Science for Homeschooling

Michael Gannotti

Figure 1: Cover

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This illustrated edition is the teaching-manual of 1 September 2026. Endnotes run in one series. Chapter-opening images are original still-lifes, not portraits of persons or children. Documents still constrain the facts.

Contents

Welcome

This book exists because the science hour at your table is the whole program. There is no department down the hall and no specialist waiting after lunch. There is you, a student, and today's idea — something to look at, a trial to try, a record to keep, a question worth waiting for. That is enough, if you know what to do with the hour.

I wrote this for a capable, busy, willing parent. You may be teaching two ages at once. You may be fitting science between a job, a toddler, and a grocery run. You may have loved school science, or you may remember it as a fog of formulas and names. Many adults feel rusty around formulas and names when they sit down to teach. That feeling is common. It is not a verdict. We will move on from it. This book will make you fluent enough in this week's idea to notice a wrong explanation and ask a good question — without taking over the notebook.

You do not need to be a scientist. You do need to understand this week's idea well enough to hear "the plant ate through its roots" as a prior idea doing work, not as a cute slip. You need a session shape you can run on a Tuesday. You need a few sentences that actually help. That is the job. A path through science — from first-grade looking-and-trying through a college-ready high-school sequence in biology, chemistry, physics, and earth and space — is possible at a kitchen table. The path is not a personality trait and it is not a percentile. It is a sequence of ideas, practiced until they hold, with you in the chair.

About 3.4 percent of U.S. students ages 5–17 were homeschooled in 2022–23 — roughly 1.765 million children.[1] That figure is context, not a ranking. You are

[1] Ellena Sempeles and Jiashan Cui, *Parent and Family Involvement in Education: 2023*, NCES 2024-113 (Washington, DC: National Center for Education Statistics, September 2024), Table A-6: 3.4 percent homeschooled, approximately 1,765,000 students, ages 5–17 with a K–12 grade equivalent, 2022–23. https://nces.ed.gov/pubs2024/2024113.pdf. Access date for URLs in these notes: 1 September 2026. Latest federal count this book uses; not a 2026 national total. A neighboring 5.2

one of those tables. Homeschooling is legal in all fifty states and the District of Columbia. The paperwork is not one load: Texas asks almost nothing of the state agency; New York asks for a written plan and regular reports.[2] There is no national homeschool diploma and no national science credit a registrar already files.[3] In the last federal tables that published the row, science at home was counted as subsubjects, not as one majority "science" percent: inquiry or experiments that year in 41 percent of households overall, and in only 25 percent of grades 9–12.[4] Earth science that year was 44 percent; biology 25 percent; chemistry or physics 15 percent. The titles that travel — Science, Life Science, Physical Science, Biology, Chemistry, Physics, Earth Science, Environmental Science — are names a stranger can read. The hour in front of you is the work.

What a good science hour looks like

You sit down already knowing today's idea. An object is on the table. The child looks. Then they try — a push, a measurement, a simple trial. They record what they saw, a picture or a number, in their own hand. You ask one good question —

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percent received instruction at home (homeschooled or full-time virtual) and is a different bucket.

[2]Texas Education Agency, "Home Schooling," https://tea.texas.gov/families-and-students/finding-school-your-child/home-schooling. New York State Education Department, "Home Instruction Questions and Answers," https://www.nysed.gov/nonpublic-schools/home-instruction-questions-and-answers. Homeschooling is legal in all fifty states and D.C.; these two pages illustrate a light-process and a heavier-process pattern, not a national template. This book is not legal advice.

[3]Texas Education Agency, "Home Schooling": "The State of Texas does not award a diploma to students that are home schooled." New York State Education Department, "Home Instruction Questions and Answers": a high school diploma "may only be awarded to a student enrolled in a registered secondary school." North Carolina Division of Non-Public Education, "Home School Records Retention & Diplomas FAQs," https://www.doa.nc.gov/divisions/non-public-education/home-schools/faqs/records-retention-diplomas: the State does not issue a diploma or a transcript; the home-school chief administrator does. NCAA Eligibility Center, *Home School Toolkit 2025–26*, http://fs.ncaa.org/Docs/eligibility_center/Student_Resources/Home_School_Toolkit.pdf, treats proof of graduation as a family- or umbrella-issued artifact.

[4]Jiashan Cui and Rachel Hanson, *Homeschooling in the United States: Results from the 2012 and 2016 Parent and Family Involvement Survey*, NCES 2020-001 (Washington, DC: National Center for Education Statistics, 2019), Table 9: among K–12-equivalent homeschoolers taught *that year*, scientific inquiry or experiments 41 percent overall and 25 percent in grades 9–12; earth sciences or geology 44 percent; biology 25 percent; chemistry or physics 15 percent. The 2023 First Look did not republish the subject-taught tables. https://nces.ed.gov/pubs2020/2020001.pdf.

not “what is the vocabulary word?” but “what did you see happen?” Then you wait. Three seconds feels long. It is the work. Practice mixes the new looking with last week’s trial. The hour ends with one short task they do alone: a spoken sentence, a caption, a claim that points at the notebook. You stop talking sooner than feels polite. The child looks and records. You hold the key. That is the hour. The next long piece of this front matter, *The Science Hour*, will teach it in full. Later chapters will not reinvent it.

Figure 2: A kitchen-table science hour

Look first, then the word. A vocabulary list is not a year. An hour that is only a hands-on activity, or only a word list, is not the hour.[5] The chapters will give you

[5]National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washington, DC: National Academies Press, 2007), Executive Summary and chap. 2: proficient students know and use scientific explanations, generate and evaluate evidence, understand how scientific knowledge develops, and participate in practices and discourse; “teaching content alone is not likely to lead to proficiency in science, nor is engaging in inquiry experiences devoid of meaningful science content.” https://nap.nationalacademies.org/catalog/11625/taking-science-to-school-learning-and-

wording. The hour will stay this shape.

What you will actually get

Each teaching chapter does eight jobs, always in the same order, so you are never hunting for the move.

You will learn why this week's idea is worth the struggle — what it unlocks later. You will understand the idea yourself, in plain language, with one everyday picture and one precise picture, and with the wrong explanations you should be able to hear. You will get a session you can run this week, including exact wording, named investigations, and a discussion box with this week's questions. You will get practice that builds learning, not a slog of coverage. Your student will get a short section of their own. If it isn't clicking, you will get three diagnostics and a next move for each, with no shame in the room. Tools, including AI, stay optional and adult-side. And you will get a plain checklist for "done enough," so you can place by skill rather than by birthday.

The eight teaching chapters follow the work, not twelve thin grade labels: looking and trying in grades 1–2; life, earth, and physical as a typical elementary band in grades 3–5; the middle-grade moves in grades 6–8; then high-school Biology, Chemistry, Physics, and Earth and space; then investigation as the lab spine. Records and resources come last.

This week you can learn the session shape and today's idea well enough to hear a wrong explanation. Today the child can look at one object, try one small trial, and write one true thing about it without you filling the silence.

What this book will not do

This book will not hand you 180 days of labs. A year of photocopies is not a teaching method, and I will not pretend it is. Coverage is a map. Depth is the hour.

It will not sell you a curriculum. Later, a short resources chapter names common programs by fit — parent load, style, worldview, how they place a student — so you can choose. Apologia, BJU Press, Abeka, Real Science-4-Kids, Elemental

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teaching-science-in-grades.

Science, Berean Builders, CK-12, OpenStax, and a kit from Home Science Tools are tools. None of them is this book, and this book is not a catalog in disguise. A family may combine. Combining does not turn a brand into a course name. The transcript still says Biology or Chemistry.

It will not promise a score. There is no guaranteed percentile, no guaranteed AP number, no guaranteed NAEP bar, and no guaranteed college letter inside these pages. What this book can promise is a path: the ideas in order, at the skill the child actually has, until they can do the next idea unaided. NAEP Proficient is not "on grade level," and there is no national homeschool science score in these pages to wave.[6]

It is not an NGSS tract, for or against. The *Next Generation Science Standards* and the National Research Council *Framework* are maps of outcomes. They are not a curriculum, not a federal law, and not a homeschool mandate.[7] California, Texas, and Virginia print their own maps, and they do not agree about whether Earth is a peer high-school year. Biology–chemistry–physics is a common sequence, not a statute. A publisher's "grade 6" book is a scope, not a legal grade.

It is not a culture-war pamphlet. Teach the idea on the table. Name a live debate in one sentence when it is load-bearing, then teach. A path through science is the promise. A culture-war win is not.

And this is not a sequel. *Mathematics for Homeschooling*, *Critical Thinking for Life*, and *Autonomous AI and Education* are other books. Measurement lives inside the science hour when a number earns its keep. Evaluation of a claim lives inside investigation — one looking move, a notebook on the table — not as a course titled Critical Thinking 101, and not as a course titled AI Science. AI is a lane

[6] National Center for Education Statistics, *The Nation's Report Card: Science 2024*, https://www.nationsreportcard.gov/reports/science/2024/: grade 8 only; 31 percent at or above NAEP Proficient. NCES states that "the NAEP Proficient achievement level does not represent grade-level proficiency as determined by other assessment standards." NCES does not publish a nationally representative homeschool NAEP science score.

[7] NGSS Lead States, *Next Generation Science Standards* front matter (June 2013 update): "The NGSS are Standards, not Curriculum"; they "do not dictate the manner or methods." FAQ: the federal government did not sponsor them; "states are deciding whether or not to adopt." https://www.nextgenscience.org/faqs/faqs. National Research Council, *A Framework for K-12 Science Education* (Washington, DC: National Academies Press, 2012). NGSS Appendix K, *Model Course Mapping in Middle and High School* (May 2013): there is not conclusive research identifying an ideal sequence; biology–chemistry–physics is "currently a common sequence." https://static.nsta.org/ngss/AppendixK-FINAL-6.5.13.pdf.

here: one science-hour box in this front matter, then a short tools box in each teaching chapter.

This is not a book that lectures your child about you, or you about your character. The student is a person, not a percentile. When this book speaks to them, it speaks with respect. No baby-talk. No research sermon.

The promise

If you only remember one sentence, remember this: a path through science is the promise.

The work is to take this child through science — looking and trying, a fair test, biology, chemistry, physics, earth and space a registrar can read — without skipping the looking because they are "a good reader," and without parking them in a book that is too easy because a catalog printed a grade on the cover. You will sometimes slow down. You will sometimes skip ahead. Both are teaching. Birthday is not placement.

Three things have to hold. You understand this week's idea well enough to hear a wrong explanation. The child does the looking and the recording before the tool. Any helper — including an AI agent — stays on your side of the table: a supplement you host and constrain, not a substitute for the child's lab notes or the talk after the trial, and not a school-safe product by default.

You can do this. You do not have to know next year's idea today. You have to know this week's idea well enough to sit still while they struggle, then ask one good question. Start here. Read *How to Use This Book This Week*, then the one-page list of five things, then *The Science Hour*. After that, open the chapter that matches the skill in front of you. You will know more after one chapter than you know this morning. Your child will have something to try today. We can do this.

How to Use This Book This Week

Start at the skill in front of you, not on page one of Grade 1 because a catalog, a birthday, or a well-meant relative said so.

This book is a handbook you open to this week's band, not a novel you read cover to cover. The teaching chapters run: grades 1–2; grades 3–5; grades 6–8; Biology; Chemistry; Physics; Earth and space; investigation. Records and resources come last. Grade labels here are sequence anchors. They tell you where an idea usually sits. They do not tell you where *this* child sits.

This book does not replace the program already on the shelf. If Apologia, BJU Press, Abeka, Real Science-4-Kids, Elemental Science, Berean Builders, CK-12, OpenStax, or a textbook path is already working, keep it. Use this book to hear a wrong explanation, to run the hour, and to name the credit a stranger can read. The transcript still says Science, Biology, or Chemistry, not a brand.

Pick the chapter by skill, not by birthday

Open the chapter you think is right. Skip to **What "done enough" looks like** at the end of the *previous* chapter, or to **If it isn't clicking** in the one you opened. If the child can already do those checks unaided, you are too early. If the checks from two chapters back are still failing, drop back.

If they still live in looking-and-drawing — if a word list is noise and a rock, a plant, and a window are the lesson — they are still in grades 1–2, whatever their age. Young children already notice a great deal. What they can do depends on what they have already been invited to look at, not on a birthday.[8] A short sit with

[8]National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washing-

an object is in range. A mole calculation is not, yet.

If they cannot yet run a fair test — one thing changed on purpose, a record a stranger can read, an answer to "can we tell for sure?" — they are still in a taught-looking stage, whatever the transcript year. Third- and fourth-graders can investigate when someone teaches the looking.[9] They are not scientists. A sixth-grader who still treats a busy demo as the whole of science is not "behind in biology." They are still learning to look.

If they can name what changed, write a number, and say a claim with a reason, and they are still in a "grade 4" reader only because the cover says so, skip ahead. Instruction for a six-year-old need not be "first grade"; it should match what the student actually needs and already knows.[10] A publisher's "grade 6" book is a scope, not a legal grade. Use this book's checklists, or a placement test from the program you own, and then teach.

Two children may need two chapters. That is ordinary. The session shape in *The Science Hour* still holds; the idea on the table changes. You may run a twenty-five-minute looking sit with one child and a forty-five-minute fair-test talk with the other. You do not need two personalities. You need two first problems.

Maps are maps

California, Texas, and Virginia do not print the same year. That is not a problem for you to solve. It is a reason not to treat any one of them as national law.

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ton, DC: National Academies Press, 2007), Executive Summary: children entering school already have substantial knowledge of the natural world; "what is developmentally appropriate is not a simple function of age or grade, but rather is largely contingent on their prior opportunities to learn"; the view of the young child as a concrete, simplistic thinker is outmoded. Access date for URLs in these notes: 1 September 2026. https://nap.nationalacademies.org/catalog/11625/taking-science-to-school-learning-and-teaching-science-in-grades.

[9]David Klahr and Milena Nigam, "The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning," *Psychological Science* 15, no. 10 (2004): 661–67: 112 third- and fourth-graders; ramps; a fair test as one contrast between conditions. The study taught the control-of-variables strategy; it does not claim the children were scientists, and it is not a homeschool trial.

[10]New York State Education Department, "Home Instruction Questions and Answers," https://www.nysed.gov/nonpublic-schools/home-instruction-questions-and-answers: instruction for a six-year-old need not be "first grade"; "instruction should be geared to the level appropriate to the student's needs and previous level of achievement."

The National Research Council *Framework* and the *Next Generation Science Standards* are maps of outcomes — practices, crosscutting concepts, and core ideas, used together. They are not a curriculum, not a federal requirement, and not a homeschool mandate.[11] Middle- and high-school standards are grade-banded because there is no research-identified ideal order. Biology–chemistry–physics is "currently a common sequence" in one of those maps. That sentence is a map fact. It is not a statute, and it is not a claim that Earth is optional.

California adopted CA NGSS on 4 September 2013. Middle school prefers an integrated path; the alternative is Earth Science in 6, Life Science in 7, Physical Science in 8. High school may be four courses or three; the local district chooses the order.[12] Texas prints grade-level Science in K–8. High school asks for three science credits; one must be Biology, and the second comes from Integrated Physics and Chemistry, Chemistry, or Physics. Virginia's 2018 science standards remain the K–Physics content map. A Standard Diploma asks for three laboratory credits from at least two of earth sciences, biology, chemistry, or physics, and statewide tests include Earth Science.

High-school science is where U.S. maps disagree about whether Earth is a peer year. The child still needs life, physical, and earth-and-space moves before a stranger-readable transcript is done. You choose the map that matches the work

[11] NGSS Lead States, *Next Generation Science Standards* front matter (June 2013 update): "The NGSS are Standards, not Curriculum." FAQ: the federal government did not sponsor them; states decide whether to adopt. https://www.nextgenscience.org/faqs/faqs. National Research Council, *A Framework for K-12 Science Education* (Washington, DC: National Academies Press, 2012): practices, crosscutting concepts, and disciplinary core ideas, used together. NGSS Appendix K, *Model Course Mapping in Middle and High School* (May 2013): middle- and high-school standards are grade-banded "because there is not conclusive research that identifies the ideal sequence for student learning"; Map 3 packages high school as biology, chemistry, and physics, with Earth and space often split among those three "because it is currently a common sequence in high schools across the United States." https://static.nsta.org/ngss/AppendixK-FINAL-6.5.13.pdf.

[12] California State Board of Education adopted CA NGSS on 4 September 2013 (Education Code § 60605.85). California Department of Education, *Science Framework for California Public Schools* (2016): middle school preferred integrated learning progression; alternative Earth Science grade 6 / Life Science grade 7 / Physical Science grade 8; high school four-course or three-course models, with the local educational agency choosing order. Texas Education Agency, 19 TAC Chapter 112: K–8 grade-level Science; high school Biology, Chemistry, IPC, Physics. 19 TAC §74.12: three science credits; one Biology; second from IPC, Chemistry, or Physics. Virginia Department of Education, 2018 Science Standards of Learning; Standard Diploma: three laboratory science credits from at least two of earth sciences, biology, chemistry, or physics; statewide SOL tests include Earth Science. These are public-school maps, not homeschool law and not each other.

on your table. Then you teach the moves.

How you use the parent half

Most of each teaching chapter is for you. Read it *before* the lesson, not over the child's shoulder.

Why this matters tells you what this idea unlocks. **For the parent: understand it yourself** gives one everyday picture, one precise picture, and three to five wrong explanations you should be able to hear. Sit with those.

How to teach it this week assumes the session shape from *The Science Hour*. It will not rebuild the hour. It will give you this week's named investigations, the wording for *this* idea, and a discussion box: an opening question about what they saw, a few follow-ups, how to wait, and what a stuck silence usually means. Later chapters supply this week's questions. They do not reinvent the shape.

Practice that actually builds learning is a short blocked set of the new looking, then mixed work so the child has to choose. A kitchen object can motivate. It does not replace the trial or the unaided sentence. **Tools, including AI** is optional, short, and for the adult. The rules live once in *The Science Hour*. **What "done enough" looks like** is how you leave: unaided work, not a perfect Tuesday. Placement is by skill, not birthday.

You do not have to read the whole chapter tonight. You do have to read the parent half of *this week's* idea before you sit down with the child.

The five-minute parent warm-up

Make this a habit.

Five minutes. Child not yet in the chair. Phone face down.

1. Read today's idea until you can say it in one sentence.
2. Look at one object yourself. Ask, out loud, what would count as a result. Stay off the key until you have looked.
3. Glance at the "wrong explanations you should be able to hear." Name the one you would have given at fourteen.

4. Write one sentence you will actually say. Not a speech. Example: “What did you see happen?” Or: “What would count as a result?”
5. Close the book to the student page. You are ready.

That five minutes is how you stay out of their working memory. If you are learning the idea *while* they are stuck, you will talk too much. Prepare first. Then sit still.

How the student uses “For the student”

Every teaching chapter includes a short section written to the student, not about them. One or two pages. Warmer. Direct. What the idea is, a tiny worked example, two tries, an “explain it back” prompt, and one challenge. Hand it over after your short model, not instead of it. You stay in the room. The challenge is optional that day.

The student page is not something to send off with an unsupervised chatbot. The attempt is still theirs. You still hold the key.

When to skip ahead

Skip ahead when this chapter’s “done enough” checklist is already true *unaided*. Slow down when the same wrong explanation repeats after a clear looking and a real attempt. **If it isn’t clicking** will give you three likely causes and a next move. Missing pictures or missing talk are skill problems, not character problems.

Diagnose the looking before you buy the high-school survey. If you need a human tutor, that is a normal high-school plan, not a failure of the kitchen.

For this week: pick the chapter by skill. Do the five-minute warm-up. Run the hour as *The Science Hour* describes it. Let the student page be theirs. Stop talking sooner than you want to. That is how you use the book.

If You Only Remember Five Things

Keep this page. The chapters will add wording, objects, and this week's questions. They will not replace these.

1. Look first, then the word. A vocabulary list is not a year. Put the object or the trial on the table. Let them see. Then name what they saw. Names of parts are useful after the child has seen the thing. Content and looking grow together; a year of words with no trial, or a year of activity with no idea, is not the hour.[13]

2. The student records. You ask one good question and wait. Three seconds. Maybe five. The silence is the work. An authentic question is one you have not already written the answer for.[14] "What is photosynthesis?" is a quiz. "What did you see happen when the plant sat in the dark?" is closer — if you do not already have the sentence you want to hear. Struggle before rescue: ask, wait, hint, then model. You do not finish the paragraph. You do not grab the notebook.

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[13]National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washington, DC: National Academies Press, 2007), chap. 2: "teaching content alone is not likely to lead to proficiency in science, nor is engaging in inquiry experiences devoid of meaningful science content." Sarah Michaels, Andrew W. Shouse, and Heidi A. Schweingruber, *Ready, Set, SCIENCE!: Putting Research to Work in K–8 Science Classrooms* (Washington, DC: National Academies Press, 2008): each of the four strands supports the others. Access date for URLs in these notes: 1 September 2026.

[14]Martin Nystrand, Lawrence L. Wu, Adam Gamoran, Susie Zeiser, and Daniel A. Long, *Questions in Time: Investigating the Structure and Dynamics of Unfolding Classroom Discourse*, CELA report ED461119 (Albany, NY: National Research Center on English Learning and Achievement, 2001), https://files.eric.ed.gov/fulltext/ED461119.pdf: an authentic question is one "for which the asker has not prespecified an answer." Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables: Their Influence on Language, Logic, and Fate Control," NARST paper, ERIC ED061103 (1972), https://files.eric.ed.gov/fulltext/ED061103.pdf: wait three to five seconds after you ask and after they stop. Rowe studied elementary science classes.

3. A trial on the table beats a paragraph about "being scientific." A push, a measurement, a simple test — then a picture or a number in their hand. Understanding does not spring from data by itself; they still need the idea and the talk.[15] The kitchen is not a high-school lab. The adult stays for the whole trial. Food-safe looking is one use of the table; chemicals and biological hazards are another. The two uses are not simultaneous. A lecture on being scientific, with nothing to try, is not the hour.

4. Coverage is a map. Depth is the hour. You cannot do every kingdom, every reaction, every standard. There is no research-identified ideal order through the sciences; biology–chemistry–physics is a common sequence, not a law.[16] The curriculum on the shelf is the map. Tuesday is one idea, one trial, one question.

5. A path through science is the promise. A percentile is not. Teach the idea on the table. Birthday is not placement. NAEP Proficient is not "on grade level," and a score is not the path.[17] You will sometimes slow down. You will sometimes skip ahead. Both are teaching. What this child can do depends on what they have already been invited to look at, not on a catalog grade.

The child looks and records before the tool. You hold the key. A helper may explain this week's idea *to you* from a named page. It does not sit in the chair

[15]National Research Council, *America's Lab Report: Investigations in High School Science*, ed. Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber (Washington, DC: National Academies Press, 2006): typical isolated labs are no more or less effective than reading, lecture, or discussion for subject-matter mastery; integrated units with discussion do better. Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!*: understanding does not miraculously emerge from data. American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016): the teacher must be physically present during the entire experiment; no food or drinks in a chemical laboratory. National Science Teaching Association, "Safety and School Science Instruction" (revised April 2024): food and drink should not be permitted where hazardous chemicals or physical or biological hazards have been used.

[16]NGSS Appendix K, *Model Course Mapping in Middle and High School* (May 2013): there is not conclusive research identifying an ideal sequence; biology–chemistry–physics is "currently a common sequence." https://static.nsta.org/ngss/AppendixK-FINAL-6.5.13.pdf. National Research Council, *Taking Science to School*, on core ideas developed over years rather than as a one-year coverage dump.

[17]National Center for Education Statistics, *The Nation's Report Card: Science 2024*, https://www.nationsreportcard.gov/reports/science/2024/: "the NAEP Proficient achievement level does not represent grade-level proficiency as determined by other assessment standards." National Research Council, *Taking Science to School*, Executive Summary: what children are capable of at a particular age is largely contingent on prior opportunities to learn, not a simple function of age or grade.

during the attempt.

If this week needs a compass, this is it. Five things. Then sit down and teach.

The Science Hour

The hour has a shape. Learn it once. Later chapters will give you today's idea, today's investigation, and today's questions. They will not rebuild this hour. When a chapter says "run the session," it means this.

You do not need a school bell. You need a looking start, a short model, a real attempt, one authentic question, mixed practice, and an unaided check. Younger children may finish in twenty-five minutes. Older students may need forty-five. The shape does not change. The idea on the table does.

Sit down having already done the five-minute parent warm-up from *How to Use This Book This Week*. You know today's idea and what would count as a result. The child looks, tries, and records. You hold the key.

1. Warm-up looking

Three to five minutes. An object, a picture, or a last-week measurement they already know. Mixed, not a quiz of names they cannot yet attach. This is retrieval, not a test of character.

Say:

"We're going to start with something you already know."

"Look at last week's drawing. What do you still notice?"

Keep this short. The warm-up is not the lesson. When you feel yourself teaching a new idea here, stop. That idea belongs in the model. A rolling marble is a story a first-grader can hold; $F = ma$ is a noise until it attaches to something they already

felt.[18]

2. Short model

Five to eight minutes. One new move, visible. An object on the table. Then you stop.

New, dense material — first fair test, first table of numbers, first claim that has to point at a measurement — is where a short model earns its keep. Show the move. Then fade.

Say:

"I'm going to show this one short. Then you'll try."

"Watch how I change only one thing. Then I write what happened."

On the second pass, leave a hole:

"Your turn to tell me what we change. I'll hold the object. You do the looking."

When the idea is new, show one incorrect example and ask what wouldn't count as a result.

If you are still talking at minute twelve, you are giving a lecture. Close the model. Hand them the object, the notebook, or the student page.

3. Student attempt

This is the center of the hour. Eight to twelve minutes. The first looking is theirs.

Hand them "For the student" if the chapter has it, or the first investigation from **How to teach it this week**. Then you talk less than you want to.

Say: "This one is yours. I'll be quiet." Then be quiet.

[18]National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washington, DC: National Academies Press, 2007), Executive Summary and chap. 3: children entering school already have substantial knowledge of the natural world; what they can do depends on prior opportunities to learn, not a birthday. Session shape in this chapter is pedagogical design for the kitchen table, not a national science-minutes study (none was found). Access date for URLs in these notes: 1 September 2026.

If they stall, use this order: ask, wait, hint, then model. Not the reverse.

Ask:

“Show me what you noticed.”

“What did you write down?”

“What would count as a result?”

Wait. Count a slow five in your head — three at the least. The silence is the work. If you fill it, you took the problem back.

Hint, one hint: “Look at the two numbers. What is different?” Or: “You already know we change one thing. Point to it.”

Then, if they are still stuck after a real try: “I’m going to show you this one step. Then you take it from here.” Show the step. Return the notebook.

If they have no idea to hang the observation on, that is a hole, not useful struggle. Fill it with a short retell, then return to the task.[19] Keep your hands off their notebook. Taking it feels kind. It teaches them to watch. The child looks and records. You hold the key.

4. One authentic question

Two or three minutes for the question itself; the talk around it can run longer, using the discussion shape below. Not “did you get it?” They will say yes. You will learn nothing.

An authentic question is one for which you have not already written the answer.[20] “What is the vocabulary word?” is recitation. “What did you see happen?” is

[19] Sarah Michaels, Andrew W. Shouse, and Heidi A. Schweingruber, *Ready, Set, SCIENCE!: Putting Research to Work in K–8 Science Classrooms* (Washington, DC: National Academies Press, 2008): understanding does not miraculously emerge from data; “simply ‘doing’ science activities often leaves students with an inaccurate sense of what science is.” Productive investigations are “not sequentially scripted. Nor are they unguided.”

[20] Martin Nystrand, Lawrence L. Wu, Adam Gamoran, Susie Zeiser, and Daniel A. Long, *Questions in Time: Investigating the Structure and Dynamics of Unfolding Classroom Discourse*, CELA report ED461119 (2001), https://files.eric.ed.gov/fulltext/ED461119.pdf: an authentic question is one “for which the asker has not prespecified an answer.” There is no kitchen-table discussion randomized trial in these pages.

closer — if you do not already have the sentence you want to hear.

Say: “What did you see happen?” Or: “Can we tell for sure it was the thing we changed — and what in the notebook makes you say that?”

Then wait. Three to five seconds after you ask. Three to five again after they stop. Mary Budd Rowe found that elementary science teachers waited about one second; when they reached three to five, students talked longer, guessed less, and asked more of their own questions. That was science class. This book uses the pause as science. It does not claim the pause raises a test score.[21]

One question. Maybe a follow-up. Then stop. If they cannot explain it back, they copied a step. Return to the looking — object first, then the word — and give one more attempt.

5. Mixed practice

Ten to fifteen minutes. First a short blocked set of the new move — four to six looks or measurements that use today’s idea — so they learn to execute. Then mix. Yesterday’s trial. Last month’s drawing.

Blocked practice teaches execution. Mixed practice teaches *when* to use the move. A page of twenty identical blanks feels like mastery at 9 p.m. It often is not still there in two weeks.

Say: “These first few are today’s move.” Then: “These are mixed on purpose. First decide what kind of job it is. Then look.”

Stop while they can still think. Coverage is a map. Depth is the hour.

[21] Mary Budd Rowe, “Wait-Time and Rewards as Instructional Variables: Their Influence on Language, Logic, and Fate Control,” NARST paper, ERIC ED061103 (1972), https://files.eric.ed.gov/fulltext/ED061103.pdf: over 300 tapes of elementary science classes; mean wait-time about one second after a teacher question and 0.9 seconds after a student response. When mean wait-times of three to five seconds were achieved, nine student variables changed, including longer responses, fewer failures to respond, and more student questions. Rowe is science class. This book uses the pause as science.

6. Unaided check

Three to five minutes. One short task. Book closed. No hints. No chatbot. No looking at the worked example.

Tonight's helped practice is not this check.[22] Say: "One task. I won't help. That's the point." A spoken sentence or a caption in the early years. A paragraph in the middle years. A claim with a named measurement in high school. When they finish, you look. If it is wrong, you diagnose which wrong explanation this is, and you note tomorrow's first move. Fade until the check does not need you.

When to stop talking

After you ask, wait. If you fill the silence, you took the problem back.

During the attempt, your job is almost nothing. If you hear yourself explaining while they look, you have moved back into the model. Stop. Let them look.

Instead of "I was never good at formulas," say today's sentence: "What did you see happen?" Praise a clear look or a number written down — not speed. Stop talking when the next sentence would be a rescue. Hands in your lap. Count five.

If you remember only one move from this page, remember that one.

The investigation shape, once

Later chapters will name this week's trial. They will not reprint this spine. When a chapter says "run the investigation," it means this.

A question that could come out otherwise. Not a recipe with a known ending.

A fair test. One thing changed on purpose. Everything else held still, as far as the table allows. Then: can we tell for sure? If two things changed, we cannot.[23]

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[22] Nicholas C. Soderstrom and Robert A. Bjork, "Learning Versus Performance: An Integrative Review," *Perspectives on Psychological Science* 10, no. 2 (2015): 176–99: current performance is "often an unreliable index" of learning. The unaided check is the check this hour trusts. A model-written report is performance. The unaided notebook the next morning is the test.

[23] David Klahr and Milena Nigam, "The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning," *Psychological Science* 15, no. 10 (2004): 661–67: a fair test as a method for creating experiments in which a single contrast is made

Data a stranger can read. Early years: a picture plus a sentence. Middle years: a table, a simple graph, a paragraph. High school: numbers with units on a page you could hand to a registrar.

A claim with evidence. What do you think happened? What did you write down? Why would that measurement count? The claim points at the record, not at a feeling that "it worked."[24]

Look first. Try. Record. Then the word. Then stop. If they run the trial with no idea of what would count as a result, they get activity. If they stay in the idea forever, they get a lecture with a demo. Elementary "done enough" is a spoken sentence or a caption. Middle school is a paragraph. High school is a claim with a named measurement.

The discussion shape, once

Later chapters will fill this week's questions. They will not reprint this shape. When a chapter prints a discussion box, it means this.

Opening question. Authentic. About what they saw or measured. No answer you have already written. Examples of the *shape*, not required topics: "What did you see happen when we pushed it harder?" "Can we tell for sure it was the thing we changed — and what in the notebook makes you say that?"

Three to five follow-ups. Pick; you do not need all five every Tuesday. Observation: What do you actually *see*? Evidence: What did you write down that supports that? Tell for sure: Can we tell it was the thing we changed? Change your mind: What would we have to see to change our minds? Revision: What would you change in what you said, now that you've looked again?

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between conditions, plus understanding that confounded experiments are indeterminate. Copy the move ("can we tell for sure?"), not a slogan about discovery. 112 third- and fourth-graders; ramps; not a homeschool trial.

[24] National Research Council, *America's Lab Report: Investigations in High School Science*, ed. Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber (Washington, DC: National Academies Press, 2006): typical isolated labs are no more or less effective than reading, lecture, or discussion for subject-matter mastery; integrated instructional units with discussion show greater effectiveness. Design principles travel: a clear learning outcome; sequenced into instruction; content with process; ongoing talk. Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!*: IQWST claim–evidence–reasoning in ordinary language is about this trial's data.

How to wait. After you ask, three to five seconds. After they stop, three to five again. If the silence is hard, look at the notebook or the setup, not at the child. Say, "Take your time. I'll wait."[25]

What a stuck silence usually means. Wait time has been too short for years — count. The question was recitation in disguise. The child does not have enough of the idea — tell a shorter one, then ask again. They saw what they already believed — ask what in the notebook would change their mind. Or they do not yet know you want the evidence: "I want what you wrote down, not a list."

Pose, wait, and point back at the record.

Safety, once

Later chapters will point here in one sentence. They will not reprint this box. The kitchen is not a secondary lab.[26]

> **The adult stays. The trial is the one written down. If it cannot be made safe, it does not happen.**
>
> Recognize the hazard, assess the risk, minimize it, and prepare — that is RAMP, said once. The adult is physically present for the entire

[25]Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!*, talk moves: revoicing; restating; agree or disagree and why; add on; explicate reasoning; wait time as "Take your time. … We'll wait." Rowe, "Wait-Time": "Mapping experience into language is an arduous process." National Research Council, *Taking Science to School*, chap. 5: distinguishing theory from evidence does not emerge without explicit instruction; even adults often meld theory and evidence into "the way things are" (Kuhn as reported).

[26]American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016): RAMP (Recognize, Assess, Minimize, Prepare); "The teacher must be physically present during the entire experiment"; no food or drinks in a chemical laboratory; never heat a flammable on a burner or hot plate; no unauthorized mixing. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/acs-secondary-safety-guidelines.pdf. National Science Teaching Association, "Safety and School Science Instruction" (revised April 2024): food and drink should not be permitted where laboratory activities will be conducted or where hazardous chemicals or physical or biological hazards have been used. Flinn Scientific, *Student Safety Contract* (© 2017): never work alone; unauthorized experiments prohibited; never leave a lit burner or anything being heated unattended. Kenneth Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020 (author's views, not necessarily NSTA official): K–5 duty of care by a responsible adult; household products with SDS and PPE; if PPE is missing, the activity is not conducted. These are professional safety objects, not a homeschool statute. The kitchen is not an ACS secondary lab.

experiment. No child works a chemical, a flame, or a biological trial alone.

Food stays off the table where chemicals or biological hazards have been used. Those two uses of a kitchen are not simultaneous.

Heating is never left unattended. Homemade explosives have no place in this hour. Unauthorized mixing has no place. The trial is the one on the page.

Goggles when there are chemicals, heat, or glass. Household products, if a chemical is needed, with a safety data sheet the adult has looked at. If the right protection is missing, the activity is not done. For grades 1–5 the duty of care sits directly on a responsible adult.

Kitchen chemistry is a picture. It is not, by itself, a Chemistry credit.

Stop the activity if you cannot make it safe. That is teaching.

The AI rules, once

Later chapters will point here in one sentence. They will not reprint this box.

Child first. You hold the key. AI is optional for the adult.

The child looks, measures, and writes before any tool is in the room. You keep the answer key. A chatbot does not sit beside them during the trial.

Use a tool, if you use one at all, to explain this week's idea *to you* from a named textbook page; to draft discussion questions you vet; to make extra practice with the answers hidden; or to diagnose work already done.

Never say "write my lab report." Never ask it to invent a data table or an observation. Never generate a gel or a microscope photo and treat it as the student's result. Never leave an unsupervised chatbot running during the trial. Never let "what's the answer" be the whole hour. Never photograph the lab sheet for a key.

In a high-school math study, an unguarded chatbot raised assisted practice about 48 percent and then cut the unaided exam about 17

percent; a hint tutor that withheld full solutions raised practice without that exam drop. That study is mathematics, not a science trial. The crutch still governs the hour: if the model produces the report, the table, or the picture, the child is a spectator.[27]

Language models invent citations: Walters and Wilder found that more than half of GPT-3.5 citations and nearly one in five GPT-4 citations were fabricated.[28] Treat every model-supplied quotation and "typical result" as untrusted until you find it in a named book or the child's notebook. A generated picture of a cell is a scene to look at together, labelled generated. It is not data.

Hermes 4 is a chat model. Hermes Agent is a different runtime. Grok the assistant is not Grok Bot. Grok Bot has no education product and is not a school-safe tutor. If you use any of these, they live on your machine or your account. They are not the child's lab partner, and they are not a companion.

Detectors fail often enough that they are not a verdict on a child's page.[29]

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[27]Hamsa Bastani, Osbert Bastani, Alp Sungu, Haosen Ge, Özge Kabakcı, and Rei Mariman, "Generative AI without guardrails can harm learning: Evidence from high school mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. Field experiment, nearly 1,000 Turkish high-school math students, GPT-4-0613: a ChatGPT-like tool raised assisted practice grades 48 percent relative to control, then cut unaided exam grades 17 percent; a hint tutor that withheld full solutions raised practice 127 percent and was statistically indistinguishable from control on the unaided exam (point estimate −0.004). GPT Base was correct on 51 percent of the practice set. The paper notes that math has objective scoring "which is unavailable in creative subjects such as writing." This is a math RCT, not a science RCT; the transferable caution is the crutch. Author PDF: https://hamsabastani.github.io/education_llm.pdf. College Board, *AP Exam Terms and Conditions* for 2026 exams (updated 27 April 2026), Section 4: no part of Test answers, work, or submission may be generated in whole or in part using AI tools, including ChatGPT; submissions may not include AI-generated text, image, or graph.

[28]William H. Walters and Esther Isabelle Wilder, "Fabrication and errors in the bibliographic citations generated by ChatGPT," *Scientific Reports* 13 (2023): 14045: 55 percent of GPT-3.5 citations and 18 percent of GPT-4 citations were fabricated; of the real citations, 43 percent (GPT-3.5) and 24 percent (GPT-4) had substantive errors, including wrong dates. Same paper: fabricated methods and results in some outputs. https://www.nature.com/articles/s41598-023-41032-5. Elsevier generative-AI policies (updated June 2026) and Nature Portfolio editorial policy: do not fabricate data, citations, or results; do not create photorealistic images as experimental evidence. A generated cell, gel, or micrograph is not data.

[29]Weixin Liang, Mert Yuksekgonul, Yining Mao, Eric Wu, and James Zou, "GPT detec-

> You can teach this entire book with no AI. Many families will. The hour still has the same shape.

A Tuesday, said plainly

Here is an illustration, not a reported family. A parent has spent five minutes looking at one object and asking what would count as a result. The child warms up on last week's drawing. The parent shows a short model — one thing changed — then puts the trial on the table. The child tries and writes. The parent asks, "What did you see happen?" and waits. Mixed practice: today's numbers next to yesterday's picture. Exit: "One sentence. Point at the notebook. I won't help." Right or wrong, the hour had a shape.

On a high-school day the same shape holds. Warm-up on two measurements. Model a claim that has to point at a number. They run the trial. Question: "Can we tell for sure?" Exit: one unaided claim with a named measurement, model closed.

You can run that hour. You need today's idea, a notebook you refuse to take, and the willingness to stop talking. Dose is not a 180-day script. There is no national table of science minutes for the kitchen.[30] Later chapters will say: run the session as in *The Science Hour*. That sentence is this page. The idea will change. The hour will not.

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tors are biased against non-native English writers," *Patterns* 4, no. 7 (2023): 100779: average false-positive rate on human TOEFL essays 61.3 percent (61.22 percent in the preprint, arXiv:2304.02819). Hermes Agent: https://hermes-agent.org/ (open-source agent runtime, February 2026). Hermes 4 is a separate chat/reasoning model family; Nous Portal docs state it is not recommended inside Hermes Agent. Grok Bot: xAI, "Introducing Grok Bot," 11 August 2026, https://x.ai/news/introducing-grok-bot, and Grok Bot FAQ, https://docs.x.ai/grok-bot/faq — cloud computer; no education product and no FERPA claim on the pages opened 1 September 2026. Grok the assistant, Grok Bot, and the El Salvador school partnership for Grok the assistant are three different objects.

[30] No IES, NCES, or NCAA page opened on 1 September 2026 prescribed a national homeschool science-minutes table. North Carolina DNPE *recommends* (not law) five hours across all subjects; Pennsylvania statute names 180 days or 900/990 hours for the whole program; New York's unit is 6,480 minutes. None of these is a national science block.

Chapter 1

Looking and trying

Figure 3: A kitchen-table still-life from a high three-quarter view: a board used as a ramp, two small objects that can slide or roll, a child's-style drawing of a trial with no face, and a window-weather card with a sky mark. No people. No logos.

Why this matters

This year is not a waiting room until “real science” begins. The work of these years is looking and trying. Senses. Living and nonliving as patterns of what something needs, not a kingdom chart. Weather as what you can see from the window today and yesterday. A push that makes something go farther. Light that makes a dark patch. A plant that gets water, or does not. A drawing of what you saw. Short sits. The child talks.

The sentence that surprises people is this one: a six-year-old who cannot say “photosynthesis” is not behind in science. The National Research Council’s *Taking Science to School* is the household picture of that miss. Children arriving at school already notice a great deal about the natural world. The picture of the “concrete, simplistic child” who must wait for abstract readiness is outmoded. What is in reach depends on prior chances to look, not on a birthday.[31] Dates and DNA are not this year’s purpose. A vocabulary list is not a year.

California’s 2016 Science Framework, Chapter 3, is another map of the same band, not a national law. Grade 1’s purpose on that map is common background experience and patterns that prompt questions. Moon phases, seasons, and inheritance will not be answered at this grade level.[32] The table in that chapter translates the eight science practices into kitchen language: wondering; drawing; “exploriments”; “I think ____ because I see or know ____.”[33] That is the skill ceiling this chapter teaches. It is not extra content you owe California if you do not live there.

Texas prints grade-level Science for kindergarten through grade 8. Virginia names Science as the elementary course. Those are public-school maps. They are not

[31] National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washington, DC: National Academies Press, 2007). Children enter school with substantial, often implicit, knowledge of the natural world; the “concrete, simplistic child” view is outmoded; what is developmentally appropriate depends on prior opportunities to learn. doi:10.17226/11625.

[32] California Department of Education, *2016 Science Framework for California Public Schools, Kindergarten Through Grade Twelve*, Chapter 3, Kindergarten Through Grade Two (Sacramento: CDE, 2018), adopted by the State Board of Education November 2016. Grade 1’s purpose: common background experience and patterns; Moon phases, seasons, and inheritance will not be answered at this grade level. Public-school map, not a homeschool statute. https://www.cde.ca.gov/ci/sc/cf/documents/scifwchapter3.pdf.

[33] California Department of Education, *2016 Science Framework*, Chapter 3, Table 3-1: K–2 language for the practices, including wondering, drawing, “exploriments,” and “I think ____ because I see or know ____.”

each other, and they are not a homeschool statute.[34] The *move* is still useful on any coast: look, try one thing, draw what happened, say one sentence.

