BFSU A-4 · TEACHER

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.)

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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.

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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.)

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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.

Weigh, Melt, Reweigh

TEACHER DEMO · KIDS READ THE NUMBERS | SET UP 9:45 · FINALE 1:20 | 10 + 15 MIN

The point

Melting changes the particles' **grip**, not the particles. Same particles, same count — so the scale reads the **same number**, frozen or melted.

Materials

- Small mason jar with lid, filled with ice, frozen overnight
- 0.1 g digital scale (fresh battery, tared)
- Sunny windowsill
- Number Log sheets + pencils

Steps

1. Show the sealed jar; **shake it** — solid clunks. "Lid stays ON all day. Nothing in, nothing out."
2. **Weigh it.** A child reads the grams aloud; everyone writes the number in the Number Log.
3. Kids **predict on the worksheet front** (pencil circle) and write a guess number in the Log.
4. Park the jar on the windowsill. **Nobody touches it.** Peek at lunch — slosh AND clunk.
5. 1:20 — **reweigh**, same scale, same spot. Read aloud, write it down.
6. **Subtract together.** Zero difference is a real measured result!
7. Kids put a 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."*

Fig. 1 — the sealed jar on the scale: nothing in, nothing out

TEACHER PREP — THE DAY BEFORE

Fill the mason jar with ice cubes, lid on tight, into the freezer. Fresh battery + tare check on the scale.

What to watch for

- The morning clunk becoming a lunch slosh-and-clunk
- Kids' guesses splitting between "less" and "the same"
- Someone realizing the lid is the whole trick — celebrate that

EXPECTED RESULT

The two weights match to the tenth of a gram. **State changed; stuff didn't** — weight comes from the particles, and every particle is still in the jar.

HONEST-MEASUREMENT TRAPS

Wipe the jar **dry** out of the freezer (condensation film fakes extra grams). Tare with the same tray, same draft-free spot, both times. An **open** cup would leak grams to evaporation — the lid is non-negotiable.

File a Solid into Particles

KIDS HANDS-ON | RUN AT 9:55 | 25 MIN

The point

A "single" solid thing is really a crowd of tiny bits holding on to each other — and even the tiniest bit you can see is still **millions of particles**.

Materials

- Basswood block, one per child
- Wood file, one per child
- White paper under each work spot
- Jumbo 10x hand lens, one per child

Steps

1. Hand out blocks: **"one thing, or a crowd?"** Let them argue first.
2. **File over the white paper** — start on an edge, not a flat face.
3. Watch the sawdust pile grow: wood IS lots of tiny wood bits.
4. **Pinch and rub** the sawdust between fingers.
5. Now the key move: **one speck under the 10x lens.** Can you see a particle? No — still millions of particles per speck.
6. Imagine on down: tinier files could halve each speck again and again… to a particle nobody can see.
7. **Save each sawdust pile** on its paper for the worksheet back (wood ↔ sawdust).

> *Say: "The file didn't MAKE the sawdust — it just un-stuck bits that were always there. And even one speck of sawdust is still a crowd of millions of particles."*

Fig. 2 — block, file, sawdust pile, and the lens that still can't find a particle

TEACHER PREP

One tray per child: block + file + white paper + lens. Keep the lenses OFF the table until step 5, or they become the activity.

SAFETY

Block hand behind the block — never in front of the file stroke. Files scrape knuckles; demonstrate the grip first.

What to watch for

- The moment "one thing" visibly becomes a heap of bits
- Lens disappointment turning into the actual insight: the particles are STILL hiding

EXPECTED RESULT

A pile of sawdust per child, and the reasoned conclusion: keep cutting and you must reach a smallest bit — a **particle**, far too small to see.

Dissolve to Particles

KIDS HANDS-ON | RUN AT 10:20 | 15 MIN

The point

A solid ball can **dissolve** — its particles let go of each other and spread out into the water. Nothing vanishes: the cloud IS the ball.

