tall clear glasses	1	\$10	Card 7 — the hot-vs-cold jiggle race needs clean single drops	Yes
☐	Basswood blocks + wood file, one per child	5	\$15	Card 2 — restock of the proven sawdust hit	Yes
☐	Jumbo 10x hand lens, one per child	5	\$12	Cards 2–4 — inspect sawdust, powder, and clouded water; the particles STILL hide below view	Yes
☐	Matte medium (art binder), restock if low	1	\$8	Card 4 — crushed rock + binder = paint (white glue thinned 1:1 with water substitutes)	No

Total new spend: ~\$80 (~\$65 if the scale is already owned from A-8).

STRETCH PURCHASES (ONLY IF PURSUING THE RANCH INSTALLS — SEE TEACHER GUIDE STRETCH)

☐	ITEM	~PRICE	FOR
☐	Liquid nitrogen (few liters, welding-gas supplier) + dewar/thermos	\$20–40	LN2 ice cream — jiggling nearly stopped, cream freezes in seconds (adult-only, gloves + face shield, outdoors)
☐	Stereo microscope, permanent science-shelf spot	\$100–150	40x particle hunt — the particles still hide below view, which is exactly the lesson
☐	Hanging scale (if not owned)	\$15	Burn-pile weigh-in at the fire pit

Tick the box beside each item as it goes in the box. Anything flagged **order ahead** ships — buy it a week before the lesson.