Among K–2-equivalent homeschoolers in the last federal subject table, 51 percent were being taught scientific inquiry or experiments that year — the highest band in that table.[35] That figure is context, not a ranking. You are one of those tables. There is no national science-minutes number in these pages. Short sits, then stop, is teaching advice from how young children actually look, not a citation of minutes.

What you are teaching is looking before the word. A push or a pull as a change you can see. Weather as observation over days, not climate. Living things as patterns of needs — water, light, food, a place — with plants in the conversation, because many children will sort a plant with the rock. Light as a path: some things block it, some do not, and objects are seen when light is there. A plant trial with one thing changed. A drawing that is a record. The child looks. The child says one sentence. You wait.

What this band unlocks is a fair test later, a measurement written down, and a sentence that points at the drawing. Skip the looking, and later "experiment" arrives as a worksheet with a blank for the hypothesis. Skip the talking, and later discussion is recitation. Skip the plant that needed water, and later "living" is a list of kingdom names with nowhere to sit.

You do not need to be a scientist. You do need to hear "what is a force?" as the wrong question for this band, and "plants aren't alive" as a prior idea doing work, not as a cute slip.

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[34]Texas Education Agency, 19 TAC Chapter 112 index, science, kindergarten through grade 8 as grade-level Science (Adopted 2021). Virginia Department of Education, 2018 Science Standards of Learning landing page: K–6 Science as course names. Public-school maps, not each other, not a national "grade 1 = neighborhoods of living things" law. Access date for URLs in these notes: 1 September 2026.

[35]Jiashan Cui and Rachel Hanson, *Homeschooling in the United States: Results from the 2012 and 2016 Parent and Family Involvement Survey*, NCES 2020-001 (Washington, DC: National Center for Education Statistics, 2019), Table 9: among K–2-equivalent homeschoolers, 51 percent were taught "scientific inquiry or experiments" that year (41 percent overall; 46 percent in grades 3–5; 45 percent in grades 6–8; 25 percent in grades 9–12). The 2023 First Look (NCES 2024-113) did not republish subject-taught tables. Context, not a ranking. https://nces.ed.gov/pubs2020/2020001.pdf.

For the parent: understand it yourself

Many adults feel rusty on how to talk about a trial without a method poster on the wall. That is ordinary. Five minutes of this section, then the warm-up at the end, is enough for tomorrow.

Everyday picture. A board on a book, two toy cars. You push one gently. It travels a little way. You push the other harder. It travels farther. You do not ask for a definition. You ask: "What did you see happen when we pushed it harder?" The child points. "It went more." "It was faster." Then you wait. Looking is the work. The word *force* can wait.

Precise picture. Science at this band is visual and bodily before it is verbal. *Taking Science to School* is the precise picture of the whole band: children already have substantial, often implicit, knowledge of the natural world. They are not bundles of wrong ideas waiting to be emptied. They do have stubborn prior ideas, and some of those ideas live in adults too, but those ideas sit inside real abilities to notice, sort, and try.[36] California's K–2 table is the precise picture of the hour: wonder, draw, try, then "I think because I see." The National Research Council's *Framework* uses the word *practices* on purpose. Inquiry is knowledge and skill at once. A single linear "scientific method" — observe, hypothesize, deduce, conclude — is a myth many textbooks still print, and the *Framework* calls that story fundamentally wrong.[37] You are not hanging a method poster. You are looking, then asking.

A living thing, in ordinary language this year, is something that needs things in order to go on: water, light, food, a place. A rock does not. A toy dog does not, even if it looks like a dog. One research view, Susan Carey's as *Taking Science to School* reports it, is that young children at first have no living world as such: animals as social beings, plants as inanimate objects. That is one cited view, not a law of age. The same synthesis reports that children may reclassify some plants from nonliving to living, and that after they do, they often overgeneralize: plants

[36] National Research Council, *Taking Science to School* (2007), Chapters 3–4. Children "certainly aren't mere bundles of misconceptions"; they do have misconceptions, some of which persist into adult life, better understood in the context of children's positive abilities.

[37] National Research Council, *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: National Academies Press, 2012), Chapter 3. "Practices" rather than "skills" because inquiry requires knowledge and skill at once; a single "scientific method" is a mistaken impression; the linear observation–hypothesis–deduction–conclusion story is "a myth perpetuated to this day by many textbooks" and "fundamentally wrong." doi:10.17226/13165.

eat, plants sleep, plants take in food through roots.[38] Your job is to hear those sentences. Your repair is another look, not a lecture on kingdoms.

Mary Budd Rowe's wait is science class, not a borrowed pause from another book. On tapes of elementary science lessons, the usual wait after a question was about one second; after a child's answer, about nine-tenths of a second. When teachers reached three to five seconds, children talked longer, offered more evidence-and-inference sentences, and asked more.[39] Three to five seconds feels long. It is the work. Look at the drawing if the silence is hard.

Wrong answers you should be able to hear

1. *You hold up a plant and a rock and ask, "Which is living?" The child says the plant is not alive, because it does not run or bark.* Living as "moves like an animal." Hear it. Put the plant and the rock on the table with a cup of water. Ask what each one needs. If they can say the plant needs water and the rock does not, the needs-pattern is starting. If they cannot, the kingdom name was never going to help.

2. *The child agrees the plant is alive, then says it eats through its roots, or that it sleeps at night the way people do.* The reclassification happened, then the overgeneralization. *Taking Science to School* names that sequence. Say: "What did we actually see this plant do?" Then wait. Food through roots is a powerful everyday idea. Sugars in leaves is later. This week, needs you can see: water, light, a place.

3. *You ask "What is a force?" after a push, and the child stares, or recites a sentence from the book they did not use.* Vocabulary as the hour. The question asked the wrong organ. Ask what they saw when you pushed harder.

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[38] National Research Council, *Taking Science to School* (2007), Chapters 3–4, reporting Susan Carey (1985) as one view that young children initially have "no sense of the living world as such"; Giyoo Hatano and colleagues (1997) on reclassifying some plants from nonliving to living; Kathleen Roth (1984) on overgeneralizing that plants eat and sleep, and take in food through roots. Carey is one cited view, not a law of age.

[39] Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control," paper to the National Association for Research in Science Teaching, Chicago, April 1972, ERIC ED061103. Over 300 tapes of elementary science classes (more than 900 after training); mean wait-time about one second after a teacher question and 0.9 seconds after a student response. When mean wait-times of three to five seconds were achieved, nine student variables changed, including length of responses and evidence–inference statements. Not a homeschool trial and not a content-knowledge test.

If they can point to a farther travel, the looking is working. The word can come after the drawing.

4. *A tablet narrates "the water cycle" in a warm voice, or a generated puppy sits on the table as if it were today's living-thing observation.* The chatbot is not the looker. A generated animal is a picture to look at together for two minutes — "what did this picture get wrong?" — then it comes off the table. A real plant, a real rock, a real window come on. A generated scene has no maker in the room.

5. *Fifteen minutes in, the child is wriggling, the parent is still explaining habitats, and no one has pointed at an object for ten minutes.* The sit is too long, or the story never landed on a thing. Short sits, then stop. A second sitting later in the week is better than a lecture that trains the child to wait you out. If silence is hard, look at the drawing together. The object is the joint attention. You are not the joint attention.

A sixth you will also hear: every unfamiliar object is named from a cartoon, or from yesterday's read-aloud, while the eyes never land on the actual plant or the actual ramp. That is a schema doing the looking. Cover the caption. Put a finger on the thing. "What do you actually *see*?" Then wait.

Five-minute parent warm-up

Do this before the lesson, with a board, two small objects, and a scrap of paper, no child in the room.

Minute 1. Set the board on a book. Push one object gently. Push the other harder. Say out loud: "I am not going to ask what a force is. I am going to ask what I saw."

Minute 2. Draw, badly, the two travels. Notice that the work is the picture, not a definition. That is the record.

Minute 3. Imagine the child saying "plants aren't alive." Decide, without performing, what a scold would do. Decide what "what does this one need?" would do instead. You are installing the miss so you can hear it tomorrow.

Minute 4. Look out the actual window. Mark today's sky on a scrap: sun, cloud, rain, wind. That is weather as observation. It does not need a climate paragraph yet.

Minute 5. Write the sentence you will actually say: "What did you see happen when we pushed it harder?" Put the pencil down. That sentence is the lesson.

If you can do those five minutes, you are ready to sit down. The child looks at the objects. You hear.

How to teach it this week

A good science hour this week has a shape. The science-hour chapter in the front of this book is the full version, including the AI rules and the safety line. Here is the shape scaled to this band.

Warm-up (2–3 minutes, unaided). One object already tried. "What did you see last time?" No device. No definition.

Short try (5 minutes). One story of a try, one object. You show a gentle push, then a harder push. Or you look out the window. Then you stop.

Student looking (8–12 minutes). The longest block, and it is still short. The child pushes, sorts, shines a light, waters, or draws. You wait. Struggle before rescue: ask, wait, hint, then a short model on *your* scrap, not on their drawing.

One good question. Not "what is a force?" A question that names the idea: "What did you see happen?" "What do you actually *see* in your drawing?" "Living or not — what makes you say that?" "What would happen if we did it again?"

Talk (3–5 minutes). One spoken sentence, or a caption the child can say while you write it: "I pushed. It went farther." You are not assigning a paragraph.

Stop. While they still have a look left in them. A second sitting later in the week beats a long sit that ends in tears.

That shape is a practice you impose on whatever book, walk, or windowsill is already in the week. It is not a 180-day plan.

Safety this year is the adult in the room the whole try. Kenneth Roy's home-instruction advice, written as the author's views, is the duty of care for K–5: a responsible adult, directly present.[40] No heat. No household cleaners. No un-

[40]Kenneth Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020. Views are the author's and do not necessarily reflect official NSTA position. K–5: duty of care provided directly by a responsible adult. Common, safer household products; if proper PPE is

supervised anything. Food-safe soil and water for a plant. Hands washed after soil. Never shine a light in eyes. A kitchen this year is a table with objects, not a chemistry lab.

Exact wording you can say

On a push or a pull:

“What did you see happen when we pushed it harder?”

“Point to the drawing that shows that.”

“What would happen if we did it again?”

On seeing:

“What do you actually *see*? Not what you remember from the story. What is on the table.”

“Cover the caption. Look again.”

On living and nonliving:

“What does this one need? What about that one?”

“Living or not — what makes you say that?”

On weather:

“What is the sky doing today? What was it doing yesterday?”

“Mark it. We will look again tomorrow.”

On light:

“Where is the dark patch? What is blocking the light?”

“Can we see the cup if I turn the light off?”

When you are about to take over:

“Your eyes. I’ll wait.”

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not available, the activity must not be conducted. https://www.nsta.org/blog/safety-hands-science-home-instruction.

Then wait. Three to five seconds after you ask, and three to five after they stop. Rowe's windows were measured in science class. Use them here as science. A follow-up that arrives in half a second trains the child to wait *you* out, not to look.

First problem for the student

A board, two objects that slide or roll, no vocabulary card:

one gentle push, one harder push.

Say: "What did you see happen when we pushed it harder?"

Wait. If the child names a force, they used a caption or a guess. Cover the word. If they say "it wanted to go," they used a desire. Ask what *on the board* was different. If they point to a farther travel, they looked. If they stare, model on a *different* pair — two paper balls, one tapped, one pushed — said as "I see a short travel here, and I see a long travel there" — then return to the board.

Later the same week, the diagnostic item:

the same two objects, same push, but you also change the board's tilt without saying so.

If they still say "harder made it go farther," two things changed. Ask whether we can tell it was the push. That is the seed of a fair test. It is not Newton's laws.

Named investigation: Push-and-Pull Ramp

Time. One short sit. Ten to fifteen minutes, including drawing. Stop while they still want one more push.

Materials. A board. A book to prop it. Two objects that slide or roll — wooden blocks, toy cars, spoons. Paper. A crayon.

SAFETY. Adult present the whole try. No high drops. No glass. Soft objects. The board stays on the floor or a low table.

The fun. Sending something down. An argument about which one went farther is the point.

The skill. Motion changes when you push harder or change direction. That is the kindergarten-to-grade-2 shape of pushes and pulls. It is not Newton's laws.

Say: “Push this one gently. Push that one harder. What did you see happen when we pushed it harder?” If they sort by color of the object, the looking missed the travel. Ask about the *path*.

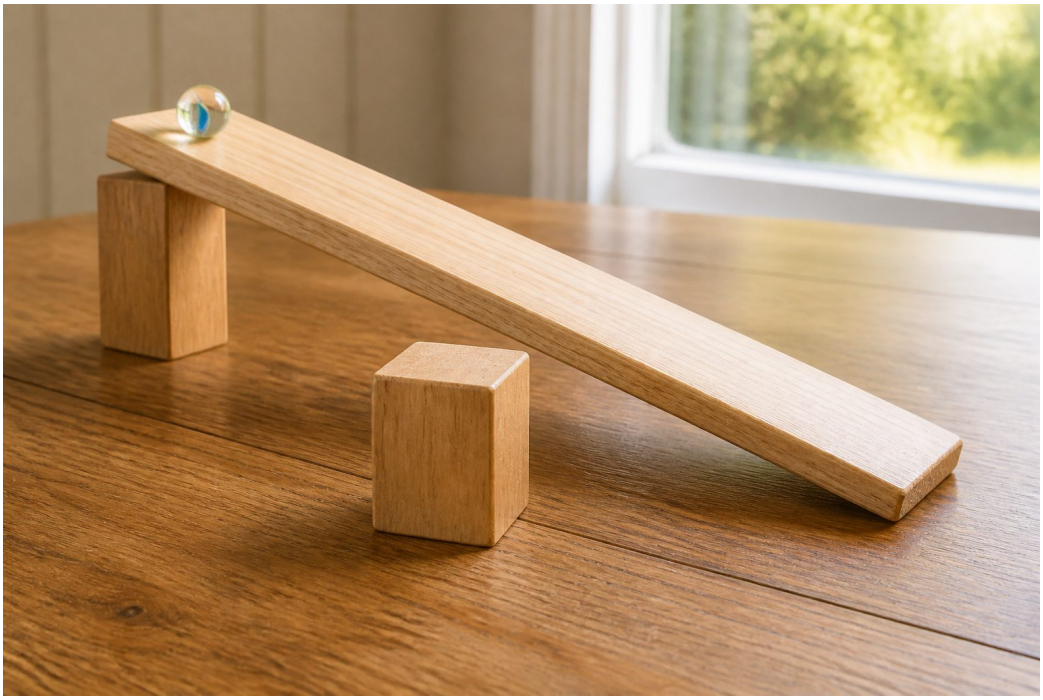

Figure 4: A board propped on a book, two small rolling objects at rest, and a child’s-style drawing of two paths, one short and one long. Adult demonstration quality. No children. No logos.

Named investigation: Weather Window

Time. Two minutes a day for a week, then one talk of five to ten minutes.

Materials. Paper. A crayon. The actual window. A card for today’s sky.

SAFETY. Ordinary looking. No climbing out. No staring at the sun.

The fun. “Today’s sky.” A mark the child owns.

The skill. Weather as observation over time. Sun, cloud, rain, wind, as what you can see. Not climate. Not a forecast lecture.

Say: “What is the sky doing today?” Then: “What was it doing yesterday?” If they recite a weather-app sentence, close the phone. The window is the instrument.

Named investigation: Living or Not, by Needs

Time. One sit with three objects. Ten to fifteen minutes.

Materials. A living plant. A rock. A toy animal. Optional: a cup of water.

SAFETY. No tasting. Wash hands after soil. Adult present.

The fun. Sorting. Being the person who notices that the toy dog does not drink.

The skill. Patterns of what living things need. Plants in the conversation on purpose, because “plants aren’t alive” is in the room.

Say: “What does this one need? What about that one?” If they say the plant is not alive, hear it. If they later say it eats through roots, hear that too. Needs you can see this week: water, light, a place. Eating and sleeping as plant-copies of people is later work, still ordinary, still not a verdict on talent.

Figure 5: A small potted plant, a rock, and a toy animal on a table, with a cup of water to one side. No children. No logos.

Named investigation: Light Path

Time. One sit. Ten minutes. Looking dies if you add a second light.

Materials. A flashlight. Paper. A cup. A piece of foil. A darkish corner of the room.

SAFETY. Never shine in eyes. Adult holds the light if needed. No lasers.

The fun. Making a dark patch. Foil that throws light back.

The skill. Objects seen when there is light. Some materials block, some do not. That is the grade-1 shape of light. It is not the speed of light.

Say: “Where is the dark patch? What is blocking the light?” If they jump to “the sun is a star,” come back to the cup. A caption they can say: “I see a dark patch.

The cup is in the way.”

Named investigation: Plant Trial, One Thing

Time. Days, two minutes each. Then one talk.

Materials. Two cups. Food-safe potting soil. Seeds. Water. A windowsill.

SAFETY. Food-safe soil. No tasting. Adult waters if mold appears — and then you stop that cup. Hands washed. No household fertilizer, no cleaners.

The fun. “Will it grow?” Checking each morning.

The skill. Plants need sunlight and water. Change one thing: water for one cup, none for the other, same sill — or light for one, a cardboard box for the other, same water. One variable. Not a biology year.

Say: “These two cups are the same except for this.” Point. If they water both “to be fair,” the trial collapsed. Fair this week is one difference you named. Coverage of every plant part can wait.

Named investigation: Draw What You Saw

Time. Five minutes at the end of any of the above.

Materials. Paper. A crayon.

SAFETY. None.

The fun. Their picture. A record they made.

The skill. A record a stranger could almost read. The word comes after the drawing. California’s table puts drawing next to “I think because I see.” That is the product this year.

Say: “Draw what you saw. Then tell me one sentence.” If they copy a diagram from the book, the book did the looking. Cover the book. Their eyes, their marks.

Discussion box

This is an illustration, not a reported family. Two objects have gone down a board. The parent has not announced the word *force*. A drawing is on the table.

Opening question

"What did you see happen when we pushed it harder?"

Not: "What is a force?"

Follow-ups (pick three to five; you will not use all of them every sitting)

1. What do you actually *see* in your drawing?
2. What would happen if we did it again?
3. Can we tell it was the push — or did something else change too?
4. What would make you change your mind?
5. What would we ask if Grandma had been watching?

How to wait

Ask. Count three to five seconds in your head. Look at the drawing, not at the child's face, if the silence is hard. After they stop talking, wait three to five seconds more before you speak. Rowe's windows were measured in elementary science class. Use them. A follow-up that arrives in half a second trains the child to wait *you* out, not to look. *Ready, Set, SCIENCE!* names the wait in ordinary language: "Take your time. We'll wait."[41] Homeschool is usually one child. Rowe's child-to-child comparisons will often be you and them. That is a setting difference, not a reason to skip the wait.

What a stuck silence usually means

The question was recitation in disguise — you already had "force" in mind. Or the wait was too short, and they learned that you will fill it. Or there was not enough of the idea on the table: a word with no push in the body. Or the sit is already too long. Mapping what they saw into a sentence is hard work; Rowe called that mapping arduous.[42] Next move: do one short try again, then ask the

[41] Sarah Michaels, Andrew W. Shouse, and Heidi A. Schweingruber, *Ready, Set, SCIENCE!: Putting Research to Work in K–8 Science Classrooms* (Washington, DC: National Academies Press, 2008), Chapter 5 talk moves, including wait time: "Take your time. … We'll wait." doi:10.17226/11882.

[42] Rowe, "Wait-Time and Rewards" (1972): mapping experience into language is an arduous process.

opening question again. Done enough this week: a spoken sentence or a caption. "I pushed. It went farther." You wrote it only if they said it.

Practice that actually builds learning

Blocked, for a new move. The day you introduce a push, give a short set that is only that: two objects, a board, push. The day you introduce living-or-not, only the three objects. The day you introduce a weather card, only the window. Mixing too early makes the child hunt for the "right" school move instead of looking.

Mixed, for when to use it. Later the same week, the ramp reappears next to the plant and the weather card. Mixing is the practice of choosing a looking move: is this a push, a needs-sort, a sky, or a light path? You impose that mix on the week you already have. A purchased reader that is all animals can still be mixed by you pulling a rock onto the same table.

Brief retrieval of tries already done. Two minutes, mixed, after the child can talk those tries untimed. Cover any vocabulary boxes. You listen. Overlearning a word list until tonight's score is perfect is the wrong retrieval for this band. Retrieval is a second look at a drawing they already own, not a race.

One incorrect example to diagnose. After the child has attempted the ramps, show a card that guessed "force" from the book's heading. Ask: "What did this person use to decide?" After "plants aren't alive," show the plant and the rock and ask what each one needs. The child names the miss. You do not narrate it as a verdict on talent.

Talk every sitting. Oral language is the product this year. A spoken sentence is done enough. A caption is a sentence you write only after they say it. Complex talk — a reason tied to a drawing — is already the thing later writing will need. You are not assigning a paragraph. You are teaching a sentence the child can hold.

Kitchen, window, and making. A grocery list is not science, but "does this apple need water the way the plant does?" is. A window is not a weather station requirement; it is how weather gets a body. A drawing of the ramp is making in the service of looking. It does not replace the objects on the table. The kitchen is a table with objects. It is not a secondary lab, and this year it does not need to pretend to be one.

Read-aloud above independent reading. Ten minutes, you reading a short science picture book, they talking. New words live here. The looking hour does not have to carry the whole language load. The try comes first. Then the question. A glossary at the end of a picture-book is still a glossary.

A weekly shape: day of a new looking move, a short blocked sitting. Same week: mixed retrieval of older drawings. Later this week: the new move next to an unlike object. Daily, if you can: one object, one sentence. You impose that shape on the walks and the windowsills you already have. The year is a map. This week is one try, one drawing, one looking move.

Ready, Set, SCIENCE! is blunt about a hope many rooms still have: that understanding will miraculously emerge from the data if children just do activities.[43] It does not. The try without the talk is activity. The talk without the try is recitation. The hour is both, and the adult holds the key.

For the student

You are learning how looking and trying work. An object can move when you push it. A plant can need water. The sky can change from yesterday. You look. You try one thing. You draw what you saw. You say one sentence. A long word is a name. You do not need the long word yet. The looking is the work.

A board on a book. Two objects. You push one gently. You push the other harder. You draw the two paths. That is science you can see.

Tiny worked example

Look at two objects on a board, with no word-card showing.

What do you actually *see*? A short travel. A long travel.

What happened when we pushed harder? It went farther — because the drawing shows a longer path.

That is looking. The caption, if you want one: “I pushed harder. It went farther.”

Two tries

[43] Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!* (2008), Chapter 3: many teachers hope scientific understanding will “miraculously emerge from the data”; being exposed to new information is not the same as integrating it.

1. Send two objects down a board. Draw what happened. Say one sentence about what was different, looking at the drawing.
2. Put a plant, a rock, and a toy animal on the table. Say what each one needs. Then say living or not, and what makes you say that.

For the second one, living is about needs you can see, not about whether something has a face.

Write nothing if writing fights the sitting. Talk the sentence. Your grown-up can remember it.

Explain it back

Tell someone at the table, in your own words, how you know a harder push changed the travel. Then point to a drawing and say what you *see*, not the word from the book. Then point to the plant and the rock and say what each one needs.

Challenge

Some people look at a plant and say it is not alive because it does not run. Some people say a plant is alive and that it eats through its roots the way we eat lunch. Some people say “force” because the heading said so. What would those three moves mean? How do you look at the *thing* on the table instead? How do you ask what you actually saw?

You are allowed to struggle. You may use a board, a window, a flashlight, two cups. You look. You talk. If you get stuck, ask for a hint — not the vocabulary word. Then try again.

Weather is what the sky is doing. You can mark today and yesterday. You do not have to explain the whole year.

When you talk, a sentence about what is in the drawing is enough for today. You do not have to write a paragraph. That is later. Today you look, you try, you say one true thing.

A plant on the windowsill is a living thing to look at. A picture a computer made of a puppy is a scene. It is interesting. It is not the plant.

If it isn't clicking

Three diagnostics. Each one has a next move. None of them is a verdict on talent, and none of them is a reason to wait for a birthday.

1. The child cannot say what happened on the ramp, or recites a word, or sorts living and nonliving by whether it has a face.

Looking is not yet attached to the *things* on the table. Next move: fewer objects, more trying. Two pushes you can talk about in the body — gentle, harder. Cover words. Name the path out loud, then ask what is different. "Plants aren't alive" is ordinary. Stay with needs you can see. If this is still the bottleneck after several weeks of short daily trying, stay here. A fair-test year on top of a child who cannot point at a path will not hold. A human who will sit with two objects and wait, not with a tablet that narrates, is a reasonable next step if you have tried the small-set work and the look still does not come.

2. The child recites the book, or a habitat script, and cannot point to a drawing.

The cue is still your voice, or a memorized performance. Next move: objects first, try second, question third. Cover the caption. Finger on the object. The prompt is always through the looking: "What do you actually *see*?" After an attempt, one incorrect example to explain ("this person said force because the heading said force — what did they use?"). Slow down the "interesting" chapter-book until a sentence can be tied to a drawing; a child who can recite a read-aloud and cannot point to the path is not ready to skip this. Go ahead once they can try, draw, and say one sentence with their eyes on the picture. A tutor is useful if recitation remains the default after a couple of weeks of daily object-first work *and* the hour has become a fight.

3. The child will not talk, or every sitting ends in "it wanted to," and the silence after your question is a wall.

Talk is the product, and a desire in the object is the mind at rest. Next move: shorter sits, one object, the opening question from the discussion box, wait three to five seconds twice. If silence is hard, you look at the drawing, not at them. An authentic question is one you do not already have the sentence for. If you hear yourself answering, you have started doing the work. For "it wanted to," ask what you would see if we did it again. One strange object a week is enough. If the hour has become a fight after a stretch of daily short sits, a human who will wait, not a

chatbot that fills the silence, is the release valve.

When to slow down. Paths still unsorted. Recitation still the default. Sits so long that looking never starts. A generated puppy doing the work of a plant. Those are brakes. “Not ready” because of age is the brake this book will not use. “Not ready” because the objects have not yet become a looking tool is a real brake. California’s grade-1 map will not answer inheritance this year; that is not a reason to skip the plant.

When to go ahead. A harder push is an easy sort from the path in the drawing. The child points, then talks. A weather card has two days they can compare. A plant and a rock have needs they can name. A light path has a dark patch they can show. Short sits are ordinary. Then the next chapter’s measurement, fair test, and picture-plus-a-sentence have somewhere to sit. Being “good at science” because a child loves dinosaurs is not a reason to skip the looking.

When to get a human tutor. You have run the two-push try, or the covered-caption looking, or the wait after the question, for a stretch of daily sittings, and the same diagnosis is still the one in the room, and the hour has become a fight. A tutor is a release valve, not a failure of the sitting. Keep yourself as the person who can still hear a vocabulary quiz and a generated-puppy-as-observation. Outsourcing the hearing is the thing to avoid, not asking for help.

A child who can push and will not talk is missing one strand. A child who can talk a stream about planets and cannot point to a path is missing another. Hearing which is thin is enough. If the child is missing the look, model a *different* pair, then guided pushing, then the board. If the child has the look and the task is a first plant trial, two cups and one difference is the second sequence.

Tools, including AI

Optional helpers for you, the adult. The full rules live in the science-hour box in the front of this book. This chapter is a pointer, not a second policy paper.

The short version: the child looks and talks first. You hold the objects and the key. A tool may explain today’s idea *to you*, make extra then-and-now pairs of “gentle / harder” with the answers on a separate page you keep, write a hint script you read aloud, or help you diagnose work the child has already done. The child looks at objects. The child talks in the room.

Leave these out of the hour: a chatbot as the looker; a model pretending to narrate the water cycle as today's observation; a generated puppy treated as a living-thing find; "what's the answer" as the whole sitting; an unsupervised chatbot during the try; a tool that writes the caption so the child does not have to look. A generated painting can be a scene to look at together for two minutes — "what did this picture get wrong?" — and then it comes off the table. A real plant or a real ramp comes on. A generated picture has no trial in the room.

A language model will happily tell the day's story, or invent a "lab note" from a first-grader. Treat every model-supplied observation, caption, and "as we saw" as untrusted until it lives in the child's drawing or in a named book page.[44] Fluent talk from a tool is performance, not the child's knowledge of the push. The unaided sentence at the board tomorrow morning is the test.[45] A high-school math study found that an unguarded chatbot raised assisted practice and then cut the unaided exam; that paper is mathematics, not a science trial. The crutch is still the sitting condition. If the tool produces the looking, the child is a spectator.[46]

A board, a window, a flashlight, and two cups are tools too. Use them, then fade them.

What "done enough" looks like

Placement is by skill, not birthday. A "grade 1 science" book is a publisher's scope, not a legal grade. A nature reader, a well-used older workbook, and a library picture book can place the same child in three different rooms, because they cut

[44]William H. Walters and Esther Isabelle Wilder, "Fabrication and Errors in the Bibliographic Citations Generated by ChatGPT," *Scientific Reports* 13 (2023): 14045. GPT-3.5: 55 percent of citations fabricated; GPT-4: 18 percent fabricated. Of the real citations, 43 percent (GPT-3.5) and 24 percent (GPT-4) had substantive errors, including wrong dates. Same paper: fabricated methods and results in some generated "studies." Treat model-supplied observations and "as we saw" as untrusted until found in the child's drawing or a named book page.

[45]Nicholas C. Soderstrom and Robert A. Bjork, "Learning Versus Performance: An Integrative Review," *Perspectives on Psychological Science* 10, no. 2 (2015): 176–199. Current performance is often an unreliable index of learning.

[46]Hamsa Bastani, Osbert Bastani, Alp Sungu, Haosen Ge, Özge Kabakcı, and Rei Mariman, "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base raised assisted practice grades 48 percent relative to control, then cut unaided exam grades 17 percent, in a high-school mathematics randomized trial. Not a science trial. The sitting condition — a tool that produces the response — is the mechanism used here.

the grain differently. Choose by fit. This book names those programs as options in the resources chapter. It does not rank them. The transcript, when you need one, still says Science. It does not say a brand.

Checklist before moving on

- The child can try a harder push and a gentler push and say what was different by pointing at a path or a drawing, not by reciting a definition.
- When asked what they saw, the child points at the object or the drawing and says a sentence. Reciting the parent's paragraph has receded as the way to *do* the hour.
- Weather has at least a few days of marks from the actual window, and the child can compare today with yesterday.
- A plant, a rock, and a toy have been sorted by needs the child can name in ordinary language. "Plants aren't alive" has been heard, not scolded.
- A light path has made a dark patch the child can show.
- A plant trial has one named difference, or is underway with two cups.
- Draw-what-you-saw can be done at the end of a try, for a few minutes.
- Sits can be short. A spoken sentence or a caption is enough. You did not require a paragraph or a method poster.
- You can hear a vocabulary quiz, a generated-puppy-as-observation, and "it wanted to," and you can ask a good question, without taking the looking.

If most of that list is true, go on to measurement, a fair test in ordinary language, and a notebook that is a picture plus a sentence, even if the birthday says otherwise. If the birthday says "third grade" and the words are still doing the work of the objects, stay. The next chapter is the fair test, with the board still in the room.

A path through science is the promise. A percentile is not.

Chapter 2

Life, earth, and physical as a band

Figure 6: A kitchen-table still-life: two small ramps with two different surfaces, a notebook open to a table with two written distances, a magnet and a few paper clips. No people. No logos.

Why this matters

This band is not three high-school courses taught early. Life, earth, and physical sit together as a typical elementary year: a living thing with a life cycle, a weather table, a magnet, a fossil as evidence, a push that you can measure. Measurement starts. A fair test in ordinary language. A notebook that is a picture plus a sentence. The child still looks. Now they also write a number.

The sentence that surprises people is this one: a nine-year-old can learn to change one thing on purpose, and they usually will not invent that move from a pile of ramps. David Klahr and Milena Nigam sat with 112 third- and fourth-graders, ramps, surfaces, and balls. One group heard what a fair test is: the experimenter built confounded and unconfounded races, asked whether you could "tell for sure," and explained why. The other group kept designing their own races with no instruction on that strategy and no feedback. Both groups were active with the ramps. Masters — at least three of four unconfounded designs later — were 40 of 52 in the taught group (77 percent) and 12 of 52 in the untaught group (23 percent). Discovery still produced masters. The contrast was intentionally magnified. A week later, the children who had mastered the move looked alike on a poster-evaluation task, however they had learned it. What is learned is more important than how it is taught.[47] That is the finding. It is not a slogan that discovery is dead, and it is not a promise that your kitchen will reprint 77 percent.

Dates in history attach around grade 5, when they hang under pictures the child already owns. Here, numbers attach to trials. A sourcing conversation is another book's hour. A "can we tell for sure?" conversation is this chapter.

NGSS grades 3–5, as a map, add balanced and unbalanced forces as qualitative, magnets the child can hold, life cycles as birth-growth-reproduction-death, traits

[47] David Klahr and Milena Nigam, "The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning," *Psychological Science* 15, no. 10 (2004): 661–667. n = 112 third- and fourth-graders; ramps, surfaces, balls. Direct instruction: experimenter designed confounded and unconfounded experiments, asked whether they could "tell for sure," and explained why. Discovery: children continued to design their own experiments "without any instruction on CVS or any feedback." Both conditions were active with the ramps. The authors intentionally magnified the difference. Masters (at least 3 of 4 unconfounded in assessment): 40 of 52 direct-instruction (77 percent) vs 12 of 52 discovery (23 percent). Discovery mean unconfounded experiments rose from 0.6 to 1.5. Day 2 poster transfer: experts, discovery masters, and direct-instruction masters looked alike. "What is learned is more important than how it is taught." Limits: extreme unguided discovery, not well-scaffolded inquiry; one metropolitan sample; not homeschool. doi:10.1111/j.0956-7976.2004.00737.x.

like parents but not copies, fossils as evidence, weather as tables and counts, energy as "faster things have more of it" and transfer by sound, light, heat, or current.[48] Full grade-5 wording on that map was not opened as a complete list in the research for this book; the band is still life, earth, and physical together. California, Texas, and Virginia print their own elementary science maps. They do not agree about every end-point. The fork is real. The *move* is still the fair test, the number, and the sentence.[49]

Among grades 3–5-equivalent homeschoolers in the last federal subject table, 46 percent were being taught scientific inquiry or experiments that year.[50] That figure is context, not a ranking. You are one of those tables.

What you are teaching is one thing changed on purpose; a distance or a count written down; living things with a cycle and variation; earth materials and weather as records, not as a feeling; physical ideas the child can manipulate — magnets, surfaces, pushes. Force as fuel, and plants eating through roots, are the traps in the room. Hear them.

What this band unlocks is a named variable later, a simple graph, and a paragraph that explains. Skip the fair test, and later "experiment" is still a race with three things different. Skip the number, and later evidence is a feeling that it worked. Skip the sentence next to the picture, and later the notebook is a coloring page.

You do not need to be a scientist. You do need to hear a confounded race as "we cannot tell for sure," not as a cute mess, and "the magnet wanted it" as a prior idea

[48]NGSS Lead States, *Next Generation Science Standards*, elementary band as opened in the disciplinary-core-idea arrangement (Washington, DC: National Academies Press, 2013). Grades 3–5: qualitative forces and fair tests; magnets; life cycles; traits like parents not copies; fossils; weather tables; energy as faster-things-have-more and transfer by sound, light, heat, current. Full grade-5 performance-expectation wording was truncated in the fetch used for this book; the band still stands. Standards, not curriculum, not national law. Access date for URLs in these notes: 1 September 2026.

[49]California State Board of Education adopted CA NGSS on 4 September 2013; elementary is grade-specific on that map. Texas, 19 TAC Chapter 112 index: K–8 grade-level Science (Adopted 2021); student-expectation wording was not fully opened and is not quoted here. Virginia 2018 Science SOL landing page: K–6 Science as course names. Public-school maps, not each other, not a homeschool statute. Grade 5 end-points differ by map; teach the band moves.

[50]Jiashan Cui and Rachel Hanson, *Homeschooling in the United States: Results from the 2012 and 2016 Parent and Family Involvement Survey*, NCES 2020-001 (Washington, DC: National Center for Education Statistics, 2019), Table 9: among grades 3–5-equivalent homeschoolers, 46 percent were taught "scientific inquiry or experiments" that year. Context, not a ranking. https://nces.ed.gov/pubs2020/2020001.pdf.

doing work.

For the parent: understand it yourself

Many adults feel rusty on what a fair test actually is. That is ordinary. Five minutes of this section, then the warm-up at the end, is enough for tomorrow.

Everyday picture. Two boards. One with a smooth towel, one with a rough towel. Same tilt. Same ball. You send the ball down each. You write two distances. You ask: "Look at the two distances you wrote. What do they say about the surface?" The child looks at the numbers, not at the memory of the race. The notebook is a picture of the two boards plus those two numbers plus one sentence.

Precise picture. A fair test is a method for making a single contrast between conditions, plus the understanding that a mixed-up test cannot tell you which thing mattered. That is Klahr and Nigam's control-of-variables strategy in ordinary language.[51] Both of their groups touched the ramps. The difference was explanation, examples, and feedback — not active versus passive. Novices need guidance; an education-general review by Paul Kirschner, John Sweller, and Richard Clark is blunt on that, and it is a review, not a science-classroom trial.[52] Your hour still has the child designing. You still show a messy race and a clean one, and you still ask whether we can tell for sure.

Taking Science to School names the prior ideas you will hear. Force as an active push needed to explain motion, rather than a change in motion. An upward force on a thrown coin for the whole upward path. No force from a table on a book. Plants reclassified as living, then overgeneralized as eating through roots.[53] Those are not

[51] Klahr and Nigam (2004): CVS is "a method for creating experiments in which a single contrast is made between experimental conditions," plus understanding that confounded experiments are indeterminate.

[52] Paul A. Kirschner, John Sweller, and Richard E. Clark, "Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching," *Educational Psychologist* 41, no. 2 (2006): 75–86. Education-general review, not a science-classroom randomized trial. Novices need guidance; the advantage of guidance recedes when prior knowledge is high. Cited as one sentence of support for teaching the fair test, not as a replacement for *Taking Science to School*'s four strands.

[53] National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washington, DC: National Academies Press, 2007), Chapters 3–4. Force as an active push needed to explain motion rather than change of motion; upward force on a thrown coin for the upward path;

personality defects. They are everyday ideas doing work. *Ready, Set, SCIENCE!* is equally blunt about a hope many rooms still have: that understanding will emerge from the data if children just do the activity. It does not. Naming comes just in time, at the moment the looking needs it, not as a glossary first and a trial to "prove the lesson."[54]

Energy this year is "the faster one has more of it," and transfer you can feel or hear — sound, light, heat, current — not a famous equation. Inheritance is "like parents, not copies." Fossils are evidence that living things and environments were here, not a paleontology syllabus. Weather is a table of counts, not climate as the year's purpose.

Wrong answers you should be able to hear

1. *Two ramps, three things different, and the child announces that "rough stops it."* A confounded race. They saw what they already believed. Ask: "Can we tell for sure it was the surface — what else was different?" Then reset so only the surface changes. Write two distances. The number is the repair, not a scold.

2. *The child says a thrown ball still has an upward force in it until it stops going up, or that a book on the table has no push from the table.* Force as fuel, and a missing contact force. *Taking Science to School* names both. You are not teaching high-school mechanics. You are hearing the idea. A soft ball, a table, a book. "What do you actually *see*?" The table-on-book look can wait for a later sitting; hearing the sentence cannot.

3. *The plant is alive, and it eats through its roots, or it sleeps like people.* The overgeneralization after reclassification. Needs and a life-cycle order are this year's work. Food through roots is a powerful everyday idea. Sugars in leaves is later. Stay with what you can see and with the four cards: birth, growth, reproduction, death.

4. *The notebook has a pretty picture and no number, or a number copied from a heading, or a generated "data table" that never met a ramp.* Recitation,

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no table-on-book force; plants reclassified then overgeneralized as eating through roots (Hatano et al., 1997; Roth, 1984, as reported). doi:10.17226/11625.

[54] Sarah Michaels, Andrew W. Shouse, and Heidi A. Schweingruber, *Ready, Set, SCIENCE!: Putting Research to Work in K–8 Science Classrooms* (Washington, DC: National Academies Press, 2008). Understanding does not miraculously emerge from data; just-in-time naming; simply "doing" activities often leaves an inaccurate sense of science. doi:10.17226/11882.

or a tool doing the recording. The product is a picture plus a sentence that uses a measurement. A stranger should be able to read the claim and the number.

5. *A generated fossil photograph sits on the table as today's find, or a tablet narrates dinosaurs while no object is in the room.* The generated picture is a scene to look at together, labelled as generated, then it comes off. A real fossil, a named photograph from a book with the credit line visible, or a library specimen comes on. A generated find has no maker in the year under study.

A sixth you will also hear: every magnet "wants" the clip, every faster thing "has more energy" as a slogan with no transfer they can point to, every weather sitting is a feeling ("it was nice") with no mark on a table. Everyday words doing different work than the science move. Put a finger on the clip, the distance, the tally. Then wait.

Five-minute parent warm-up

Do this before the lesson, with two boards, two surfaces, one ball, and a scrap of paper, no child in the room.

Minute 1. Set two ramps the same except the surface. Say out loud: "I am not going to ask for the vocabulary word. I am going to ask what the two distances say."

Minute 2. Send the ball twice. Write two numbers. Notice that the work is the contrast, not the race-as-entertainment.

Minute 3. Imagine a third race where tilt, ball, and surface all change. Decide what "we cannot tell for sure" would do. Decide what a scold would do. You are installing the confound so you can hear it tomorrow.

Minute 4. Sketch a tiny table: Surface / Distance. Two rows. That is the notebook as a picture plus a sentence waiting to be said.

Minute 5. Write the sentence you will actually say: "Look at the two distances you wrote. What do they say about the surface?" Put the pencil down. That sentence is the lesson.

If you can do those five minutes, you are ready to sit down. The child measures. You hear.

How to teach it this week

A good science hour this week has a shape. The science-hour chapter in the front of this book is the full version, including the AI rules and the safety line. Here is the shape scaled to this band.

Warm-up (3–5 minutes, unaided). Yesterday's two numbers, covered. "Which surface? What makes you say that?" Paper. No device.

Short model (5 minutes). One confounded race you built on purpose, then one clean race. You ask whether we can tell for sure. You explain why. Then you stop. That is Klahr's taught move, scaled to the table. It is not a lecture on experimental design.

Student attempt (15–20 minutes). The child sets the ramps, or the magnets, or the cards. They write. You wait. Struggle before rescue: ask, wait, hint, then a short model on *your* scrap, not on their table.

One good question. Not "define a controlled variable." A question that names the idea: "Look at the two distances you wrote. What do they say about the surface?" "Can we tell for sure?" "What did you write down that supports that?"

Talk (5 minutes). One sentence that uses a measurement as evidence. You are not assigning a five-paragraph lab report.

Stop. While they still have a look left in them. A second sitting later in the week beats a long sit that ends in a fight.

Safety this year is still the adult in the room the whole try. No heavy balls at head height. Magnets pinch, and they stay off electronics and mouths. No tasting fossils or soil. No heat, no household cleaners, no unsupervised mixing. The kitchen is a table with a notebook. It is not a secondary lab.

Exact wording you can say

On a fair test:

"Look at the two distances you wrote. What do they say about the surface?"

"Can we tell for sure it was the surface — what else was different?"

"What would we have to see next time to change our minds?"

On the notebook:

“A stranger should be able to read the claim and the number.”

“Picture plus a sentence. The number lives in the sentence.”