Materials

- Playdoh or soft clay, 2 marble-size balls per child (water-based — tested)
- Clear jar or glass of water per child, filled halfway
- Spoon per child
- Jumbo hand lenses

Steps

1. Ball in hand: "one thing, or a crowd?" **Drop it in.**
2. **Stir and mash** with the spoon — the water clouds as the ball's particles spread out. That spreading is called **dissolve**.
3. Hold jars to the window: clear water is **transparent**, the cloudy mix is **opaque** (or in between — **translucent**). Sort the jars by see-through-ness.
4. **Lens on the cloud:** still no single particle visible.
5. **Leave one jar still all afternoon** — check it at closing circle: the particles are settling into a layer at the bottom.

> *Say: "Where did the ball go? Nowhere — its particles are ALL still in there, spread out and hiding in the water. That's what dissolve means."*

Fig. 3 — the ball becoming a cloud of its own particles

TEACHER PREP

Pre-portion 2 balls per child. **Test one ball the day before** — oil-based modeling clay will NOT dissolve; water-based playdoh clouds beautifully.

What to watch for

- The water clouding exactly the color of the ball
- Kids using transparent / translucent / opaque unprompted (the vocabulary moment worth waiting for)
- At closing circle: the settled layer — the particles never stopped existing

EXPECTED RESULT

Cloudy, opaque water — the whole ball, spread out as particles; by day's end a settled layer proves **nothing disappeared**.

Rock into Paint

KIDS HANDS-ON · ADULT AT THE MORTAR | RUN AT 10:45 | 30 MIN

The point

Even the **hardest** thing in the room is a crowd of particles — and once the crowd is crushed apart, it can be built into something brand new. Paint IS crushed rock.

Materials

- Soft rocks (sandstone or chalk), 6+ pieces, tested
- Iron mortar and pestle (in a tray)
- Kid-size safety goggles
- White paper (powder smear) + heavy paper (painting)
- Matte medium (or white glue thinned 1:1 with water) + spoon
- Paintbrushes
- Jumbo hand lenses

Steps

1. Goggles on. Each child takes a turn **crushing rock in the mortar** — adult hand over small hands for the first grinds.
2. Tip some powder onto white paper; **smear a pinch with a fingertip** — see the fine specks.
3. **Lens check:** are the specks particles? Still too big — the real ones hide below even the lens.
4. **Stir powder into a spoonful of matte medium** — rock has become paint.
5. **Paint with it.** The painting is crushed rock, glued back together in a new shape.

> *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."*

Fig. 4 — rock → powder → paint: the same particles, rearranged

TEACHER PREP — DAYS BEFORE

Collect 6+ soft rocks (sandstone/chalk) and **test-crush one** — hard river rocks will not give. Stage one rock in the mortar for the oration, plus a spare.

SAFETY

Goggles stay on at the mortar — grit flicks up. Mortar stays low in its tray. Adult hands over small hands for the first grinds.

What to watch for

- The grinding sound turning gravel into flour
- Paint color = rock color (nobody added color!)

EXPECTED RESULT

Real paint from rock powder + binder; a painting whose color came entirely from the crushed rock. The particles **never stopped being rock particles**.

Spray and Bubbles

KIDS HANDS-ON | RUN AT 11:15 · OUTDOORS | 20 MIN

The point

Liquids and gases are crowds of particles too. Water can be broken into flying bits that **join back into plain water**; air can be parceled into bubble "packages" of any size.

Materials

- Spray bottle per child, set to finest mist (from the A-8 kit)
- Glass of soapy water per child (water + a squirt of dish soap)
- Drinking straw per child

Steps

1. **Spray a fine mist at the sky** — the bottle breaks water into tiny flying bits.
2. Spray again and again **at one spot on your other hand**: the bits join back into drops, then a trickle — the same water, re-formed.
3. Ask it out loud: did the water change? **No — broken apart and joined back, same water.**
4. Now the air: **blow gently through the straw** into the soapy water.
5. Look close at the foam: big bubbles and **tiny, tiny ones** — each one a little package of air particles.
6. **Watch a bubble pop** — the package opens and its air particles fly free and mix back into the air.

