TEACHER NOTES · STEM SCIENCE COMPANION

Yechiel's Fishery Farm

George the Cranky Guppy

Book 1 · Ages 7–10

Water is a living chemistry — and a fish's body is always quietly adjusting to it.

How to use these notes

This companion pulls the real science out of Book 1 so you can plan around it. The story follows a small freshwater guppy who suddenly finds himself in water his body was never prepared for — and the biology of that single situation drives everything: salinity, gills, stress, and the slow, careful work of helping an animal adjust.

Every chapter is built on accurate aquarium and fishery science. Use the notes to decide where to pause, what to explain, and which quick demonstration will make an invisible idea suddenly visible to a seven-to-ten-year-old.

> **A spoiler-free promise**
>
> These notes name the science, never the plot. You can read every line aloud to a class that hasn't opened the book yet — nothing here gives away a single surprise. The discoveries stay inside the cover, where they belong.

The science at a glance

A one-line map of the real biology, ecology, and physics inside each chapter — handy for planning which lesson to pair with which read-aloud.

Ch.	Science focus
1	**The Water Has Opinions.** Water quality and salinity as something a fish can physically feel.
2	**Roots That Listen.** Brackish water, estuaries, and the nursery role of

Ch.	Science focus
	mangrove roots.
3	**I Already Checked.** Why acclimation must be slow — and how fish and plants can share water.
4	**The Peacekeeper's Kind Mistake.** Every species has its own tolerance range.
5	**Three Doors That Don't Open.** Barriers, currents, and the difference between a real wall and one an animal only believes in.
6	**Pinchy's Terrible Advice.** Nutrient cycling and closed-loop water systems, seen from an invertebrate's eye-level.
7	**Archerfish and the Rude Appetite.** Specialised hunting and the bending of light (refraction).
8	**The Man With the Wet Boots.** Measuring the invisible with the right instrument.
9	**The Slow River.** The lateral line sense and gentle, low-stress handling.
10	**What the Water Said.** Recirculating systems and learning from a mistake.
11	**The Bridge.** Crossing salinities safely along a gradient.
12	**Home, With a Window.** Matching an organism to the right environment.

Chapter by chapter

Each note explains the concept for you, the teacher, so you can pitch it to the class at the right level. None of these reveal what happens in the story.

Chapter 1 — The Water Has Opinions

Science focus: *Water quality and salinity as something a fish can physically feel.*

Water is never just water. It carries dissolved minerals and salt, and the amount of salt — its salinity — is invisible to our eyes but very real to a fish. A fish's gills are its front line: they sense and exchange chemicals with the surrounding water every second. This chapter also introduces stress as a biological state, not just a mood: an animal under the wrong conditions shows measurable changes.

In the classroom: Ask students how they can tell water is salty without tasting it. Lead them toward the idea that scientists use tools, not tongues.

Chapter 2 — Roots That Listen

Science focus: *Brackish water, estuaries, and the nursery role of mangrove roots.*

Brackish water is a mix of fresh and salt, the kind found where rivers meet the sea. Mangrove roots stabilise muddy edges and shelter young animals, making such places natural nurseries. The chapter introduces euryhaline animals — species whose bodies tolerate a wide range of salinity — and the word acclimation, the slow process of letting a body adjust to new water.

In the classroom: Find an estuary on a map. Discuss why the 'in-between' water there is one of the richest habitats on Earth.

Chapter 3 — I Already Checked

Science focus: *Why acclimation must be slow — and how fish and plants can share water.*

A fish moved between salinities too quickly can be harmed, because its cells need time to rebalance the salt and water inside them. The gentle drip method mixes new water in slowly. The chapter also opens up aquaponics and hydroponics: fish waste feeds plants, plants clean the water, and very little water is wasted — a real solution in dry places.

In the classroom: Pose the puzzle: how could growing fish actually help grow lettuce? Let students propose loops before you explain the real one.

Chapter 4 — The Peacekeeper's Kind Mistake

Science focus: *Every species has its own tolerance range.*

What is comfortable for one animal can be stressful for another. Some species shrug off a salinity change; others cannot. This is the idea of a tolerance range — and why kindness that ignores another creature's biology can still cause harm.

In the classroom: Compare to human comfort: a temperature that's pleasant for one person is freezing for another. Same world, different ranges.

Chapter 5 — Three Doors That Don't Open

Science focus: *Barriers, currents, and the difference between a real wall and one an animal only believes in.*

Fisheries keep different waters separate on purpose, so each habitat keeps its own chemistry. The chapter explores physical barriers, machine-made currents (you cannot out-swim a pump), and behavioural barriers such as a curtain of bubbles — which only feels like a wall. It's a quiet lesson in how animals read their environment.

In the classroom: Distinguish 'can't pass' from 'won't pass.' Ask for everyday examples of barriers that are really just signals.

Chapter 6 — Pinchy's Terrible Advice

Science focus: *Nutrient cycling and closed-loop water systems, seen from an invertebrate's eye-level.*

Fish water carries invisible nutrients that plants can drink, while the plants return cleaner water. This is nutrient cycling — the same nutrients used again and again rather than thrown away. The chapter also widens the cast of a habitat to include its invertebrates.

In the classroom: Introduce 'nothing is wasted' as an engineering goal. Where else do students see things reused in a loop?