On magnets:

“It pulls without touching. What did you actually *see*?”

“What happens if a card is in between?”

On a life cycle:

“Put these in order. Birth, growth, reproduction, death — where does this card sit?”

On weather:

“How many sunny days in our table? Not how it felt. What we marked.”

On a fossil:

“This was a living thing. What in the object makes you say that?”

When you are about to take over:

“Your numbers. I’ll wait.”

Then wait. Three to five seconds after you ask, and three to five after they stop. Rowe’s windows were measured in elementary science class.[55] Use them here as science. Homeschool is usually one child. Child-to-child comparisons will often be you and them. That is a setting difference, not a reason to skip the wait.

First problem for the student

Two ramps, two surfaces, one ball, same tilt:

only the surface changes.

Say: “Look at the two distances you wrote. What do they say about the surface?”

Wait. If the child names “friction” from a heading, they used a caption. Cover the word. Ask about the numbers. If they say “rough stops it” before measuring, they

[55]Mary Budd Rowe, “Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control,” paper to the National Association for Research in Science Teaching, Chicago, April 1972, ERIC ED061103. Elementary science tapes; wait of three to five seconds. Not a homeschool trial.

used a belief. Send the ball. Write. If they stare, model on a *different* pair — two paper slides, same push, one smooth page and one crumpled — said as “I wrote 12 here and 4 there” — then return to the ramps.

Later the same week, the diagnostic item:

a race with tilt, ball, *and* surface different.

If they still claim the surface, the confound is in the room. Ask whether we can tell for sure. Reset. That is the taught move. It is not a discovery-is-dead sermon.

Named investigation: Fair-Test Ramps

Time. Twenty-five to forty minutes, including the talk. Stop while they still want one more race.

Materials. Two boards. Two surfaces (towel, paper, cloth, sandpaper if it will not shed into eyes). One ball, or two of the same kind. A ruler or a marked string. A notebook.

SAFETY. Adult present. No heavy balls at head height. Soft ball if the room is small. The boards stay low.

The fun. Racing. Catching the messy race is part of the fun.

The skill. One thing changed on purpose. “Can we tell for sure?” Klahr and Nigam’s prompt, in ordinary language. Not a slogan that unguided discovery is banned. Both of their groups were active. Yours is too. You still explain.

This is an illustration of the apparatus shape, not a copy of their laboratory and not a promise of their percents.

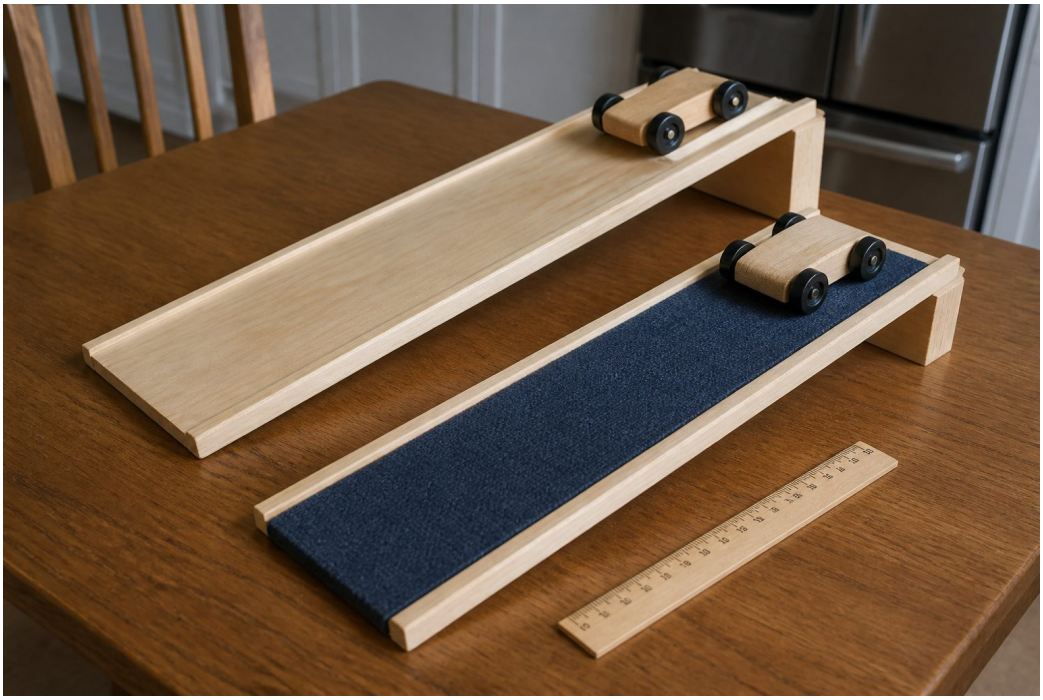

Figure 7: Two low ramps side by side, one smooth surface and one rough, one ball at rest, a notebook open to two distances. Adult demonstration quality. No children. No logos.

Named investigation: Magnet Cause-and-Effect

Time. One sit. Fifteen to twenty minutes.

Materials. Magnets the child can hold. Paper clips. A table. A card or a thin book to put in between.

SAFETY. Pinch warning. Keep magnets off electronics, credit cards, and mouths. Adult present. No small magnets if a younger sibling is in the room.

The fun. “It pulls without touching.”

The skill. A non-contact interaction the student can manipulate. That is the grade-3 shape. It is not field theory.

Say: “What did you see when the magnet came near?” If they say it wanted the clip, hear the desire. Ask what you would see if we did it again with the card in between.

Named investigation: Life-Cycle Cards of One Organism

Time. One sit. Fifteen minutes.

Materials. Four pictures of one real organism — seed to fruit, or egg to adult. Cut from a book you own or a library photocopy the library allows. No generated “life cycle” as if it were a field observation. No portraits of real children.

SAFETY. None.

The fun. Putting in order. An argument about which card is “grown” is the point.

The skill. Birth, growth, reproduction, death as common. Traits like parents, not copies, can sit next to the cards another day. No human-reproduction details in this sitting.

Say: “Put these in order. What makes you say that?” If they order by size of the picture on the page, the looking missed the organism. Cover decorative borders.

Named investigation: Weather Table, Not a Feeling

Time. A week of two-minute looks, then one sitting to make a bar of counts.

Materials. A paper table: date, sky, wind, rain. A crayon. The actual window.

SAFETY. Ordinary looking. No staring at the sun.

The fun. “How many sunny days.” A bar they colored from their own marks.

The skill. Represent data. Weather as a record, not a mood. Not climate change as a grade-3 syllabus. Climate as evidence is a later chapter.

Say: “How many sunny days in our table?” If they say “it was a nice week,” ask what the marks say.

Named investigation: Fossil as Evidence, Not a Storybook Dragon

Time. One sit. Fifteen to twenty minutes.

Materials. One fossil, or a named photograph of one with the credit line visible. A notebook.

SAFETY. No tasting. Wash hands after handling specimens. Adult present.

The fun. "This was a living thing." The chip, the ridge, the thing nobody mentioned.

The skill. Past organisms and environments as evidence. Not a paleontology year. Not a culture-war script. Teach the object on the table.

Say: "What in this object makes you say a living thing was here?" If they tell a dragon story, come back to the ridge. A generated fossil image can be a scene to look at together — "what did this picture invent?" — then the named photograph comes on.

Named investigation: Notebook, Picture Plus a Sentence

Time. Five to ten minutes at the end of any of the above. Product of the week, not a separate unit.

Materials. The notebook. A pencil.

SAFETY. None.

The fun. A page a stranger could read.

The skill. A claim and a number in the same breath. Picture plus a sentence. Not a lab report.

Say: "Draw the two ramps. Write the two distances. Say one sentence that uses those numbers." If they write "it worked," the feeling did the recording. Point at the table. Wait.

Figure 8: An open notebook: a simple drawing of two ramps, a two-row table of surfaces and distances, and one handwritten sentence under it. No children. No logos.

Discussion box

This is an illustration, not a reported family. Two distances are in the notebook. The parent has not announced the phrase *controlled variable*.

Opening question

"Look at the two distances you wrote. What do they say about the surface?"

Not: "Define a controlled variable."

Follow-ups (pick three to five; you will not use all of them every sitting)

1. What did you write down that supports that?
2. Can we tell for sure it was the surface — what else was different?

3. What would we have to see next time to change our minds?
4. Say more about that.
5. (If two people) Do you agree, and why?

How to wait

Ask. Count three to five seconds in your head. Look at the notebook, not at the child's face, if the silence is hard. After they stop talking, wait three to five seconds more before you speak. Rowe's windows were measured in science class. *Ready, Set, SCIENCE!* adds: "Take your time. We'll wait."[56] A follow-up that arrives in half a second trains the child to wait *you* out, not to look at the numbers. The claim–evidence–reasoning spine from IQWST, as that book reports it, is ordinary language this year: what do you think happened; what did you write down; why would that measurement count.[57] Grades 3–5 can hold a sentence. They do not owe a five-paragraph report.

What a stuck silence usually means

The question was recitation in disguise — you already had "friction" in mind. Or there was not enough of the idea on the table: a race with no numbers. Or they saw what they already believed, and the notebook was never opened. *Taking Science to School*, reporting Deanna Kuhn and colleagues, is plain: even adults meld theory and evidence into "the way things are."[58] Or wait-time 2 was cut. Next move: reset so only the surface changes, write two distances, ask the opening question again. Done enough this week: talk plus a sentence that uses a measurement as evidence.

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[56]Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!* (2008), Chapter 5: wait time as a talk move, "Take your time. … We'll wait."

[57]Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!* (2008), reporting the IQWST framework: claim (what happened, and why), evidence (what information or data support the claim), reasoning (what justification shows why the data count as evidence). Ordinary language for this band; not a second course in argumentation.

[58]National Research Council, *Taking Science to School* (2007), Chapter 5, reporting Deanna Kuhn, Eric Amsel, and Michael O'Loughlin (1988) as cited: even adults meld theory and evidence into "the way things are." This book did not open the 1988 monograph; the wording is TSTS's.

Practice that actually builds learning

Blocked, for a new move. The day you introduce a fair test, only ramps, only one contrast. The day you introduce magnets, only magnets. The day you introduce a weather table, only the window and the tally. Mixing too early makes the child hunt for the school move instead of measuring.

Mixed, for when to use it. Later the same week, the ramp reappears next to the magnet and the fossil. Mixing is the practice of choosing: is this a fair test, a non-contact pull, a cycle, a count, or evidence from an object? You impose that mix on the week you already have. A purchased book that is all weather can still be mixed by you pulling two ramps onto the table.

Brief retrieval of numbers already written. Two minutes, mixed, after the child can talk those numbers untimed. Cover the headings. You listen. Overlearning a vocabulary list until tonight's score is perfect is the wrong retrieval for this band. Retrieval is a second look at a table they already own.

One incorrect example to diagnose. After the child has attempted the clean ramps, show a card of a race with three things different and a claim that "rough stops it." Ask: "Can we tell for sure? What did this person use?" After "it wanted to," show the magnet and the clip and ask what you would see next time. The child names the miss. You do not narrate it as a verdict on talent.

Talk every sitting. A sentence that uses a measurement is done enough. Complex talk — a reason tied to a number — is already the thing later paragraphs will need. You are not assigning a lab report. You are teaching a sentence the child can hold.

Kitchen, window, and making. A grocery scale can motivate a measurement sitting. It does not replace the two distances on the ramps. A walk in weather is not a field-trip requirement; it is how a table gets a body. A drawing of the two ramps is making in the service of the number. The kitchen is still not a secondary lab.

Read-aloud above independent reading. Ten minutes, you reading a short science book, they talking. New words live here. The looking hour does not have to carry the whole language load. The try comes first. Then the question. A glossary is still a glossary.

A weekly shape: day of a new move, a short blocked sitting. Same week: mixed retrieval of older tables. Later this week: the new move next to an unlike object.

Daily, if you can: one number, one sentence. You impose that shape on the book already on the shelf. The year is a map. This week is one fair test, one notebook page.

Grade 5 end-points differ by map. Name the fork in one sentence if a publisher's "grade 5" book and your state's pamphlet disagree. Then teach the band moves: a fair test, a measurement, a picture plus a sentence. Coverage of fifty science facts is a map. Depth is the hour.

For the student

You are learning how a fair test looks. Two ramps. One thing different on purpose. Two distances written down. You look at the numbers. You say what they tell you about the surface. A long word is a name. The numbers are the work.

A notebook page with a picture of the two ramps, two numbers, and one sentence. That is science a stranger could read.

Tiny worked example

Two ramps. Same tilt. Same ball. One smooth. One rough.

What did you write? 18 on smooth. 7 on rough.

What do those distances say about the surface? The rough one went a shorter way — because 7 is less than 18, and only the surface was different.

That is a fair test. The caption: "Rough went 7. Smooth went 18. Only the surface changed."

Two tries

1. Set two ramps so only the surface changes. Write two distances. Say what a stranger would need to believe the claim, looking at the notebook.
2. Hold a magnet near a clip, then put a card between. Draw what you saw. Say one sentence about what happened when something was in the way.

For the second one, "it wanted to" is a feeling. The drawing is the work.

Write the numbers even if writing is slow. The number is the evidence. Your grown-up can help with the letters after you say the sentence.

Explain it back

Tell someone at the table, in your own words, how you know a test was fair. Then point to two numbers and say what they claim. Then point to a life-cycle order or a weather tally and say what the record shows.

Challenge

Some people change the tilt and the ball and the surface, then say the surface did it. Some people say a thrown ball still has an upward force in it until it stops going up. Some people say a plant eats through its roots. What would those three moves mean? How do you look at the *numbers* and the *object* instead? How do you ask whether we can tell for sure?

You are allowed to struggle. You may use two boards, a magnet, four cards, a window table. You measure. You talk. If you get stuck, ask for a hint — not the vocabulary word. Then try again.

A fossil is evidence that a living thing was here. You can say what in the object makes you say that. You do not have to win a fight about the whole past.

When you talk, a sentence that uses a measurement is enough for today. You do not have to write a lab report. That is later. Today you change one thing, you write the number, you say one true thing.

A picture a computer made of a fossil is a scene. It is interesting. It is not the find.

If it isn’t clicking

Three diagnostics. Each one has a next move. None of them is a verdict on talent, and none of them is a reason to wait for a birthday.

1. The child cannot set a fair test, or always changes two things, or announces the surface before writing a number.

The contrast is not yet a tool. Next move: fewer variables, more teaching. You build one messy race and one clean race. You ask whether we can tell for sure. You explain why. Then they try. Klahr and Nigam’s taught group heard that explanation; their untaught group did not. Third- and fourth-graders were the sample. This is not too young. Stay with two ramps and one contrast. If this is still the bottleneck after several weeks of short daily races, stay here. A middle-grade variable

year on top of a child who cannot tell a messy race from a clean one will not hold. A human who will sit with two ramps and wait, not with a tablet that fills in the table, is a reasonable next step if you have tried the taught contrast and the number still does not come.

2. The child recites the book, or writes a pretty page with no measurement, and cannot point to a number.

The cue is still your voice, or a performance of "doing science." Next move: numbers first, words second. Cover the heading. Finger on the table. The prompt is always through the record: "What did you write down?" After an attempt, one incorrect example to explain ("this person changed three things and still blamed the surface — can we tell for sure?"). Slow down the "interesting" chapter-book until a sentence can be tied to a number; a child who can recite energy slogans and cannot write two distances is not ready to skip this. Go ahead once they can set one contrast and say one sentence with their eyes on the notebook. A tutor is useful if recitation remains the default after a couple of weeks of daily number-first work *and* the hour has become a fight.

3. The child will not talk, or every sitting ends in "it wanted to," or they saw what they already believed, and the silence after your question is a wall.

Talk is the product, and melding the theory with the data is the mind at rest. Next move: shorter sits, two numbers already written, the opening question from the discussion box, wait three to five seconds twice. If silence is hard, you look at the notebook, not at them. If you hear yourself answering, you have started doing the work. For "rough stops it" said before the race, send the ball, write, then ask what the distances say. One strange confound a week is enough. If the hour has become a fight after a stretch of daily short sits, a human who will wait, not a chatbot that writes the sentence, is the release valve.

When to slow down. Races still confounded and claimed. Recitation still the default. Sits so long that measuring never starts. A generated fossil doing the work of a find. Those are brakes. "Not ready" because of age is the brake this book will not use — Klahr and Nigam's children were in grades 3–4. "Not ready" because the contrast has not yet become a tool is a real brake.

When to go ahead. A fair test is an easy set: one thing different, two numbers, a sentence. The child points at the table, then talks. Magnets have a pull they can show without a story about wanting. A life cycle of one organism is in order. A weather table has counts. A fossil has a ridge they can point to. Short sits

are ordinary. Then the next chapter's named variable, model, and paragraph have somewhere to sit. Being "good at science" because a child loves a kit is not a reason to skip the number.

When to get a human tutor. You have run the two-ramp contrast, or the covered-heading looking, or the wait after the question, for a stretch of daily sittings, and the same diagnosis is still the one in the room, and the hour has become a fight. A tutor is a release valve, not a failure of the sitting. Keep yourself as the person who can still hear a confounded race and a generated table. Outsourcing the hearing is the thing to avoid, not asking for help.

A child who can measure and will not talk is missing one strand. A child who can talk a stream about magnets and cannot write two distances is missing another. Hearing which is thin is enough. If the child is missing the contrast, model a *different* pair, then guided setting, then the ramps. If the child has the contrast and the task is a first weather table, marks first, then the bar, is the second sequence.

Tools, including AI

Optional helpers for you, the adult. The full rules live in the science-hour box in the front of this book. This chapter is a pointer, not a second policy paper.

The short version: the child measures and talks first. You hold the key. A tool may explain today's idea *to you* from a named textbook page, make extra isomorphic measurement practice with the answers on a page you keep, write a hint script you read aloud, or help you diagnose a notebook page the child has already made. A two-minute generated scene may be looked at together — "what did this picture invent?" — then a named textbook picture or a real object comes on. The child writes on paper. The child talks in the room.

Leave these out of the hour: a chatbot that writes the paragraph; a model that invents a data table or an observation; a generated fossil treated as a find; "what's the answer" as the whole sitting; an unsupervised chatbot during the try; a photo-to-key of the worksheet. A generated picture of a cell or a "lab result" is a scene. It is never Figure 1.[59]

[59]Elsevier generative-AI policies (page updated June 2026): AI tools must not be used to fabricate results or invent or alter underlying data; primary research images including microscopy must not be created or altered by AI. Nature Portfolio AI policy: fabricating data, citations, or results, and creating photorealistic images, are not permitted. Publisher integrity rules, not a homeschool

A language model will happily fill a table that never met a ramp. Treat every model-supplied number, caption, and "typical result" as untrusted until it lives in the child's notebook or on a named book page.[60] Fluent talk from a tool is performance, not the child's knowledge of the surface. The unaided two distances tomorrow morning are the test.[61] A high-school math study found that an unguarded chatbot raised assisted practice and then cut the unaided exam; that paper is mathematics, not a science trial. The crutch is still the sitting condition. If the tool produces the table, the child is a spectator.[62]

Two boards, a magnet, four cards, and a window table are tools too. Use them, then fade them.

What "done enough" looks like

Placement is by skill, not birthday. A "grade 4 science" book is a publisher's scope, not a legal grade. Life, earth, and physical as a band can live in a purchased reader, a kit path, or a notebook you keep. Choose by fit. This book names those programs as options in the resources chapter. It does not rank them. The transcript, when you need one, still says Science. It does not say a brand.

Checklist before moving on

- The child can set two conditions so that one thing is different on purpose, write two measurements, and say what they claim.
- When asked whether we can tell for sure, the child can point at a confound or at a clean contrast. Reciting "controlled variable" has receded as the way to *do* the hour.

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statute; they name the split this hour needs. A generated picture is a scene, never a result.

[60] William H. Walters and Esther Isabelle Wilder, "Fabrication and Errors in the Bibliographic Citations Generated by ChatGPT," *Scientific Reports* 13 (2023): 14045. GPT-3.5: 55 percent of citations fabricated; GPT-4: 18 percent. Of the real citations, 43 percent and 24 percent had substantive errors, including wrong dates. Same paper: fabricated methods and results.

[61] Nicholas C. Soderstrom and Robert A. Bjork, "Learning Versus Performance: An Integrative Review," *Perspectives on Psychological Science* 10, no. 2 (2015): 176–199.

[62] Hamsa Bastani, Osbert Bastani, Alp Sungu, Haosen Ge, Özge Kabakcı, and Rei Mariman, "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent assisted practice, then −17 percent unaided exam, in high-school mathematics. Not a science trial. The sitting condition is the mechanism used here.

- The notebook is a picture plus a sentence that uses a number. A stranger could almost read the claim.
- Magnets have a pull the child can show, without a story that the magnet wanted the clip as the whole explanation.
- One organism has a life-cycle order the child can put in sequence.
- Weather has a table of counts, not only a feeling.
- One fossil or named photograph has been treated as evidence, not as a storybook dragon.
- Force-as-fuel and plants-eat-through-roots have been heard. You did not require a mechanics year or a photosynthesis year to hear them.
- Sits can end with talk. You did not require a five-paragraph lab report.
- You can hear a confounded race, a generated table, and “it wanted to,” and you can ask a good question, without taking the notebook.

If most of that list is true, go on to a named independent variable, a model on the table, and a paragraph that explains, even if the birthday says otherwise. If the birthday says “sixth grade” and the races are still three-things-different, stay. The next chapter is the move, not every kingdom of life.

A path through science is the promise. A percentile is not.

Chapter 3

Moves, not every kingdom

Figure 9: A kitchen-table still-life: a simple hand-drawn graph, a card that names one variable, two open notebook pages, and a physical model of cups and arrows on a tray. No people. No logos.

Why this matters

This band is a fork, not a single national middle-school syllabus. Typical content is life, earth, and physical — integrated across three years, or rotating as named courses — and the job is the *moves*: a named variable, a model on the table, a paragraph that explains. It is not every kingdom of life. A still-guessing sixth-grader who cannot run a fair test is not "behind in biology." They are still in a taught-looking stage.

The sentence that surprises people is this one: the maps disagree about the wrapper, and they agree more than they look about the work. California prefers an integrated middle-school sequence and offers Earth Science in grade 6 / Life Science in grade 7 / Physical Science in grade 8 as the alternative. Texas is grade-level Science in grades 6–8. Virginia names Life Science and Physical Science as course titles. NGSS grades 6–8 is grade-banded; Appendix K's maps are starting points, not finished products, and there is not conclusive research that identifies an ideal order.[63] One sentence, then teach. California's alternative model wraps Earth Science as a sixth-grade course. That wrapper is one coast's option, not a national rule.

The National Research Council's *Framework* is the precise picture of the move. Middle-grade students, on that progression, learn standard graphs and averaging, identify independent and dependent variables, and run multiple trials.[64] A single linear "scientific method" — observe, hypothesize, deduce, conclude — is a myth

[63]California Department of Education, CA NGSS page: State Board adopted CA NGSS on 4 September 2013; on 6 November 2013 the Board preferred the Integrated Learning Progression for middle school, with a discipline-specific alternative of Earth Science grade 6 / Life Science grade 7 / Physical Science grade 8. Texas Education Agency, 19 TAC Chapter 112 index: Science, Grades 6–8, Adopted 2021; student-expectation wording was not fully opened and is not quoted here. Virginia Department of Education, 2018 Science SOL landing page: Life Science and Physical Science as course titles. NGSS Lead States, Appendix K, *Model Course Mapping in Middle and High School* (6 May 2013): middle-school standards are grade-banded "because there is not conclusive research that identifies the ideal sequence for student learning"; the maps are "starting points, not finished products." Access date for URLs in these notes: 1 September 2026. Public-school maps, not each other, not a homeschool statute. Earth Science as a sixth-grade wrapper is California's alternative model, not a national rule.

[64]National Research Council, *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: National Academies Press, 2012), Chapter 3, practices progressions: middle-grade students learn standard graphs and averaging; identify independent and dependent variables; multiple trials. doi:10.17226/13165.

many textbooks still print. The *Framework* calls that story fundamentally wrong.[65] Your hour is practices in the plural: a question, a fair test, a record, an argument about this trial's data.

NAEP Science 2024 was given to eighth graders only. Thirty-one percent were at or above NAEP Proficient; 38 percent were below Basic; the average was four points lower than in 2019. NAEP Proficient is not "on grade level." There is no national homeschool science score in these pages to wave.[66] That figure is context, not a report card for your table, and not a morality play about saving science.

Among grades 6–8-equivalent homeschoolers in the last federal subject table, 45 percent were being taught scientific inquiry or experiments that year.[67] That figure is context, not a ranking. You are one of those tables.

What you are teaching is a variable as a tool for grouping trials; a model as a tool, not the thing; a table, a simple graph, and a paragraph; a claim with evidence and a because-sentence; two accounts of the same trial, so a belief can sit next to a number; force-as-fuel heard and put next to an observation. Force as fuel and plants eating through roots persist. Hear them again.

What this band unlocks is high-school Biology, Chemistry, Physics, and Earth and space as the map places them, with a notebook a stranger can read. Skip the named variable, and later "lab" is still a recipe. Skip the model, and later a diagram is a coloring page. Skip the paragraph, and later a lab report is a genre with no trial inside.

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[65] National Research Council, *Framework* (2012), Chapter 3: "practices" rather than a single "scientific method"; the linear observation–hypothesis–deduction–conclusion story is "a myth perpetuated to this day by many textbooks" and "fundamentally wrong."

[66] National Assessment Governing Board / National Center for Education Statistics, NAEP Science 2024, grade 8 only (administration January–March 2024; results with the 9 September 2025 release). About 23,000 students. Scale 0–300. At or above NAEP Proficient: 31 percent (4 percentage points lower than 2019). Below NAEP Basic: 38 percent. At or above Basic: 62 percent. Average 4 points lower than 2019. NCES: "the NAEP Proficient achievement level does not represent grade-level proficiency as determined by other assessment standards." Grades 4 and 12 were not administered in 2024. The exact 2024 mean integer was not taken from a chart in the research for this book. No nationally representative homeschool NAEP science score was opened. Context, not a household report card.

[67] Jiashan Cui and Rachel Hanson, *Homeschooling in the United States: Results from the 2012 and 2016 Parent and Family Involvement Survey*, NCES 2020-001 (Washington, DC: National Center for Education Statistics, 2019), Table 9: among grades 6–8-equivalent homeschoolers, 45 percent were taught "scientific inquiry or experiments" that year. Context, not a ranking. https://nces.ed.gov/pubs2020/2020001.pdf.

You do not need to be a scientist. You do need to hear a vocabulary quiz on "independent variable" as recitation, and a paragraph with no number as a feeling dressed as an argument.

For the parent: understand it yourself

Many adults feel rusty on variables and on what a model is for. That is ordinary. Five minutes of this section, then the warm-up at the end, is enough for tomorrow.

Everyday picture. The family's actual ramps, or two plants, or two cups of water. You name, out loud, the one thing you are changing on purpose. You name what is staying put. You run two trials. You write a small table. You ask: "Can we tell for sure it was the variable we named — and what in the notebook makes you say that?" The child points at a cell in the table, not at the memory of the try. The paragraph has to point at that cell.

Precise picture. An independent variable is the thing you change on purpose. A dependent variable is the thing you measure to see whether it followed. Everything else that could have mattered stays put, or you cannot tell. That is Klahr and Nigam's fair test grown a name. Their sample was grades 3–4. Copy the shape — a messy trial next to a clean one, "tell for sure," then the child designs — not their 77 percent as a middle-school promise.[68] *Ready, Set, SCIENCE!* is the precise picture of the miss you will hear: school science oscillating between predetermined-step labs and "activity mania." Productive investigations are not sequentially scripted. They are not unguided. The adult structures the hour so the activity is purposeful.[69] IQWST's three-part spine, as that book reports it, is the paragraph: a claim about what happened; evidence from the notebook; reasoning that says why those numbers count.[70] That argument is about this trial's data. It is not a historian's sourcing seminar, not a debate club, and not a second book on

[68] David Klahr and Milena Nigam, "The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning," *Psychological Science* 15, no. 10 (2004): 661–667. Sample is grades 3–4. Copy the shape (confounded vs unconfounded; "tell for sure"), not the 77 percent as a middle-school effect.

[69] Sarah Michaels, Andrew W. Shouse, and Heidi A. Schweingruber, *Ready, Set, SCIENCE!: Putting Research to Work in K–8 Science Classrooms* (Washington, DC: National Academies Press, 2008), Chapter 7: predetermined-step labs versus "activity mania"; productive investigations "are not sequentially scripted. Nor are they unguided." doi:10.17226/11882.

[70] Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!* (2008), reporting the IQWST framework: claim, evidence, reasoning. Argument about this trial's data.

thinking.

A model is a tool for thinking, not the thing itself. Cups and arrows can stand for water in a system. Cards can stand for who eats whom in *this* habitat. The model predicts. The window or the tray checks. If the model already summarized the hour, the data table never had a chance.

Force as an active push needed to explain motion, rather than a change in motion; an upward force on a thrown ball for the whole upward path; no push from a table on a book — *Taking Science to School* still names those in this band, because they persist.[71] Plants eating through roots persist too. The Newtonian construction is not obvious even to many high-school and college students who have had a mechanics course. You are not teaching that course this week. You are putting an observation next to the everyday idea.

Wrong answers you should be able to hear

1. *The child can say "independent variable" and cannot point to what they changed, or they changed two things and still blame the one they named.* Recitation, or a confound with a label. Ask what in the notebook makes us tell for sure. If the table shows two things different, the name did not do the work.

2. *The paragraph explains beautifully and never points at a measurement, or the graph was drawn from a belief before the table existed.* Performance. A feeling dressed as an argument. Put a finger on the cell. "What would a stranger reading only the notebook believe?"

3. *The model — water cycle in cups, a food-web card set — has already told the story, so the trial is a play that matches the poster.* The model filled the data. RSS's warning: understanding does not emerge from the activity, and it also does not emerge from the diagram. Look at the tray. Then look at the cards. Ask what the model would predict next, and what would make you change the cards.

[71] National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8*, ed. Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse (Washington, DC: National Academies Press, 2007), Chapters 3–4. Force as an active push needed to explain motion; upward force on a thrown coin for the upward path; no table-on-book force; plants eating through roots. The elegant Newtonian construction "is by no means obvious even to high school or college students who have had courses in introductory mechanics." doi:10.17226/11625.

4. *A thrown ball "still has force in it" until it stops going up; a book on a table has no push from the table; a plant eats through its roots.* The everyday ideas, still at work. Hear them. A soft ball indoors, a book on a table, a plant on the sill. "What do you actually *see*?" You are not finishing high-school physics or biology this sitting. You are refusing to let the prior idea be the whole hour.

5. *A chatbot writes the CER paragraph, or invents a data table, or the child compacted into a high-school Biology book while the fair test is still unprompted.* The tool did the argument, or the map skipped the move. A fluent paragraph is performance. The unaided notebook is the test. Biology as a transcript title is later. The fair test is now.

A sixth you will also hear: every disagreement is "my hypothesis versus yours," as if the hour were a contest to pick a winner. Scientific argument, as *Ready, Set, SCIENCE!* defines it, is about the idea and the observation, not about the person.[72] "Which hypothesis is true?" is the wrong opening. "What in the notebook makes you say that?" is the right one.

Five-minute parent warm-up

Do this before the lesson, with the family's actual apparatus and a scrap of paper, no child in the room.

Minute 1. Name, out loud, the one thing you will change on purpose. Name what will stay put. Say: "I am not going to ask which hypothesis is true. I am going to ask whether we can tell for sure."

Minute 2. Sketch a tiny table: Variable / Trial 1 / Trial 2. Leave the cells blank. Notice that the work is the grouping, not the vocabulary.

Minute 3. Imagine the child saying "I already knew rough stops it." Decide what putting the two distances next to that sentence would do. Decide what a scold would do. You are installing the meld of theory and evidence so you can hear it tomorrow.

Minute 4. Sketch a bad graph with no table underneath. Cross it out. The graph comes after the numbers.

[72] Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!* (2008), Chapter 5: scientific argumentation focuses on ideas; criticism targets ideas and observations, not the individuals who express them. Default I-R-E recitation does not carry the evidence-and-discourse strands.

Minute 5. Write the sentence you will actually say: "Can we tell for sure it was the variable we named — and what in the notebook makes you say that?" Put the pencil down. That sentence is the lesson.

If you can do those five minutes, you are ready to sit down. The child names the variable. You hear.

How to teach it this week

A good science hour this week has a shape. The science-hour chapter in the front of this book is the full version, including the AI rules and the safety line. Here is the shape scaled to this band.

Warm-up (3–5 minutes, unaided). Yesterday's table, covered. "What did we change on purpose? What did we measure?" Paper. No device.

Short model (5–8 minutes). One confounded trial you built on purpose, then one clean one, with the variable named on a card. You ask whether we can tell for sure. You explain why. Then you stop. Klahr's shape, not Klahr's percents.

Student attempt (20–25 minutes). The child names the variable, runs the trials, or builds the model. They write. You wait. Struggle before rescue: ask, wait, hint, then a short model on *your* scrap, not on their paragraph.

One good question. Not "which hypothesis is true?" A question that names the idea: "Can we tell for sure it was the variable we named — and what in the notebook makes you say that?"

Talk (8–10 minutes). A paragraph that makes a claim and points to a measurement. Claim, evidence, because. You are not assigning a five-page lab report.

Stop. While they still have a look left in them. A second sitting later in the week beats a long sit that ends in a fight.

Safety this year is still the adult in the room the whole try. Before you start, a short RAMP in ordinary language: recognize what could harm; assess whether this try is the one you wrote down; minimize — smallest amounts, food-safe if it is a kitchen table; prepare — you stay.[73] No unauthorized mixing. No homemade

[73]American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016): RAMP — Recognize, Assess, Minimize, Prepare; the teacher must be physically present during the entire experiment; no food in a chemical lab-

explosives. No child alone with heat. If the kitchen is used, the activity uses food-safe materials, or the surface is treated as contaminated until you clean it; lunch and the try are not simultaneous. The kitchen is not a secondary chemistry lab. This band's trials live on ramps, plants, water in a tray, a soft ball, a notebook. Simulations can illustrate a model. They are not, in any page this book opened, a ruling on athletic-eligibility lab credit.

Exact wording you can say

On a variable:

"Can we tell for sure it was the variable we named — and what in the notebook makes you say that?"

"What did you change on purpose? What did you measure? What stayed put?"

"What else was different?"

On a model:

"This is a tool, not the creek. What would it predict next?"

"What would we have to see in the tray to change the cards?"

On the paragraph:

"What do you think happened? What did you write down? Why would that measurement count?"

"What would a stranger reading only the notebook believe?"

On two accounts:

"Here is your first sentence. Here are the numbers. What do they do to each other?"

On force as fuel:

"You said it still had force in it. What did you actually *see* after it left your hand?"

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oratory; no unauthorized mixing. Designed mainly for the high-school chemistry teacher — the ceiling a home table must not pretend to clear. National Science Teaching Association, Position Statement, "Safety and School Science Instruction," revised April 2024: no food where laboratory activities or chem/bio hazards have been used. Flinn Scientific, *Student Safety Contract* (© 2017): never work alone; unauthorized experiments prohibited; never leave heating unattended. Kenneth Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020 (author's views): if proper PPE is not available, the activity must not be conducted; middle/high simulations named in a pandemic remote-school context, not as athletic-eligibility language.

When you are about to take over:

“Your notebook. I’ll wait.”

Then wait. Three to five seconds after you ask, and three to five after they stop. Rowe’s windows were measured in elementary science class; the pause still belongs here.[74] Mapping a table into a paragraph is hard work. A follow-up that arrives in half a second trains the child to wait *you* out, not to look at the cell.

First problem for the student

The family’s actual apparatus — ramps, plants, or water — with one named variable on a card:

two trials, one thing different, a table started.

Say: “Can we tell for sure it was the variable we named — and what in the notebook makes you say that?”

Wait. If the child recites “independent variable,” they used a heading. Cover the card. Ask what they changed. If they changed two things, the name did not hold. Reset. If they stare, model on a *different* pair — two paper slides, named “surface only” — said as “I can tell because the table shows only surface different, and the distances are 18 and 7” — then return to their apparatus.

Later the same week, the diagnostic item:

their first explanation on the left, the numbers on the right.

If the left already knew the answer and the right was never consulted, theory and evidence have melded. Ask what would make them change their mind. That is the move. It is not a course titled Critical Thinking.

Named investigation: Named Independent Variable

Time. One sitting plus a redesign. Thirty to forty minutes the first day; ten the next.

[74] Mary Budd Rowe, “Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control,” paper to the National Association for Research in Science Teaching, Chicago, April 1972, ERIC ED061103. Wait of three to five seconds. Not a homeschool trial.

Materials. The family's actual apparatus — ramps, plants, water in cups. Index cards. A notebook.

SAFETY. Adult present the whole try. RAMP before you start, in ordinary language. No unauthorized mixing. Food-safe materials if you are at a kitchen table. Water stays in the tray.

The fun. Catching the confound. Naming the thing you are actually testing.

The skill. Name what changed on purpose and what stayed put. Then redesign until the table matches the name.

Say: "Write the name of the one thing we are changing. Then run it. Then look: did we actually change only that?" If the redesign never happens, the first try was a performance.

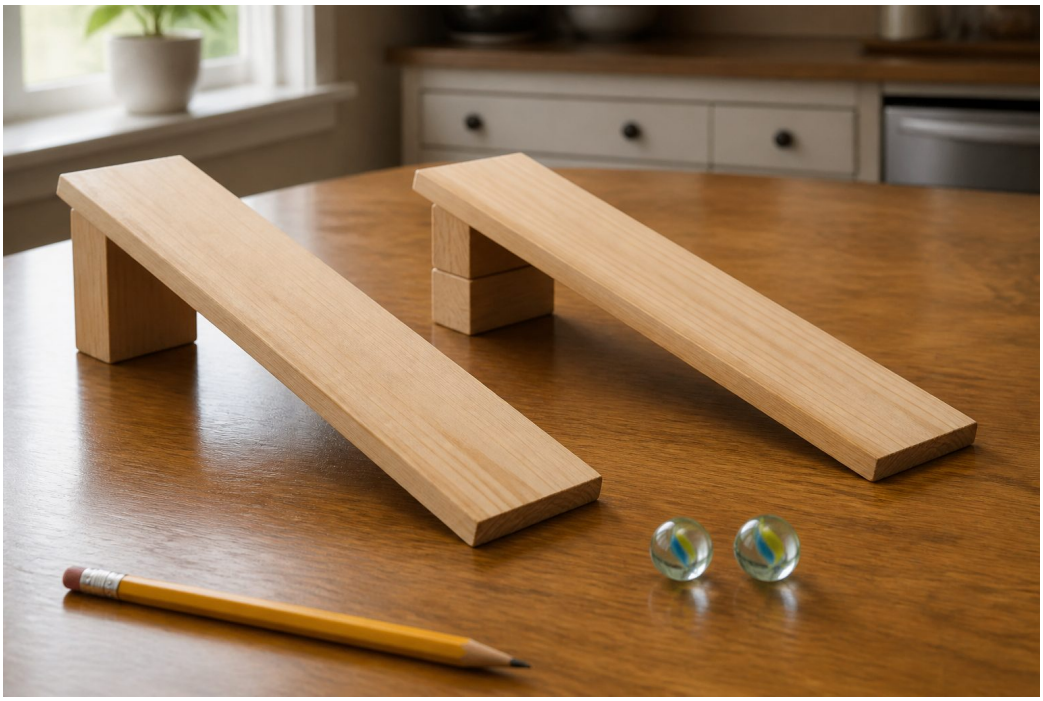

Figure 10: An index card that names one variable, two ramps or two cups set alike except for that one thing, a notebook table with two trials. Adult demonstration quality. No children. No logos.

Named investigation: Model on the Table

Time. One sit. Twenty to thirty minutes.

Materials. Paper. A physical model of *this* system: water cycle in cups on a tray, or a food-web card set of *this* habitat — backyard, creek, vacant lot — not every biome.

SAFETY. Water stays in the tray. Adult present. No tasting.

The fun. Moving the pieces. An argument about where the arrow goes is the point.

The skill. A model is a tool, not the thing. It predicts. The tray or the window checks. Middle-grade earth and life shape, not every biome and not every sphere named.

Say: “What would this model predict next? What would we have to see to change a card?” If the poster already told the story, take the poster off. The cups are the looking.

Figure 11: A tray with cups and simple arrows standing for water moving in a system, next to a few habitat cards, and a blank prediction line on paper. No children. No logos.

Named investigation: Table, Simple Graph, Paragraph

Time. One sit after data exist. Twenty to twenty-five minutes. Looking dies if you start the graph before the table.

Materials. The notebook. Graph paper or a drawn grid. A pencil.

SAFETY. None.

The fun. "The line goes up." A graph they built from their own cells.

The skill. Middle-grade data practice as the *Framework* names it: a table, a simple graph, averaging if you have enough trials. Not a statistics course.

Say: "Table first. Graph second. Paragraph third, and the paragraph points at

a number." If they draw the graph from a memory of the try, the belief did the graphing. Cover the graph. Open the table.

Named investigation: Claim–Evidence–Reasoning in Ordinary Language

Time. One sit after a table exists. Fifteen to twenty minutes.

Materials. The notebook. No chatbot in the room.

SAFETY. None.

The fun. Being the person who can defend a sentence with a cell.

The skill. One claim, the numbers, a because-sentence. IQWST's spine as *Ready, Set, SCIENCE!* reports it. Argument about this trial's data, not a debate to win.

Say: "What do you think happened? What did you write down that supports that? Why would that measurement count?" If they write a beautiful because with no number, the because is a feeling. Finger on the cell. Wait.

Named investigation: Two Accounts of the Same Trial

Time. One sit. Fifteen minutes. Two pages side by side.

Materials. The child's first explanation, written before or during the try. The notebook numbers after.

SAFETY. None.

The fun. Catching yourself. "I already knew" next to 18 and 7.

The skill. Theory next to evidence. *Taking Science to School*, reporting Kuhn and colleagues, is plain: even adults meld them into "the way things are."[75] "I already knew rough stops it" is the misconception. The numbers are the second account.

[75] National Research Council, *Taking Science to School* (2007), Chapter 5, reporting Deanna Kuhn, Eric Amsel, and Michael O'Loughlin (1988) as cited: even adults meld theory and evidence into "the way things are." This book did not open the 1988 monograph; the wording is TSTS's.

Say: “Read your first sentence. Read the table. What do they do to each other? What would make you change your mind?” If they rewrite history so the first sentence always matched, the meld won. Keep the first page. Date it.

Named investigation: “Force as Fuel” Repair

Time. One sit. Fifteen to twenty minutes.

Materials. A soft ball. A table. A book. Indoor space.

SAFETY. Soft ball. Indoor. No throwing at people. Adult present. The book stays on the table; no stacking to make a stunt.

The skill. Hear the prior idea. Put the observation next to it. Not a high-school mechanics year.

The fun. A throw you can watch twice. A book that does not fall through the table.

Say: “You said it still had force in it going up. Watch again. What do you actually *see* after it leaves your hand?” Then, another day if needed: “The book is sitting. What would have to be true of the table?” If they still tell the fuel story, you heard it. Stay. One observation a week is enough. Plants eating through roots can use the same shape on a different day: what did we actually see this plant do?

Discussion box

This is an illustration, not a reported family. A named-variable card is on the table. A notebook is open to a table of trials. The parent has not announced a winner.

Opening question

“Can we tell for sure it was the variable we named — and what in the notebook makes you say that?”

Not: “Which hypothesis is true?”

Follow-ups (pick three to five; you will not use all of them every sitting)

1. What did you measure?

2. What else was different?
3. What would a stranger reading only the notebook believe?
4. What would we have to see to change our minds?
5. What would the model predict next?