> *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."*

Fig. 5 — bubble packages of air; the mist bottle that breaks water into bits

TEACHER PREP

Set every nozzle to finest mist the day before. Mix soapy glasses just before heading out. Pick a wind-sheltered corner.

BLOW, DON'T SUCK

Practice straw-blowing on plain water first — a mouthful of soap ends the station. Hand out spray bottles only after the straw round, then allow one minute of free spray as the pressure valve.

What to watch for

- Mist re-forming into running drops on a palm
- Someone spotting the very tiniest bubbles unprompted

EXPECTED RESULT

Water: broken to bits, rejoined, unchanged. Air: parceled into packages from fist-size to speck-size — and released again when they pop.

Build the Three States

KIDS HANDS-ON | RUN AT 11:50 | 15 MIN

The point

Solid, liquid, and gas are the **same spheres in different arrangements**. The balls never change — only the spacing and the grip.

Materials

- Chunky ball-and-stick or magnetic-sphere particle model set (pooled, one shared build)

Steps

1. **SOLID:** snap spheres into a tight, rigid grid.
2. Try to **push one sphere past another** without breaking it out — you can't. That's why solids hold their shape.
3. **LIQUID:** unsnap into a loose clump, touching but free. **Slide spheres slowly past each other** — the clump flows into a ring of hands, its "container."
4. **GAS:** scatter the spheres across the whole table, far apart, none touching.
5. The punchline, pointing at the spheres: **show me where a ball got bigger… it never did.**
6. Rebuild all three fast, calling back to the acting game: hug → handshakes → fly free.

> *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."*

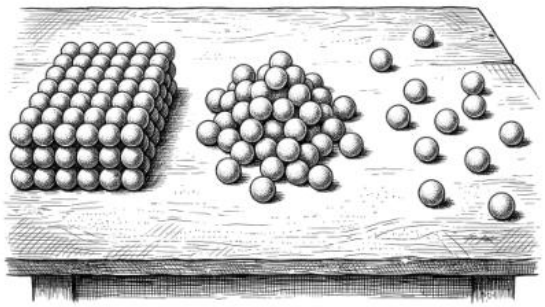


Fig. 6 — one set of spheres, three arrangements: solid, liquid, gas

TEACHER PREP

Pool the whole set for one shared build and rotate builders — too few spheres makes a sad "solid."

SAFETY

Magnetic spheres **pinch** (keep hands at table level) and are a **swallow hazard** — keep the set away from any under-3 visitor entirely.

What to watch for

- The "can't push past" moment in the solid grid
- The liquid clump genuinely flowing to fit its container
- A child narrating the acting game onto the table unprompted

EXPECTED RESULT

All three states built from identical spheres — **arrangement and grip are the only differences**, and the spheres never change size or shape.

Hot vs. Cold Jiggle Race

TEACHER DEMO · KIDS DROP & TIME | RUN AT 12:45 | 15 MIN

The point

Particles never stop jiggling — and **hot particles jiggle faster**. The spreading color is the jiggle made visible: nobody stirs, the water does it alone.

Materials

- 2 identical tall clear glasses on a towel
- Thermos of hot (not boiling) water
- Fridge-cold water
- Food-coloring droppers
- Tape labels HOT / COLD + marker
- Timer + Number Log sheets

Steps

1. Fill both glasses **to the same line** — hot (adult pours, 2–3 min early so it calms) and cold. Label them.
2. Kids **police the fair test out loud**: same amount, same color, ONE drop each, same moment — only temperature differs.
3. Kids **predict on the worksheet front** (pencil circle).
4. Two kids, droppers **just above the surface**, release **on the count of three**. Start the timer.
5. **No stirring, no bumping** — hands in laps. Narrate what the color does in each glass.
6. **Log the seconds** to full, even color in each glass (cold may still be swirling at cleanup — log "still going!").
7. Big **✓ on the true worksheet picture**. Debrief: what pushed the color around?