Chapter 7 — Archerfish and the Rude Appetite

Science focus: *Specialised hunting and the bending of light (refraction).*

An archerfish knocks insects down with a precise jet of water — and to aim, it must correct for refraction, the way light bends as it crosses between air and water. The same bending makes a straw look broken in a glass. The chapter also reinforces that stress in a fish is a visible condition: faded colour, clamped fins, changed breathing.

In the classroom: Drop a coin in a clear cup of water and look from the side — it appears to shift. That displacement is what the archerfish solves.

Chapter 8 — The Man With the Wet Boots

Science focus: *Measuring the invisible with the right instrument.*

Salt in water cannot be seen, but a refractometer reads salinity by measuring how the water bends light. The deeper point is a habit of science: trust calibrated tools and records over a hunch. Good fishkeeping, like good science, is built on measurement and notes.

In the classroom: Talk about other invisible things we trust because instruments reveal them — temperature, a phone signal, the wind's speed.

Chapter 9 — The Slow River

Science focus: *The lateral line sense and gentle, low-stress handling.*

A fish 'feels' moving water through its lateral line, a row of sense organs along each side that detects pressure and motion — a kind of distant touch. Handling an animal calmly and supporting its body reduces stress and the risk of injury during a transfer.

In the classroom: Have students close their eyes and sense air movement with a hand. That 'feeling without seeing' is the lateral line's job in water.

Chapter 10 — What the Water Said

Science focus: *Recirculating systems and learning from a mistake.*

In a recirculating system, the same water travels tank to filter to tanks and back, cleaned and reused, so almost none is wasted. The chapter also models good practice when something goes wrong: notice it, fix it calmly, and write down what you learned so it doesn't happen twice.

In the classroom: Draw the water's journey as a loop with arrows. Where does it get cleaned? What happens if one arrow stops?

Chapter 11 — The Bridge

Science focus: *Crossing salinities safely along a gradient.*

A gradient — fresh at one end, salty at the other, in-between in the middle — lets a tolerant animal move between waters without shock, mimicking a natural estuary. The chapter also touches a gentle truth: very different organisms can care for one another even when they cannot truly 'talk.'

In the classroom: Lay a row of cups from fresh to salty as a 'bridge.' Discuss why crossing one step at a time is safer than one big jump.

Chapter 12 — Home, With a Window

Science focus: *Matching an organism to the right environment.*

The closing idea is simple and powerful: there are no ‘bad’ animals, only animals in the wrong conditions. Put a creature in water that fits its biology and it thrives. Good husbandry is the art of the right fit.

In the classroom: Sort picture cards of animals into the habitats that suit them. Reframe ‘difficult animal’ as ‘wrong habitat.’

Key vocabulary

Teacher-facing definitions. Introduce the words your class is ready for; the book itself defines them gently in context.

- **Salinity —** the amount of dissolved salt in water; invisible to the eye but central to where an animal can live.
- **Brackish water —** a mix of fresh and salt water, typical of estuaries where rivers meet the sea.
- **Euryhaline —** describes an animal whose body tolerates a wide range of salinities (mollies are a good example).
- **Acclimation —** the slow process of letting an animal's body adjust to new water, often by adding new water drop by drop.
- **Gills —** the organs on the sides of a fish's head used to breathe and to exchange salts and gases with the water.
- **Lateral line —** a row of sense organs along a fish's side that detects water movement and pressure — a 'distant touch.'
- **Refraction —** the bending of light as it passes between air and water; it makes submerged objects look displaced.
- **Refractometer —** a small instrument that measures salinity by reading how much the water bends light.
- **Aquaponics / Hydroponics —** growing fish and plants together (aquaponics) or plants in water without soil (hydroponics); both save water.
- **Recirculating system —** a setup where the same water is filtered and reused continuously rather than discarded.
- **Stress (in a fish) —** a physiological condition with visible signs: clamped fins, faster or irregular breathing, faded colour, hiding.

Big ideas & curriculum connections

- Structure and function: gills, the lateral line, and a refractometer each 'read' the water in a different way.
- Stability and change: small changes in salinity can have large effects, and slow change is safer than sudden change.

- Systems and cycles: water can be cleaned and reused; fish and plants can support one another in a loop.
- Tools extend the senses: scientists measure what the body cannot see.

Connects naturally to elementary life-science and engineering strands — for example, NGSS-style topics such as structure and function in living things, organisms and their habitats, and the engineering idea of designing a system that reuses a resource. Treat these as starting points, not a checklist.

Extend it: simple classroom activities

Low-prep, safe, and matched to ages 7–10. Each one makes one of the book's invisible ideas visible.

Make salt visible — Float a raw egg in a glass of plain water (it sinks), then stir in salt until it rises. The salt you can’t see is now doing something you can. Links to Chapter 1.

The broken straw — Put a straw or pencil in a clear glass of water and look from the side — it appears bent at the surface. That’s refraction, the puzzle an archerfish solves every time it shoots. Links to Chapter 7.

Spot the stress — Watch a short clip of healthy fish, then list calm signs (open fins, steady breathing, bright colour). Discuss how a keeper ‘reads’ an animal before it ever looks sick. Links to Chapters 1 & 7.

Draw the loop — As a class, draw the water’s path through a recirculating fishery with arrows, labelling where it gets cleaned. Erase one arrow and predict what happens. Links to Chapter 10.

The science in this companion is drawn from a working fishery and nearly five decades of real observation. Slow, my friend, slow — the water will change with you.