How to wait

Ask. Count three to five seconds in your head. Look at the notebook, not at the child's face, if the silence is hard. After they stop talking, wait three to five seconds more before you speak. Rowe's windows. *Ready, Set, SCIENCE!*: "Take your time. We'll wait." Homeschool is usually one child. Child-to-child comparisons will often be you and them. That is a setting difference, not a reason to skip the wait. Revoice if you need a bridge: "So let me see if I've got your thinking right. You're saying ____?" Then wait again.[76]

What a stuck silence usually means

The question was recitation in disguise — "what is the independent variable" as a vocab quiz. Or there was not enough of the idea on the table: a paragraph with no trial. Or they melded the theory with the data, and the first account already "knew." Or the model already summarized the hour, so looking felt redundant. Or wait-time 2 was cut. Next move: put the two accounts side by side, finger on one cell, ask the opening question again. Done enough this week: a paragraph that makes a claim and points to a measurement. Not a five-page report. Not a chatbot in the room.

Practice that actually builds learning

Blocked, for a new move. The day you introduce a named variable, only that apparatus, only one contrast, a redesign. The day you introduce a model, only the tray or the cards. The day you introduce CER, only one claim from a table that already exists. Mixing too early makes the child hunt for the school move instead of pointing at a cell.

[76] Michaels, Shouse, and Schweingruber, *Ready, Set, SCIENCE!* (2008), Chapter 5, six talk moves, including revoicing ("So let me see if I've got your thinking right. You're saying _____?") and wait time ("Take your time. … We'll wait.").

Mixed, for when to use it. Later the same week, the named variable reappears next to the model and the two accounts. Mixing is the practice of choosing: is this a grouping of trials, a tool that predicts, a graph of numbers we already have, or a prior idea sitting next to an observation? You impose that mix on the year you already have. A purchased book that is all kingdoms can still be mixed by you pulling one habitat and one fair test onto the table. Depth is the hour. Coverage of every kingdom is a map.

Brief retrieval of tables already written. Two minutes, mixed, after the child can talk those tables untimed. Cover the headings. You listen. Overlearning a method poster until tonight's score is perfect is the wrong retrieval for this band. Retrieval is a second look at a cell they already own.

One incorrect example to diagnose. After the child has attempted a clean named-variable sitting, show a paragraph with no number, or a graph with no table, or a race with two things different and a confident claim. Ask: "What would a stranger believe? Can we tell for sure?" After "I already knew," put the first account next to the numbers. The child names the miss. You do not narrate it as a verdict on talent.

Talk every sitting. A paragraph that points at a measurement is done enough. Complex talk — a reason tied to a cell, a model's prediction checked — is already the thing later lab writing will need. You are not assigning a full report every Tuesday. You are teaching a paragraph the child can hold.

Kitchen, tray, and making. A kitchen scale can motivate a measurement sitting. It does not replace the named variable on the family's actual apparatus, and it does not turn the kitchen into a secondary lab. A model made of cups is making in the service of a prediction. It does not replace the window. Heat, household cleaners, and unauthorized mixing stay off the table.

Read-aloud and a short text. Ten to fifteen minutes, you reading a short science text or they reading one page, then talking. New words live here. The investigation hour does not have to carry the whole language load. The try comes first. Then the question. A glossary is still a glossary.

A weekly shape: day of a new move, a blocked sitting. Same week: mixed retrieval of older tables. Later this week: the new move next to an unlike object — a plant trial next to a ramp, a model next to a thrown ball. Daily, if you can: one cell, one sentence. You impose that shape on the integrated year or the rotating year you already have. The maps differ. The move does not.

Live debate, named in one sentence, then teach: whether "everyone does integrated now" — California preferred, not Texas grade-level, not Virginia's Life/Physical titles, not Appendix K's refusal of an ideal order. Whether to compact this child into high-school Biology while the fair test is still unprompted. Whether to empty the year for every kingdom. Coverage is a map. Depth is the hour.

For the student

You are learning how a variable works, and how a paragraph has to point at a number. You name the one thing you are changing on purpose. You write a table. You say whether we can tell for sure, and you point at the notebook when you say it. A long word is a name. The cell is the work.

A card that names the variable. A table with two trials. A paragraph that uses one of those numbers. That is science a stranger could read.

Tiny worked example

Card: surface. Tilt the same. Ball the same.

Table: smooth 18; rough 7.

Can we tell for sure it was the surface? Yes — because the notebook shows only surface different, and 7 is less than 18.

That is a named variable plus a paragraph. The because lives in the table.

Two tries

1. Write one paragraph that states a claim, points to one real measurement in the notebook, and names one thing that was *not* changed — without a chatbot in the room.
2. Put your first explanation of a trial next to the numbers from that trial. Say what they do to each other. Say what would make you change your mind.

For the second one, "I already knew" is a feeling. The numbers are the second account.

Write the paragraph even if writing is slow. The number has to be in it. Your grown-up can help with spelling after you say the because.

Explain it back

Tell someone at the table, in your own words, what an independent variable is *in this trial*. Then point to a cell and say what a stranger would believe. Then point to a model and say what it would predict next, and how you would check.

Challenge

Some people change two things and still name one variable. Some people write a paragraph with no number. Some people say a thrown ball still has force in it until it stops going up. Some people let a poster of the water cycle do the looking. What would those four moves mean? How do you look at the *notebook* instead? How do you ask whether we can tell for sure?

You are allowed to struggle. You may use ramps, cups, a soft ball, two notebook pages. You name. You measure. You talk. If you get stuck, ask for a hint — not the vocabulary word. Then try again.

A model is a tool. It is not the creek. You can move the pieces and still be wrong, and that is the work.

When you talk, a paragraph that points at a measurement is enough for today. You do not have to write a five-page report. That is later. Today you name one thing, you write the table, you say one true because.

A picture a computer made of a cell, or a data table a computer filled, is a scene. It is interesting. It is not your trial.

If it isn’t clicking

Three diagnostics. Each one has a next move. None of them is a verdict on talent, and none of them is a reason to wait for a birthday.

1. The child cannot name what they changed, or the table always has two things different, or they recites “independent variable” without pointing.

The grouping is not yet a tool. Next move: fewer variables, more teaching. You build one messy trial and one clean one. You ask whether we can tell for sure. You explain why. Then they name and redesign. Klahr and Nigam’s shape was grades 3–4; the shape still holds. Stay with one apparatus. If this is still the bottleneck after several weeks of short daily naming, stay here. A high-school Biology year

on top of a child who cannot tell a messy trial from a clean one will not hold. Compacting into a ninth-grade book because a catalog printed a grade on the cover is the wrong next move. A human who will sit with a table and wait, not with a tablet that writes the paragraph, is a reasonable next step if you have tried the named contrast and the cell still does not come.

2. The child writes a fluent paragraph with no number, or draws a graph before the table, or lets the model tell the story.

The cue is still a genre, or a poster. Next move: table first, graph second, paragraph third, finger on a cell. Cover the model until a prediction is written. The prompt is always through the record: "What did you write down?" After an attempt, one incorrect example to explain ("this paragraph never points at a number — what would a stranger believe?"). Slow down the "interesting" survey until a because can be tied to a cell; a child who can recite kingdoms and cannot point at a trial is not ready to skip this. Go ahead once they can name one variable, fill a table, and write a paragraph with a number in it. A tutor is useful if the fluent empty paragraph remains the default after a couple of weeks of daily cell-first work *and* the hour has become a fight.

3. The child will not talk, or every sitting ends in "I already knew," or force-as-fuel swallows the observation, and the silence after your question is a wall.

Talk is the product, and melding theory with evidence is the mind at rest. Next move: shorter sits, two accounts already on the table, the opening question from the discussion box, wait three to five seconds twice. If silence is hard, you look at the notebook, not at them. If you hear yourself answering, you have started doing the work. For "I already knew," keep the first page, date it, put the numbers next to it. One force-as-fuel sitting a week is enough. If the hour has become a fight after a stretch of daily short sits, a human who will wait, not a chatbot that fills the paragraph, is the release valve.

When to slow down. Variables still unnamed in the actual try. Paragraphs still empty of numbers. Models still doing the looking. Fair test still unprompted while a high-school book sits on the shelf. Those are brakes. "Not ready" because of age is the brake this book will not use. "Not ready" because the move has not yet become a tool is a real brake. NAEP's 31 percent at or above Proficient is not a reason to panic this child, and it is not a reason to skip the table.

When to go ahead. A named variable is an easy set: one thing different, a table, a paragraph that points. The child points at a cell, then talks. A model predicts

and gets checked. Two accounts can sit side by side. Force-as-fuel has been heard, not scolded. Short sits are ordinary. Then Biology, Chemistry, Physics, and Earth and space — as the map you actually use places them — have somewhere to sit. Being "good at science" because a child loves a dense textbook is not a reason to skip the notebook.

When to get a human tutor. You have run the named-variable sitting, or the two-accounts page, or the wait after the question, for a stretch of daily sittings, and the same diagnosis is still the one in the room, and the hour has become a fight. A tutor is a release valve, not a failure of the sitting. Keep yourself as the person who can still hear an empty paragraph and a generated table. Outsourcing the hearing is the thing to avoid, not asking for help.

A child who can measure and will not argue from the cell is missing one strand. A child who can talk a stream about cells and cannot name what they changed is missing another. Hearing which is thin is enough. If the child is missing the variable, model a *different* apparatus, then guided naming, then theirs. If the child has the variable and the task is a first model, prediction first, then the tray, is the second sequence.

Tools, including AI

Optional helpers for you, the adult. The full rules live in the science-hour box in the front of this book. This chapter is a pointer, not a second policy paper.

The short version: the child names, measures, and writes first. You hold the key. A tool may explain one model *to you* from a named textbook page, make extra isomorphic graph practice with the answers on a page you keep, write a hint script for a claim, or diagnose a paragraph the child has already written. The child writes on paper. The child talks in the room.

Leave these out of the hour: a chatbot that writes the lab report or the CER paragraph; a model that invents a data table or an observation; a generated micrograph or "result" treated as Figure 1; "what's the answer" as the whole sitting; an unsupervised chatbot during the trial; a photo-to-key of the lab sheet. A generated picture of a cell may be a discussion object, labelled as generated. It is never the measurement.[77]

[77] Elsevier generative-AI policies (page updated June 2026) and Nature Portfolio AI policy: do not fabricate data, citations, or results; do not create photorealistic images as experimental evidence.

A language model will happily produce a lab-report-shaped page. Treat every model-supplied number, citation, and "typical result" as untrusted until it lives in the child's notebook or on a named book page.[78] Fluent talk from a tool is performance, not the child's knowledge of the variable. The unaided paragraph tomorrow morning is the test.[79] A high-school math study found that an unguarded chatbot raised assisted practice and then cut the unaided exam; that paper is mathematics, not a science trial. The crutch is still the sitting condition. If the tool produces the table or the paragraph, the child is a spectator.[80]

A named-variable card, a tray of cups, a soft ball, and two notebook pages are tools too. Use them, then fade them.

What "done enough" looks like

Placement is by skill, not birthday. A "grade 6 science" book is a publisher's scope, not a legal grade. Integrated, rotating life/earth/physical, or a purchased middle-grade reader can place the same child in three different rooms. Choose by fit. This book names those programs as options in the resources chapter. It does not rank them. The transcript, when you need one, still says Science, Life Science, or Physical Science as the work matches. It does not say a brand. It does not say Inquiry 101.

Checklist before moving on

- The child can name the one thing changed on purpose, name what was measured, and name one thing that stayed put, pointing at the notebook.
- When asked whether we can tell for sure, the child can point at a cell, or at a confound, and say what a stranger would believe.

A generated cell is a scene, never Figure 1.

[78]William H. Walters and Esther Isabelle Wilder, "Fabrication and Errors in the Bibliographic Citations Generated by ChatGPT," *Scientific Reports* 13 (2023): 14045. GPT-3.5: 55 percent of citations fabricated; GPT-4: 18 percent. Of the real citations, 43 percent and 24 percent had substantive errors, including wrong dates. Same paper: fabricated methods and results.

[79]Nicholas C. Soderstrom and Robert A. Bjork, "Learning Versus Performance: An Integrative Review," *Perspectives on Psychological Science* 10, no. 2 (2015): 176–199.

[80]Hamsa Bastani, Osbert Bastani, Alp Sungu, Haosen Ge, Özge Kabakcı, and Rei Mariman, "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent assisted practice, then −17 percent unaided exam, in high-school mathematics. Not a science trial. The sitting condition is the mechanism used here.

- A simple graph exists only after a table exists, and a paragraph points at a number.
- Claim–evidence–reasoning can be done in ordinary language about this trial, without a chatbot in the room.
- Two accounts of the same trial can sit side by side. “I already knew” has been heard.
- A model has predicted something that could have come out otherwise, and been checked.
- Force-as-fuel and plants-eat-through-roots have been heard and put next to an observation. You did not require a high-school mechanics year or a photosynthesis year to hear them.
- The map you actually use — integrated, grade-level Science, Life/Physical titles — has been named in one sentence. One state’s alternative sequence is not a national rule.
- Sits can end with a paragraph. You did not require a five-page report or a method poster as the whole hour.
- You can hear an empty paragraph, a generated table, and a vocabulary quiz on “independent variable,” and you can ask a good question, without taking the notebook.

If most of that list is true, go on to high-school Biology as the map places it, even if the birthday says otherwise. If the birthday says “ninth grade” and the fair test is still unprompted, stay. The next chapter is cells, genetics, ecology, and a body as a system — with this notebook still in the room.

A path through science is the promise. A percentile is not.

Chapter 4

Biology

Figure 12: A kitchen-table still-life: a potted plant, an open notebook, a named textbook cell diagram (not a micrograph), a closed pencil. No people, no logos, no gels.

Why this matters

High-school Biology is how a student learns that living things are systems — cells doing jobs, matter and energy moving, traits varying in a group, living things depending on one another in a place — and then to answer a real question from an observation that actually happened. It is not a slog of every kingdom. It is not a brand. It is not an exam title unless you chose that exam.

That is worth the struggle because the rest of a college-ready science path hangs on it. Chemistry will ask where the atoms in a sugar came from. Physics will ask how energy moves. Earth science will ask how living things and a planet change one another. A year that races through a table of contents, never sits with a plant or a named figure, and never lets the student write a claim that points at what they saw is Biology in name. Name the year by the systems you actually went into, the questions you actually asked, and the looking the student actually did.

There is no national biology syllabus. The National Research Council's *Framework* maps life science as four core ideas: organisms as systems, ecosystems, heredity, and biological evolution.[81] The *Next Generation Science Standards* package those ideas as high-school life science. They are goals, not a curriculum and not a homeschool law.[82] California's four-course biology year names the segments in ordinary language: structure and function; growth; matter and energy flow; ecosystems; inheritance; variation; common ancestry; natural selection; adapta-

[81] National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: The National Academies Press, 2012), doi:10.17226/13165. Life-science core ideas LS1–LS4: from molecules to organisms; ecosystems; heredity; biological evolution. Access date for URLs in these notes: 1 September 2026.

[82] NGSS Lead States, *Next Generation Science Standards: For States, By States* (Washington, DC: The National Academies Press, 2013), front matter and Appendix A. The NGSS are "standards, or goals"; "The NGSS are Standards, not Curriculum"; they "do not dictate nor limit curriculum and instructional choices." Appendix K: middle- and high-school standards are grade-banded because there is not conclusive research identifying an ideal sequence. Biology–chemistry–physics is described as "currently a common sequence," not as a statute.

tion.[83] Texas's public diploma makes Biology a required science credit.[84] Virginia names Biology I and tests it.[85] None of those maps is homeschool law. None of them is the other coast. If this family did not already spend two middle-school years on life science, you are not behind a national clock. California's integrated middle school is one coast. Texas's grade-level Science is another. You are starting a high-school year. Teach the moves.

The registrar word is **Biology**. NCAA's sample transcript uses that ordinary title — and *Biology with Lab* when the family claims the lab. The lab claim is a records job; this chapter is the looking that would have to sit in the folder.[86] Never write a curriculum brand in the title column. Never write "AP Biology" unless the student is actually sitting that course-and-exam.

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[83]California Department of Education, *2016 Science Framework for California Public Schools*, Chapter 8, Four-Course Model: Life Science/Biology, https://www.cde.ca.gov/ci/sc/cf/documents/scifwchapter8.pdf. Instructional segments include structure and function; growth and development; matter and energy flow; interdependent relationships; inheritance; variation; evidence of common ancestry; natural selection; adaptation. Assessment boundaries quoted in that chapter: HS-LS1-1 does not include identification of specific cell or tissue types or whole-body systems; HS-LS1-4 does not include rote memorization of the steps of mitosis; HS-LS1-5 / HS-LS1-7 assessment does not include specific biochemical steps of photosynthesis or respiration. California State Board adopted CA NGSS on 4 September 2013. Local educational agencies choose high-school course order.

[84]19 Tex. Admin. Code §74.12 (Foundation High School Program), as displayed on Cornell LII: three science credits; one must be Biology (or AP/IB Biology); second from IPC, Chemistry, or Physics (or named equivalents). Texas Education Agency, 19 TAC Chapter 112 index, Biology (One Credit), Adopted 2020, https://tea.texas.gov/laws-and-rules/texas-administrative-code/19-tac-chapter-112. Public-school map, not homeschool law. Student-expectation wording in the TEKS PDFs was not successfully opened for this book.

[85]Virginia Department of Education, Science Standards of Learning page, https://www.doe.virginia.gov/teaching-learning-assessment/k-12-standards-instruction/science/standards-of-learning: Biology I as a course; statewide SOL tests named include Biology. Standard Diploma: three laboratory-science credits from at least two of earth sciences, biology, chemistry, or physics, https://www.doe.virginia.gov/parents-students/for-students/graduation/diploma-options/standard-diploma-graduation-requirements. Public-school map, not homeschool law. Full 2018 SOL PDF not successfully downloaded for quoted student-expectation text.

[86]NCAA Eligibility Center, *Home School Toolkit 2025–26*. Sample titles include Biology with Lab. Course name on the worksheet should match the transcript title. Division I Academic Standards fact sheet (September 2023, still hosted 1 September 2026): 16 core courses including Science (including one year of lab, if offered) — 2 years. High School Review Committee language names the core area natural/physical science. CLEP / credit-by-exam is not an NCAA-approved core course. A standalone "Chemistry Lab" is not approved separately.

AP Biology is an optional College Board object. The current overview names it as an introductory college-level biology course, with high-school biology and chemistry as recommended prerequisites, and with a quarter of instructional time in hands-on laboratory work.[87] It is a possible beyond. It is not this chapter's floor. If the student sits the exam, College Board forbids AI-generated answers, including text, image, and graph.[88] Credit is by college. A path through biology does not require the letters AP.

Coverage is a map. Depth is the hour. You will not finish every organelle, every cycle name, every biome. You will finish some questions, in some systems, with an observation on the table. Dissection is optional. This book never requires it. The public maps this book opened do not require it either.[89] If a family uses it, it is a choice with a safety plan, not a badge.

This week you can learn why "plants take in food through roots" is a prior idea doing work, and how to hear a coverage slog as "we need one observation and a claim, not another kingdom." Today the student can answer one biology question from one real observation — a plant, a slide, or a named figure — pointing at what they saw, model closed.

For the parent: understand it yourself

You do not need to be a biologist. You do need to understand today's idea well enough to hear "cells eat like tiny mouths" and "the mass of this plant came from the soil" not as cute slips.

Everyday picture. Think of a kitchen. The kitchen is not a mouth. It is a system: parts doing jobs, inputs coming in, outputs going out, a loop that fails if the drain

[87] College Board, AP Biology course overview PDF (© 2026), https://apcentral.collegeboard.org/media/pdf/ap-biology-course-overview.pdf, and course page https://apcentral.collegeboard.org/courses/ap-biology. Introductory college-level biology; recommended prerequisites high-school biology and chemistry; 25 percent of instructional time in hands-on laboratory work; exam 3 hours. College Board course-and-exam. Credit by college. Optional beyond, not this chapter's floor.

[88] College Board, AP Exam Terms and Conditions 2026, Section 4 (updated 27 April 2026): no part of test answers, work, or submission may be generated in whole or in part using AI tools, including text, image, and graph.

[89] Architecture of this book, matching opened NGSS / California Framework pages: no performance expectation opened for this book requires dissection. Dissection remains a family choice with a safety plan.

backs up. A cell is more like that kitchen than like a person chewing. A plant is more like a factory that builds sugar from air, water, and light than like a diner that orders food through roots. An ecosystem is more like a neighborhood of kitchens sharing ingredients than like a poster of biomes. The body is more like several kitchens talking to one another than like a labelled chart of parts.

Precise picture. A *cell* is a living system. Parts have jobs. The membrane is a boundary that lets some things through. The interior is where chemistry happens. Plants and animals are built of cells; a cell is not an atom, and an atom is not a cell. The nucleus holds information; it does not sit in a director's chair giving orders in English. When a student treats a cell as a tiny mouth that chews, they have taken a human picture and shrunk it. The repair is a job list, not a scold.[90]

Photosynthesis, in the language this year actually needs, is inputs and outputs. Light, water, and carbon dioxide in; sugar and oxygen out. Cellular respiration is the other direction of that flow, not a synonym for breathing. The assessment maps this book opened stop short of biochemical steps and of rote mitosis lists. You do not need the Calvin cycle this week. You need a model the student can point at: what went in, what came out, where the mass of a growing plant could have come from.[91] Many adults are surprised that much of a plant's mass comes from the air around it. That surprise is the idea, not a trick.

Variation is that members of a group are not copies. Leaves on one tree differ. Seed pods differ. Offspring resemble parents and are not identical to them. Inheritance is the map's word for how information moves from one generation to the next. You do not need meiosis memorized as a chant. You need "not copies," then a first account of how a trait can be more common in a later generation.

Evolution, as the public maps place it, is change in a population over generations: variation exists, some variants leave more offspring in this environment, the mix of traits in the group shifts.[92] Families teach this idea inside different worldviews.

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[90] National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8* (Washington, DC: The National Academies Press, 2007). Cellular misconceptions as TSTS reports them (citing Dreyfus and Jungworth, 1989; Flores, Tovar, and Gallegos, 2003): cells as inanimate; confuse atoms and cells; anthropomorphic nucleus "directing" the cell; nutritive processes as miniature chewing; confuse cellular respiration with breathing.

[91] California *2016 Science Framework*, Chapter 8, assessment boundaries for HS-LS1-5 and HS-LS1-7, as in note 83.

[92] NRC, *Framework* (n. 81), LS4; California Framework Chapter 8 segments on evidence of common ancestry, natural selection, and adaptation; NCAA Home School Toolkit worksheet-instructions sample names evolution of populations among biology topics. Teach the idea as the

Teach the idea on the table. A culture-war week is not this hour.

An *ecosystem* is a place. Who eats whom *here*. What limits how many. One habitat, one question, beats a slog of biomes. The *human body as a system* is interacting loops that keep conditions in range — feedback — not a medical-school anatomy year and not a dissection requirement.

A generated picture of a cell or a gel is a scene to look at together, labelled generated. It is not Figure 1. It is not what the student saw at 400×.[93]

Wrong answers you should be able to hear

1. Cells as tiny mouths. "The cell eats." "The nucleus tells it what to chew." "Atoms and cells are the same small things."

What it usually means. A human picture got shrunk. Nutritive processes were imagined as miniature chewing. Atoms and cells were collapsed because both are "too small to see." The nucleus became a person.

What to say. "A cell is a system, not a mouth. What part is doing which job in this figure? An atom is a piece of stuff. A cell is a living system made of lots of stuff. Let's keep those two sizes apart."

2. Plants eat through roots. "The plant's food is in the soil." "It drinks food." After plants are recognized as living, the student overgeneralizes eating and sleeping onto them.

What it usually means. A powerful prior idea is doing work: living things take in food the way we do. Roots take up water and minerals. Sugar is built in the leaves from inanimate raw materials.[94]

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maps place it.

[93] William H. Walters and Esther Isabelle Wilder, "Fabrication and Errors in the Bibliographic Citations Generated by ChatGPT," *Scientific Reports* 13 (2023): 14045. GPT-3.5: 55 percent of citations fabricated; GPT-4: 18 percent. Of the real citations, 43 percent (GPT-3.5) and 24 percent (GPT-4) had substantive errors, including wrong dates. Elsevier generative-AI policies (updated June 2026) and Nature Portfolio AI editorial policy: do not fabricate data or create photorealistic images as experimental evidence. A generated cell is a labelled scene, never Figure 1.

[94] NRC, *Taking Science to School* (n. 90): after plants are recognized as living, overgeneralization that plants eat and sleep; "a powerful idea for them is that plants take in their food through their roots, rather than understanding that they synthesize sugars in their leaves from inanimate raw materials" (Roth, 1984, as cited). Many adults "are quite surprised at how much of the mass of plants comes from the air around them."

What to say. “Roots take up water and minerals. Food, in this model, is the sugar the plant builds. Where did the mass come from — and what did you actually see that makes you say that?”

3. Respiration means breathing; a cycle name is the explanation. “Photosynthesis is the Calvin cycle.” “It happened because of mitosis.”

What it usually means. A label replaced the flow. Breathing and cellular respiration got fused. A cycle name was treated as a cause.

What to say. “Breathing moves air. Cellular respiration is a cell using sugar. Name what went in and what came out. The cycle name is a hanger, not the observation.”

4. Coverage as the year’s purpose. Forty kingdoms named, two finished, no observation on the table after October. Or dissection treated as the proof that Biology happened.

What it usually means. The table of contents won. Depth felt like falling behind. A dramatic lab was treated as the year.

What to say. “We will finish this question in this system. Then another. The transcript will tell the truth about what we studied. A list of kingdoms we sped past is not a year. Dissection is a choice. It is never the badge this book requires.”

5. A fluent report whose observation no one can reopen. Diction jumped a grade. The “micrograph” was generated. The gel is a picture a model made. The citations look real.

What it usually means. The work was outsourced. Language models invent titles, dates, and results. A generated cell is a scene, not data.

What to say. “Show me the notebook. Finger on the observation. If we cannot open it, it comes off. You will write the claim with what you saw. The model stays closed.”

Five-minute parent warm-up

Before the lesson, on paper, no student in the room:

1. Write one sentence: a cell is a system, not a mouth. Name two jobs a part of a cell does in the figure you will actually use this week.

2. Write photosynthesis as inputs and outputs, not as a cycle chant. Then write one sentence on where a growing plant's mass could have come from, and what you would still need to measure.
3. Write tonight's question in one line an observation on the table can speak to. Star it if a named figure will have to stand in for a microscope.

If those three are fluent for you, you can hear a tiny-mouth and a coverage slog. That is the job. The student still does the looking.

How to teach it this week

Run the door before you call the year Biology.

Is there a question? If the hour is "read chapter 14 and tell me the organelles," you have coverage. Write a question an observation can answer.

Is there a real observation? If every "result" is a chatbot summary or a generated micrograph, stop. A plant, a slide the adult prepared, or a named textbook figure. Then the notebook.

Can they point at what they saw? If they dive into a cycle name, cover the page. What did you see? Then the word.

When the gates are open, here is the shape of a sitting. Warm-up. Short model. Student attempt. One good question. Mixed practice. Exit ticket. The science hour at the front of this book already taught this shape. This chapter fills it with a biology year.

Warm-up (3–5 minutes, unaided). Yesterday's system in one sentence. One "what went in / what came out" on a figure they have already seen. One trait that varied in a group they have already looked at. No tool.

Short model (5–8 minutes). You put a plant or a named figure on the table. Think aloud: "Here is the question. Here is what I am going to look at. Here is what I write down — not what I hope. My claim, which you could argue with, is ____. The because-link is this line in the notebook. The model on paper predicts ____ that we have not measured." Keep it short. You are showing looking, not delivering a lecture on a kingdom.

Fade as soon as you can. Second sitting: they explain your observation. Third: they record while you watch. Fourth: they write the claim unaided, model closed.

Include one incorrect example: a cell as a tiny mouth; a generated "what I saw at 400×"; a cycle name treated as the mass of the plant.

Exact wording you can steal.

On a cell: "A cell is a system, not a mouth. What job is this part doing in the figure?"

On photosynthesis: "What went in? What came out? Where could the mass have come from?"

On roots: "Roots take up water and minerals. Food, here, is the sugar the plant builds."

On variation: "Not copies. What is the same in this group? What is different?"

On an ecosystem: "We are staying in this place long enough to answer one question. We will skip a list of biomes on purpose."

On the body: "What happens if this loop fails? That is a system question, not an anatomy chant."

On evolution, once: "The public maps place change in a population here. We will teach the idea on the table: variation, then what happens to the mix of traits over generations. Then we look."

On the chatbot: "If we cannot open the observation, it is not data. A picture a model made is a scene to look at. It is not what you saw."

First problem for the student, after the model. One question, one real observation (plant, slide, or named figure). Product goal on a sticky note: a claim in their own words, with a finger on what they saw. Book or packet open for the named figure if that is the observation. Model closed. You wait. Struggle before rescue. You do not summarize the looking for them. You do not finish the paragraph.

One good question. After the attempt: "If I hid the notebook, would your claim still know where it came from?" The student generates the why.

Student attempt, then mixed practice. Two or three short claims of the new type, unaided, after the fade — not five lab reports. Then mix: yesterday's cell jobs, last week's inputs and outputs, one "generated scene, then a named figure," one "plants eat through roots" repair.

Exit ticket (5–10 minutes, unaided). One question, one named observation already on the table, a three-to-five-sentence claim. Tool closed. You grade the unaided ticket. A fluent report with an unopenable observation is performance. The claim that points is the test.

Every report the transcript will claim needs an unaided draft the model did not open. That is the year, not a special integrity week. If they sit AP, the exam already says the same thing in its own language.

How to fade help. You look and record → they explain your observation → they record the second sitting → they write the claim → they choose the next system's question with you. When they can name inputs and outputs without your prompt, put the scaffold away. Bring it back when a new kind of system arrives — an ecosystem, a body loop, a population.

When to stop talking. After one model and one question. You do not become the textbook. You hold the key: is there a question, a real observation, and a claim that points?

Investigation 1 — Cells as Systems, Not Tiny Mouths

Time. One science hour.

Materials. A named textbook figure of a cell as a diagram, *or* — if the family has a microscope and can do it safely — one real slide the adult prepared. Notebook. Pencil.

SAFETY. Adult present the entire time. No homemade stains from cleaners. Microscope lamp never near water. If there is no microscope, the named figure is enough. A generated "what I saw at 400×" is not the observation.

The fun of it. Parts doing jobs. The student gets to treat a cell as a kitchen, not as a mouth.

The skill it builds. Structure and function without a medical-school year. A cell as a living system. Atoms and cells kept apart.

How to run it. Put the named figure on the table. "What jobs do you see?" They label two or three parts by job, not by a list they chanted. If you have a slide, they draw what they actually see and write one sentence that a stranger could check. A generated cell, if you ever show one, is labelled generated, looked at for two minutes, then taken off. The named figure or the slide stays.

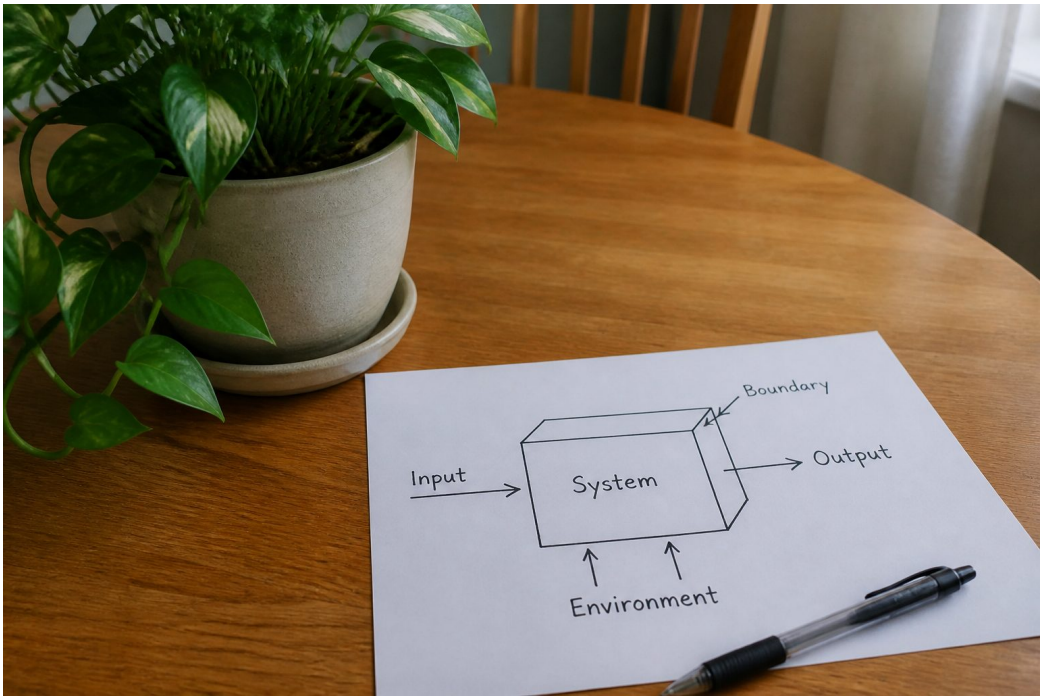

Figure 13: A named textbook-style cell diagram on a table as a still-life, notebook open, no people, no logos, not a micrograph.

Investigation 2 — Photosynthesis as Inputs and Outputs

Time. A multi-day plant trial already in the house, or one sitting with a paper model of inputs and outputs if a trial is not running.

Materials. A plant, light, water, notebook. Or a paper diagram of arrows: light, water, carbon dioxide in; sugar and oxygen out.

SAFETY. Food-safe materials. No sealed containers that can burst. Adult present if anything is moved or watered as part of the trial.

The fun of it. Where did the mass come from? Adults are often surprised. Students like being the person who can say why.

The skill it builds. Energy and matter flow as a model, not biochemical steps.

How to run it. Write the question before you look: *Where did the mass of this plant come from — and what did you actually see that makes you say that?* Record

mass, or height, or a leaf count, or simply the condition of soil and air as honestly as you can. Then the model on paper. What does it predict that you have not measured? That missing measurement is information, not a failure.

Investigation 3 — Trait Variation in a Group

Time. One sitting.

Materials. A real group the family can see: leaves on one tree, seed pods from one plant, beans in a bag. Notebook.

SAFETY. No tasting wild plants the adult cannot name. Adult present outdoors. Wash hands after handling soil or plants.

The fun of it. Not copies. Difference you can see without a microscope.

The skill it builds. Variation exists. Inheritance as resemblance-plus-difference, not meiosis memorization.

How to run it. Collect or photograph (phone as a record, not as a search) a handful of leaves from one tree. Sort. Measure one feature. Write: what is the same, what is different. Then: if these were offspring, what would "like the parent, not a copy" look like in the notebook?

> **Discussion box**
>
> *Illustration, labelled as such: a potted plant the family has been watering, a notebook with two mass or height numbers, a paper inputs/outputs sketch. Composite table, not a reported family.*
>
> **Opening.** "Where did the mass of this plant come from — and what did you actually see that makes you say that?"
>
> Not: "Define photosynthesis."
>
> **Follow-ups** (pick three to five). What in the notebook supports that? What would have to be true if the mass came from the soil? What does the model (inputs/outputs) predict that we have not measured? What would change your mind? If two accounts are on the table, can both be useful for different questions?
>
> **How to wait.** Three to five seconds after you ask. Three to five after they stop talking. Look at the plant or the notebook if the silence is

hard. Wait time of that length is a finding from elementary science classrooms, not a biology-score promise.[95]

Stuck silence usually means. The hour was a coverage dump with no observation; the question was recitation of a cycle name; the model already wrote the report; or the prior idea "plants eat like we do" has frozen them.

Done enough. A claim with a named real observation. An unaided draft if the transcript will claim Biology.

Practice that actually builds learning

Understanding and practice grow together. Practice a new move this week, with a model and a why. A stack of kingdom quizzes with no observation is assignment, not teaching.

Typical isolated labs are no more or less effective than reading for content; looking and talk belong in the same week.[96] Then teach. The plant trial without the discussion box is a demo. The discussion box without the plant is a recitation.

Blocked, for a new move. The day a student first writes inputs and outputs, a short blocked set is honest: two more systems, same move, different organisms. Same for a first cell-as-jobs sitting, a first variation table, a first unaided claim.

Mixed, for when to use it. Later the same week, mix: a cell-jobs sitting, an inputs/outputs return, a variation sort, one "generated scene then named figure," yesterday's claim rewritten without looking. Choosing *when* to go deep is part of the skill.

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[95] Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control" (NARST paper, ERIC ED061103, 1972). Elementary science classrooms; wait 3–5 seconds after a question and after a student stops talking. Not a biology-score finding.

[96] National Research Council, *America's Lab Report: Investigations in High School Science*, Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, eds. (Washington, DC: The National Academies Press, 2006), Executive Summary: typical isolated laboratory experiences are no more or less effective than reading, lectures, or discussion for subject-matter mastery; integrated instructional units with discussion show greater effectiveness in small-scale studies. Design principles: clear learning outcomes; sequenced into instruction; content integrated with process; ongoing reflection and discussion. Conclusion 3 describes U.S. high-school labs as of that report, not a census of homeschool kitchens.

Brief retrieval. Yesterday's jobs; the inputs of Tuesday's plant; one trait that varied. A short oral at the start of the hour. Cycle names that are not retrieved turn into wallpaper — and wallpaper is not the hour.

One incorrect example to diagnose. Show a fluent paragraph whose only observation is "as the cell chewed," with no figure in the house. Or a report whose Figure 1 is a generated gel. Ask what they thought counted as an observation. Then an isomorphic claim, unaided, from a real plant or a named figure.

Kitchen and garden can motivate. A meal, a compost pail, a walk — those are doors into a system. They do not replace the unaided claim. A garden will not teach a cell as a system by itself.

Investigation 4 — Ecosystem as a Place, One Question

Time. One field sitting or one named habitat in a book.

Materials. Notebook, a place the family can actually stand in — a yard, a park edge, a window feeder — or a named habitat page if weather or access blocks the door.

SAFETY. Adult present outdoors. No collecting protected organisms. No tasting. Wash hands. Stay off roads and water edges the adult has not judged.

The fun of it. Who eats whom *here*. Staying put. Skipping the biome slog feels like getting away with something. It is the work.

The skill it builds. Interdependent relationships. Carrying capacity as "what limits how many *here*," not a formula dump.

How to run it. Name the place. Write the question before you look: *Who is eating, and what would happen if this food became scarce?* Record who you actually see, not who a poster promised. Then a short unaided claim. You will not "do biomes" this week. You will answer one question in one place.

Figure 14: A still-life of a notebook, a leaf, and an unbranded outdoor edge — a patch of ground, no people, no logos.

Investigation 5 — Human Body as a System

Time. One sitting.

Materials. A named diagram of interacting systems — not a list of every bone. A simple feedback picture: too hot, sweat, cooler; thirsty, drink, less thirsty.

SAFETY. No diagnostic medical play. No blood. No experimenting on a person's body as if it were a lab. This is a diagram-and-talk sitting.

The fun of it. What happens if this loop fails. The body becomes a set of talking kitchens, not a chart to memorize.

The skill it builds. Feedback as a system. Homeostasis as "keeping a condition in range," not a vocabulary badge.

How to run it. One loop. "What is being kept in range? What happens if the message does not arrive?" The student writes a three-sentence claim that points at

the diagram. Anatomy boot camp can wait. If a family later chooses a second-year anatomy elective, that is a different title.

Investigation 6 — Unaided Claim with a Named Observation

Time. Fifteen to twenty-five minutes.

Materials. The observation already used this week; paper; model closed; your key of what a good claim looks like, hidden.

SAFETY. Whatever the original sitting required, still in force. If a family chooses dissection, it is optional, planned, adult-present the entire time, with splash goggles and a written procedure. This book never requires it. If it cannot be made safe, it is not done.[97]

The fun of it. The sentence is theirs. That click is the point.

The skill it builds. A claim with evidence from this observation. The year the transcript will name.

How to run it. Sticky-note product: one claim someone could disagree with; one named observation; one because-sentence that is not a restatement; one clause on what you have not measured. Tool closed. You are the reader: "I cannot find this in the notebook." You are not the co-author.

Set the product goal every sitting. Read the claim aloud. Check the trail. Then change one sentence — usually the because-link. Monthly: an unannounced miniature, observation in the room, tool closed.

If you sample AP-style items, treat them as a check on the same skills — a short figure, a claim — not as the Biology course. The unaided claim from a real observation is still the kitchen object.

[97] American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016): the teacher must be physically present during the entire experiment; splash goggles; no unauthorized mixing. National Science Teaching Association, Position Statement, "Safety and School Science Instruction" (revised April 2024): eliminate the activity if it cannot be performed safely. Flinn Scientific, *Student Safety Contract* (© 2017): never work alone; unauthorized experiments prohibited.

For the student

Biology is how you answer a question about living systems, using an observation someone else could check. It is not a list of kingdoms, and it is not an exam brand unless you chose that exam.

A *cell* is a system, not a tiny mouth. Parts do jobs. An atom is a piece of stuff. A cell is a living system made of lots of stuff. Keep those sizes apart.

Photosynthesis is inputs and outputs. Light, water, and carbon dioxide in; sugar and oxygen out. Roots take up water and minerals. The plant's food, in this model, is the sugar it builds. A lot of a plant's mass comes from the air. That sentence surprises people. You can be the person who can say why.

Variation means not copies. Leaves on one tree differ. You resemble your family and you are not a photocopy.

Evolution, as this course's maps place it, is what happens to the mix of traits in a group over generations when variation meets an environment. We teach the idea. We look. We do not turn the hour into an argument about a church.

An *ecosystem* is a place. Who eats whom *here*. The *body* is loops that keep conditions in range. Dissection is a choice some families make. You do not have to do it for this book to call the year Biology.

A picture a computer made of a cell or a gel is a scene to look at. It is not data. It is not what you saw. A quotation a computer invented is not a quotation.

Tiny worked example. Question: *Where did the mass of this plant come from?*

Observation (already in the notebook): the soil level looks about the same; the plant is heavier than last month; we did not add soil.

Claim: *Most of the new mass did not come from the soil we can see; the inputs/outputs model says carbon from the air is a candidate we have not weighed.*

Because: *If the mass came from the soil as "food," we would expect the soil to shrink as the plant gained. We did not see that. The model predicts air-carbon we have not measured yet — so the claim is pointed, and unfinished on purpose.*

The because-sentence is not "because photosynthesis." That restates a label. The because-sentence is the rule about what the observation can and cannot show.

Try 1. Point at a named cell figure. Name two jobs, not two chanted words. Say why a cell is not a mouth.

Try 2. One real observation — plant, leaves, or a place. Write a claim with a finger on what you saw. Model closed.

Explain it back. In two sentences, tell someone why "plants eat through roots" is a prior idea doing work, and how you would check a micrograph tonight without treating a generated picture as Figure 1.

Challenge. Answer one biology question from one real observation, in a paragraph someone could disagree with. Name what you saw. If you cannot point at the notebook, you are still in summary country. Stay there until the finger works.

You are allowed to struggle. A missing measurement is information, not a verdict. Look. Write the claim. The tool does not take this test. You do.

If it isn't clicking

Three diagnostics, and the next move for each. No shame. Placement is by skill, not by birthday.

Diagnostic 1 — there is no question, or no observation. The student can recite a chapter title and cannot say what they saw. The "year" is a table of contents.