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

Fig. 7 — same drop, same water, different jiggle speed

TEACHER PREP

Fridge a bottle of water the day before. Fill the thermos the morning of — the race needs a big hot-cold contrast on cue.

SAFETY

Hot water is **adult-pour only** — hot, not boiling. Glasses stay on the towel at the table's center.

What to watch for

- Hot: wisps and curls, full color in a couple of minutes
- Cold: a slow creeping cloud that may outlast the block
- A child connecting it to the acting game's HOTTER call

EXPECTED RESULT

The hot glass reaches full color several times faster. Same drop, same water — **temperature set the jiggle speed**, and the jiggle did the mixing.

Reversible or Not

TEACHER DEMO | RUN AT 1:00 | 20 MIN

The point

Melting can go back because **the particles never changed**. Burning can never go back — it **breaks the particles and makes new, different ones** that fly off as smoke.

Materials

- A pat of butter + small pan
- Hot plate or stove (lowest heat) + oven mitt
- Fridge (re-hardens the butter)
- Matches + a scrap of paper
- Fireproof dish + tongs
- Cup of water (douse + the "cool it all you like" test)

Steps

1. Kids **predict on the worksheet front**: which comes back — the butter, the match, or both?
2. **Melt the butter** over lowest heat — solid to golden liquid. "The warm jiggling just beat the grip."
3. **Straight into the fridge.** It re-hardens during the weigh-in finale.
4. Adult: **strike a match over the fireproof dish**, burn halfway, drop it. Burn the paper scrap too — watch the smoke climb.
5. **Let everything cool completely.** Pass the cold ash. "Is it turning back?"
6. **Dunk the ash in the water cup** — as cold as it gets, still ash. Not reversible.
7. ~1:30 — **bring the butter back out: solid again.** Reversible. Big ✓ on the true worksheet 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."*

Fig. 8 — two changes on one counter: one can go back, one never will

TEACHER PREP

Stage butter, pan, matches, paper scrap, fireproof dish, tongs, and the water cup by the stove before lunch. Crack a window (smoke alarm).

SAFETY

Flame is adult-only. Matches struck over the fireproof dish; water cup standing by; kids' hands stay on the table edge. One match + one paper scrap is plenty.

What to watch for

- Butter looping solid → liquid → solid, unbothered
- The smoke climbing — particles leaving for good
- The disappointment of the ash that will not turn back — that IS the lesson

EXPECTED RESULT

Butter: fully reversible, could loop a hundred times. Match and paper: permanently ash + smoke — **new particles, no way back**, no matter how cold.

Matter Is Made of Particles

Tiny pieces, far too small to see — and how tightly they hold on

*Everything — rock, water, air, and **you** — is made of **particles**: tiny pieces far too small to see. A big rock doesn't have bigger particles than a pebble… it just has **more of them**.*