Next move. Stop the slog. One system. One question. One real observation — plant, named figure, or a place. Talk before writing. A calendar-grade 9 or 10 student who cannot point at an observation is not "behind in Biology." They are still in a taught-looking stage. The survey waits until the looking is prompted. Small looking can continue: one question, one figure, oral credit.

Diagnostic 2 — a tiny mouth, or a morality play. Every cell chews. Every plant eats through roots. Or every sitting becomes an argument about a church instead of a look at variation in a group.

Next move. Put the kitchen picture on the table and say what a cell is not. Ask where the mass came from, with the plant in view. Teach the public-map idea in one sitting — variation, then the mix of traits — and go back to the leaves. Presentism's cousin here is "living things eat like we do." You will ask the inputs question more than once.

Diagnostic 3 — a fluent page the house cannot reopen. The report arrived. The micrograph is generated. The citations look professional.

Next move. Objects in the hands. Finger on the observation. If it cannot be opened, it comes off. Unaided miniature, tool closed. A model-supplied result is untrusted until it matches the notebook. Detectors are not a verdict; the reopenable trail is.[98]

When to get a human tutor. You cannot hear a tiny-mouth, even after the five-minute warm-up. Or the student has weeks of observation sittings, and the unaided ticket is still a dump or a blank. A tutor, a co-op, or a later dual-enrollment biology survey is a normal plan. Stay the supervisor who can still ask "what did you see?" Dual-enrollment biology is a *college* transcript object, distinct from this kitchen year. AP Biology is an overlay, not a requirement; it lists chemistry as a recommended prerequisite; credit is by college.

When to go ahead. Questions are real. A cell is a system in their mouth, not a mouth in their drawing. Inputs and outputs can be named. Variation is visible in a group. Unaided claims point at named observations. Then lengthen: a short paper with three observations; a second system in depth; an optional AP-style sitting if you chose that exam. Diagnose. Then move.

Tools, including AI

Optional helpers for you. The student looks. You hold the observation.

> **AI box — Biology**
>
> Use a tool to explain *this week's system* to *you* from a named textbook page, to generate extra "inputs/outputs" items with answers hidden from the student, to write a hint script that withholds the claim, or to diagnose a paragraph already written.
>
> The student looks and writes the claim. No "write my lab report," no invented data table, no generated gel or micrograph as the student's result, no unsupervised chatbot during the attempt, no "what's the answer" as the whole hour.

[98] Weixin Liang et al., "GPT Detectors Are Biased Against Non-Native English Writers," *Patterns* 4, no. 7 (2023). High false-positive rates on human TOEFL essays in that study. Detectors are not a kitchen verdict.

> A model-supplied observation, coefficient, or "typical result" is untrusted until it matches the notebook or a named page. Find it or drop it.
>
> A generated cell is a scene to look at together for two minutes, labelled generated. It is not Figure 1. Then it comes off the table.

A named textbook, a prepared slide, and a plant are research tools. A chatbot list of "what you would have seen" is not. In a high-school mathematics study, an unguarded chatbot raised assisted practice and then cut the unaided exam.[99] That study is math, not a Biology trial. The same crutch is available here. The unaided claim the next morning is the test.

What "done enough" looks like

A "grade 9 Biology" book is a publisher's or a state's scope, not a legal grade and not a national sequence. Done enough is skill, plus systems actually studied, plus writing the student produced.

Checklist before moving on.

- Treats a cell as a system with jobs, not as a tiny mouth; keeps atoms and cells apart.
- Names photosynthesis as inputs and outputs, and can say why "food through roots" is the prior idea.
- Finds variation in a real group and can say "not copies."
- Stays in one place long enough to answer one ecosystem question, rather than naming biomes.
- Treats the body as interacting loops, not as an anatomy chant; dissection was a choice, never a requirement of this book.
- Writes an unaided claim with a named real observation; the model did not open the draft the transcript will claim.
- Treats a generated image as a scene, not as data.

[99] Hamsa Bastani et al., "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent on practice, −17 percent on an unaided exam. Math, not a Biology RCT. The paper notes that creative subjects lack math's objective scoring. The crutch still governs the science hour: the student attempts first; the unaided ticket is the test.

What can still be thin: every unit on an AP list; a second high-school anatomy year; college-density textbooks. Those can travel. The slog of kingdoms with no observation cannot count as done.

Transcript. Write **Biology**. If the family used a conversational Christian text, a textbook survey, a classical pairing, or a college open text *inside* the year, the description can say so. The title is still Biology. Never a brand. If the student sits AP Biology, put the exam on a separate line. Safer kitchen practice is a readable title plus the score as an artifact. *With Lab* is a claim the records chapter will teach you how to make honestly. This chapter is the looking that would have to be in the folder.

NCAA counts natural and physical science as core, two years, including one year of lab if offered; records will handle the worksheet.[100] The year on the table is still Biology.

A parent who felt rusty should be able to say, after this chapter: I know why a cell is not a mouth. I know what a coverage slog usually means. I know what to say tomorrow — a question, an observation, a claim that points. The student still does the looking. We can do this.

[100] NCAA Eligibility Center, Division I Academic Standards fact sheet (September 2023); *Home School Toolkit 2025–26*; High School Review Committee Policies 2025–26 / Staff Policies 2026–27. Print both labels: the fact sheet cell says Science; HSRC says natural/physical science. Two years, including one year of lab if offered. Whether Division I adopted a 2026 proposal to drop "lab if offered" is not treated as settled in this book; the live sheet still has the lab language.

Chapter 5

Chemistry

Figure 15: A kitchen-table still-life: splash goggles, a labelled household bottle, a written procedure in a notebook, a stove with the knob visibly off. No people, no logos, no food on the same surface.

Why this matters

High-school Chemistry is how a student learns that stuff has properties you can observe, that a reaction is a change you can stop, that amount can be counted in packages, and that matter is not created when a mixture fizzes — then to answer a real question from a measurement that actually happened, safely. It is not a slog of every named compound. It is not a brand. It is not a volcano on the counter called a credit.

That is worth the struggle because later science hangs on it. Biology already asked where a plant's mass came from; chemistry is the year the atoms get counted. Physics will ask how energy moves in a reaction. Earth science will ask what water does to rock. A year that races through a table of contents, never weighs anything, and never lets the student write a claim that points at a number is Chemistry in name. A year of kitchen wow with no written procedure and no goggles is a picture. Name the year by the properties you actually compared, the reactions you actually ran, and the numbers the student actually wrote.

There is no national chemistry syllabus. The *Framework* maps physical science's first core idea as matter and its interactions: structure and properties, chemical reactions, nuclear processes.[101] The *Next Generation Science Standards* package those ideas as high-school physical science. They are goals, not a curriculum and not a homeschool law.[102] California's four-course chemistry year names the segments in ordinary language: properties; structure; reactions; modifying reactions; energy.[103] Texas names Chemistry as a one-credit course, and also names Inte-

[101] National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: The National Academies Press, 2012), doi:10.17226/13165. Physical-science core idea PS1: matter and its interactions (structure and properties of matter; chemical reactions; nuclear processes). Access date for URLs in these notes: 1 September 2026.

[102] NGSS Lead States, *Next Generation Science Standards: For States, By States* (Washington, DC: The National Academies Press, 2013), front matter and Appendix A. Standards, not curriculum, not national law. Appendix K's Modified Science Domains model assigns most PS1 ideas to Chemistry. A numbered NGSS performance expectation for the mole was not opened as quoted text for this book; the mole is taught here as typical high-school content — an amount — without a code.

[103] California Department of Education, *2016 Science Framework for California Public Schools*, Chapter 8, Four-Course Model chemistry instructional segments: Properties of Matter; Structure of Matter; Understanding Chemical Reactions; Modifying Chemical Reactions; Conservation of Energy and Energy Transfer. https://www.cde.ca.gov/ci/sc/cf/documents/scifwchapter8.pdf. California State Board adopted CA NGSS on 4 September 2013. Local educational agencies choose

grated Physics and Chemistry as a different one-credit course.[104] Virginia names Chemistry I and tests it.[105] None of those maps is homeschool law. None of them is the other coast.

The registrar word is **Chemistry**. NCAA's sample transcript uses that ordinary title.[106] Never write a curriculum brand in the title column. Never write "IPC" without a parent note if a stranger in another state will read the page — Integrated Physics and Chemistry is a Texas course name, readable there, opaque elsewhere. This book prefers Chemistry, Physics, or Physical Science. Never write "AP Chemistry" unless the student is actually sitting that course-and-exam.

AP Chemistry is an optional College Board object. The opened course page names nine units, from atomic structure through applications of thermodynamics, with inquiry-based investigations.[107] It is a possible beyond. It is not this chapter's floor. If the student sits the exam, College Board forbids AI-generated answers, including text, image, and graph.[108] Credit is by college. A path through chemistry does not require the letters AP.

Safety is first, not a paragraph at the back. The American Chemical Society's secondary guidelines were written mainly for the high-school chemistry teacher. Use them as the ceiling the home must not pretend to clear. The adult is physically

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high-school course order.

[104]Texas Education Agency, 19 TAC Chapter 112 index: Chemistry (One Credit), Adopted 2020; Integrated Physics and Chemistry (One Credit), Adopted 2020, https://tea.texas.gov/laws-and-rules/texas-administrative-code/19-tac-chapter-112. 19 Tex. Admin. Code §74.12: three science credits; one Biology; second from IPC, Chemistry, or Physics (or named equivalents). Public-school map, not homeschool law. Student-expectation wording in the TEKS PDFs was not successfully opened for this book.

[105]Virginia Department of Education, Science Standards of Learning page: Chemistry I as a course; statewide SOL tests named include Chemistry. Standard Diploma: three laboratory-science credits from at least two of earth sciences, biology, chemistry, or physics. Public-school map, not homeschool law.

[106]NCAA Eligibility Center, *Home School Toolkit 2025–26*. Sample titles include Chemistry. Course name on the worksheet should match the transcript title.

[107]College Board, AP Chemistry course page, https://apcentral.collegeboard.org/courses/ap-chemistry. Nine units as listed on the opened page: Atomic Structure and Properties; Molecular and Ionic Compound Structure and Properties; Intermolecular Forces and Properties; Chemical Reactions; Kinetics; Thermodynamics; Equilibrium; Acids and Bases; Applications of Thermodynamics. College Board course-and-exam. Credit by college. Optional beyond, not this chapter's floor.

[108]College Board, AP Exam Terms and Conditions 2026, Section 4 (updated 27 April 2026): no AI-generated submissions, including text, image, and graph.

present the entire experiment. Food does not share a surface with a chemical trial. No unauthorized mixing. Never heat a flammable on a burner or a hot plate. Splash goggles when liquids can splash. If the gear is missing, the activity is not done.[109] A baking-soda volcano is a picture of a reaction. It is not, by itself, a Chemistry credit.

This week you can learn that the mole is an amount, and why a volcano is a picture — not a Chemistry credit — unless a written, supervised investigation sits in the notebook. Today the student can run one written, adult-present trial with goggles on, write the numbers, and say what changed — model closed.

For the parent: understand it yourself

You do not need to be a chemist. You do need to understand today's idea well enough to hear "it changed, so it is a chemical change" with no number, and "a mole is a molecule" as a size collapse, not as cute slips.

Everyday picture. Think of a pantry. You do not start by naming every spice. You start by what you can observe: white crystals that dissolve in water; a yellow powder that does not; an oil that floats. A reaction is a change you planned, with a way to stop, not a surprise in the sink. A mole is a package size — a dozen eggs is twelve, a mole is a much larger dozen for things too small to count one by one. Conservation is the grocery bag that still weighs what it weighed, even after you mix the flour and the water inside a sealed bag.

Precise picture. *Properties* come before names. Density, melting, dissolving, color, whether it conducts as a liquid — those are observations. Sodium chloride is a name you earn after the salt on the table has been sorted by what it does. The hour is the sorting. The vocabulary is the hanger.

A *chemical reaction*, in the language this year actually needs, is a change in what

[109] American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016). RAMP: Recognize, Assess, Minimize, Prepare. Designed mainly for the high-school chemistry teacher. "The teacher must be physically present during the entire experiment, concentrating on the students the entire time." Chemical splash goggles "an absolute requirement." "No mixing of chemicals should be allowed, other than that specified in an experimental procedure." Food and drinks not permitted in a chemical laboratory. Lowest concentrations and smallest volumes. "In no case should a burner be used to heat a flammable or combustible chemical." Flammables "must never be heated on a hot plate." Mercury devices out of the pre-college laboratory.

the stuff is, with a record: a temperature change you measured, a gas you can see leaving, a solid that appears, a color that stays after mixing. The public maps care that students can use evidence. They do not care that the student won a vocabulary trap called "chemical or physical." A reaction you can stop is a written procedure with an amount, a time, and an adult who is in the room. Unauthorized mixing — "let's see what happens if we combine these cleaners" — is not curiosity. It is how people get hurt.[110]

The *mole* is an amount. A dozen is twelve. A mole is a named package of very many particles, used so chemists can weigh a pile and talk about a count. You do not need a performance-expectation code to teach that. You need beans or a textbook page and the sentence: this many is a package. Algebra is a tool for the arithmetic of amount, not a wall that ends the path. If the arithmetic is rusty, repair the arithmetic beside the idea. A letter in an equation is not a reason to postpone the year.

Conservation is weighing. In a sealed bag, the mass after a fizz is the mass before, because the gas is still in the bag. If the bag is open, the mass can drop because something left. Matter was not destroyed. It moved. That is the idea, not a slogan on a poster.

Kitchen chemistry is a picture. Baking is a real change. It can motivate. It does not, by itself, make a lab year. A family that skips every experiment in a book that "has labs" has a reading year. A family that does every kitchen experiment still needs the habits: adult present, written plan, goggles, no food on that surface, no substitutions because the bottle was empty.[111] Household products are not safe because they came from the grocery store. They are a preferred class of chemical, used with a Safety Data Sheet and with PPE, or they stay on the shelf.[112]

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[110] ACS 2016 (n. 109), unauthorized mixing. Flinn Scientific, *Student Safety Contract* (© 2017): "Never work alone. No student may work in the laboratory without an instructor present"; unauthorized experiments prohibited; "Never leave a lit burner unattended. Never leave anything that is being heated or is visibly reacting unattended."

[111] Apologia homeschool science FAQ, as opened for this book, describes experiments as encouraged and not mandatory. That is publisher copy about a program, not a safety plan and not an athletic-eligibility plan.

[112] Kenneth Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020. Author's views, not necessarily official NSTA policy. Prefer common, safer household products; hold Safety Data Sheets; PPE including indirectly vented chemical splash goggles (ANSI/ISEA Z87.1 D3 for liquids); if proper PPE is not available, the activity is not conducted; no unapproved substitutions. K–5: duty of care by a responsible adult. Middle/high simulations in that post are pandemic remote-school advice, not an NCAA ruling.

A generated spectrum or a chatbot "typical result" is not data. ChatGPT will produce a lab-report-shaped page. That is a genre, not the student's measurement.[113]

Wrong answers you should be able to hear

1. Names before properties. "It's sodium bicarbonate, so it fizzes." The bottle was never opened. The observation was the label.

What it usually means. Vocabulary won. The hour skipped what the stuff does.

What to say. "Cover the name. What can you observe? Color, whether it dissolves, whether it floats. Then we can hang a name on it."

2. Chemical-or-physical as a trap. "It changed, so chemical." "It looks the same, so physical." No number. No stop. No procedure.

What it usually means. A category name replaced evidence. The wow replaced the record.

What to say. "What did you see change — and what did you measure that a stranger could check? What stayed the same?"

3. A mole is a molecule, or a wall. "Mole means the little thing." Or: "I can't do chemistry; that's math."

What it usually means. Two sizes collapsed, or algebra was treated as a gate instead of a tool.

What to say. "A molecule is one. A mole is a package of very many. We will count with the package. If the arithmetic is rusty, we repair the arithmetic. We do not stop the year."

4. The kitchen is the lab. A volcano every Friday. No goggles. Lunch on the same board. Substituting a cleaner because the recipe's bottle was empty. Or: skipping every experiment because a publisher said experiments are encouraged, not mandatory.

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[113] John K. West et al., "Here to Stay: Quality Science Teaching Requires Quality Laboratory Reports — Even Those Written by ChatGPT," *Journal of Chemical Education* 100 (2023): 4351–59 (abstract opened; full PDF not opened for this book): ChatGPT laboratory reports generated across the chemistry curriculum and graded as if they were student reports. Sarah M. Humphry and Amy L. Fuller, "Potential ChatGPT Use in Undergraduate Chemistry Laboratories," *Journal of Chemical Education* 100 (2023): 1434–36 (abstract opened): an example in which ChatGPT writes the discussion portion of a lab report. Capability of the genre, not a homeschool RCT.

What it usually means. A picture was upgraded to a credit, or a publisher FAQ was upgraded to a safety plan. Neither move holds.

What to say. "The volcano is a picture of a reaction. Chemistry with a lab claim needs a written procedure, an adult in the room, goggles, and a notebook. If we cannot make it safe, we do not run it. Encouraged-not-mandatory is not a plan."

5. A fluent report whose numbers no one measured. Diction jumped a grade. The data table was invented. The "spectrum" was generated.

What it usually means. The work was outsourced. Models will write Discussion. They will not have been in the room.

What to say. "Show me the notebook. Finger on the number you wrote while the goggles were on. If we cannot open it, it comes off. The model stays closed."

Five-minute parent warm-up

Before the lesson, on paper, no student in the room:

1. Write RAMP in one line you can say: recognize the hazard, assess the risk, minimize it, prepare for a spill or a splash. Name tonight's hazard out loud. If splash goggles are missing, the trial is not tonight's work.
2. Write the mole as a package size, in one sentence, with a dozen as the everyday picture. Circle the word a student who says "mole means molecule" is collapsing.
3. Write tonight's question in one line a measurement can speak to. Star the stop: how you will end the reaction, and that you will be in the room the entire time.

If those three are fluent for you, you can hear a vocabulary trap and a kitchen-as-credit. That is the job. The student still does the measuring.

How to teach it this week

Run the door before you call the year Chemistry.

Is there a written procedure? If the hour is "mix these and see," stop. Write the steps, the amounts, the stop.

Is the adult present the entire time? If you need to answer the door with a flame on, the flame goes off first. ACS is blunt: even a momentary absence can turn a small incident into an emergency.[114]

Is food off that surface? If the board will be lunch, this is not a chemical trial. If this is a chemical trial, lunch waits, and the adult cleans.

When the gates are open, here is the shape of a sitting. Warm-up. Short model. Student attempt. One good question. Mixed practice. Exit ticket. The science hour at the front of this book already taught this shape. This chapter fills it with a chemistry year, safety first.

Warm-up (3–5 minutes, unaided). Yesterday's property in one sentence. One "what stayed the same?" on a trial they have already seen. One mole-as-package item with beans or marks on paper. No tool. Goggles on the table as a reminder, even if today's warm-up is paper.

Short model (5–8 minutes). You put the written procedure on the table. Think aloud: "Here is the question. Here is the hazard I named. Here are goggles. Here is the smallest amount. Here is how we stop. Here is what I write down — not what I hope. My claim, which you could argue with, is ____. The because-link is this number." Keep it short. You are showing a reaction you can stop, not delivering a lecture on the periodic table.

Fade as soon as you can. Second sitting: they explain your measurement. Third: they record while you watch, goggles on both of you. Fourth: they write the claim unaided, model closed. Include one incorrect example: a volcano with no number; a name offered as the observation; a chatbot Discussion paragraph.

Exact wording you can steal.

On properties: "Cover the name. What can you observe?"

On a reaction: "What did you see change — and what did you measure that a stranger could check?"

On stopping: "We run the procedure we wrote. We do not add a bonus bottle to see."

On the mole: "A dozen is twelve. A mole is a package. We weigh the package so we can talk about a count."

[114] ACS 2016 (n. 109), supervision paragraph.

On conservation: “If the bag is sealed, where would the mass go? If the bag is open, what left?”

On the kitchen: “Baking is a picture. The transcript year still needs a written, supervised investigation.”

On algebra: “The letter is an amount. If the arithmetic is rusty, we repair it here. It is a tool, not a gate.”

On the chatbot: “If we did not measure it, it is not data. A report a model wrote is a genre. It is not the hour.”

First problem for the student, after the model. One written procedure, adult present, goggles on, smallest amount. Product goal on a sticky note: a claim in their own words, with a finger on a number. Model closed. You wait. Struggle before rescue. You do not finish the table. You do stay in the room.

One good question. After the attempt: “If I hid the notebook, would your claim still know where it came from?” The student generates the why.

Student attempt, then mixed practice. Two or three short claims of the new type, unaided, after the fade — not five lab reports. Then mix: yesterday’s properties, last week’s weighing, one “kitchen picture then the lab path,” one “mole as a package.”

Exit ticket (5–10 minutes, unaided). One question, one named measurement already in the notebook, a three-to-five-sentence claim. Tool closed. You grade the unaided ticket. A fluent report with invented numbers is performance. The claim that points is the test.

Every report the transcript will claim needs an unaided draft the model did not open. That is the year, not a special integrity week.

How to fade help. You run and record → they explain your number → they record the second sitting → they write the claim → they help name the next procedure’s hazard with you. When they can name a property without the bottle’s title, put the name-covering scaffold away. Bring it back when a new kind of change arrives.

When to stop talking. After one model and one question. You do not become the textbook. You hold the key: is there a question, a measurement, a stop, and an adult in the room?

Investigation 1 — Properties Before Names

Time. One science hour.

Materials. Three household substances the adult has checked against a Safety Data Sheet: for example, water, cooking oil, table salt. Small clear cups. Notebook. Splash goggles if any liquid can splash.

SAFETY. Adult present the entire time. Food-safe materials only at this step. No tasting as a "test." Goggles if splash is possible. Kitchen surface not simultaneous with lunch. Lowest amounts. No substitutions.

The fun of it. Sorting by what you observe. The student gets to be right about a bottle whose name is covered.

The skill it builds. Matter by properties. Names as hangers, not as the hour.

How to run it. Cover the labels. Observe: color, whether it pours, whether a pinch of salt dissolves, whether oil floats on water. Record. Then uncover the names. The name is the hanger you earned.

Investigation 2 — A Reaction You Can Stop

Time. One sitting.

Materials. One written procedure. Lowest concentration, smallest volume. Splash goggles. A way to stop: a timed amount, a lid, a wet paper towel for a small acid-base household pair the adult has SDS-checked — or a vinegar-and-baking-soda fizz in an open cup, measured, then ended. Not a rainbow demonstration.[115]

SAFETY. RAMP first, spoken. Goggles on. Adult present the entire time, concentrating on the trial — not on a phone. No substitutions. No mixing cleaners. No heating a flammable on a burner or a hot plate. Stop if PPE is missing. Never leave anything that is visibly reacting unattended.[116]

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[115] ACS secondary chemistry safety materials include a rainbow-demonstration safety alert. Do not run a rainbow demo as a kitchen hour.

[116] Flinn, *Student Safety Contract* (n. 110). National Science Teaching Association, Position Statement, "Safety and School Science Instruction" (revised April 2024): eliminate the activity if it cannot be performed safely; food and drink should not be permitted where laboratory activities will be conducted or where hazardous chemicals or physical/biological hazards have been used.

The fun of it. Something actually changes, on purpose, and then it stops.

The skill it builds. A chemical change with a record. Not a wow.

How to run it. Read the procedure together. Name the hazard. Goggles. Smallest amount. Student records time, temperature if you have a kitchen thermometer used only for this, or height of foam, or mass. Then stop. Then the claim.

Figure 16: A still-life of a written procedure, goggles, a small clear cup with a finished fizz at rest, heat off. No people, no logos.

Investigation 3 — The Mole as an Amount

Time. One paper-and-objects sitting.

Materials. Dried beans, or paper clips, or a named textbook page that treats the mole as a counting unit. Notebook. No chemicals required.

SAFETY. None if it stays paper and beans. If beans will later go near a chemical surface, they stay in the math pile and do not migrate.

The fun of it. This many is a package. A dozen, then a bigger dozen.

The skill it builds. Amount as a counting idea. Algebra as a tool for "how many packages," not a talent wall.

How to run it. Count twelve beans. That is a dozen. Then: if a "mole-bag" on paper stands for a huge dozen, how many bags for this pile? Keep the arithmetic in reach. If the student panics at the letter, write the same step with numbers first, then put the letter back. You are not teaching a performance-expectation code. You are teaching a package.

> **Discussion box**
>
> *Illustration, labelled as such: a small open-cup fizz, a notebook with two masses or a foam height, goggles on the table. Composite table, not a reported family.*
>
> **Opening.** "What did you see change — and what did you measure that a stranger could check?"
>
> Not: "Is this a chemical or physical change?"
>
> **Follow-ups** (pick three to five). What stayed the same? Can we tell for sure it was the reactant we named? Why would that measurement count as evidence? What would we have to see to change our minds? What hazard did we name before we started?
>
> **How to wait.** Three to five seconds after you ask. Three to five after they stop talking. Look at the notebook if the silence is hard. Wait time of that length is a finding from elementary science classrooms, not a chemistry-score promise.[117]
>
> **Stuck silence usually means.** Recitation of "chemical change"; the kitchen-wow with no number; the model already wrote Discussion; or the hazard talk ate the hour and no one looked at the cup.
>
> **Done enough.** A claim with a measured change. If the transcript claims Chemistry with lab, the folder holds investigations that actually happened, safely. The words *with lab* are a records job. This

[117] Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control" (NARST paper, ERIC ED061103, 1972). Elementary science classrooms; wait 3–5 seconds. Not a chemistry-score finding.

chapter is the notebook those words would rest on.

Practice that actually builds learning

Understanding and practice grow together. Practice a new move this week, with a procedure and a why. A stack of element quizzes with no measurement is assignment, not teaching.

Typical isolated labs are no more or less effective than reading for content; looking and talk belong in the same week.[118] Then teach. The fizz without the discussion box is a demo. The discussion box without a number is a recitation.

Blocked, for a new move. The day a student first weighs a sealed bag, a short blocked set is honest: two more conservation pictures, same move. Same for a first properties sort, a first mole-as-package sitting, a first unaided claim.

Mixed, for when to use it. Later the same week, mix: a properties sitting, a reaction return, a mole-package item, one "kitchen picture then the lab path," yesterday's claim rewritten without looking. Choosing *when* to go deep is part of the skill.

Brief retrieval. Yesterday's property; the stop you used on Tuesday; one mole sentence. A short oral at the start of the hour. Formula names that are not retrieved turn into wallpaper.

One incorrect example to diagnose. Show a fluent Discussion whose only evidence is "it fizzed, so chemical," with no number in the house. Or a report whose data table was generated. Ask what they thought counted as a measurement. Then an isomorphic claim, unaided, from a real weighing.

Baking can motivate. A cookie is a door into a reaction. It does not replace the unaided claim. A recipe will not teach conservation by itself, and the cookie sheet is not the chemical surface.

[118] National Research Council, *America's Lab Report: Investigations in High School Science*, Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, eds. (Washington, DC: The National Academies Press, 2006), Executive Summary: typical isolated labs no more or less effective than reading, lectures, or discussion for subject-matter mastery; integrated units with discussion show greater effectiveness in small-scale studies. Conclusion 3 describes U.S. high-school labs as of that report, not a census of homeschool kitchens.

Investigation 4 — Conservation as a Weighing

Time. One sitting.

Materials. A sealable bag; two household reactants the adult has SDS-checked in tiny amounts (vinegar and baking soda is the ordinary picture); a kitchen scale. Or a named demonstration the adult can do without heat.

SAFETY. No heating of flammables. Adult present the entire time. Goggles. Bag sealed before the fizz if you want the gas to stay. Open-cup version is a different measurement: mass can drop because gas left. Name which measurement you ran, and keep them distinct.

The fun of it. It still weighs — or it doesn't, and you can say why.

The skill it builds. Matter is not created in the reaction as the map places it. An open system and a closed system are different measurements.

How to run it. Weigh before. Run the procedure. Weigh after. Two columns. Then: if the number changed, what left or entered? If it did not, what does that say?

Investigation 5 — Kitchen Picture, Then the Lab Path

Time. Twenty to thirty minutes, once, early in the year, then a five-minute return when someone wants to call baking "the lab."

Materials. A baking change you were already going to make — muffins, bread — as a *picture*. Then the written procedure from Investigation 2 on the table beside it. Goggles stay with the procedure, not with the muffin tin.

SAFETY. Food is food. The chemical trial is not on that board. NSTA's line is plain: food and drink do not belong where chemical hazards have been used.[119] If you bake, you bake. If you run a trial, you run a trial. Not both on one board in one hour.

The fun of it. Naming the picture as a picture. Students usually like being in on the distinction.

The skill it builds. Architecture's sentence, taught once: kitchen chemistry is a picture, not a Chemistry credit by itself.

[119] NSTA Position Statement (n. 116).

How to run it. Watch the batter change. Say out loud: this is a reaction picture. Then point at the notebook procedure. “The transcript year still needs investigation with a written plan, PPE, and a number. Baking is welcome. It is not the credit.”

Figure 17: Splash goggles, a closed labelled bottle, a notebook procedure, stove knob off. Still-life, no people, no logos.

Investigation 6 — Unaided Notebook Page

Time. Fifteen to twenty-five minutes.

Materials. The measurement already taken; paper; model closed; your key of what a good claim looks like, hidden.

SAFETY. Goggles stay in force if any residue is still on the table. Adult still present until the surface is cleaned. The adult cleans.

The fun of it. The sentence is theirs.

The skill it builds. Question, procedure, data the student measured, claim. The year the transcript will name.

How to run it. Sticky-note product: one claim someone could disagree with; one named measurement; one because-sentence that is not a restatement; one clause on the hazard you named. Tool closed. You are the reader: “I cannot find this number in the notebook.” You are not the co-author.

If a co-op or a college lab is available, use it as a supplement with its own safety rules. A simulation can teach a model when a wet trial cannot be made safe. Whether a simulation satisfies an athletic-eligibility lab line is not a question this book answers from opened pages. Title the year honestly.[120]

Set the product goal every sitting. Read the claim aloud. Check the trail. Then change one sentence — usually the because-link. Monthly: an unannounced miniature, notebook in the room, tool closed.

For the student

Chemistry is how you answer a question about stuff — what it does, how it changes, how much of it you have — using a measurement someone else could check. It is not a list of names, and it is not a volcano.

Properties come first. Cover the label. What color? Does it dissolve? Does it float? Then you may hang a name on it.

A *reaction* is a change you planned, with a way to stop. You write the steps. An adult stays. Goggles on. You do not mix a bonus bottle to see. You measure. You stop.

A *mole* is a package, like a dozen, for things too small to count one by one. A molecule is one. A mole is a huge package of ones. If the arithmetic feels rusty, say so. We repair the arithmetic. We do not treat a letter as a gate that ends the year.

Conservation is weighing. In a sealed bag, the mass after a fizz is the mass before, because the gas is still in the bag. If the bag is open, something may have left. Matter moved. It was not destroyed.

[120] NCAA fact sheets and High School Review Committee policies, as opened for this book, are silent on whether virtual or simulated labs satisfy “lab if offered.” OpenStax College Physics 2e describes Take-Home Investigations and PhET simulations as textbook features, not as an athletic-eligibility ruling. Title the year honestly.

Baking is a picture of a reaction. It is welcome. It is not, by itself, the credit. Food and a chemical trial do not share a board.

A report a computer wrote is a genre. It is not your data. A spectrum a computer made is a scene. It is not what you measured.

Tiny worked example. Question: *Did the mass change in this fizz — and what does that say?*

Observation (already in the notebook): sealed bag, 42.3 g before, 42.3 g after; bag puffed.

Claim: *The mass stayed the same while a gas appeared, so the gas is still in the bag; matter moved form, it did not leave.*

Because: *If matter had been destroyed, the number would drop. If the bag had been open, the number might drop because gas left — a different measurement. We sealed it on purpose.*

The because-sentence is not "because of conservation of mass." That restates a label. The because-sentence is the rule about what this weighing can show.

Try 1. Cover three labels. Sort by one property you can observe. Then uncover.

Try 2. One written, adult-present trial, goggles on. Write the number. Say what changed. Model closed.

Explain it back. In two sentences, tell someone why a mole is a package and not a molecule, and why a volcano without a notebook is a picture rather than a credit.

Challenge. Run one written procedure, write the numbers, and write a paragraph someone could disagree with. Name the measurement. Name the hazard you named before you started. If you cannot point at the notebook, you are still in wow country. Stay there until the finger works.

You are allowed to struggle. A missing number is information, not a verdict. Measure. Write the claim. The tool does not take this test. You do.

If it isn't clicking

Three diagnostics, and the next move for each. No shame. Placement is by skill, not by birthday.

Diagnostic 1 — there is no measurement, or no stop. The student can recite an element and cannot say what they weighed. The "year" is a table of contents, or a volcano.

Next move. Stop the slog. One property sort. One written procedure. One number. Talk before writing. A calendar-grade 10 or 11 student who cannot point at a measurement is not "behind in Chemistry." They are still in a taught-looking stage. The survey waits until the looking is prompted. Small looking can continue: one property, one cup, oral credit.

Diagnostic 2 — a vocabulary trap, or algebra as a wall. Every change is "chemical." Every letter in an amount problem ends the sitting. Or the mole collapsed into molecule.

Next move. Cover the names. Ask what stayed the same. Put beans on the table and rebuild the package. Repair the arithmetic beside the idea. Algebra is a tool. It is not a verdict on the path.

Diagnostic 3 — a fluent page the house cannot reopen, or a kitchen treated as a stockroom. The report arrived. The table was generated. Or cleaners were mixed because the hour felt brave.

Next move. Objects in the hands. Finger on the number. If it cannot be opened, it comes off. Unauthorized mixing ends. The activity is not done if it cannot be made safe. Unaided miniature, tool closed. Detectors are not a verdict; the reopenable trail is.[121]

When to get a human tutor. You cannot hear a name offered as an observation, even after the five-minute warm-up. Or the student has weeks of procedure sittings, and the unaided ticket is still a dump or a blank. Or the safety habits will not hold in this house — then a co-op or college lab with its own rules is a normal plan, not a failure. Stay the supervisor who can still ask "what did you measure?" Dual-enrollment chemistry is a *college* transcript object, distinct from this kitchen year. AP Chemistry is an overlay, not a requirement; credit is by college.

When to go ahead. Properties come before names in their mouth. A reaction has a stop and a number. The mole is a package. Conservation is a weighing. Unaided claims point at named measurements. Safety is a habit, not a poster. Then lengthen:

[121]Weixin Liang et al., "GPT Detectors Are Biased Against Non-Native English Writers," *Patterns* 4, no. 7 (2023). Detectors are not a kitchen verdict.

a short paper with three trials; a second kind of reaction; an optional AP-style sitting if you chose that exam. Diagnose. Then move.

Tools, including AI

Optional helpers for you. The student measures. You hold the procedure and the key.

> **AI box — Chemistry**
>
> Use a tool to explain *this week's idea* to *you* from a named textbook page, to generate extra mole-as-package items with answers hidden from the student, to write a hint script that withholds the claim, or to diagnose a notebook page already written.
>
> The student runs the procedure and writes the claim. No "write my lab report," no invented data table, no generated spectrum as the student's result, no unsupervised chatbot during the attempt, no "what's the answer" as the whole hour.
>
> A model-supplied reading, coefficient, or "typical result" is untrusted until it matches the notebook or a named page. Find it or drop it.
>
> A generated flask is a scene to look at together for two minutes, labelled generated. It is not data. Then it comes off the table.

A named textbook, a scale, and splash goggles are tools. A chatbot Discussion is not. In a high-school mathematics study, an unguarded chatbot raised assisted practice and then cut the unaided exam.[122] That study is math, not a Chemistry trial. The same crutch is available here. College instructors have already shown that a chatbot will write a lab-shaped report. The unaided claim the next morning is the test.

[122] Hamsa Bastani et al., "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent on practice, −17 percent on an unaided exam. Math, not a Chemistry RCT. The crutch still governs the science hour.

What “done enough” looks like

A “grade 10 Chemistry” book is a publisher’s or a state’s scope, not a legal grade and not a national sequence. Done enough is skill, plus reactions actually run, plus writing the student produced, plus safety that held.

Checklist before moving on.

- Sorts matter by properties before reaching for a name.
- Runs a written reaction with a stop, an adult present, and a number; no unauthorized mixing.
- Treats the mole as an amount — a package — and uses algebra as a tool, not a wall.
- Weighs conservation instead of chanting it.
- Can say out loud that a kitchen picture is a picture, not the credit.
- Writes an unaided claim with a named real measurement; the model did not open the draft the transcript will claim.
- Treats a generated image or a chatbot report as a scene or a genre, not as data.

What can still be thin: every unit on an AP list; a stockroom year; college-density textbooks. Those can travel. The slog of names with no measurement cannot count as done. A volcano-only year cannot count as a lab year.

Transcript. Write **Chemistry**. If the family used a conversational Christian text, a textbook survey, a classical pairing, or a college open text *inside* the year, the description can say so. The title is still Chemistry. Never a brand. If the family used Texas’s Integrated Physics and Chemistry, write that full name and add a parent note that it is a laboratory physical-science course. If the student sits AP Chemistry, put the exam on a separate line. Safer kitchen practice is a readable title plus the score as an artifact. *With Lab* is a claim the records chapter will teach you how to make honestly. This chapter is the looking that would have to be in the folder.

NCAA counts natural and physical science as core, two years, including one year of lab if offered; a standalone “Chemistry Lab” is not approved separately.[123] The

[123] NCAA Eligibility Center, Division I Academic Standards fact sheet (September 2023); *Home School Toolkit 2025–26*; High School Review Committee Policies 2025–26 / Staff Policies 2026–27. Fact sheet cell: Science, including one year of lab if offered — 2 years. HSRC: natural/physical science; a standalone “Chemistry Lab” will not be approved separately. CLEP is not NCAA core.

year on the table is still Chemistry.

A parent who felt rusty should be able to say, after this chapter: I know the mole is a package. I know why a volcano is a picture. I know what to say tomorrow — a written procedure, goggles, an adult in the room, a number, a claim that points. The student still does the measuring. We can do this.

Whether Division I adopted a 2026 proposal to drop “lab if offered” is not treated as settled in this book; the live sheet still has the lab language.

Chapter 6

Physics

Figure 18: A kitchen-table still-life: a cart at rest, a notebook with a simple force sketch, a battery-pack and bulb kit unplugged from any wall, a rope coiled. No people, no logos, no outlet in use.

Why this matters

High-school Physics is how a student learns that force is about *change* of motion, not a fuel you pour into a moving ball — then to answer a real question from a motion they actually watched, with algebra as a tool rather than a wall. It is not a slog of every formula. It is not a brand. It is not a course titled simply "AP Physics."

That is worth the struggle because the rest of a quantitative science path hangs on it. Chemistry already asked you to count amount; physics asks you to say how motion, energy, and waves behave, with a number when a number earns its keep. Earth and space will ask how gravity and light work on a sky. A year that races through a table of contents, never rolls a cart, and never lets the student write a claim that points at a path is Physics in name. A year that stalls at the first letter in an equation, and never looks at the motion, has treated algebra as a gate. Name the year by the motions you actually measured, the energy transfers you actually named, and the diagrams the student actually drew.

There is no national physics syllabus. The *Framework* maps physical science as motion and forces, energy, and waves.[124] The *Next Generation Science Standards* package those ideas as high-school physical science. They are goals, not a curriculum and not a homeschool law.[125] California's four-course physics year names the segments in ordinary language: forces and motion; types of interactions; energy; waves and electromagnetic radiation.[126] Texas names Physics as a one-credit course.[127] Virginia names Physics I; it was not listed as a statewide SOL test on

[124]National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: The National Academies Press, 2012), doi:10.17226/13165. Physical-science core ideas PS2 (motion and stability: forces and interactions), PS3 (energy), PS4 (waves). Access date for URLs in these notes: 1 September 2026.

[125]NGSS Lead States, *Next Generation Science Standards: For States, By States* (Washington, DC: The National Academies Press, 2013), front matter and Appendix A. Standards, not curriculum, not national law. Appendix K notes that forces, interactions, waves, and energy are historically components of a Physics course, and that ESS1.A and ESS1.B sometimes find a home in Physics because of motion and forces — one map, not a requirement that astronomy live only in this chapter.

[126]California Department of Education, *2016 Science Framework for California Public Schools*, Chapter 8, Four-Course Model physics instructional segments: Forces and Motion; Types of Interactions; Energy; Waves and Electromagnetic Radiation. https://www.cde.ca.gov/ci/sc/cf/documents/scifwchapter8.pdf.

[127]Texas Education Agency, 19 TAC Chapter 112 index: Physics (One Credit), Adopted 2020. Public-school map, not homeschool law.

the page this book opened, and the course still exists.[128] None of those maps is homeschool law. None of them is the other coast.

California's Framework names a live debate in one sentence, then we teach: physics late (more mathematically rigorous) versus physics earlier (concepts concrete and everyday).[129] This book's promise is a path, not a percentile. If the student has enough algebra to treat a letter as an amount, you can start. If they do not, you repair the algebra beside the cart. You do not wait for a birthday, and you do not end the path because a formula looked like math class.

The registrar word is **Physics**. NCAA's sample transcript uses that ordinary title.[130] Never write a curriculum brand in the title column. Never write "AP Physics." College Board's opened catalogue is four named courses: AP Physics 1: Algebra-Based, AP Physics 2: Algebra-Based, AP Physics C: Mechanics, AP Physics C: Electricity and Magnetism.[131] A transcript that says only "AP Physics" is ambiguous against that list. Those four are optional beyond. They are not this chapter's floor. Physics 1, on the opened page, includes Fluids in the current course and is algebra-based. The C courses are calculus-based. If the student sits an exam, College Board forbids AI-generated answers, including text, image, and graph.[132] Credit is by college. A path through physics does not require the letters AP.

Appendix K sometimes homes the universe and the solar system in Physics because of motion and forces. That is one map. It is not a requirement that astronomy

[128]Virginia Department of Education, Science Standards of Learning page: Physics I as a course. Statewide SOL tests named on the opened page include Grade 5, Grade 8, Biology, Chemistry, and Earth Science; Physics was not listed as a statewide SOL test there. The course still exists. Public-school map, not homeschool law.

[129]California *2016 Science Framework*, Chapter 8, course-sequencing discussion: physics traditionally late, to a small population; some argue later allows a more mathematically rigorous lens; others argue earlier is approachable because the concepts are concrete and everyday. Local educational agencies choose high-school course order. The "typical sequence" of biology–chemistry–physics "for more than 100 years since the Committee of Ten" is that chapter's historical comment, not a national census.

[130]NCAA Eligibility Center, *Home School Toolkit 2025–26*. Sample titles include Physics.

[131]College Board AP Central course pages, opened 1 September 2026: AP Physics 1: Algebra-Based (current units include Fluids); AP Physics 2: Algebra-Based; AP Physics C: Mechanics; AP Physics C: Electricity and Magnetism. There is no course titled simply "AP Physics" on those pages. College Board course-and-exam. Credit by college. Optional beyond, not this chapter's floor.

[132]College Board, AP Exam Terms and Conditions 2026, Section 4 (updated 27 April 2026): no AI-generated submissions, including text, image, and graph.

live only here. Looking up belongs to the next chapter as a discipline.[133]

Electricity in this house has household-safe limits. A commercial battery pack and a bulb, or a simulation if the adult cannot make a kit safe. No mains. No homemade coils on wall current. If it cannot be made safe, it is not done. Skip rather than improvise.

This week you can learn that force is not a fuel in the thrown ball — and that algebra is a tool you can learn beside the idea, not a gate that ends the path. Today the student can roll or toss one object, write what they saw, and say whether an extra force is needed after it leaves the hand — pointing at the motion, model closed.

For the parent: understand it yourself

You do not need to be a physicist. You do need to understand today's idea well enough to hear "the ball goes up because an upward force is still in it" and "the table isn't doing anything" not as cute slips.

Everyday picture. Think of a grocery cart. If no one pushes or rubs, it keeps doing what it was doing — rest, or rolling — until something changes that. A push changes the motion. The push is not a tank of fuel that the cart burns until it is empty. A book on a table is not "just sitting there with gravity winning." The table is pushing up. You cannot see the push. You can see that the book is not falling. A wave on a rope is a pattern travelling; the rope itself is not the thing that arrives at the other end. A circuit is a complete path; a bulb lights when the path is closed, and only with a pack that is meant for it.

Precise picture. Force, in the Newtonian picture this year is building, is related to *change* of motion — speeding up, slowing down, turning — not to motion itself. A coin thrown upward does not need an upward force from the hand for the whole upward path. After release, the force that matters for the throw in the usual classroom picture is downward (and air, if you are being careful). Students still postulate that leftover upward force. The construction "is by no means obvious even to high school or college students who have had courses in introductory mechanics."[134] You will hear it. That is the work.

[133] NGSS Appendix K, as in note 125. Earth and space as a discipline is Chapter 7 of this book.

[134] National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8* (Washington, DC: The National Academies Press, 2007), on force and motion: stu-

A table on a book is a push. Students fail to see forces a Newtonian analysis requires: the force exerted by a table on a book resting on it. If the table did not push up as much as the earth pulls down, the book would start moving down. Rest is a balanced-force story, not a no-force story.

Cartoon trajectories are a cousin. Students predict that a runner off a cliff will, as in a Wile E. Coyote cartoon, continue a short way and then fall straight down, or that an object leaving a circular tube will keep curving. What you actually see, once the object is free, is a path that does not need a leftover curve-force. Look. Then the word.

Energy transfer is naming where it went: motion, sound, light, heat, a current in a safe kit. Faster things have more of the motion kind. The grade-4 idea deepens here. You do not need $E = mc^2$ this year. You need "where did it go?" with a finger on the cup, the band, or the bulb.

A *wave* is a repeating pattern. Amplitude is how big the disturbance is. Wavelength is how far from crest to crest. The rope can show both. Interference theory can wait unless this family is already there.

A *circuit* is a complete path. Household-safe means a kit made for batteries, or a skip. This book does not invent amperage rules. If you are unsure, you skip. A simulation can teach the complete-path idea when a kit cannot be made safe. A generated spark photograph is not data.

Algebra is a tool. $v = d/t$ is a compression of a measurement you already took. If the letters panic them, write the same relation in words, then put the letters back. The cart is still on the table.

Wrong answers you should be able to hear

1. Force as fuel. "It keeps going because the force is still in it." "The throw puts an upward force that lasts until the top."

What it usually means. Motion is being treated as something that needs a continuous push, like a car that dies when the tank is empty. After release, a leftover force

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dents tend to think of forces as active pushes needed to explain motion rather than as related to change of motion; they postulate an upward force on a thrown coin for the duration of the upward trajectory; they fail to see the force exerted by a table on a book; they predict circular-tube and cliff-cartoon trajectories. Newtonian construction "is by no means obvious even to high school or college students who have had courses in introductory mechanics."

was invented to explain the rest of the path.[135]

What to say. "Force is about change of motion. After it left your hand, what did you see it do? Do we need an upward force the whole way to explain that?"

2. The table does nothing. "Gravity pulls; the table is just in the way." "Nothing is pushing up."

What it usually means. The missing-force prior idea. Invisible pushes do not feel like pushes.

What to say. "If the table did not push up, the book would start moving down. Rest is two pushes (or a pull and a push) that add to no change. Let's draw both."

3. Cartoon path. "It will keep curving after the tube." "It runs off the cliff, then drops."

What it usually means. The path of the constraint was treated as a force that remains after the constraint is gone.

What to say. "What would the cartoon predict that we did *not* see? What path did this object actually take after it left?"

4. Algebra as a wall. The sitting dies at the first letter. Or the formula is chanted with no motion on the table.

What it usually means. Math class arrived as a gate, or the formula replaced the look.

What to say. "The letter is a measured amount. Let's write the same sentence in words. Then the symbol. The cart stays on the table. We do not end the year here."

5. A fluent diagram the house did not draw, or a spark no one made. The free-body diagram arrived from a chatbot. The "spark photo" is generated. The circuit was on a wall outlet.

What it usually means. The work was outsourced, or safety was improvised.

What to say. "Show me the motion you watched. Finger on the path. If we cannot open it, it comes off. We do not use the wall. If the kit is not safe, we skip."

[135] Same TSTS force-and-motion list as note 134.

Five-minute parent warm-up

Before the lesson, on paper, no student in the room:

1. Toss a soft object once, yourself. Write one sentence: after it leaves my hand, I do not need an upward force from the throw for the rest of the upward path. Circle the leftover force a student will invent.
2. Put a book on the table. Draw two arrows: down, up. Write: rest is no *change*, not no force.
3. Write tonight's question in one line a motion can speak to. Star where algebra will help, and where you will walk around it in words if the letters panic them.

If those three are fluent for you, you can hear force-as-fuel and a missing table-push. That is the job. The student still watches the motion.

How to teach it this week

Run the door before you call the year Physics.

Is there a motion on the table? If the hour is "read Newton's laws and copy the three statements," you have coverage. Roll something.

Is algebra a tool today? If the letters are the whole hour and no one looked, stop. Write the relation in words. Then the symbol.

Is electricity household-safe — or skipped? If the plan involves a wall outlet, homemade coil, or anything you cannot name the hazard for, the plan changes. Skip is a legal teaching move.

When the gates are open, here is the shape of a sitting. Warm-up. Short model. Student attempt. One good question. Mixed practice. Exit ticket. The science hour at the front of this book already taught this shape. This chapter fills it with a physics year.

Warm-up (3–5 minutes, unaided). Yesterday's path in one sketch. One "table on book" arrow pair. One "where did the energy go?" on a cup or a band they have already seen. No tool.

Short model (5–8 minutes). You put a ball or a cart on the table. Think aloud: "Here is the question. Here is what I see after it leaves my hand. Here is the leftover

force I am *not* drawing. Here is what I write down. My claim, which you could argue with, is ____. The because-link is this path. Algebra helps here: ____. If the letter is a wall today, the words still work." Keep it short. You are showing a change-of-motion, not delivering a lecture on a century of mechanics.

Fade as soon as you can. Second sitting: they explain your sketch. Third: they record while you watch. Fourth: they write the claim unaided, model closed. Include one incorrect example: an upward force after release; a cartoon cliff; a chatbot free-body diagram; a generated spark.

Exact wording you can steal.

On a throw: "When the ball left your hand, what did you see it do — and do we need an upward force the whole way to explain that?"

On the table: "The table pushes. Rest is no change, not no force."

On a cartoon: "What would Wile E. Coyote predict that we did *not* see?"

On energy: "Where did it go — motion, sound, light, heat? Point."

On a wave: "How big is the disturbance? How far from bump to bump? That is the pattern."

On a circuit: "A complete path. Battery pack only. If we cannot make it safe, we skip."

On algebra: "The letter stands for a number we could measure. Say it in words first."

On the chatbot: "If we did not watch this motion, it is not data. A diagram a model drew is a scene. It is not your sketch."

First problem for the student, after the model. Roll or toss one object. Product goal on a sticky note: a claim in their own words, with a finger on the path, and a sentence on whether an extra force is needed after release. Model closed. You wait. Struggle before rescue. You do not finish the sketch.

One good question. After the attempt: "If I hid the motion, would your claim still know where it came from?" The student generates the why.

Student attempt, then mixed practice. Two or three short claims of the new type, unaided, after the fade — not five problem sets with no motion. Then mix:

yesterday's table-on-book, last week's energy transfer, one "cartoon path," one "words then letters."

Exit ticket (5–10 minutes, unaided). One question, one named motion already watched, a three-to-five-sentence claim or a sketch plus one number. Tool closed. You grade the unaided ticket. A fluent diagram with no motion in the house is performance. The claim that points is the test.

Every problem and every claim the transcript will claim needs an unaided attempt the model did not open. That is the year, not a special integrity week.

How to fade help. You roll and sketch → they explain your arrows → they sketch the second sitting → they write the claim → they choose whether algebra helps today. When they can refuse the leftover upward force without your prompt, put the "after release" scaffold away. Bring it back when a new path arrives — a curve, a wave, a circuit.

When to stop talking. After one model and one question. You do not become the textbook. You hold the key: is there a motion, a sketch that matches it, and an algebra tool that did not eat the hour?

Investigation 1 — Change-of-Motion, Not Force-as-Fuel

Time. One science hour.

Materials. A cart or a ball. A notebook. A soft landing zone.

SAFETY. Soft objects. No throwing at heads. Adult present. Indoor floor clear. No hard projectiles.

The fun of it. It keeps going. The leftover force they expected is not required by what they saw.

The skill it builds. Force as related to *change* of motion. Not a calculus wall.

How to run it. Roll on a smooth floor. Then on a rug. Write what changed and what you did to change it. Then a gentle toss. After it leaves the hand: what path? Which force are we *not* drawing? The student records. You wait.

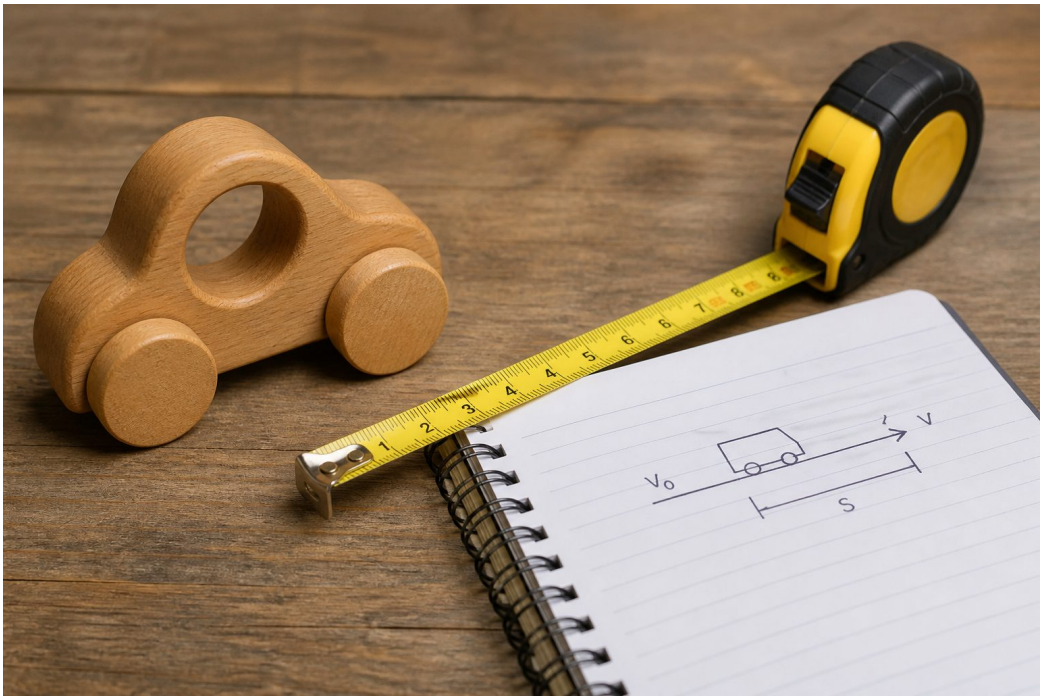

Figure 19: A cart and a ball on a table, a notebook sketch of a path after release, no people, no logos.

Investigation 2 — Table-on-Book

Time. Five to ten minutes, then a return whenever rest is treated as "nothing happening."

Materials. A book. A table.

SAFETY. None beyond not dropping the book on a toe.

The fun of it. The table pushes? Students like the strangeness of an invisible up-arrow.

The skill it builds. Hearing the missing-force prior idea. Balanced forces as no *change*.

How to run it. Book on table. "Draw every force you think is here." Then: "If the table did not push up, what would the book start to do?" Two arrows. Rest is the story of no change.

Investigation 3 — Energy Transfer You Can Name

Time. One sitting.

Materials. A rubber band; a warm cup the adult handled; a flashlight. Notebook.

SAFETY. No open flame. No mains electricity. Hot cup handled by the adult. Rubber band not aimed at faces.

The fun of it. Where did it go.

The skill it builds. Energy transfer by sound, light, heat, motion — a high-school deepening of the grade-4 idea, not $E = mc^2$.

How to run it. Stretch and release (soft). Warm hands near the cup. Flashlight on, then off. Each time: where did it go? Point. Write. One because-sentence that is not "because energy."

Discussion box

Illustration, labelled as such: a soft ball tossed upward and caught, a notebook with a path sketch, two arrows on a book. Composite table, not a reported family.

Opening. "When the ball left your hand, what did you see it do — and do we need an upward force the whole way to explain that?"

Not: "State Newton's first law."

Follow-ups (pick three to five). What did you measure? What would a cartoon (Wile E. Coyote cliff) predict that we did *not* see? Can we tell for sure? What would change your mind? Where is algebra helping, and where is it a wall we can walk around today?

How to wait. Three to five seconds after you ask. Three to five after they stop talking. Look at the path if the silence is hard. Wait time of that length is a finding from elementary science classrooms, not a physics-score promise.[136]

Stuck silence usually means. Recitation of a law name; algebra panic covering the idea; the chatbot already "explained gravity"; or

[136] Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control" (NARST paper, ERIC ED061103, 1972). Elementary science classrooms; wait 3–5 seconds. Not a physics-score finding.

no one watched the motion because the formula page won.

Done enough. A claim about this motion with a measurement or a path. Physics as a transcript line only if the work matches.

Practice that actually builds learning

Understanding and practice grow together. Practice a new move this week, with a motion and a why. A stack of formula quizzes with no cart is assignment, not teaching.

Typical isolated labs are no more or less effective than reading for content; looking and talk belong in the same week.[137] Then teach. The toss without the discussion box is a demo. The discussion box without a toss is a recitation.

Blocked, for a new move. The day a student first refuses the leftover upward force, a short blocked set is honest: two more releases, same move. Same for a first table-on-book sketch, a first energy-transfer list, a first unaided number.

Mixed, for when to use it. Later the same week, mix: a toss, a book, a wave on a rope, one "cartoon path," one "words then letters." Choosing *when* to go deep is part of the skill.

Brief retrieval. Yesterday's path; the up-arrow on the table; one place energy went. A short oral at the start of the hour. Law names that are not retrieved turn into wallpaper — and wallpaper is not the hour.

One incorrect example to diagnose. Show a fluent paragraph whose only evidence is "Newton's first law," with no motion in the house. Or a free-body diagram a model completed. Ask what they thought counted as the look. Then an isomorphic claim, unaided, from a real roll.

Sports and bikes can motivate. A throw, a ride, a swing — those are doors into a motion. They do not replace the unaided sketch. A game will not teach table-on-book by itself.

[137] National Research Council, *America's Lab Report: Investigations in High School Science*, Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, eds. (Washington, DC: The National Academies Press, 2006), Executive Summary: typical isolated labs no more or less effective than reading, lectures, or discussion for subject-matter mastery; integrated units with discussion show greater effectiveness in small-scale studies.

Investigation 4 — Wave Pattern on a Rope or Water Tray

Time. One sitting.

Materials. A rope, or a shallow tray with a little water. Notebook.

SAFETY. Water in the tray; floor dry; adult present. Rope not used as a whip. Electrical devices nowhere near the tray.

The fun of it. Making a pattern you can see travel.

The skill it builds. Amplitude and wavelength as a model. Not interference theory unless the family is already there.

How to run it. Send a pulse. Then a repeating shake. How big? How far from bump to bump? Draw. The rope stays; the pattern travels. That sentence is the idea.

Investigation 5 — Circuit with Household-Safe Limits (or Skip)

Time. One sitting — or skip.

Materials. A commercial battery pack and bulb kit, *or* a simulation if the adult cannot make a kit safe.

SAFETY. No mains. No homemade coils on wall current. No taking apart household electronics. Adult present. Stop if unsure. If proper gear is missing, the activity is not done.[138] Skip is teaching. Improvising on a wall is not.

The fun of it. The bulb lights. A complete path is suddenly not a slogan.

The skill it builds. A complete path. Fields and household current wait for a kit and a course that can hold them.

How to run it. One pack, one bulb, one switch if the kit has it. Closed path, light. Open path, dark. Draw. If you skip, say so in the notebook: we did not run

[138] American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016): adult physically present the entire experiment. National Science Teaching Association, Position Statement, "Safety and School Science Instruction" (revised April 2024): eliminate the activity if it cannot be performed safely. Kenneth Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020 (author's views): if proper PPE is not available, the activity is not conducted. This book invents no household-amperage rules.

a circuit because we could not make it safe; we used a named simulation, or we waited. Title the year honestly.

Investigation 6 — Unaided Diagram Plus a Number

Time. Fifteen to twenty-five minutes.

Materials. The motion already watched; paper; model closed; your key of what a good sketch looks like, hidden.

SAFETY. Same as the original sitting. No wall outlets in use.

The fun of it. The sketch is theirs. The number is theirs.

The skill it builds. A claim about this motion with a measurement. Algebra as a compression of the look, not a replacement for it.

How to run it. Sticky-note product: one sketch someone could disagree with; one named motion; one number or a words-first relation; one clause on the leftover force you did *not* draw. Tool closed. You are the reader: "I cannot find this path in the notebook." You are not the co-author. The student never photographs the answer key into a chatbot.

If you sample AP Physics 1–style items, treat them as a check on the same skills — a short motion, a claim — not as the Physics course, and not as a title that says only "AP Physics." The unaided sketch from a real motion is still the kitchen object.

Set the product goal every sitting. Read the claim aloud. Check the trail. Then change one sentence — usually the leftover force. Monthly: an unannounced miniature, cart in the room, tool closed.

For the student

Physics is how you answer a question about motion, force, energy, waves, and — if we can make it safe — a simple circuit, using a look someone else could check. It is not a list of laws, and it is not a course titled "AP Physics."

Force is about change of motion. After a ball leaves your hand, you do not need an upward force from the throw for the rest of the upward path. The leftover force is a prior idea doing work. You will hear yourself reach for it. That is normal. Look at the path.

A book on a table is two stories at once: the earth pulls down, the table pushes up. Rest is no *change*, not no force.

Cartoons lie about paths. A runner does not pause in the air. An object leaving a tube does not have to keep curving. Watch what this object did.

Energy is "where did it go?" Motion, sound, light, heat. Point.

A *wave* is a pattern. How big? How far from bump to bump? The rope stays; the pattern travels.

A *circuit* is a complete path, and only with a pack meant for it. If we cannot make it safe, we skip. That is part of the science.

Algebra is a tool. A letter stands for a number you could measure. If the letter panics you, say the same sentence in words. Then put the letter back. The cart stays on the table. You are not done with physics because a formula looked like math class.

A diagram a computer drew is a scene. It is not your sketch. A spark photograph a computer made is not data.

Tiny worked example. Question: *After the ball left my hand, did I need an upward force from the throw for the rest of the way up?*

Observation (already in the notebook): the ball left my hand, slowed, came down; I was no longer touching it.

Claim: *After release I do not need an upward throw-force to explain the rest of the upward path; the path we saw is a change of motion after contact ended.*

Because: *A leftover upward force was a story I brought. The observation is: contact ended, the ball was still going up and slowing. Force, here, is about that change, not about pouring fuel into the ball.*

The because-sentence is not "because Newton's first law." That restates a label. The because-sentence is the rule about what this path can show.

Try 1. Toss a soft object. Sketch the path after it leaves your hand. Mark the leftover force you are *not* drawing.

Try 2. Book on table. Draw both arrows. Say why rest is not "nothing happening."

Explain it back. In two sentences, tell someone why force is not a fuel, and how you would write $v = d/t$ in words if the letters were a wall today.

Challenge. Watch one motion, write a number, and write a paragraph someone could disagree with. Name the path. If you cannot point at the notebook, you are still in slogan country. Stay there until the finger works.

You are allowed to struggle. A missing number is information, not a verdict. Look. Sketch. The tool does not take this test. You do.

If it isn't clicking

Three diagnostics, and the next move for each. No shame. Placement is by skill, not by birthday.

Diagnostic 1 — there is no motion, or the leftover force will not leave. The student can recite a law and cannot say what the ball did after release. The "year" is a formula list.

Next move. Stop the slog. One toss. One sketch. One "what are we not drawing?" Talk before writing. A calendar-grade 11 or 12 student who cannot point at a path is not "behind in Physics." They are still in a taught-looking stage. The survey waits until the looking is prompted. Small looking can continue: one roll, one oral credit.

Diagnostic 2 — algebra as a wall, or a cartoon as the model. The sitting dies at the letter. Or every path is Wile E. Coyote.

Next move. Words first, then the symbol. The cart stays. Ask what the cartoon predicts that you did *not* see. Repair the arithmetic beside the idea. Physics late versus physics earlier is a sequence debate, not a talent verdict. You can start when the gates are open. You can keep going in words when the letters are rusty.

Diagnostic 3 — a fluent page the house cannot reopen, or a wall outlet. The diagram arrived. The spark is generated. Or someone reached for mains.

Next move. Objects in the hands. Finger on the path. If it cannot be opened, it comes off. Mains are off the table. Skip the circuit if it cannot be made safe. Unaided miniature, tool closed. Detectors are not a verdict; the reopenable trail is.[139]

[139]Weixin Liang et al., "GPT Detectors Are Biased Against Non-Native English Writers," *Patterns* 4, no. 7 (2023). Detectors are not a kitchen verdict.

When to get a human tutor. You cannot hear force-as-fuel, even after the five-minute warm-up. Or the student has weeks of motion sittings, and the unaided ticket is still a dump or a blank. A tutor, a co-op, or a later dual-enrollment physics survey is a normal plan. Stay the supervisor who can still ask "what did you see after it left your hand?" Dual-enrollment physics is a *college* transcript object, distinct from this kitchen year. AP Physics 1, 2, C Mechanics, and C E&M are overlays, not a requirement, and not a title that says only "AP Physics." Credit is by college.

When to go ahead. The leftover upward force is refused without a prompt. The table pushes. Energy can be named as a transfer. A wave is a pattern. Circuits were safe or skipped on purpose. Algebra helps more often than it walls. Unaided sketches point at named motions. Then lengthen: a short paper with three motions; a second kind of interaction; an optional named AP-style sitting if you chose that exam. Diagnose. Then move.

Tools, including AI

Optional helpers for you. The student watches. You hold the motion and the key.

> **AI box — Physics**
>
> Use a tool to explain *this week's idea* to *you* from a named textbook page, to generate extra "words then letters" items with answers hidden from the student, to write a hint script that withholds the leftover-force diagnosis, or to diagnose a sketch already drawn.
>
> The student watches the motion and writes the claim. No "complete my free-body diagram," no invented data table, no generated spark as the student's result, no photo-to-key of a worksheet, no unsupervised chatbot during the attempt, no "what's the answer" as the whole hour.
>
> A model-supplied coefficient, quotation, or "typical result" is untrusted until it matches the notebook or a named page. Find it or drop it.
>
> A generated spark or a generated motion blur is a scene to look at together for two minutes, labelled generated. It is not data. Then it comes off the table.

A cart, a named textbook, and a battery-pack kit are tools. A chatbot law-name is not. In a high-school mathematics study, an unguarded chatbot raised assisted practice and then cut the unaided exam.[140] That study is math, not a Physics trial. The same crutch is available here. The unaided sketch the next morning is the test.

What "done enough" looks like

A "grade 12 Physics" book is a publisher's or a state's scope, not a legal grade and not a national sequence. Done enough is skill, plus motions actually watched, plus writing the student produced. Physics late or physics earlier is a family sequence choice, not a talent myth.

Checklist before moving on.

- Treats force as related to change of motion, and can refuse a leftover upward force after release.
- Draws the table's push on a resting book.
- Names an energy transfer by pointing at where it went.
- Treats a wave as a pattern (how big, how far from bump to bump).
- Runs a household-safe circuit — or skips on purpose, in writing, because it could not be made safe.
- Uses algebra as a tool: words first if the letters panic, then the symbol; the cart stays.
- Writes an unaided claim or sketch with a named real motion; the model did not open the draft the transcript will claim.
- Treats a generated image as a scene, not as data.

What can still be thin: every unit on an AP list; calculus-based mechanics; a stockroom electronics year. Those can travel. The slog of law names with no motion cannot count as done. A wall-outlet improvisation cannot count as done.

Transcript. Write **Physics**. If the family used a conversational Christian text, a textbook survey, a classical pairing, or a college open text *inside* the year, the description can say so. The title is still Physics. Never a brand. Never "AP Physics" as an undifferentiated title. If the student sits AP Physics 1: Algebra-Based, or

[140] Hamsa Bastani et al., "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent on practice, −17 percent on an unaided exam. Math, not a Physics RCT. The crutch still governs the science hour.

Physics 2, or Physics C: Mechanics, or Physics C: Electricity and Magnetism, put that *named* exam on a separate line. Safer kitchen practice is a readable title plus the score as an artifact. A full astronomy year is not silently relabelled Physics; looking up lives in the next chapter unless this family actually taught astronomy as the year. *With Lab* is a claim the records chapter will teach you how to make honestly. This chapter is the looking that would have to be in the folder.

NCAA counts natural and physical science as core, two years, including one year of lab if offered.[141] The year on the table is still Physics.

A parent who felt rusty should be able to say, after this chapter: I know force is not a fuel. I know the table pushes. I know what to say tomorrow — a motion, a sketch, words then letters if we need them. The student still watches. We can do this.

[141] NCAA Eligibility Center, Division I Academic Standards fact sheet (September 2023); *Home School Toolkit 2025–26*; High School Review Committee Policies 2025–26 / Staff Policies 2026–27. Fact sheet cell: Science, including one year of lab if offered — 2 years. HSRC: natural/physical science. CLEP is not NCAA core.

Chapter 7

Earth and space

Figure 20: A kitchen-table still-life: a notebook sky log, a rock, an unbranded outline map, a window with daylight. No people, no logos, no weather-app screen.

Why this matters

Earth and space science is a discipline. It is how a student learns that a planet is systems talking to one another, that weather becomes climate only when a record exists, and that astronomy starts by looking up — then to answer a real question from a sky, a rock, or a named table that actually sat on this table. It is not leftover weeks after biology. It is not a brand. It is not a national ninth-grade clock.

That is worth the struggle because the public maps disagree about whether Earth is a peer year, and the student still needs the moves. Biology asked about living systems. Chemistry asked about stuff. Physics asked about motion. This year asks how a planet and a sky work, and how people change both. A year that races through a planet list, never logs a Moon, and never lets the student write a claim that points at a record is Earth Science in name. Name the year by the systems you actually went into, the skies you actually logged, and the numbers the student actually used.

The *Framework* is unambiguous that Earth and space is a core domain, not an extra: Earth's place in the universe; Earth's systems; Earth and human activity.[142] The *Next Generation Science Standards* package those ideas as high-school earth and space science. They are goals, not a curriculum and not a homeschool law.[143] Appendix K names the high-school problem this chapter exists to fix: Earth and space ideas are often split among biology, chemistry, and physics "because it is currently a common sequence," and Earth and space science is often missing as a required course.[144] That sentence is a map fact. It is not a statute that Earth is optional intellectually, and it is not a census of ninth grade.

California's four-course model treats Earth and space sciences as a year; local

[142]National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: The National Academies Press, 2012), doi:10.17226/13165. ESS1 Earth's place in the universe; ESS2 Earth's systems; ESS3 Earth and human activity (including natural resources, natural hazards, human impacts, global climate change). Access date for URLs in these notes: 1 September 2026.

[143]NGSS Lead States, *Next Generation Science Standards: For States, By States* (Washington, DC: The National Academies Press, 2013), front matter and Appendix A. Standards, not curriculum, not national law.

[144]NGSS Appendix K, Modified Science Domains model: Earth and space performance expectations often split among biology, chemistry, and physics "because it is currently a common sequence in high schools across the United States"; Earth and space science is often missing as a required course. Map fact, not a statute, not a ninth-grade census. This book opened no national enrollment percentage for grade-9 Earth versus grade-9 Biology.

schools choose order, including Earth-first. California's three-course model folds Earth into The Living Earth, Chemistry in the Earth System, and Physics of the Universe.[145] Texas lists Earth Systems Science, Astronomy, and Environmental Systems as high-school courses a student *may* take; Biology is the required credit, and the second credit comes from IPC, Chemistry, or Physics.[146] Virginia treats earth sciences as a diploma discipline: three lab credits from at least two of earth sciences, biology, chemistry, or physics, and a statewide Earth Science test.[147] None of those maps is homeschool law. None of them is the other coast. Both patterns exist: Earth as a peer year, and Earth as a fourth or elective. This book does not invent a national ninth-grade percentage, and it does not freeze biology-first as a national habit.

The registrar word is **Earth Science**. Optional **Environmental Science** is a transcript title when the work matches — a local human-impact year with evidence, not a dump of someone else's nine units. NCAA's sample list uses ordinary titles; Earth Science is a stranger-readable name even when it is not on that short sample.[148] Never write a curriculum brand in the title column. Never silently relabel a full astronomy year as Physics. Astronomy is a real title in some publisher lists and in OpenStax's college catalogue. If this family taught astronomy as the year, say so in the description. The locked stranger-readable list still prefers Earth Science

[145]California Department of Education, *2016 Science Framework for California Public Schools*, Chapter 8, Four-Course Model: Earth and Space Sciences as a year-long course; local educational agencies choose order. Three-course model titles on the Framework landing page: The Living Earth; Chemistry in the Earth System; Physics of the Universe (Chapter 7 PDF not fully fetched for instructional-segment text). CA NGSS adopted 4 September 2013.

[146]Texas Education Agency, 19 TAC Chapter 112 index: Earth Systems Science, Astronomy, Environmental Systems (One Credit each), Adopted 2021; Biology, Chemistry, IPC, Physics Adopted 2020. 19 Tex. Admin. Code §74.12: three science credits; one Biology; second from IPC, Chemistry, or Physics. Earth Systems Science is additional, not the required second credit. Public-school map, not homeschool law.

[147]Virginia Department of Education, Standard Diploma graduation requirements: three laboratory-science credits from at least two of earth sciences, biology, chemistry, or physics. Science SOL page: statewide tests named include Earth Science. Physics is a course; it was not listed as a statewide SOL test on the opened page. 2018 Science SOL remain the K–Physics content map; 11 December 2025 Board action added 2025 Expanded High School Science SOL including Environmental Science and Earth Science II tracks. Public-school map, not homeschool law. Full 2018 SOL PDF not successfully downloaded for quoted student-expectation text.

[148]NCAA Eligibility Center, *Home School Toolkit 2025–26*. Sample titles include Physical Science; Biology with Lab; Chemistry; Physics. Locked stranger-readable titles for this book also include Earth Science and Environmental Science. Course name on the worksheet should match the transcript title.

unless the work was actually an astronomy year.

AP Environmental Science is an optional College Board object. The opened page names nine units; content is not changing for the 2026–27 clarifications.[149] It is a possible beyond. It is not this chapter's kitchen method. If the student sits the exam, College Board forbids AI-generated answers, including text, image, and graph.[150] Credit is by college. A path through earth and space does not require the letters AP.

Climate and human impact appear on the public maps. Teach them as the maps place them: a claim that needs a record, not a feeling, and not a pamphlet.[151] Weather in the early chapters of this book was observation. Here weather-to-climate is evidence.

This week you can learn that Earth is a discipline, and that climate is a claim that needs a record, not a feeling. Today the student can look up (or at a landform), write what they saw, then say what else we would need before treating it as settled — model closed.

For the parent: understand it yourself

You do not need to be a geologist or an astronomer. You do need to understand today's idea well enough to hear a planet chant offered as astronomy, and "the climate changed because I felt hot in July" offered as evidence, not as cute slips.

Everyday picture. Think of a house. The roof, the plumbing, the furnace, and the people who live there are systems. A leak in the roof shows up in the ceiling. Weather is what the house did this afternoon. Climate is what this house usually does in July, from a log, not from a mood. Looking up is stepping outside at dusk

[149] College Board, AP Environmental Science course page, https://apcentral.collegeboard.org/courses/ap-environmental-science. Nine units as opened: Ecosystems; Biodiversity; Populations; Earth Systems and Resources; Land and Water Use; Energy Resources and Consumption; Atmospheric Pollution; Aquatic and Terrestrial Pollution; Global Change. Content not changing for 2026–27 clarifications. College Board course-and-exam. Credit by college. Optional beyond, not this chapter's kitchen method.

[150] College Board, AP Exam Terms and Conditions 2026, Section 4 (updated 27 April 2026): no AI-generated submissions, including text, image, and graph.

[151] NRC, *Framework* (n. 142), ESS3; California Framework Chapter 8 Earth and space segments including climate and human impacts; AP Environmental Science as an optional exam object (n. 149). Teach as the maps place the ideas.

and noticing that the Moon is not where it was last Tuesday. A generated postcard of the Moon is a scene. The window is the observation.

Precise picture. *Earth systems* means materials, water, air, life, and people interacting. A rock is a record of a process that usually took longer than a day. Plate motion, water's work on a surface, a mountain, a farm — one place, one mechanism as the map places it. You will skip a slog of every landform. That is triage, not a failure.

Weather is the state of the air here, now, or this week: temperature, wind, cloud, rain, written down. *Climate* is the pattern of weather over a long enough record that a single July does not get to be the story. Human impact and global climate change are on the *Framework*'s ESS3 list. Teach them as claims that need a named table: who measured this, over what span, what would change our minds. A culture-war week is not this hour.

Astronomy as looking up is ESS1 in kitchen language. Sky patterns. The Moon's place. A planet you can actually find, if you can. Never look at the Sun. A planet-name list with no night in the notebook is coverage. A generated Hubble shot is a scene, labelled generated — never the night's observation.[152] A labelled schematic of the water cycle may be looked at together. Then the tray or the map of *this* watershed comes on.

If the number did not come from this house, it is a claim someone else already made. Who measured this? If it is a website, leave the page: new tab, who is this maker, then back. That is one looking move. Civic Online Reasoning already lives in *Critical Thinking for Life*. This book does not park a second course here.[153]

Wrong answers you should be able to hear

1. Planet names as the year. "We did astronomy: Mercury, Venus, Earth…" No log. No look.

What it usually means. Coverage won. Looking up never happened.

[152] Elsevier generative-AI policies (updated June 2026) and Nature Portfolio AI editorial policy: do not fabricate data or create photorealistic images as experimental evidence. A generated sky is a labelled scene, never the night's observation.

[153] One looking move, as this book's frame: Who measured this? If a website, leave the page. Civic Online Reasoning already lives in *Critical Thinking for Life*. Not a second evaluation course here.

What to say. "Name one thing you saw in the actual sky. If we have not looked, we have a list, not astronomy."

2. A feeling as climate. "It was hot, so the climate changed." Or: the sitting becomes an argument about a party instead of a table of numbers.

What it usually means. Weather (this week) was upgraded to climate (a pattern). Or the hour left the evidence.

What to say. "Weather is this week. Climate is the pattern in a record. What table are we pointing at — and who measured it?"

3. Earth as leftover. "We'll get to rocks if biology finishes early." Or a ninth-grade Earth year treated as a national clock. Or the opposite freeze: "Real high school is bio–chem–physics; Earth never."

What it usually means. One coast's habit was treated as a national clock. Appendix K's common sequence was treated as a law, or Virginia's peer discipline was treated as a law.

What to say. "Earth is a discipline. Maps disagree about whether it is a required year. We will teach the moves. We are not following a national ninth-grade clock."

4. A generated sky as the observation. "We looked at the Hubble picture the model made." Or a weather-app screenshot treated as the student's log.

What it usually means. A scene was upgraded to data. A generated image of a sky is not a night's looking.

What to say. "That picture is labelled generated. It comes off. The window, or a named atlas plate, stays. Who measured this if the number is not ours?"

5. A fluent page the house cannot reopen. Diction jumped a grade. The "data table" was invented. The citations look real.

What it usually means. The work was outsourced. Language models invent titles, dates, and results.

What to say. "Show me the log. Finger on the night or the table. If we cannot open it, it comes off. The model stays closed."

Five-minute parent warm-up

Before the lesson, on paper, no student in the room:

1. Write one sentence: Earth is a discipline, not leftover weeks. Name which map this family is using — a peer Earth year, Earth folded into the other three, or an elective Earth / Environmental title — and why.
2. Open tonight's sky or tonight's rock. Write what you actually see, before any name. Star whether a generated picture will have to be kept off the table.
3. Write tonight's question in one line a record can speak to. If a number will come from a printed table, write "who measured this?" above it.

If those three are fluent for you, you can hear a planet chant and a feeling offered as climate. That is the job. The student still looks up.

How to teach it this week

Run the door before you call the year Earth Science.

Is there a look? If the hour is "read chapter 14 and list the planets," you have coverage. Step to the window, or put a rock on the table.

Is weather being asked to do climate's job? If the claim is a mood, stop. Put a table on the table.

If a number is not ours, can they say who measured it? If the page is a website, leave it, then come back.

When the gates are open, here is the shape of a sitting. Warm-up. Short model. Student attempt. One good question. Mixed practice. Exit ticket. The science hour at the front of this book already taught this shape. This chapter fills it with earth and space.

Warm-up (3–5 minutes, unaided). Yesterday's sky in one sentence. One "who measured this?" on a number they have already used. One rock or landform they can still name. No tool.

Short model (5–8 minutes). You put the window or a rock on the table. Think aloud: "Here is the question. Here is what I actually see. Here is what I write down — not what a poster promised. If this number is not ours, here is who measured it. My claim, which you could argue with, is ____. The because-link is this line in the log. What I still need is ____." Keep it short. You are showing looking, not delivering a lecture on a solar system.

Fade as soon as you can. Second sitting: they explain your log. Third: they record

while you watch. Fourth: they write the claim unaided, model closed. Include one incorrect example: a planet chant; a generated Hubble scene treated as last night; a hot afternoon offered as climate.

Exact wording you can steal.

On the sky: “What had to be true about this sky for what we saw to happen — and what did we actually record?”

On the Sun: “We never look at the Sun. If an eclipse is the plan and we cannot do it safely, we skip.”

On a rock: “This took longer than a day. What process is a candidate — and what would we still need?”

On weather and climate: “This week is weather. The pattern in the table is climate. Who measured the table?”

On a website: “Leave the page. New tab. Who is this maker? Then we come back.”

On a generated sky: “What did the model invent? Two minutes. Then it comes off. The window stays.”

On Environmental Science as a title: “One local question with evidence. Not nine units copied from an exam list.”

On the chatbot: “If we did not look, it is not an observation. A sky a model made is a scene.”

First problem for the student, after the model. Look up, or look at a landform. Product goal on a sticky note: a claim in their own words, with a finger on what they recorded, and one sentence on what else we would need. Model closed. You wait. Struggle before rescue. You do not narrate the sky for them.

One good question. After the attempt: “If I hid the log, would your claim still know where it came from?” The student generates the why.

Student attempt, then mixed practice. Two or three short claims of the new type, unaided, after the fade — not five planet quizzes. Then mix: yesterday’s sky, last week’s rock, one “who measured this?,” one “generated scene then the window.”

Exit ticket (5–10 minutes, unaided). One question, one named observation or printed table already on the table, a three-to-five-sentence claim. Tool closed. You

grade the unaided ticket. A fluent page with an unopenable sky is performance. The claim that points is the test.

Every report the transcript will claim needs an unaided draft the model did not open. That is the year, not a special integrity week.

How to fade help. You look and log → they explain your log → they record the second sitting → they write the claim → they help choose the next system's question with you. When they can separate weather from climate without your prompt, put the scaffold away. Bring it back when a new kind of system arrives — water, a hazard, a human-impact question.

When to stop talking. After one model and one question. You do not become the textbook. You hold the key: is there a look, a record, and a claim that points?

Investigation 1 — Sky Pattern, Looking Up

Time. Several short looks, then one talk.

Materials. The actual sky. A notebook. A pencil. Optional: a named atlas plate *after* the look.

SAFETY. Never look at the Sun. Eclipse rules are adult-enforced, with proper solar filters, or the activity is skipped. Night looks: adult present outdoors; known place; no roads. Cold-weather common sense.

The fun of it. The Moon moved. A pattern you did not have to memorize because you saw it.

The skill it builds. ESS1 as looking, not a planet-name slog.

How to run it. Three nights, five minutes each, same window or same yard. Sketch the Moon's place against a rooftop or a tree. Then one talk: what changed? What would we still need before we treated a planet story as settled? A named plate can come on after. A generated sky, if you ever show one, waits for Investigation 5.

Figure 21: A notebook sky log with a simple Moon-against-roofline sketch, a window, no people, no logos, no app UI.

Investigation 2 — Rock or Land as a System

Time. One sitting or one walk.

Materials. One rock, or one named landform the family can actually see, or a named map of a place you can point at.

SAFETY. Adult present outdoors. No cliff edges. No hammering near eyes without goggles. No collecting from protected ground. Wash hands.

The fun of it. This took longer than a day. Time becomes visible in a thing you can hold.

The skill it builds. Earth events fast or slow; surface change, now with a mechanism as the map places it — water, ice, a slope, a plate story at the level of "this coast is not finished."

How to run it. Look. What do you see? Grain, layer, roundness, a fossil if one is

honestly there. Write a candidate process. Then: what would we still need? You will not "do geology" this week. You will answer one question about one rock or one hill.

Investigation 3 — Weather to Climate as Evidence

Time. One sitting with a table the family already kept, or a named public data table the parent printed.

Materials. Numbers, not a feeling. A printed page with a source line: who, where, what span. Notebook.

SAFETY. None for a paper table. If you go outside to add a weather row, adult present; no storm chasing.

The fun of it. July is usually… — and you can point at why you may say so.

The skill it builds. Climate as a pattern of weather. Human impact as the map places it, with evidence, not a pamphlet.

How to run it. Two columns if you have them: this week's weather, and a span of Julys or a span of years. Question: *Is this week's heat (or cold, or rain) the same kind of claim as the pattern in the table?* Who measured the table? What would change your mind? If the table is a website, leave the page, check the maker, come back. Teach the idea. A party is not the hour.

Discussion box

Illustration, labelled as such: a three-night Moon log, a printed temperature table with a source line, a rock. Composite table, not a reported family.

Opening. "What had to be true about this place (or this sky) for what we saw to happen — and what did we actually record?"

Not: "Name the planets."

Follow-ups (pick three to five). What did you see? What would we still need before we treated this as settled? Who measured this if the number did not come from us — and is that a primary observation or a claim? If it is a website, what happens when we leave the page? What would change your mind?

How to wait. Three to five seconds after you ask. Three to five after they stop talking. Look at the log if the silence is hard. Wait time of that length is a finding from elementary science classrooms, not an earth-science-score promise.[154]

Stuck silence usually means. Recitation of planet names; a lecture filling the hour; the chatbot already "explained climate"; or weather was asked to do climate's job and the student can feel the mismatch.

Done enough. A spoken claim tied to a named observation or a named data table. Earth Science or Environmental Science as a transcript line only if the work matches.

Practice that actually builds learning

Understanding and practice grow together. Practice a new move this week, with a look and a why. A stack of planet quizzes with no night is assignment, not teaching.

Typical isolated labs are no more or less effective than reading for content; looking and talk belong in the same week.[155] Then teach. The sky log without the discussion box is a diary. The discussion box without a log is a recitation.

Blocked, for a new move. The day a student first separates weather from climate, a short blocked set is honest: two more tables, same move. Same for a first Moon log, a first rock sitting, a first unaided claim.