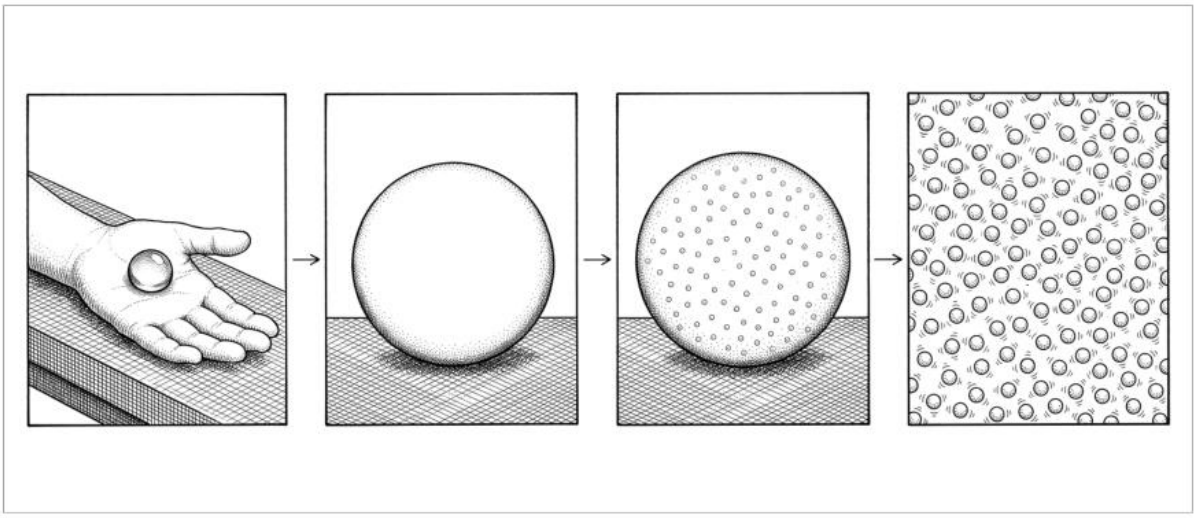
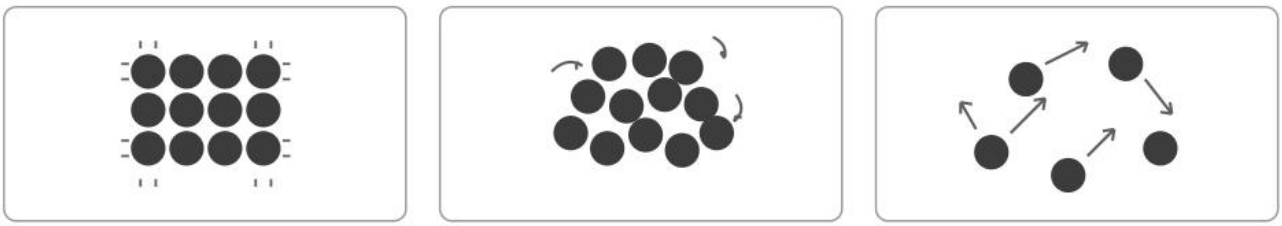


*Fig. 1 — **cut it in half, and in half again,** a million times: at the very bottom you would hold one particle — far too small to see. Even the smallest speck you CAN see is still millions of particles.*

Same Particles — Different Grip



SOLID
holding tight — jiggling in place

LIQUID
loose grip — slipping and sliding

GAS
let go — flying free

Same dots in every box — the particles never change. Only the grip changes… and a hotter flame means faster jiggling.

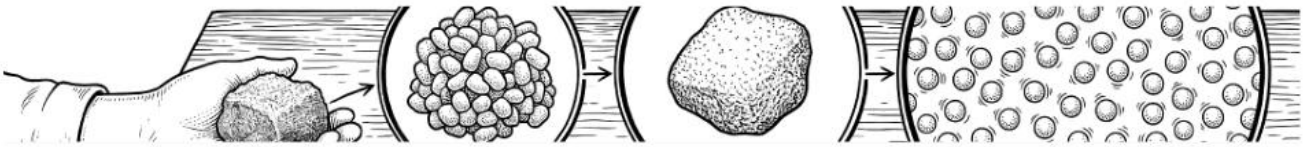
Words to Know

particle · attract · jiggle · tiny · melt · freeze · reversible · dissolve

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*

Watch For This in Everyday Life

- Sugar stirred into warm tea vanishes. *Where did its particles go?*
- Sawdust, crumbs, or crayon shavings where something was cut. *What are those little bits?*
- Steam rising off your soup. *What is escaping into the air?*
- An ice cube melting in your drink. *Who is winning — the jiggle or the grip?*



particle

particle

attract

attract

tiny

tiny

BFSU A-4

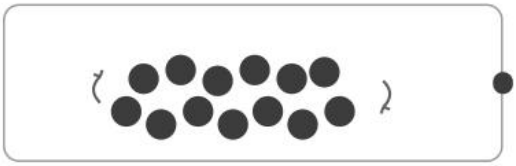
Matter Is Made of Particles

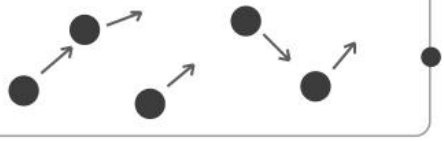
Match the particles — and make your hypotheses — front

WORKSHEET

1 · Match the particles

The dots are the particles — the same dots in every box. Draw a line from each particle picture to the state it makes.