Mixed, for when to use it. Later the same week, mix: a sky sitting, a rock, a water tray, one "who measured this?," one "generated scene then the window." Choosing *when* to go deep is part of the skill.

Brief retrieval. Last night's Moon place; who measured Tuesday's table; one process candidate for the rock. A short oral at the start of the hour. Planet names that are not retrieved turn into wallpaper — and wallpaper is not the hour.

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[154] Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control" (NARST paper, ERIC ED061103, 1972). Elementary science classrooms; wait 3–5 seconds. Not an earth-science-score finding.

[155] National Research Council, *America's Lab Report: Investigations in High School Science*, Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, eds. (Washington, DC: The National Academies Press, 2006), Executive Summary: typical isolated labs no more or less effective than reading, lectures, or discussion for subject-matter mastery; integrated units with discussion show greater effectiveness in small-scale studies.

One incorrect example to diagnose. Show a fluent paragraph whose only evidence is "as NASA showed," with no named table in the house, or a generated sky captioned as last night. Ask what they thought counted as an observation. Then an isomorphic claim, unaided, from the window or a printed page with a source line.

Walks and windows can motivate. A hike, a farm, a river — those are doors into a system. They do not replace the unaided claim. A vacation will not teach climate by itself.

Investigation 4 — Water in the System

Time. One sitting.

Materials. A tray, soil, ice, or a named map of a local watershed. Notebook. Water in a pitcher.

SAFETY. Water in the tray; floor dry; adult present. Ice handled with ordinary care. No pouring near electrical devices.

The fun of it. Where does our rain go.

The skill it builds. Water as a surface process. A local watershed as a system, not a cycle chant.

How to run it. Make a small slope in the tray. Pour. Watch. Then the named map: where would our rain go from *this* roof or *this* street? Write a claim. The cycle name is a hanger, not the observation.

Investigation 5 — Generated Sky, Then the Window

Time. Two minutes of looking at a generated picture together, then the generated picture comes off.

Materials. Optional: a generated image of a sky, a nebula, or a "Hubble photo," parent account, labelled generated. Then the actual sky or a named atlas plate.

SAFETY. Still never look at the Sun. The generated picture is paper or a screen held by the adult, not a reason to skip the Sun rule.

The fun of it. Catching what the model invented. Students usually like being right about a mistake.

The skill it builds. A generated image is not data. Looking at it together, then putting it away, keeps the tool from becoming the night.

How to run it. "What did the model invent — extra colors, a Moon phase that does not match tonight, a telescope view no backyard has?" Two minutes. Then the generated picture leaves the table. The window or the named plate stays. If you never generate a picture, skip this activity. A named plate is enough. Say the limit once: a picture a model made is a scene. It is not last night.

Investigation 6 — Optional Environmental Science as a Title

Time. One sitting shape, not a dump of nine exam units.

Materials. One local human-impact question with evidence: a stream the family can see, a printed air or water table with a source line, a land-use map of *this* county. Notebook.

SAFETY. Adult present outdoors. No collecting from posted ground. No tasting water. Wash hands. Roads and water edges judged by the adult.

The fun of it. A question that is ours. The title becomes true because the work was local and evidenced.

The skill it builds. ESS3 as a claim with a record. Environmental Science as a transcript title when the work matches — optional, not a second slog.

How to run it. Write the question first: *What is changing in this place, and what table or look makes us say that?* Record. Who measured this if the number is not ours? Leave the page if it is a website. Then a short unaided claim. If this sitting is a one-off inside Earth Science, the transcript stays Earth Science. If the family actually spent a year on local systems, resources, hazards, and human impact with investigations, Environmental Science is an honest title. Combining does not authorize a franken-name.

Set the product goal every sitting. Read the claim aloud. Check the trail. Then change one sentence — usually "who measured this?" Monthly: an unannounced miniature, log in the room, tool closed.

If you sample AP Environmental Science–style items, treat them as a check on the same skills — a short table, a claim — not as the Earth Science course and not as nine units imported into the kitchen.

For the student

Earth and space science is how you answer a question about a planet and a sky, using a look or a table someone else could check. It is not a list of planets, and it is not leftover weeks after biology.

A *system* means parts affecting one another. A rock is a slow story you can hold. Water moves stuff. Weather is this week. Climate is a pattern in a record. If you felt hot on Tuesday, that is weather. If you want to talk about climate, you need a table and a who-measured-this.

Looking up is the start of astronomy. Sketch the Moon against a roof. Never look at the Sun. A list of planet names with no night in the notebook is a list.

A picture a computer made of a nebula is a scene to look at. It is not last night. It is not data. If a number did not come from this house, ask who measured it. If it is a website, leave the page, find the maker, come back.

Environmental Science is a title you earn with a local question and evidence. It is not a dump of someone else's unit list.

Tiny worked example. Question: *Is this week's heat the same kind of claim as "July is usually hot here"?*

Observation (already in the notebook): Tuesday 92 °F on our porch thermometer; a printed table of July averages for this town, source line visible, span of years named.

Claim: *Tuesday is weather I measured; "July is usually hot here" is a climate claim that depends on the table, not on Tuesday.*

Because: *One hot afternoon cannot do the work of a pattern. If the table were missing, I would still have Tuesday, and I would not yet have climate.*

The because-sentence is not "because weather is not climate." That restates a label. The because-sentence is the rule about what one day can and cannot show.

Try 1. Look up tonight. Sketch one thing you actually see. Never the Sun.

Try 2. One printed table with a source line, or one rock. Write a claim with a finger on the record. Say what else you would need. Model closed.

Explain it back. In two sentences, tell someone why Earth is a discipline rather

than leftover weeks, and how you would check a sky picture tonight without treating a generated image as the observation.

Challenge. Answer one earth or space question from one real look or one named table, in a paragraph someone could disagree with. Name the record. If you cannot point at the log, you are still in poster country. Stay there until the finger works.

You are allowed to struggle. A missing night is information, not a verdict. Look up. Write the claim. The tool does not take this test. You do.

If it isn't clicking

Three diagnostics, and the next move for each. No shame. Placement is by skill, not by birthday.

Diagnostic 1 — there is no look, or no record. The student can recite planets and cannot say what they saw. The "year" is a table of contents.

Next move. Stop the slog. One window. One rock. One printed table with a source line. Talk before writing. A calendar-grade 9 student who cannot point at a log is not "behind in Earth Science." They are still in a taught-looking stage. The survey waits until the looking is prompted. Small looking can continue: one night, one oral credit.

Diagnostic 2 — a feeling as climate, or a sequence rumor as the map. Every sitting is a mood, or a fight. Or the family is rearranging the year because a ninth-grade Earth year is assumed to be national, or because a bio–chem–physics sequence is assumed to drop Earth.

Next move. Put a table on the table. Who measured this? Teach the idea as the maps place it. Then say the map fact once: coasts disagree; there is no national ninth-grade census in this book. Choose this family's year on purpose. Go back to the window.

Diagnostic 3 — a fluent page the house cannot reopen. The report arrived. The Hubble shot is generated. The citations look professional.

Next move. Objects in the hands. Finger on the log. If it cannot be opened, it comes off. Unaided miniature, tool closed. A model-supplied night is untrusted until it matches the window. Detectors are not a verdict; the reopenable trail is.[156]

[156]Weixin Liang et al., "GPT Detectors Are Biased Against Non-Native English Writers," *Pat-*

When to get a human tutor. You cannot hear a planet chant offered as astronomy, even after the five-minute warm-up. Or the student has weeks of log sittings, and the unaided ticket is still a dump or a blank. A tutor, a co-op, or a later dual-enrollment earth-science or environmental-science survey is a normal plan. Stay the supervisor who can still ask "what did you see?" Dual-enrollment is a *college* transcript object, distinct from this kitchen year. AP Environmental Science is an overlay, not a requirement; credit is by college.

When to go ahead. The sky has been logged. A rock has a process candidate. Weather and climate are different kinds of claim in their mouth. Water has a local path. Generated pictures come off. Unaided claims point at named records. Then lengthen: a short paper with three records; a second system in depth; an optional Environmental Science year if the work will match. Diagnose. Then move.

Tools, including AI

Optional helpers for you. The student looks. You hold the log.

> **AI box — Earth and space**
>
> Use a tool to explain *this week's system* to *you* from a named textbook page, to generate extra "weather or climate?" items with answers hidden from the student, to write a hint script that withholds the claim, or to diagnose a paragraph already written.
>
> The student looks and writes the claim. No "write my lab report," no invented data table, no generated Hubble shot as the student's result, no unsupervised chatbot during the attempt, no "what's the answer" as the whole hour.
>
> A model-supplied measurement, coefficient, or "typical result" is untrusted until it matches the log or a named page. Find it or drop it. Who measured this?
>
> A generated sky is a scene to look at together for two minutes, labelled generated. It is not data. Then it comes off the table. The window stays.

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terns 4, no. 7 (2023). Detectors are not a kitchen verdict. William H. Walters and Esther Isabelle Wilder, "Fabrication and Errors in the Bibliographic Citations Generated by ChatGPT," *Scientific Reports* 13 (2023): 14045.

A named atlas, a printed table with a source line, and a window are tools. A chatbot climate essay is not. In a high-school mathematics study, an unguarded chatbot raised assisted practice and then cut the unaided exam.[157] That study is math, not an Earth Science trial. The same crutch is available here. The unaided claim the next morning is the test.

What "done enough" looks like

A "grade 9 Earth Science" book is a publisher's or a state's scope, not a legal grade and not a national sequence. Done enough is skill, plus systems actually studied, plus writing the student produced. Ninth-grade Earth is one pattern among others, not a rule this book will print.

Checklist before moving on.

- Treats Earth as a discipline, not leftover weeks, and can name which map this family used.
- Logs a sky pattern from looking up; never looks at the Sun.
- Gives a rock or landform a process candidate and a "what we still need."
- Separates weather from climate and points at a record; teaches human impact as a claim with evidence.
- Follows water in a local system, not only as a cycle chant.
- Treats a generated sky as a scene, then returns to the window or a named plate.
- Writes an unaided claim with a named real observation or a named table; the model did not open the draft the transcript will claim.
- If the title is Environmental Science, the folder holds local human-impact work with evidence, not a copied unit list.

What can still be thin: every unit on an AP Environmental Science list; a college astronomy textbook paced as ninth grade; a second-year geology elective. Those can travel. The slog of planets with no night cannot count as done.

Transcript. Write **Earth Science**. If the family spent a year on local systems, resources, hazards, and human impact with investigations, **Environmental Sci-**

[157] Hamsa Bastani et al., "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent on practice, −17 percent on an unaided exam. Math, not an Earth Science RCT. The crutch still governs the science hour.

ence is an honest optional title. If the family used a conversational Christian text, a textbook survey, or a college open text *inside* the year, the description can say so. The title is still Earth Science or Environmental Science. Never a brand. A full astronomy year should not be silently relabelled Physics; put Astronomy in the description, and keep a stranger-readable discipline name in the title column if a registrar needs one of the locked nouns. If the student sits AP Environmental Science, put the exam on a separate line. Safer kitchen practice is a readable title plus the score as an artifact. *With Lab* is a claim the records chapter will teach you how to make honestly. This chapter is the looking that would have to be in the folder.

NCAA counts natural and physical science as core, two years, including one year of lab if offered.[158] The year on the table is still Earth Science — or Environmental Science, if that is the work.

A parent who felt rusty should be able to say, after this chapter: I know Earth is a discipline. I know climate needs a record. I know what to say tomorrow — a look, a log, who measured this. The student still looks up. We can do this.

[158]NCAA Eligibility Center, Division I Academic Standards fact sheet (September 2023); *Home School Toolkit 2025–26*; High School Review Committee Policies 2025–26 / Staff Policies 2026–27. Fact sheet cell: Science, including one year of lab if offered — 2 years. HSRC: natural/physical science. CLEP is not NCAA core.

Chapter 8

Investigation

Figure 22: A kitchen-table still-life: a notebook open to a blank data table, a kitchen timer, splash goggles, one apparatus at rest. No people, no logos, no chat-bot screen.

Why this matters

This chapter is the science hour's lab spine, named. A question that could come out otherwise. A fair test, taught. Data a stranger can read. A claim that points at the notebook. A ten-minute talk after the trial. If the number came from a website, leave the page. Safety as a habit. It is not a second book titled *Critical Thinking for Life*. It is not a branded inquiry program. It is not a poster of eight practice titles without the hours that make them real.

That is worth the struggle because every other teaching chapter in this book already pointed here. Grades 1–2 looked and tried. Grades 3–5 ran a fair test in ordinary language. Middle school named a variable and wrote a paragraph. Biology, Chemistry, Physics, and Earth Science asked for an unaided claim from an observation that actually happened. None of that is a course titled Inquiry 101. Investigation lives inside the science hour. This chapter is the looking, slowed down, so you can return here when a trial dies.

The *Framework* rejects a single linear "scientific method." A focus on practices, in the plural, "avoids the mistaken impression that there is one distinctive approach common to all science." The observation–hypothesis–deduction–conclusion story is "a myth perpetuated to this day by many textbooks" and is "fundamentally wrong."[159] Methodology belongs "in the context of pursuing specific questions … rather than as templates or invariant recipes."[160] Productive investigations are not sequentially scripted and not unguided.[161] Teach the fair test. Show a confounded trial and an unconfounded one. Ask whether we can tell for sure. Explain

[159]National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, DC: The National Academies Press, 2012), Chapter 3. A focus on practices (in the plural) "avoids the mistaken impression that there is one distinctive approach common to all science—a single 'scientific method.'" The observation–hypothesis–deduction–conclusion story is "a myth perpetuated to this day by many textbooks" and is "fundamentally wrong." Eight practices, Box 3-1. Access date for URLs in these notes: 1 September 2026.

[160]National Research Council, *Taking Science to School: Learning and Teaching Science in Grades K–8* (Washington, DC: The National Academies Press, 2007), Recommendation 3: methodology in the context of pursuing specific questions rather than as templates or invariant recipes.

[161]Sarah Michaels, Andrew W. Shouse, and Heidi A. Schweingruber, *Ready, Set, SCIENCE!: Putting Research to Work in K–8 Science Classrooms* (Washington, DC: The National Academies Press, 2008), Chapter 7: productive investigations are "not sequentially scripted. Nor are they unguided." "Simply 'doing' science activities often leaves students with an inaccurate sense of what science is." Understanding does not miraculously emerge from the data.

why. Then the student designs. A pile of ramps will not invent that move, at nine or at sixteen. Inquiry is not banned.[162]

Typical isolated labs are no more or less effective than reading for content; looking and talk belong in the same week.[163] Then teach. The trial without the talk is a demo. The talk without the trial is a recitation. Integrated looking and discussion is the hour this book already promised. This chapter is how to run it on a Tuesday.

Evaluating a science website is one looking move: who measured this? Primary observation or claim? If it is a website, leave the page. Civic Online Reasoning already lives in *Critical Thinking for Life*. Here you get that one move, in kitchen language, and a talk you can actually run.[164]

This week you can learn three investigation moves in kitchen language — a question that could come out otherwise, one thing changed on purpose, a claim that points at the notebook — and how to wait after the question. Today the student can cover the "right answer," say what they measured, then say what else we would need — ten minutes, model closed.

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[162]David Klahr and Milena Nigam, "The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning," *Psychological Science* 15, no. 10 (2004): 661–67. n = 112 third- and fourth-graders; ramps; direct instruction versus unguided discovery, contrast intentionally magnified. Masters (at least 3 of 4 unconfounded experiments): 40 of 52 (77%) direct instruction versus 12 of 52 (23%) discovery. Discovery still produced 23% masters. Both conditions were active with materials. Masters then looked alike on a science-fair poster task. Copy the finding: teach the fair test; do not leave a child to invent it; do not announce that inquiry is banned. Not a homeschool sample and not a high-school chemistry coefficient.

[163]National Research Council, *America's Lab Report: Investigations in High School Science*, Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, eds. (Washington, DC: The National Academies Press, 2006), Executive Summary. Typical isolated laboratory experiences are no more or less effective than reading, lectures, or discussion for subject-matter mastery. Integrated instructional units with discussion show greater effectiveness for mastery, reasoning, and interest in small-scale studies; most such units in small numbers of classrooms. Design principles: clear learning outcomes; sequenced into instruction; content integrated with process; ongoing reflection and discussion. Conclusion 3 ("The quality of current laboratory experiences is poor for most students") describes U.S. high-school labs as of that report, not a census of homeschool kitchens. Laboratory experience means interacting with the material world or with data drawn from it; teacher-constructed fake data sets do not count.

[164]One looking move, as this book's frame: Who measured this? If a website, leave the page. Civic Online Reasoning already lives in *Critical Thinking for Life*. Not a second evaluation course here.

For the parent: understand it yourself

You do not need to be a laboratory director. You do need to understand today's idea well enough to hear a recitation question wearing a discussion hat, and a fluent report whose numbers no one in the house measured, not as cute slips.

Everyday picture. Think of tasting two soups to decide whether salt changes the flavor — and realizing you also changed the pot, the stove, and the bread on the side. You cannot tell for sure it was the salt. A fair test is soup where only the salt changes. A notebook a stranger can read is the recipe plus what happened, written so a neighbor could check. A ten-minute talk is not a seminar brand. It is one pot, one question you have not already answered, and a wait that feels too long.

Precise picture. A *question that could come out otherwise* is one the trial might not confirm. "Does this surface change how far the ball goes?" can surprise you. "Confirm that rough surfaces slow balls" cannot. Strand 2 starts with a question, not a recipe.[165]

A *fair test*, in ordinary language, is one thing changed on purpose. Control of variables is a taught procedure: create a contrast in which a single factor differs, because a confounded experiment cannot tell you which factor did the work.[166] In a study of 112 third- and fourth-graders with ramps, the condition that *explained* that idea produced more students who could then design unconfounded tests (77 percent versus 23 percent on that assessment). Discovery, in that paper, was extreme unguided exploration, intentionally magnified, and it still produced some masters. Masters from both paths then looked alike on a later poster task. Copy the finding, not a slogan. Teach the move. Both groups were active with the ramps. The difference was explanation, examples, and feedback.[167]

Data a stranger can read is a table, a simple graph when a graph earns its keep, units, and a line about what was *not* changed. The notebook is the evidence, not

[165] NRC, *Taking Science to School* (n. 160), four strands: know, use, and interpret scientific explanations; generate and evaluate scientific evidence and explanations; understand the nature and development of scientific knowledge; participate productively in scientific practices and discourse. Strand 2 is evidence, not a recipe.

[166] Klahr and Nigam (n. 162): "Procedurally, CVS is a method for creating experiments in which a single contrast is made between experimental conditions. The logical aspects of CVS include an understanding of the inherent indeterminacy of confounded experiments."

[167] Same study as note 162. Limits the paper names: discovery here is extreme unguided exploration; CVS is a circumscribed procedure; one metropolitan elementary sample; one-week poster transfer.

the feeling that "it worked." Teacher-constructed fake data sets do not count as laboratory experience.[168] Neither does a table a model invented.

A *claim with evidence, then reasoning* is three parts in ordinary language. Claim: what happened, and why do you think so? Evidence: what in the notebook supports that? Reasoning: why would that measurement count?[169] Grades 1–2 were a picture plus a sentence. High school adds alternative explanations and the limits of the data.[170] This is about *this trial's* data. It is not a debate club and not Wineburg's sourcing curriculum.

A *ten-minute talk* is one object of joint attention (the notebook), one authentic question (one you have not already written the answer to), wait time, three to five follow-ups, then stop. Wait three to five seconds after you ask, and three to five after they stop talking.[171] That finding is from elementary science classrooms. It is a teaching move, not a score promise. Homeschool is usually one student, not a class of twenty-four. The wait still holds. Recitation — a question with a prespecified answer — is the default in classrooms. You will feel the pull. The repair is an authentic how or why about what they saw.

Safety is the habit the science hour already licensed: RAMP in one sentence; adult present the entire trial; written plan; no unauthorized experiments; goggles when chemicals, heat, or glass; never leave heating unattended; no food where chemical or biological hazards have been used; stop if it cannot be made safe.[172] This

[168] *America's Lab Report* (n. 163), definition of laboratory experiences.

[169] *Ready, Set, SCIENCE!* (n. 161), reporting the IQWST three-part framework: claim (what happened, and why); evidence (information or data that support the claim); reasoning (justification showing why the data count as evidence). Ordinary-language kitchen version in this chapter.

[170] NRC, *Framework* (n. 159), argument-from-evidence progression: elementary "I think ___ because I see ___"; middle grade claim, evidence, and reasoning; high school alternative explanations and limits of the data.

[171] Mary Budd Rowe, "Wait-Time and Rewards as Instructional Variables, Their Influence on Language, Logic, and Fate Control" (NARST paper, ERIC ED061103, 1972). Elementary science classrooms; over 300 tapes initially, more than 900 after training. Mean wait-time on the order of one second (wait-time 1) and 0.9 seconds (wait-time 2). When mean wait-times of three to five seconds are achieved, Rowe reports changes on nine student discourse variables. Training-sequence contrasts, not a modern RCT and not a homeschool content-knowledge test. History's borrowed pause is a different book; this chapter uses Rowe as science class.

[172] American Chemical Society, Committee on Chemical Safety, *Guidelines for Chemical Laboratory Safety in Secondary Schools* (2016): RAMP; teacher physically present the entire experiment; splash goggles; no unauthorized mixing; no food in a chemical laboratory; never heat a flammable on a burner or hot plate. National Science Teaching Association, Position Statement, "Safety and School Science Instruction" (revised April 2024): no food where chem/bio hazards

chapter does not write a new standard. It puts RAMP on the same page as the question.

A model-supplied quotation, coefficient, or "typical result" is untrusted until you find it. A generated gel is not Figure 1. Detectors are not a verdict on a student's paragraph.[173] The reopenable notebook is.

Wrong answers you should be able to hear

1. A five-step poster as the year. "We did the scientific method." Hypothesis, materials, procedure, results, conclusion — every week, same blanks, no question that could come out otherwise.

What it usually means. A textbook myth replaced practices in the plural. The recipe ate the question.

What to say. "What could have come out otherwise? If the trial could not surprise us, we had a recipe, not a question."

2. A confounded trial treated as proof. Two things changed; one claim. "Rough makes it stop" when steepness, length, and the ball also changed.

What it usually means. The fair test was never taught, or the wow replaced "can we tell for sure?"

What to say. "Can we tell for sure it was the variable we named — and what in the notebook makes you say that? What else was different?"

3. Recitation in a discussion costume. "What are three steps?" "Which one is the independent variable?" You already have the sentence. They can hear that you do.

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have been used; eliminate the activity if it cannot be performed safely. Flinn Scientific, *Student Safety Contract* (© 2017): never work alone; never leave heating or a visible reaction unattended; unauthorized experiments prohibited. Licensed in this book's science-hour chapter; this chapter makes the habit, not a new standard.

[173] William H. Walters and Esther Isabelle Wilder, "Fabrication and Errors in the Bibliographic Citations Generated by ChatGPT," *Scientific Reports* 13 (2023): 14045. Weixin Liang et al., "GPT Detectors Are Biased Against Non-Native English Writers," *Patterns* 4, no. 7 (2023): high false-positive rates on human TOEFL essays in that study. Elsevier (June 2026) and Nature Portfolio: do not fabricate data or create photorealistic images as experimental evidence. A generated gel is never Figure 1.

What it usually means. The question was not authentic. Silence will be filled, because it always has been, in about one second.

What to say. "I do not have a sentence in my pocket for this. Look at the notebook. What do you actually see?" Then wait. Look at the page if the silence is hard.

4. Hands-on as a personality, or a website as the lab. "They did a lot of activities, so they think like a scientist." Or a simulation, a video, or a page of results treated as the student's measurement without a who-measured-this.

What it usually means. Isolated activity was upgraded to a trait, or someone else's data was upgraded to this house's observation. Reasoning is tangled with what the student knows about *this* phenomenon. Doing a kitchen trial does not mint a scientific thinker who then thinks scientifically about everything.[174]

What to say. "What did we change on purpose *this* time? Who measured this if the number is not ours? If it is a website, we leave the page."

5. A fluent report whose numbers no one measured. Diction jumped a grade. The table was invented. The gel is generated. A detector score was treated as a grade.

What it usually means. The work was outsourced. Or a tool was asked to be a cop.

What to say. "Show me the notebook. Finger on the number you wrote. If we cannot open it, it comes off. I am not running a detector. I am asking for a trail."

Five-minute parent warm-up

Before the lesson, on paper, no student in the room:

1. Write tonight's question so it could come out otherwise. If you cannot imagine a surprise, rewrite the question. Put RAMP on the same line: hazard, how we minimize it, how we stop.
2. Sketch a confounded version of tonight's trial and an unconfounded one. Circle the extra thing that changed in the first sketch. That circle is the teaching move.

[174] NRC, *Taking Science to School* (n. 160), Chapter 5: scientific reasoning is intimately intertwined with conceptual knowledge of the phenomenon under investigation; distinguishing theory from evidence and many aspects of modeling do not emerge without explicit instruction. No opened study measures a general scientific-thinking trait after hands-on years as a transferable personality.

3. Write the opening question — a how or why about what they will have seen — that you do *not* already have a sentence for. Time yourself waiting five seconds after you say it out loud to an empty room. It will feel long. That feeling is the point.

If those three are fluent for you, you can hear a recipe and a recitation. That is the job. The student still measures.

How to teach it this week

Run the door before you call the week "investigation."

Is there a question that could come out otherwise? If the hour is "do the lab in the book to confirm chapter 14," stop. Rewrite until a surprise is possible.

Is one thing being changed on purpose? If two things move, you cannot tell for sure.

Will you wait? If you cannot bear three seconds, the talk will not start. Practice the empty-room five.

When the gates are open, here is the shape of a sitting. Warm-up. Short model. Student attempt. One good question. Mixed practice. Exit ticket. This chapter *is* the investigation shape. Earlier chapters already used it. You can return here when a trial dies.

Warm-up (3–5 minutes, unaided). Yesterday's variable, from memory. One "can we tell for sure?" on a pair of sketches they have seen. One "who measured this?" on a number they have already used. No tool.

Short model (5–8 minutes). Two setups — one confounded, one not. You ask whether we can tell for sure. You wait, even though you are modeling — count. You explain why the unconfounded one uniquely identifies the factor. You show the follow-up order once: observation, notebook evidence, tell-for-sure, change-your-mind, revision. Then you stop talking sooner than feels polite.

Fade as soon as you can. Second sitting: they catch the confound. Third: they design while you watch. Fourth: they write the claim unaided, model closed. Include one incorrect example: a five-step poster with no surprise possible; a chatbot data table; a generated gel as Figure 1.

Exact wording you can steal.

On the question: “What could come out otherwise? If we already know, we do not have a question.”

On the fair test: “Can we tell for sure it was the variable we named? What else was different?”

On the notebook: “Would a stranger know what we changed, what we did not, and what we measured?”

On the claim: “What do you think happened? What did you write down that supports that? Why would that measurement count?”

On the talk: “Take your time. I’ll wait.” Then look at the notebook if the silence is hard.

On a website: “Leave the page. New tab. Who measured this? Then we come back.”

On safety: “RAMP is on this page. If we cannot make it safe, we do not run it.”

On the chatbot: “If we did not measure it, it is not data. A report a model wrote is a genre. It is not the notebook.”

First problem for the student, after the model. Cover the textbook’s “right answer.” Run or redesign tonight’s trial so only one thing changes. Product goal on a sticky note: a claim in their own words, with a finger on the table, and one sentence on what else we would need. Model closed. You wait. Struggle before rescue. You do not finish the table.

One good question. After the attempt: “If I hid the notebook, would your claim still know where it came from?” The student generates the why.

Student attempt, then mixed practice. Two or three short claims of the new type, unaided, after the fade — not five lab reports. Then mix: yesterday’s fair test, last week’s “who measured this?,” one confounded sketch to catch, one website to leave.

Exit ticket (5–10 minutes, unaided). One question, one named table already in the notebook, a three-to-five-sentence claim. Tool closed. You grade the unaided ticket. A fluent report with invented numbers is performance. The claim that points is the test.

Every report a Biology, Chemistry, Physics, or Earth Science transcript will claim needs an unaided draft the model did not open. This chapter serves those lab claims. The words *With Lab* are a records job. The folder those words would rest on is built here, sitting by sitting.

How to fade help. You design both versions → they catch the confound → they design the next trial → they write the claim → they write the next question with you. When they can say "tell for sure" without your prompt, put the two-sketch scaffold away. Bring it back when a new kind of trial arrives — a field sit, a weighing, a sky log.

When to stop talking. After one model and one question. You do not become the textbook. You hold the key: is there a question that could surprise us, one thing changed, a notebook a stranger can read, and a wait?

Investigation 1 — Question That Could Come Out Otherwise

Time. Ten minutes before any trial.

Materials. Today's idea in ordinary words. A sticky note. The same page will carry one RAMP line.

SAFETY. RAMP as a written line on the same page: recognize the hazard, assess the risk, minimize it, prepare to stop. If the question cannot be made safe, it is not tonight's question.

The fun of it. We might be wrong. Students usually like being allowed to be.

The skill it builds. Strand 2 starts with a question, not a recipe.

How to run it. Write the question. Ask: if we ran this, could we be surprised? If not, rewrite. Star the variable. Write the stop. Then, and only then, get the apparatus.

Investigation 2 — Fair Test, Taught

Time. One science hour.

Materials. Two versions of a simple trial the family can actually run — ramps and surfaces, or two cups, or two plants. Notebook. The Klahr shape, not the Klahr coefficient as a kitchen promise.

SAFETY. Adult present. Soft objects if anything rolls. Goggles if liquids. The adult stays through both versions.

The fun of it. Catching the confound. Being the person who can say we could not tell for sure.

The skill it builds. One thing changed on purpose. “Tell for sure” as a sentence in the mouth.

How to run it. Show the confounded setup first. “Can we tell for sure?” Wait. Explain why not. Then the unconfounded setup. Then the student designs the next one. You do not leave them to invent the move from a pile of parts. You also do not announce that looking is banned. Both of you stay active with the materials. The difference is the explanation.

Investigation 3 — Data a Stranger Can Read

Time. Twenty to thirty minutes, after a trial, or as a rewrite of a messy page.

Materials. The numbers already taken. Paper. A ruler if a simple graph will help. Your key of what a stranger would need, hidden.

SAFETY. Residue from the trial is already cleaned, or the adult is still present until it is.

The fun of it. A neighbor could check. The page becomes a thing, not a feeling.

The skill it builds. The notebook is the evidence. Units. What was *not* changed.

How to run it. Three columns at least: what we changed, what we measured, what we kept the same. Units on the measurement. One sentence of what we did not see. A graph only if it earns its keep — two numbers do not need a chart to hide them. Fake data does not go in. Invented data does not go in.

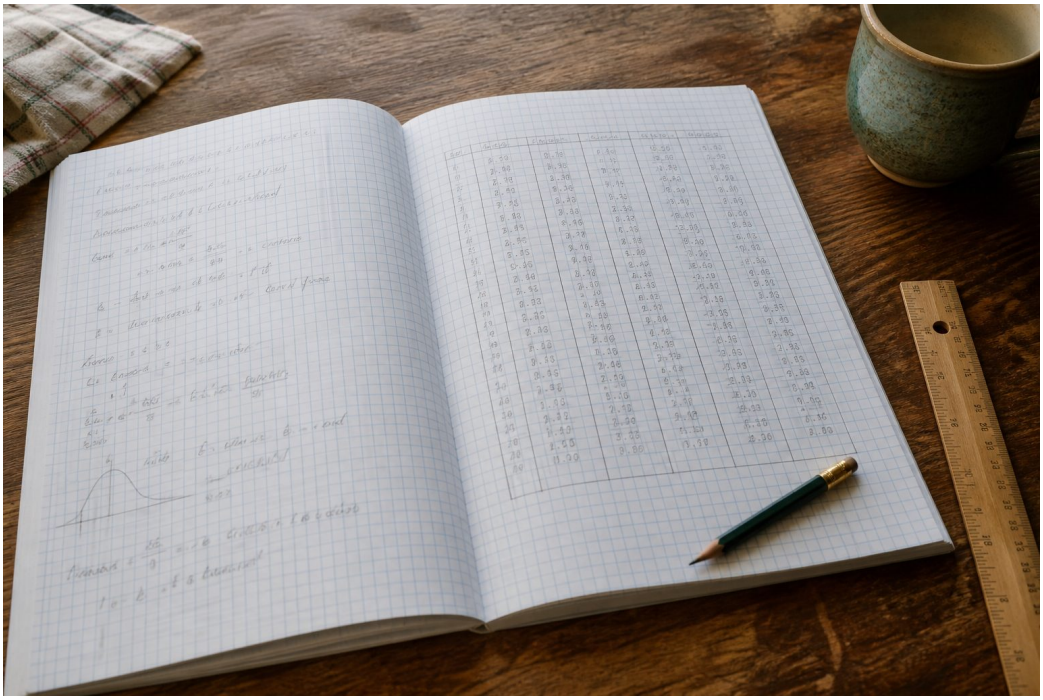

Figure 23: A notebook open to a simple table with units, a timer set aside after the wait, goggles at rest. No people, no logos.

Discussion box — the template

This is the box the other teaching chapters already used. Illustration, labelled as such: two ramps, two surfaces, two distances in a notebook. Composite table, not a reported family. Not a classroom trial copied onto your kitchen as a promise.

Opening. An authentic how or why about **what they saw or measured**, no prespecified recitation answer. Example: "Can we tell for sure it was the surface — and what in the notebook makes you say that?"

Not: "List the steps of the scientific method."

Follow-ups (this order unless the trial demands otherwise). 1. Observation: What did you see happen? 2. Evidence in the notebook: What did you write down that supports that? 3. Tell for sure: Can we tell for sure it was the variable we named? What else was different? 4.

Change your mind: What would we have to see to change our minds?
5. Revision: What would you change if we ran it again?

How to wait. Wait-time 1: three to five seconds after you ask, before you rephrase, repeat, or rescue. Wait-time 2: three to five seconds after they stop talking, before you evaluate or ask the next thing. Look at the notebook if the silence is hard. Say, if you need a sentence: "Take your time. I'll wait." Rowe's default in taped science lessons was about one second after the question and about 0.9 seconds after the answer. Three to five is the trained length. It is a discourse finding, not a guarantee that content is learned.[175]

Stuck silence usually means. The question had a known recitation answer; wait-time 2 was cut; the student is still mapping experience into words; the idea on the table was never made clear, so there is nothing to hang the observation on; or the model already wrote the report and there is nothing left to think.

A short talk checklist, once, not a franchise. Did we listen? Did we say how we know? Did we connect the claim to the record on the table?[176]

Done enough. A claim with a named real measurement. An unaided draft if a science transcript will claim the investigation. This chapter serves Biology, Chemistry, Physics, and Earth Science lab claims. Records owns the words *With Lab*.

Practice that actually builds learning

Understanding and practice grow together. Practice a new move this week, with a trial and a why. A stack of method-poster quizzes with no notebook is assignment, not teaching.

Typical isolated labs are no more or less effective than reading for content; looking and talk belong in the same week. That sentence is now in your ear. Teach the

[175]Rowe 1972 (n. 171). Table I training-sequence contrasts in that paper are discourse variables, not a content test.

[176]Accountable Talk as a short checklist, after *Ready, Set, SCIENCE!* talk moves: listen; say how we know; connect the claim to the record. Not a franchise and not a science RCT.

integrated hour: a named idea, a trial that could surprise, a record, a talk, a stop.

Blocked, for a new move. The day a student first catches a confound, a short blocked set is honest: two more paired sketches, same move. Same for a first stranger-readable table, a first claim-evidence-reasoning, a first unaided talk.

Mixed, for when to use it. Later the same week, mix: a fair-test sitting, a table rewrite, a ten-minute talk, one "who measured this?," one website to leave. Choosing *when* to go deep is part of the skill.

Brief retrieval. Yesterday's variable; what was *not* changed on Tuesday; one opening question they can still ask. A short oral at the start of the hour. Practice titles that are not retrieved turn into wallpaper.

One incorrect example to diagnose. Show a fluent lab report whose data table was generated, or a five-step poster whose question could not come out otherwise. Ask what they thought counted as a question, or as a measurement. Then an isomorphic claim, unaided, from a real table.

Kitchen trials can motivate. They do not replace the unaided claim. Activity mania is not investigation.[177] A wow will not teach "tell for sure" by itself.

Investigation 4 — Claim with Evidence, Then Reasoning

Time. Fifteen to twenty-five minutes.

Materials. The notebook from today's trial. Paper. Model closed.

SAFETY. Trial already stopped; adult still present if anything is still wet or hot.

The fun of it. The because-sentence is theirs, and it is not a restatement.

The skill it builds. Three parts in ordinary language. High school: alternative explanations and limits of the data. Not a second critical-thinking course.

How to run it. Sticky-note product: claim (what happened, why you think so); evidence (the line in the notebook); reasoning (why that measurement counts); one clause on what the data cannot show. Tool closed. You are the reader: "I cannot find this in the table." You are not the co-author. Grades 1–2, if a younger sibling is at the table, remain a picture plus a sentence. The word *reasoning* is not required of

[177] *Ready, Set, SCIENCE!* (n. 161), Chapter 7: school science often oscillates between predetermined-step labs and "activity mania."

a seven-year-old. It is required, in ordinary language, of the high-schooler whose transcript will claim the lab.

Investigation 5 — Ten-Minute Talk After the Trial

Time. Ten minutes. Then stop.

Materials. The notebook as the object of joint attention. A timer you can see. The opening question already written.

SAFETY. Apparatus at rest. Goggles off only if the hazard is gone.

The fun of it. Being heard. The wait that feels too long, then a sentence that would not have arrived at one second.

The skill it builds. Talk as the science, not a moral add-on. Rowe as science class, not as History's borrowed pause.

How to run it. One authentic question about what they saw. Wait 3–5 seconds. They talk. Wait 3–5 after they stop. Three to five follow-ups in the template order. Then stop, sooner than feels polite. You do not turn it into a lecture about being scientific. You do not fill the silence with "good." Mapping experience into language is arduous. The wait is the work.[178] A worksheet question with a right answer in your mouth is not this talk. Materials do not by themselves get a student talking.

Investigation 6 — If It Is a Website, Leave the Page

Time. Five to ten minutes, when a number did not come from this house — then back to the notebook.

Materials. One science webpage the parent opened. A second tab. The notebook.

SAFETY. Adult-hosted browser. No unsupervised open-web agent during the trial. The looking move is short on purpose.

The fun of it. Catching a page that wanted to be believed. Students usually like leaving.

[178] Rowe 1972 (n. 171): "Mapping experience into language is an arduous process." RSS talk move: "Take your time. … We'll wait."

The skill it builds. One looking move: who measured this? Primary observation or claim? Pointer to *Critical Thinking for Life*, not a sequel. Then back to the notebook.

How to run it. "This number is not ours. Leave the page. New tab. Who is this maker? What would we still need?" Two minutes. Then the website is not the lab. The notebook is. Simulations can teach a model when a wet trial cannot be made safe. Whether a simulation satisfies an athletic-eligibility lab line is not a question this book answers from opened pages. Title the year honestly.[179] A digital-literacy course does not park here.

Set the product goal every sitting. Read the claim aloud. Check the trail. Then change one sentence — usually the tell-for-sure. Monthly: an unannounced miniature, notebook in the room, tool closed.

For the student

Investigation is how you answer a question that might have come out otherwise, using a measurement someone else could check. It is not a five-step poster, and it is not a second course about thinking.

A *question* is one we might be wrong about. If we already know, we have a recipe.

A *fair test* is one thing changed on purpose. If two things changed, we cannot tell for sure it was the one we named. Catching that is the skill.

A *notebook a stranger can read* has what we changed, what we measured, what we kept the same, and units. A feeling that "it worked" is not the evidence. A table a computer invented is not the evidence.

A *claim* needs three parts: what you think happened; what you wrote down; why that measurement counts. At high school, add what the data cannot show.

After the trial, we talk for ten minutes. One question about what you saw. A wait that feels too long. You are allowed to use that wait. Mapping what you saw into words is hard. That is the work.

[179] NCAA fact sheets and High School Review Committee policies, as opened for this book, are silent on whether virtual or simulated labs satisfy "lab if offered." Kenneth Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020 (author's views): simulations as pandemic remote-school advice when school labs are unavailable — not an NCAA ruling.

If a number is not ours, ask who measured it. If it is a website, leave the page, find the maker, come back. Then the notebook is still the lab.

A report a computer wrote is a genre. A gel a computer made is a scene. Neither is Figure 1. Detectors are not your grade. The trail is.

Tiny worked example. Question: *Does the surface change how far the ball goes?*

Observation (already in the notebook): same ramp steepness, same length, same ball; smooth 142 cm; rough 61 cm.

Claim: *On this ramp, the rough surface shortened the run; we can tell for sure it was the surface because steepness, length, and ball stayed the same.*

Because: *If steepness had also changed, the two distances would be a mixed story. The table shows one thing changed. The data still cannot tell us about a different ball or a wet floor — those would be new trials.*

The because-sentence is not "because we did a fair test." That restates a label. The because-sentence is the rule about what this table can show.

Try 1. Cover the "right answer" in a book lab. Rewrite the question so it could come out otherwise. Name the one thing you would change.

Try 2. Look at a messy notebook page. Make a table a stranger could read: changed, measured, kept the same. Model closed.

Explain it back. In two sentences, tell someone why a five-step poster is not the year, and how you would wait after a question tonight without rescuing at one second.

Challenge. Run or redesign one trial, write the table, and talk for ten minutes from one authentic question. Then write a paragraph someone could disagree with. Name the measurement. If you cannot point at the notebook, you are still in poster country. Stay there until the finger works.

You are allowed to struggle. A confound is information, not a verdict. Measure. Wait. Write the claim. The tool does not take this test. You do.

If it isn't clicking

Three diagnostics, and the next move for each. No shame. Placement is by skill, not by birthday.

Diagnostic 1 — there is no question, or no fair test. The student can recite steps and cannot say what could have come out otherwise. Two things changed; one claim. The "year" is a poster.

Next move. Stop the recipe. One question that can surprise. Two sketches, confounded and not. "Can we tell for sure?" Wait. A calendar-grade 9 or 11 student who cannot catch a confound is not "behind in lab science." They are still in a taught-looking stage. Biology, Chemistry, Physics, and Earth Science wait until the looking is prompted. Small looking can continue: one question, one table, oral credit.

Diagnostic 2 — recitation in a discussion costume, or activity mania. Every question has the answer in your mouth. Or every hour is a wow with no notebook.

Next move. Rewrite the opening so you do not already have a sentence. Time the empty-room five. Put the notebook in the middle. Isolated activity does not mint a scientist. The talk is part of the science. Practice "what would change your mind?" until that sentence is easy.

Diagnostic 3 — a fluent page the house cannot reopen. The report arrived. The table was generated. The gel is a picture a model made. A detector was asked to grade.

Next move. Objects in the hands. Finger on the number. If it cannot be opened, it comes off. No detector. Unaided miniature, tool closed. A model-supplied "typical result" is untrusted until it matches the notebook.[180]

When to get a human tutor. You cannot hear a confound, even after the five-minute warm-up. Or the student has weeks of trial sittings, and the unaided ticket is still a dump or a blank. Or safety will not hold in this house — then a co-op or college lab with its own rules is a normal plan. Stay the supervisor who can still ask "can we tell for sure?" Dual-enrollment lab science is a *college* transcript object, distinct from this kitchen year.

When to go ahead. Questions can surprise. One thing changes on purpose. Tables

[180] Walters and Wilder (n. 173); Liang et al. (n. 173). Detectors are not a kitchen verdict.

a stranger can read. Claims point, with a limit. Ten-minute talks happen, with a wait. Websites get left. Safety is a habit. Then lengthen: a short paper with three trials; a second apparatus; the next science year this chapter already served. Diagnose. Then move.

Tools, including AI

Optional helpers for you. The student measures. You hold the notebook and the key.

> **AI box — Investigation**
>
> Use a tool to explain *this week's move* to *you* from a named textbook page, to generate extra confounded/unconfounded sketches with answers hidden from the student, to write a hint script that withholds the claim, or to diagnose a notebook page already written.
>
> The student runs the trial and writes the claim. No "write my lab report," no invented data table, no generated gel or micrograph as the student's result, no unsupervised chatbot during the trial, no "what's the answer" as the whole hour.
>
> A model-supplied quotation, coefficient, or "typical result" is untrusted until it matches the notebook or a named page. Find it or drop it.
>
> A generated apparatus or a generated gel is a scene to look at together for two minutes, labelled generated. It is not Figure 1. Then it comes off the table. The notebook stays.
>
> Detectors are not a kitchen verdict. Skip them.

A timer, a notebook, and splash goggles are tools. A chatbot Discussion is not. In a high-school mathematics study, an unguarded chatbot raised assisted practice and then cut the unaided exam.[181] That study is math, not an investigation RCT. The same crutch is available here. The unaided claim the next morning is the test.

[181] Hamsa Bastani et al., "Generative AI without Guardrails Can Harm Learning: Evidence from High School Mathematics," *Proceedings of the National Academy of Sciences* 122, no. 26 (2025): e2422633122. GPT Base: +48 percent on practice, −17 percent on an unaided exam. Math, not an investigation RCT. The crutch still governs the science hour.

There is no Grok Bot education product in these pages, and no student-facing autonomous open-web school agent this book will treat as a lab partner. Any helper stays on your side of the table.[182]

What "done enough" looks like

Investigation is not a birthday and not a separate transcript title. Done enough is skill, used inside Biology, Chemistry, Physics, and Earth Science, plus writing the student produced. A publisher's "Inquiry 101" is not a registrar word.

Checklist before moving on.

- Writes a question that could come out otherwise, with RAMP on the same page.
- Catches a confound and can design a trial with one thing changed on purpose.
- Keeps a notebook a stranger can read: changed, measured, kept the same, units.
- Writes a claim with evidence and reasoning, including what the data cannot show.
- Talks for ten minutes after a trial from an authentic question, with a 3–5 second wait twice.
- Leaves a webpage to ask who measured this, then returns to the notebook.
- Writes an unaided draft the model did not open, for any investigation a science transcript will claim.
- Treats a generated image as a scene, not as data. Does not use a detector as a grade.

What can still be thin: every NGSS practice title on a poster; a science-fair week with no talk; a simulation-only year offered as if it had been ruled equivalent to lab. Those can travel only if the title stays honest. The slog of method-steps with no measurement cannot count as done.

Transcript. This chapter does not earn its own course name. It serves **Biology**, **Chemistry**, **Physics**, and **Earth Science** (or **Environmental Science**) lab claims.

[182] Frame of this book, matching opened product pages: Hermes 4 is not Hermes Agent; Grok, Grok Bot, and a ministry assistant in another country are not one product; no Grok Bot education SKU on pages opened for this book. Any agent is a parent-hosted supplement, not a substitute for the notebook or the talk.

Never Inquiry 101. Never a brand. *With Lab* is a claim the records chapter will teach you how to make honestly — a single course title that includes the lab, plus evidence of investigations that actually happened, not a second credit called Lab. NCAA asks for two years of science, including one year of lab if offered; a standalone "Chemistry Lab" is not approved separately.[183] This chapter is the looking that would have to be in the folder.

A parent who felt rusty should be able to say, after this chapter: I know three moves — a question that could surprise us, one thing changed on purpose, a claim that points at the notebook. I know how to wait. I know what to say tomorrow. The student still measures. We can do this.

[183] NCAA Eligibility Center, Division I Academic Standards fact sheet (September 2023); *Home School Toolkit 2025–26*; High School Review Committee Policies 2025–26 / Staff Policies 2026–27. Fact sheet cell: Science, including one year of lab if offered — 2 years. HSRC: natural/physical science; a standalone "Chemistry Lab" will not be approved separately. Sample titles include Biology with Lab. Course name on the worksheet should match the transcript title. CLEP is not NCAA core. Whether Division I adopted a 2026 proposal to drop "lab if offered" is not treated as settled in this book; the live sheet still has the lab language.

Chapter 9 — Records

The science *work* can be as serious as any school's. The *credit* is a family claim until a stranger can use it — a college admissions reader, an NCAA Eligibility Center staffer, a public-school counselor placing a transfer. That stranger will not have sat at your kitchen table. They will have a page.

This chapter is how you make that page. Lawful, safe, and readable to a stranger are three jobs. Keep them in view.

This week you can take last year's science folder and write one course line a counselor would recognize. Today the student can list the investigations they actually ran.

Illustration. A folder spread with dummy titles only: Biology, Chemistry, Physics. Dummy text. No real names. No portraits.

What you are making

You are making a record of science, not a national diploma.

There is no federal homeschool diploma and no national science credit. Texas, North Carolina, and New York do not issue one.[184] [185] [186] The NCAA Eligibility

[184] Texas Education Agency, "Home Schooling" and "Alternative Schooling" (accessed 1 September 2026). No state homeschool diploma. *Leeper* list: reading, spelling, grammar, mathematics, good citizenship — science is not named. Transfer treated like an unaccredited private school.

[185] North Carolina DNPE, diplomas FAQ and "Starting a Home School" (last modified 3 August 2026; accessed 1 September 2026). State issues neither diploma nor transcript. Annual test: English grammar, reading, spelling, mathematics — not science. Five-hour day is a recommendation. G.S. 115C-563(a) allows non-parent instructors.

[186] NYSED, "Home Instruction Questions and Answers"; 8 NYCRR 100.10 (Cornell LII). No

Center treats proof of graduation as a family or umbrella document.[187] Pennsylvania has its own supervisor or approved-organization diploma after listed graduation courses, including three years of science.[188] That credential is Pennsylvania's, not a U.S. Department of Education diploma. A parent-issued diploma can be a real piece of paper. It is not a registrar's national science credit.

Four other objects belong in their own envelopes. Dual-enrollment Chemistry lives on a *college* transcript. AP and CLEP are exam scores. A state-compliance packet — a Pennsylvania evaluator letter, a Virginia evidence-of-progress file, a North Carolina annual test (English and math, not science), a New York IHIP and quarterlies — is what your statute asked for. A college that wants a transcript is asking for a different envelope.

Titles a stranger can read

Use titles a counselor already has a slot for:

Science, Life Science, Physical Science, Biology, Chemistry, Physics, Earth Science, Environmental Science.

Those names travel. NCAA's sample homeschool transcript uses Physical Science; Biology with Lab; Chemistry; Physics. The Core-Course Worksheet wants the course name on the worksheet to match the title on the transcript.[189] That is good practice even if no one in the house will ever play college sports.

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local or Regents diploma for home instruction. Science in 1–6; two units in 7–8; two units in 9–12; a unit is 6,480 minutes. Placement by need. Regents exam with a lab requirement: admission if IHIP, quarterlies, and/or teacher verification show the lab was met. No part-time public instructional participation.

[187] NCAA Eligibility Center, *Home School Toolkit 2025–26*. Proof of graduation is a family or umbrella artifact. Evaluation after documents are in *and* an NCAA school has placed the student on an Institutional Request List. Homeschool means parent, tutor, or umbrella creates, instructs, assesses, and awards grades. Dual-enrollment designated on the homeschool transcript as a college course, plus the official college transcript. Hawaii and New York: a homeschool-issued diploma is not accepted as proof of graduation.

[188] 24 P.S. § 13-1327.1; PDE Home Education BEC (a review date of 10 August 2026 listed among others). Science required at elementary and secondary; three years at 9–12; no laboratory named. Pennsylvania-specific supervisor or approved-organization diploma. 22 Pa. Code § 11.31a. Evaluator experience list includes biology, chemistry, and physics — evaluator, not student sequence.

[189] NCAA Toolkit and Core-Course Worksheet. Sample titles: Physical Science; Biology with Lab; Chemistry; Physics. Worksheet course name equals the transcript title.

The title is the genre. The program you bought is the method. *Exploring Creation with Biology*, a BJU Press Biology kit, *Discovering Design with Chemistry*, OpenStax *Biology 2e* — those may appear in a description. They are not the course name. "Biology — Exploring Creation" is still a brand in the title column. "Inquiry 101" is not a science credit.

Two honest shapes both map. One keeps **Science** in the earlier years, then splits in high school: **Biology**; **Chemistry**; **Physics**; **Earth Science** if that is the work. The other names **Life Science** and **Physical Science** in the middle grades or ninth grade, then the high-school nouns. **Environmental Science** is a real title when you taught it. Science is the usual elementary title. The high-school credit clock has not started until you mean it to.

There is no national Carnegie-unit law hanging over the kitchen. NCAA's "year" of science is an athletic-eligibility object. Public-school diploma maps are useful pictures of titles a stranger already knows — Texas's three science credits including required Biology; Virginia's three laboratory science credits from at least two of earth sciences, biology, chemistry, and physics — and they describe public-school diplomas, not homeschool law.[190]

Health is not natural or physical science for NCAA core. Computer science has its own NCAA chart; it is not Biology. Forensics still needs a title a stranger can map — read the current High School Review Committee chart for that title.[191] Marine Biology can be **Biology** if the work was a biology year, or **Environmental Science** if that is the better noun. Astronomy can be **Earth Science** if the work was earth-and-space. It is not a silent Physics.

"With Lab" is a claim

Biology with Lab is on NCAA's sample list. "With Lab" is a claim you can defend.

The live Division I fact sheet this book opened on 1 September 2026 asks for two

[190] 19 TAC § 74.12 (Cornell LII): three science credits, Biology required, second from IPC / Chemistry / Physics. Virginia Standard Diploma (opened 1 September 2026): three laboratory science credits from at least two of earth sciences, biology, chemistry, physics. Public-school maps, not homeschool law.

[191] NCAA HSRC *Policies and Procedures 2025–26* and Staff Policies 2026–27. Core area: natural/physical science. Computer science has its own chart. Health is not that core area. Forensics mapping left to the current chart.

years of science, **including one year of lab if offered**.[192] The High School Review Committee wants investigations embedded in the course and will not approve a standalone "Chemistry Lab" as a separate course.[193] The practical record, if you claim lab, is a *single* course title that includes the lab, plus student work that shows investigations.

Build investigation into at least one of the two science years. Title that year honestly. Keep the work.

If you claim lab, keep objects you already produce: a dated notebook (question, method, data, claim); a materials list; a note that eye protection and other gear were used when a home-lab safety article would require them.[194] No opened statute in the five states below requires a bound lab notebook. The notebook is how you defend the claim.

A kitchen picture is a picture. A year of kitchen trials can be a lab path if investigations happened, hazards were named, and the title is honest. A year that skipped every experiment in a book that "has labs in the chapters" is a reading year. Title it **Biology**. Leave "with Lab" off unless you built investigation some other way you can show.

Simulations can teach a skill. Whether a virtual lab satisfies an athletic "lab if offered" sentence is a question for the Eligibility Center in the year you file.[195]

What belongs on the science line

For each high-school science course, write:

- the **title** from the list above, or **Biology with Lab** when the lab claim is true;
- the **year**, and the grade equivalent you actually used;

[192] NCAA Division I Academic Requirements fact sheet, September 2023, still live 1 September 2026. Sixteen core courses including 2 years SCIENCE (Including one year of lab, if offered); extra English/math/science year; 10/7 rule; 2.3 core GPA.

[193] HSRC 2025–26: investigations embedded in the course; a standalone "Chemistry Lab" will not be approved separately.

[194] Ken Roy, "Safety for Hands-On Science Home Instruction," NSTA Safety Blog, 28 July 2020 (author's views). SDS; splash goggles when liquids are involved; stop if PPE is unavailable. ACS RAMP.

[195] Opened NCAA pages are silent on whether virtual labs satisfy "lab if offered." OpenStax College Physics 2e PhET pointers are a textbook feature. Roy 2020 is remote-school safety advice, not NCAA language.

- the **credit** — commonly 1.0 for a year; New York's "unit" is 6,480 minutes, not a brand;
- the **grade** and the scale (A = 90–100, or whatever scale you truly used);
- a **brief description** of texts, lab load, writing, and grading — not a brand as the course name;
- **who taught and who graded**;
- your **signature** and a date;
- **external artifacts** when they exist: ACT Science as an optional signal, not a credit; an AP score; a CLEP score; a dual-enrollment college transcript; a state-required test or evaluator letter.

Name the texts. Name the lab load. Name the writing. Name the grading. A sentence that says only a product name is a brand, not a course.

Here is an illustration, not a reported family:

> **Biology with Lab** · 2025–26 · 1.0 credit · Grade: A (A = 90–100, B = 80–89)
>
> High-school biology: cells as systems, genetics, ecology, the human body as a system. Readings: [named textbook]. Lab load: sixteen investigations, each with a question, a method, a data table, and a claim; splash goggles used when liquids could splash. Writing: two unaided claims from data, one short paper from named sources. Grading: 40 percent investigations and notebook, 40 percent unaided writing and tests, 20 percent discussion. Instructor: [parent name]. Signature: _____ Date: _____

Change the books and the investigation count to what is in *your* folder. The shape stays. The folder is not the transcript. The transcript is the map to the folder.

The law is a pattern, not one form

U.S. homeschooling is state law. There is no federal science office. Dates and subject lists change. Read your current department page and the statute it cites. A color-coded chart on a membership site is not your statute.[196] Five official-page examples show the range.

[196] Official department pages illustrate a pattern, not a fifty-state code. This chapter is not legal advice. A membership chart is not a statute.

Texas. The Agency does not regulate home-school programs.[197] Parents follow a bona fide written curriculum: reading, spelling, grammar, mathematics, and good citizenship. Science is not named. Lawful without a science course is legality, not a college-ready plan. Texas does not award a homeschool diploma. Transfer is treated like an unaccredited private school.

North Carolina. Notice of Intent. Nine calendar months. Each year, a nationally standardized test in English grammar, reading, spelling, and mathematics — not science.[198] The home school, not the State, issues the diploma. A five-hour day is a recommendation, not the statute. Persons other than the parent may instruct. The homeschool still issues the transcript.

Pennsylvania. Science is required at elementary and secondary. Biology and chemistry *may* be included at the supervisor's discretion. Graduation in grades 9–12 requires **three years of science**. The statute does not name a laboratory.[199] Portfolio tests in grades 3, 5, and 8 are reading/language arts and mathematics, not science. A supervisor or approved organization may issue a Pennsylvania home-school diploma. That credential is Pennsylvania's. The evaluator's experience list includes biology, chemistry, and physics — a description of the evaluator, not a required student sequence.

Virginia. Notice by 15 August, a parent-written list of subjects, and evidence of progress by 1 August: a composite score at or above the fourth stanine, **or an equivalent SAT, ACT, or PSAT score**, or an evaluation or college transcript the superintendent accepts.[200] Science is not named as required. Those sittings are not science exams, and Virginia's SAT option is not a national rule that "home-

[197]Texas Education Agency, "Home Schooling" and "Alternative Schooling" (accessed 1 September 2026). No state homeschool diploma. *Leeper* list: reading, spelling, grammar, mathematics, good citizenship — science is not named. Transfer treated like an unaccredited private school.

[198]North Carolina DNPE, diplomas FAQ and "Starting a Home School" (last modified 3 August 2026; accessed 1 September 2026). State issues neither diploma nor transcript. Annual test: English grammar, reading, spelling, mathematics — not science. Five-hour day is a recommendation. G.S. 115C-563(a) allows non-parent instructors.

[199]24 P.S. § 13-1327.1; PDE Home Education BEC (a review date of 10 August 2026 listed among others). Science required at elementary and secondary; three years at 9–12; no laboratory named. Pennsylvania-specific supervisor or approved-organization diploma. 22 Pa. Code § 11.31a. Evaluator experience list includes biology, chemistry, and physics — evaluator, not student sequence.

[200]Virginia Department of Education, "Home Instruction"; Code of Virginia § 22.1-254.1 (accessed 1 September 2026). Notice by 15 August; evidence of progress by 1 August; SAT/ACT/PSAT as one option. Science is not named as required.

schoolers take the SAT instead of a diploma."

New York. Letter of intent, an Individualized Home Instruction Plan, quarterly reports, and an annual assessment. Science in grades 1–6; two units in 7–8; two units in 9–12 (6,480 minutes per unit).[201] Home instruction does not yield a local or Regents diploma. If a Regents exam has a laboratory requirement, the student may be admitted with evidence the lab was met — IHIP, quarterlies, and/or teacher verification.[202] That is about sitting a Regents exam, not about NCAA. The legislature has not authorized part-time public instructional participation. Placement is by need, not birthday.

If you live in none of those states, you still have a department page. Open it.

If they transfer

Transfer is a local placement problem. Texas districts commonly assess mastery. New York leaves grade placement to the principal. North Carolina notes that a conventional-school principal has no legal obligation to accept home-school credit, especially in grades 10–12.[203] A brand in the title column will not be read as Biology. Another reason the title should already look like Biology.

College-ready objects — not the course

Scores help a stranger believe the transcript. They do not replace the looking and the notebook.

[201] NYSED, "Home Instruction Questions and Answers"; 8 NYCRR 100.10 (Cornell LII). No local or Regents diploma for home instruction. Science in 1–6; two units in 7–8; two units in 9–12; a unit is 6,480 minutes. Placement by need. Regents exam with a lab requirement: admission if IHIP, quarterlies, and/or teacher verification show the lab was met. No part-time public instructional participation.

[202] NYSED, "Home Instruction Questions and Answers"; 8 NYCRR 100.10 (Cornell LII). No local or Regents diploma for home instruction. Science in 1–6; two units in 7–8; two units in 9–12; a unit is 6,480 minutes. Placement by need. Regents exam with a lab requirement: admission if IHIP, quarterlies, and/or teacher verification show the lab was met. No part-time public instructional participation.

[203] TEA "Home Schooling"; NYSED Q&A; North Carolina DNPE records FAQ (accessed 1 September 2026). A conventional-school principal has no legal obligation to accept home-school credit, especially in grades 10–12.

The SAT is not a science test in this book. Science-flavored passages, if they appear, are a reading object. They do not certify Biology.[204]

ACT Science is optional. On the enhanced ACT, Science is not in the Composite. The Composite is English, math, and reading. Science, if taken, is 40 questions in 40 minutes. Sitting it is a signal. Sitting it is not a Biology credit.[205]

AP Biology, AP Chemistry, AP Physics 1, AP Physics 2, AP Physics C: Mechanics, AP Physics C: Electricity and Magnetism, and AP Environmental Science are optional exam objects. There is no course titled simply "AP Physics." AP Biology's opened overview describes an introductory college-level course with about 25 percent of instructional time in hands-on lab work. Credit is set by each college.[206] Put the score on its own line. Until you have confirmed how a home course may carry the AP title, the safer transcript line is **Biology**, **Chemistry**, **Physics**, or **Environmental Science**, with the exam as a separate artifact.

CLEP Biology and Chemistry may become college credit. They are not NCAA core. ACE's typical recommendation is a score of 50 for six semester hours; each college sets policy. About 9 percent of CLEP Chemistry is experimental-chemistry *items* — questions about experiments, not a lab year.[207] Audited, CLEP, and credit-by-exam courses are not NCAA-approved core courses.

Dual enrollment is a college course taken during high school. Federal statistics define it as postsecondary credit during high school, excluding AP and IB — not a homeschool rate.[208] Access is local. Map the course to **Chemistry** or **Biology** or **Physics**, with the college named. Send the official college transcript. NCAA wants the college course designated on the homeschool transcript, plus that sepa-

[204] SAT as a science examination was not treated as a fetched science test for this book.

[205] ACT Enhanced ACT K–12 FAQs; Science Test Description; Understanding Your ACT Scores (accessed 1 September 2026). Science optional; not in the Composite; 40 questions / 40 minutes; not a course credit.

[206] College Board AP Central (accessed 1 September 2026): AP Biology (Course Overview PDF © 2026: about 25 percent of instructional time in hands-on lab); AP Chemistry; AP Physics 1; AP Physics 2; AP Physics C: Mechanics; AP Physics C: Electricity and Magnetism; AP Environmental Science. No course titled simply "AP Physics." Credit is institution-specific.

[207] College Board CLEP Biology and CLEP Chemistry (accessed 1 September 2026). ACE typical recommendation: score 50, 6 semester hours. CLEP Chemistry experimental-chemistry slice about 9 percent of exam items. NCAA Toolkit: CLEP is not core.

[208] NCES 2019-176. Dual/concurrent enrollment as postsecondary credit during high school, excluding AP and IB. Not a homeschool science rate.

rate college transcript.[209]

NCAA, if athletics are in view

If Division I or Division II sports might be in the picture, science planning starts in ninth grade. Science **is** a core area.

The public fact sheet says **Science**. The High School Review Committee says **natural/physical science**. Earth science, biology, chemistry, physics, and environmental science sit inside that family.[210]

Division I asks for sixteen core-course credits, including **two years of science, including one year of lab if offered**. One extra core year may be English, math, *or science*. Ten of the sixteen, including seven in English, math, or natural/physical science, must be finished before the seventh semester — the 10/7 rule. Minimum core GPA is **2.3**.[211] Waiting until twelfth grade to start science is a 10/7 problem even if two science years eventually appear. That is an athletic calendar, not a teaching claim.

A 2026 Division I committee recommended dropping the "lab if offered" sentence. The live Division I sheet on 1 September 2026 still carried it. Plan as if the lab year is still in the picture.[212] Division II's public sheet still said two years of science including lab if offered; a 2026 council action adopted elimination of that laboratory requirement. Read the live sheet in the year you file.[213]

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[209] NCAA Eligibility Center, *Home School Toolkit 2025–26*. Proof of graduation is a family or umbrella artifact. Evaluation after documents are in *and* an NCAA school has placed the student on an Institutional Request List. Homeschool means parent, tutor, or umbrella creates, instructs, assesses, and awards grades. Dual-enrollment designated on the homeschool transcript as a college course, plus the official college transcript. Hawaii and New York: a homeschool-issued diploma is not accepted as proof of graduation.

[210] NCAA HSRC *Policies and Procedures 2025–26* and Staff Policies 2026–27. Core area: natural/physical science. Computer science has its own chart. Health is not that core area. Forensics mapping left to the current chart.

[211] NCAA Division I Academic Requirements fact sheet, September 2023, still live 1 September 2026. Sixteen core courses including 2 years SCIENCE (Including one year of lab, if offered); extra English/math/science year; 10/7 rule; 2.3 core GPA.

[212] NCAA Division I Academics and Eligibility Committee, January 2026: recommended a June 2026 proposal to eliminate "lab if offered," effective 1 August 2026. Live DI fact sheet on 1 September 2026 still carried the lab language.

[213] NCAA Division II Academic Requirements Committee, February/March 2026, recommended

The homeschool packet includes a transcript, an administrator statement that instruction followed *state* law, a Core-Course Worksheet for each core course, and proof of graduation. The worksheet title equals the transcript title. Evaluation begins after those documents are in **and** an NCAA school has placed the student on an Institutional Request List.[214] There is no preapproved homeschool science curriculum. A full-time online school with online teachers is not a homeschool on that toolkit's definition.

CLEP is not a workaround. Hawaii and New York have a graduation-proof rule, not a science rule: the Eligibility Center cannot accept proof of graduation from a homeschool-issued diploma in those states.[215]

Place by skill, not birthday

A publisher's "grade 6 science book" is a scope, not a legal grade. New York already says instruction should match the student's needs and previous achievement.[216]

Can the child look, try, and record what happened? If not, they are still in a looking-and-trying year. Can they name the one thing that changed in a fair test and write a claim from the table they made? If not, they are still in a taught-investigation

eliminating the laboratory requirement effective 1 August 2026. Management Council, 13–14 April 2026, adopted it. Public DII fact sheet still showed the lab sentence at the 1 September 2026 fetch.

[214]NCAA Eligibility Center, *Home School Toolkit 2025–26*. Proof of graduation is a family or umbrella artifact. Evaluation after documents are in *and* an NCAA school has placed the student on an Institutional Request List. Homeschool means parent, tutor, or umbrella creates, instructs, assesses, and awards grades. Dual-enrollment designated on the homeschool transcript as a college course, plus the official college transcript. Hawaii and New York: a homeschool-issued diploma is not accepted as proof of graduation.

[215]NCAA Eligibility Center, *Home School Toolkit 2025–26*. Proof of graduation is a family or umbrella artifact. Evaluation after documents are in *and* an NCAA school has placed the student on an Institutional Request List. Homeschool means parent, tutor, or umbrella creates, instructs, assesses, and awards grades. Dual-enrollment designated on the homeschool transcript as a college course, plus the official college transcript. Hawaii and New York: a homeschool-issued diploma is not accepted as proof of graduation.

[216]NYSED, "Home Instruction Questions and Answers"; 8 NYCRR 100.10 (Cornell LII). No local or Regents diploma for home instruction. Science in 1–6; two units in 7–8; two units in 9–12; a unit is 6,480 minutes. Placement by need. Regents exam with a lab requirement: admission if IHIP, quarterlies, and/or teacher verification show the lab was met. No part-time public instructional participation.

stage. High-school *titles* can still be Biology while the description tells the truth about supports.

A template, a signature, and the truth

A tool, including an AI helper on your side of the table, may draft a **template**: blank lines for title, year, credit, grade, texts, lab load, writing, grading, signature. That is a form. It is not a record until you fill it from the folder.

You read every line. You check the books against the shelf and the investigation count against the notebook. Then you sign. Hours that were not taught are a false statement. A polished lab report the child did not write is not the child's science. A generated data table is not Figure 1. The tool may format. You attest.

For the student

Your transcript is a picture of work you did. You looked. You measured. You wrote what happened. When a parent asks you to list what you finished this year, name the books, the investigations, and two claims you actually wrote from data you took. If a line on the page is not true, say so before anyone signs.

What "done enough" looks like

You can hand a stranger one page per high-school science course. The title is from the list a counselor already knows. "With Lab" appears only when investigations happened. The description names texts, lab load, writing, and grading, and you would still sign it tomorrow morning. The folder matches the page. That is enough.

Chapter 10 — Resources

This chapter names programs families actually use. It does not rank them. It does not sell them. It is a fit list so you can match a stack to the table you already have: how much of the teaching you will carry, whether the house wants a religious frame or a secular one, whether the publisher describes a high-school credit shape, how the child is placed, and where the kit path lives.

A "grade 6 science book" is a publisher's scope, not a legal grade. Placement is by skill. The transcript, as Chapter 9 said, still says Science, or Biology, or Chemistry. Combining two honest programs does not mint a new title.

This week you can name *why* the books on your shelf fit this child. Today the student can read one page from a book that is actually in the house, or set out one investigation the book actually asks for.

Illustration. A table of books as objects — closed spines, a notebook, goggles, a rock. Not product-pack shots. No brand logos. No portraits.

How to read a program

Five questions do the work.

Parent load. Is the adult reading aloud at the elementary table? Sitting nearby while a high-schooler works a conversational text written to the student? Running a textbook with optional video? Building lessons around a college open text?

Worldview. Some programs say Christian on the first page. Some describe a young-earth frame. Some are secular or college-science in tone. Fit is a house decision, not a ranking. This book teaches the idea on the table. It does not pick a church.

High-school credit shape. Does the publisher describe a year of Biology, Chemistry, or Physics a stranger could file? Or is this an elementary or middle-grades path? A publisher's "credit" sentence is a scope. The registrar still wants a mappable title and a description of the work.

Placement. The grade on the cover? Multi-age? "Any order"? A college book used in eleventh grade? Skill first.

Kit path. Household items? A purchased kit sold for use with that program? Safety gear as a separate purchase? A kit is stuff. A kit does not complete a risk assessment.

Where a company makes a strong claim — experiments not mandatory, no science background needed, lessons of a certain length, a free customizable text — that claim is the company's. This chapter reports what the page said. It does not certify the slogan.

This chapter names titles the publishers list. It does not print a year-by-year cycle or a lesson count. Open the current publisher page if you use the program, and write the transcript from the work the child actually did.

Apologia — Exploring Creation

Apologia describes a Christian homeschool science curriculum, conversational in tone, written directly to the student. Elementary is the Young Explorer series, described as Charlotte Mason style, K–6, usable multi-age. A support article dated 16 March 2026 states elementary titles may be used in any order. The publisher names eight elementary titles. Middle school: General Science and Physical Science. High-school titles named on the pages opened for this book: Biology, Chemistry, Physics, Marine Biology, Advanced Biology, Advanced Chemistry, Advanced Physics, Astronomy, Forensics, Health.[217]

[217] Apologia, "Homeschool Science Curriculum," https://www.apologia.com/homeschool-science-curriculum/; "Curriculum Scope," https://www.apologia.com/curriculum-scope/ (accessed 1 September 2026). Company copy: Christian, conversational, written to the student; Young Explorer elementary, any-order note in a 16 March 2026 support article; eight elementary titles named by the publisher; General Science and Physical Science; high-school Biology, Chemistry, Physics, Marine Biology, Advanced Biology/Chemistry/Physics, Astronomy, Forensics, Health. FAQ: experiments encouraged, not mandatory. HTML recommended sequence labelled as one possible option. Scope-and-sequence PDF not used as a source; lesson counts not reprinted here.

The publisher describes hands-on work using household items, and lab-report templates in student notebooks. A company FAQ states that hands-on experiments are encouraged but not mandatory. That is the company's sentence. It is not a safety plan, and it is not an athletic lab year. Live classes, self-paced, and co-op options are described.

An HTML "recommended course sequence" on the publisher's site is labelled as one possible option. This book reports that label. It does not adopt the sequence as its own cycle. A linked scope-and-sequence file was not used as a source here, so this chapter does not reprint topic lists or lesson counts.

Fit. A Christian family that wants a student-facing narrative, household experiments, and a recognizable high-school noun (Biology, Chemistry, Physics). Parent load is moderate if the student can read the conversational text; you still host safety and the talk after the trial. Not a fit if the house wants a secular text.

Transcript. Biology, Chemistry, Physics. Never "Exploring Creation." Marine Biology maps to **Biology** or **Environmental Science** if that is the substance. Astronomy maps to **Earth Science** if that is the substance, not to a silent Physics. Health is its own line.

BJU Press science

BJU Press describes science from a biblical worldview, including a young-earth framing on the pages opened for this book. Named levels: Science 1–6; Life Science; Earth Science; Physical Science; Biology; Chemistry; Physics; Health. Video Course kits and Textbook kits are both sold. Hands-on work and a Homeschool Hub that can track labs are described.[218]

An elementary scope-and-sequence file was offered on a page and was not used as a source here. This chapter does not reprint lesson counts or a four-year high-school cycle.

Fit. A Christian family that wants a traditional textbook look, optional video, and titles that already match the locked transcript list. Young-earth framing is part of

[218] BJU Press Homeschool Science, https://www.bjupresshomeschool.com/science (accessed 1 September 2026). Company copy: biblical worldview, young-earth framing on opened pages; Science 1–6; Life Science; Earth Science; Physical Science; Biology; Chemistry; Physics; Health; Video Course kits and Textbook kits. Elementary scope PDF not used as a source.

the product, not an optional sticker. Parent load is the textbook hour plus labs you actually run; video can carry explanation if you still hear a wrong account.

Transcript. Life Science, Earth Science, Physical Science, Biology, Chemistry, Physics. Never "BJU Science 5."

Abeka science

Abeka describes Christian materials with spiral learning, offered since 1972. Science/Health is a shop-by-subject category. Parent-led textbooks sit beside Abeka Academy video (K4–12, with an accredited option). Subject kits for science/health in grades 4–6 are named. Full-grade kits include science.[219]

This book does not list a grade-by-grade Abeka high-school science sequence. Title the year from the work.

Fit. A Christian family already using Abeka for other subjects, or one that wants video-academy structure. Parent-led Abeka is still a homeschool if the parent instructs and grades. An accredited Abeka Academy student may be on a *school* transcript path, not a homeschool worksheet path. NCAA treats a full-time online school with online teachers as a school, not a homeschool.[220]

Transcript. Science, Biology, Chemistry, Physics as the work matches. Never the brand.

Real Science-4-Kids / Gravitas

Gravitas Publications, on the Real Science-4-Kids site, describes an "atoms first" approach by Dr. Rebecca Woodbury. Books 1–4 elementary, Books 5–7 middle, plus K–2 dashboards. Lessons are described as 35–45 minutes — a company timing, not a research finding. Experiment kits are listed for Books 1, 2, and 5; kits for 3, 4, 6, and 7 were described as "coming soon" on the page opened for this

[219] Abeka Homeschool, https://www.abeka.com/homeschool/ (accessed 1 September 2026). Company copy: Christian materials, spiral learning since 1972; Science/Health as a shop-by-subject; parent-led textbooks and Abeka Academy video (K4–12, accredited option). Exact high-school science title sequence not listed here.

[220] NCAA Eligibility Center, *Home School Toolkit 2025–26*. Homeschool means the parent, tutor, or umbrella creates the curriculum, instructs, assesses, and awards grades. An online school with online teachers is not a homeschool on that definition.

book. Climate change is discussed via molecules on that page — secular-leaning science content as the publisher presents it.[221]

A high-school four-year credit sequence was not claimed on the homepage this book opened. This chapter does not invent one.

Fit. An elementary or middle-grades family that wants secular-leaning, atoms-first science with short lessons and optional kits. Parent load is designed to be light on the clock; you still hear a wrong explanation. Not, on the opened homepage, a complete high-school Biology–Chemistry–Physics replacement.

Transcript. Science, Life Science, or Physical Science as the work matches in those years. Not a book-number as the course name.

Elemental Science

Elemental Science (Paige Hudson named on the site) describes three keys: hands-on work, reading, and writing it down. Classical Grammar / Logic / Rhetoric stages are used. Product lines named: Sassafras (story-based), Science Chunks, and high-school Biology, Chemistry, Physics, plus Rhetoric Physical Science. "No science background" is a publisher claim about the parent.[222]

Day-by-day counts and any year-cycle file were not used as sources here.

Fit. A classical homeschool that wants science to look like doing, reading, and notebooking, with high-school titles that already match Biology, Chemistry, Physics. Parent load is the three keys you actually run. Still a curriculum, not a lab safety plan.

Transcript. Biology, Chemistry, Physics; Physical Science if that is the rhetoric-level work. Never a program nickname.

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[221] Real Science-4-Kids / Gravitas Publications, https://realscience4kids.com/ (accessed 1 September 2026). Company copy: atoms-first; Books 1–4 elementary, Books 5–7 middle, K–2 dashboards; lessons described as 35–45 minutes; kits for Books 1, 2, and 5; kits for 3, 4, 6, and 7 "coming soon" on the opened page. High-school four-year credit sequence not claimed on that homepage.

[222] Elemental Science, https://elementalscience.com/ (accessed 1 September 2026). Company copy: hands-on, reading, writing it down; classical Grammar / Logic / Rhetoric; Sassafras, Science Chunks; high-school Biology, Chemistry, Physics, Rhetoric Physical Science. "No science background" is a publisher claim about the parent. Day-by-day counts not reprinted here.

Berean Builders / Jay Wile

Berean Builders describes Christian science by Dr. Jay Wile. Elementary is chronological: *Science in the Beginning*, *Science in the Ancient World*, *Science in the Scientific Revolution*, *Science in the Age of Reason*, *Science in the Industrial Age*, *Science Through HiStory*. Junior high: *Science in the Atomic Age*, *Discovering Design with Earth Science*. Senior high: *Discovering Design with Biology*, *Discovering Design with Chemistry*, *Discovering Design with Physics*, *Discovering Design with Earth Science*. Hands-on work is described as woven in. Online classes via Memoria Academy are named.[223]

Those named titles are the publisher's list, not a four-year cycle invented here. Which year a family takes which title, and lesson counts, belong to the current publisher page and to the work on your table.

Fit. A Christian family that wants chronological elementary science and high-school titles that map cleanly to Biology, Chemistry, Physics, Earth Science. Worldview is part of the product. Parent load is the text plus the hands-on work actually done.

Transcript. Biology, Chemistry, Physics, Earth Science. Never "Discovering Design."

CK-12 FlexBooks

CK-12 describes a FlexBook as a free, online, customizable digital textbook. A help article dated 29 May 2026 says a FlexBook may include chapters and lessons, explanations, images, practice questions, interactive simulations, videos, and assessments. Exact content "varies by subject and textbook." Science subjects named on an opened list include Science K–5, Earth Science, Life Science, Physical Science, Biology, Chemistry, Physics.[224]

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[223] Berean Builders, https://bereanbuilders.com/ (accessed 1 September 2026). Company copy: Christian science by Dr. Jay Wile; named elementary chronological titles; junior high *Science in the Atomic Age* and *Discovering Design with Earth Science*; senior high *Discovering Design with Biology / Chemistry / Physics / Earth Science*. Named titles are the publisher's list, not a cycle invented here.

[224] CK-12 Foundation, "What Is a FlexBook Textbook?" (CK-12 Trainer note 212 May 2026), https://help.ck12.org/hc/en-us/articles/200344155-What-Is-a-FlexBook-Textbook; Overview, https://www.ck12.org/pages/overview/; subject list, https://info.ck12.org/freetextbooks (accessed

This chapter names those subjects. It does not reprint chapter lists from books that were not opened as readable pages.

Simulations are a described feature. They are not, by themselves, an athletic lab year.

Fit. A secular or mixed-worldview family that wants free adaptable texts whose titles already match the locked list. Parent load is high if you must build the hour around a digital text: you still choose investigations, hold the key, and host the talk. Not a packaged lab kit.

Transcript. Science, Life Science, Physical Science, Biology, Chemistry, Physics, Earth Science. Never "CK-12."

OpenStax

OpenStax is a college open-textbook path, not a homeschool franchise. *Biology 2e* (Clark, Douglas, Choi; 28 March 2018) is described as a typical two-semester biology for science majors, written with an evolutionary lens; free on the web and as PDF, low-cost print. *Chemistry 2e* is a college chemistry text. *College Physics 2e* (Urone and Hinrichs) is algebra- and trigonometry-based, not calculus-based; the preface describes Take-Home Investigations and points students to PhET simulations. *Astronomy 2e* is an introductory non-majors text usable in one or two semesters.[225]

PhET on that preface is a textbook feature. It is not NCAA language.

Pacing a two-semester majors *Biology 2e* as a ninth-grade homeschool year is a family decision, not a publisher homeschool cycle. These are college books. There

1 September 2026). Company copy: free, customizable digital textbooks; simulations may be included; science subjects named include Science K–5, Earth Science, Life Science, Physical Science, Biology, Chemistry, Physics. FlexBook 2.0 book internals not reprinted here.

[225] Mary Ann Clark, Matthew Douglas, and Jung Choi, *Biology 2e* (OpenStax / Rice University), preface, 28 March 2018, https://openstax.org/books/biology-2e/pages/preface — two-semester majors biology, evolutionary lens. Paul Flowers et al., *Chemistry 2e*, https://openstax.org/books/chemistry-2e/pages/1-introduction. Paul Peter Urone and Roger Hinrichs, *College Physics 2e*, preface, 13 July 2022, https://openstax.org/books/college-physics-2e/pages/preface — algebra/trig; Take-Home Investigations; PhET pointers as a textbook feature. Andrew Fraknoi, David Morrison, and Sidney C. Wolff, *Astronomy 2e*, preface, 9 March 2022, https://openstax.org/books/astronomy-2e/pages/preface. College OER, not a K–12 homeschool cycle.

is no K–12 scope-and-sequence here.

Fit. A late-high-school student who can read college prose, possibly aiming at AP-adjacent or dual-enrollment rigor without buying a commercial homeschool brand. Parent load is high if you have to build lessons around a chapter written for an introductory college course. Not a fit for grade 3. Evolutionary framing in *Biology 2e* is explicit in the opened preface — relevant to families who chose Apologia, BJU, Abeka, or Berean for worldview reasons.

Transcript. Biology, Chemistry, Physics. If you used *Astronomy 2e* and need a locked noun, **Earth Science** only if the work was earth-and-space in substance. The license is not the course name.

Home Science Tools — kits, not a rank

Home Science Tools sells kits and supplies for use with Abeka, Apologia, Berean Builders, BJU Press, and Real Science-4-Kids, plus its own Science Unlocked line (Wonder K–2, Accelerate 3–7, Launch 8–12). Chemistry safety equipment and dissection supplies are in the catalog.[226]

That is a common kit path this book can name from an opened page. It is not a ranked curriculum. Science Unlocked is the company's own program; a scope file for that line was not used as a source here, so this chapter does not print its year-cycle.

A purchase is stuff. Splash goggles, a listed chemical, a dissection pan — those can make an investigation possible. They do not complete a risk assessment. They do not write Biology on a transcript.

Fit. Any of the programs above that expect household or kit materials, or a family building investigations without a branded curriculum. You still name hazards before the fun.

[226] Home Science Tools, https://www.homesciencetools.com/ (accessed 1 September 2026). Company catalog: kits for use with Abeka, Apologia, Berean Builders, BJU Press, and Real Science-4-Kids; Science Unlocked (Wonder K–2, Accelerate 3–7, Launch 8–12); chemistry safety equipment and dissection supplies. A kit company, not a curriculum rank. Science Unlocked scope PDF not used as a source.

Combining honestly

A family may combine. Honest combinations follow the products' own jobs.

Young Explorer, Real Science-4-Kids, or Elemental Grammar-stage work in the early years, when looking and trying are the hour. A BJU, Abeka, Apologia, or Berean high-school year later, when the house wants a Christian text with a Biology or Chemistry noun. An OpenStax or CK-12 year later, when the student can hold college or adaptable digital prose. Home Science Tools as the kit path inside any of them.

The child who cannot yet look, try, and record is still in a looking-and-trying year, whatever the birthday. The high-schooler who cannot yet write a claim from a table they made is still in a taught-investigation stage, whatever the transcript year. High-school *titles* can still be Biology while the description tells the truth about supports.

Combining does not mint a new course title. The transcript still says **Biology**, or **Chemistry**, or **Physics**. The description may say "conversational high-school biology text; sixteen household investigations; kit materials from a supply company; two unaided claims from data." A stranger can file that. A kitchen nickname is a kitchen nickname.

Worldview is a fit variable. Apologia, BJU Press, Abeka, and Berean Builders are opened as Christian products; BJU's opened pages include young-earth language. Real Science-4-Kids, CK-12, and OpenStax *Biology 2e* are opened as secular or college-science products; *Biology 2e* names an evolutionary lens. Elemental Science's opened homepage is classical method more than an origins statement. Name the fit. Teach the idea on the table.

What "done enough" looks like

You can say, in one sentence, why this year's science stack fits *this* child: parent load you can actually carry, a worldview the house chose on purpose, a high-school credit shape only where the work is a high-school survey, placement by skill, and a kit path that still leaves safety to you.

The programs have names. The transcript has titles a stranger can read. The two lists are not the same list.

A Note on Sources

Studies named in the chapters are listed in Notes, in one series at the back. That is where the full citations live, so the teaching pages can stay a teaching voice.

Some items the research behind this book did not open stay out of the teaching voice. I did not invent a coefficient, a statute, or a product feature to fill a hole. If a study is in the chapter, it is in the notes. If we could not open it, it is not used as a finding here.

Program prices and credit claims in the resources chapter are taken from the companies’ own pages. Access date 1 September 2026.