Solid

Liquid

Gas

2 · My hypotheses

***Before** each experiment: circle your guess with a pencil. **After:** put a big ✓ on what really happened.*

Weigh, Melt, Reweigh · CARD 1

The sealed jar of ice sits in the sun all day and melts. What will the scale say then?

a smaller number — less

the very same number

a bigger number — more

Hot vs. Cold Jiggle Race · CARD 7

One drop of color falls into a HOT glass and a COLD glass at the same moment. Which glass mixes to full color first?

the hot glass wins

the cold glass wins

both at the same time

Reversible or Not · CARD 8

Melted butter goes into the fridge. A burned match cools all the way down. Which one comes BACK the way it was?

the butter comes back

the match comes back

both come back

BFSU A-4

Match the Thing to Its Tiny Bits

Every big thing breaks into little pieces of itself

WORKSHEET

1 · Draw a line from each thing to its broken bits

 *a wood board*	 *crumbs*
 *a stick of chalk*	 *a little hill of sand*
 *a hard rock*	 *sawdust*
 *a loaf of bread*	 *sugar grains*
 *a crayon*	*fine chalk dust*
 *a sugar cube*	 *crayon shavings*

*Even these tiny bits are NOT single particles — every speck you can see is still **millions** of particles, far too small to see.*

2 · Think like a scientist

Pick one speck — a crumb, a grain, a bit of dust. If you could keep cutting it in half, and in half again, a million times… **what would you finally hold?** Tell someone.

Number Log

Every experiment gives us a number — write it big

1 · Weigh, Melt, Reweigh

Read the scale and write the grams. A grown-up can write it first for you to copy.

WHEN	GRAMS (G)
 *morning — frozen jar*	
 *my guess for later*	
 *afternoon — melted jar*	
= *afternoon − morning =*	

2 · Hot vs. Cold Jiggle Race

Watch the clock — how many seconds until the whole glass is one even color?

GLASS	SECONDS
 *HOT glass*	
 *COLD glass (write "still going!" if it never finished)*	

3 · Think like a scientist

The melt numbers matched — **zero difference is a real result!** Tell someone why the jar weighed the same: what did melting change, and what did it never change?

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Tiny Jiggling Particles

the lesson's song — sing it, then say what it means

SONG

Verse 1

Take a drop of water, cut it right in two,
Cut it again and again — what's left when you're through?
A particle! A particle! Too tiny to see —
And everything is made of them, even you and me!

Chorus

Hold on tight — that's a SOLID! (hug!)
Hold hands loose — that's a LIQUID! (slide!)
Let go now — that's a GAS! (fly free!)
Same little particles, one-two-three!
It's all in the grip, it's all in the grip —
Hold tight, hold loose, or let go and zip!

Verse 2

Particles are jigglers, they never sit still,
Warm them up, they wiggle fast — cold makes them chill.
Attract means holding on, like a hug that won't quit —
The jiggle and the grip play tug-of-war, that's it!

(Chorus)

Verse 3

Freeze a cup of water and it locks up tight,
Melt it in the morning and it pours out right —
Reversible! Reversible! It goes back fine.
But burn a stick of wood and there's no rewind!

(Chorus ×2, second time stomp on "one-two-three!")

Tag (spoken, kids, doing the motions): "Solid... liquid... gas... JIGGLE!"

How to use it. Play the recording once while everyone just listens. Play it again and join in on the chorus only — that is the part carrying the lesson. By the third time most children have the chorus. Then close the binder and ask what the words actually mean; a child who can sing it and explain it has the idea for good.