Name: _____ Date: _____

The Tax Collector's Rain

Reading level 14 · 1355 words

Stand beside a river at the end of a dry summer and it is still flowing. Weeks have passed without rain, yet the channel carries water day after day. For most of recorded history, that steady flow looked like proof that rain could not be the source. Rain came and went and seemed thin; rivers were steady and huge. The obvious answer was that rivers must be fed from somewhere hidden. The idea that the sky alone keeps every river on Earth running, which a schoolchild now draws as a circle of arrows, was a minority opinion for roughly two thousand years. It was first put to the test not by a famous philosopher but by a ruined tax official who did something the philosophers had not: he added up the water.

The ancient answers were clever. In many traditions, the land was thought to float on a body of water, with rivers rising from below. Aristotle proposed that most river water was made in underground caverns, where air somehow condensed into water. Others pictured the sea leaking into hollows underground, rising as steam, and cooling again into springs. What makes Aristotle interesting is that he also described the sun lifting fresh water into the sky as vapor, which the cold turns back into rain. He held both ideas at once. The correct mechanism was on the table, but most writers judged that it could not possibly supply enough water, and the weight of authority sat with the caverns.

Greek writers had guessed long before that much river water comes from rain, but they still believed water rising through the earth added a great deal. Bernard Palissy, a French potter and hydraulics engineer, is usually credited as the first published thinker to insist, in 1580, that rainfall alone was sufficient. Palissy argued that water rising from underground played no vital part at all. He was right, but he offered an argument rather than a measurement. What the question needed was a number: how much rain falls on a piece of land in a year, and how much water leaves it by its river? If the rain came out larger, the caverns were unnecessary. If the river came out larger, the rain was not enough. For nearly a century after Palissy, nobody sat down to do the sum.

Pierre Perrault was an unlikely candidate. In 1654 he bought the post of Receiver General of Finances for Paris, collecting taxes for Louis XIV and keeping a percentage. The arrangement ruined him. The king, wishing to calm angry taxpayers, cancelled all taxes that were still owed after ten years, and Perrault had already spent some of his collections paying his own creditors. He could not deliver the money and was forced into bankruptcy. He turned to natural science as an amateur, choosing the question of where springs come from. He came from a gifted family: one younger brother, Claude, designed part of the Louvre, and another, Charles, wrote the fairy tales collected as Mother Goose.

Perrault chose a stretch of the upper Seine near its source and worked out how much land drained into it. He estimated the rain that fell on that area in a year, made an allowance for losses, and compared the total with the river's yearly flow. The result was lopsided. Only about one-sixth of the year's rain was needed to account for everything the river carried away. The remainder was more than enough to cover evaporation, plants and anything that soaked in. Hydrologists now call this kind of accounting a catchment water balance: what enters a basin must leave it or be stored there. Perrault published the work without his name in 1674, as a book on the origin of springs.

Others soon tightened the figures. In 1686 the physicist Edme Mariotte measured how fast the Seine flowed near the Pont Royal in Paris by timing boats and floating debris as they drifted past on the current. Speed multiplied by the area of the river's cross section gives discharge, the volume of water passing a point each second. Edmond Halley approached from the opposite direction. He estimated how much water evaporates from the Mediterranean and showed that it was enough to supply all the rivers that pour into it. Between them, the three men had measured both halves of the loop: rain enough to fill the rivers, and evaporation enough to refill the rain.

Perrault did not get everything right, and that is part of what makes him worth reading. His experiments convinced him that rain soaks no deeper than about two feet into the soil, so he concluded that most rain does not reach springs. Today we know that infiltration is exactly how aquifers are recharged, and that the summer river is fed by groundwater seeping slowly into its bed. Historians do not entirely agree on how much of this he grasped; one account credits him with first describing infiltration and the steady groundwater flow that sustains rivers between storms. Either way, his central argument met resistance. The rain-fed cycle did not become the mainstream scientific view until the early nineteenth century.

In 2024, hydrologists published something Perrault could not have imagined: an audit of his own fieldwork. A team returned to his headwater catchment, only about 119 square kilometers, which they called rather peculiar. They re-ran parts of his calculations and collected new data. They found real uncertainty in both his flow and his area estimates, along with some mistaken ideas about the paths water takes underground, and they produced new estimates of the age of the spring-fed site where he worked. Nobody now doubts his conclusion; rivers are gauged against rainfall every day. But the most famous proof in hydrology turns out to rest on rougher numbers than the textbooks let on.

Modern water accounting runs Perrault's ledger for the whole planet. At any moment the atmosphere holds about 12,900 cubic kilometers of water; if it all fell at once, it would cover the planet only 2.5 centimeters deep. Yet some 495,000 cubic kilometers pass through the sky every year, so the air's whole supply is emptied and refilled nearly forty times. Divide a year by forty and you get the other famous figure: a water molecule stays aloft for only nine or ten days. Below ground, the clock runs differently. Deep groundwater can stay put for more

than ten thousand years, and one core drilled in Antarctica held ice 2.7 million years old. The cycle is not one loop but many, turning at wildly different speeds.

The cycle also moves energy, which is why it drives the weather. Evaporating a gram of water takes 540 calories, about five times the energy needed to heat that gram from freezing to boiling. That energy, called latent heat, does not disappear. It travels with the vapor and is released when the vapor condenses into cloud droplets, warming the surrounding air. A towering storm cloud is, in part, the sun's energy, collected where water evaporated and released far from where it began. This sensitivity matters now. The amount of water the air can hold rises by about 7 percent for every degree Celsius of warming, and satellites and weather balloons confirm that atmospheric water vapor is increasing. Climate models agree that rainfall should grow more variable, though many details remain uncertain.

Perrault asked where a river comes from, and the answer kept moving outward: from rain, then from the sea that feeds the rain, and finally from beyond the planet itself. Where did Earth's water come from in the first place? One clue is a chemical fingerprint, the ratio of heavy hydrogen, called deuterium, to ordinary hydrogen. Most comets measured so far carry about twice the ocean's ratio, and one, measured by the Rosetta spacecraft, carries three times as much. Only one comet matches seawater, so the oceans cannot have come only from comets. Many geochemical studies conclude that water-rich asteroids were most likely the main source, but the case is not closed. A bankrupt tax collector turned the river question into a ledger. The ledger for the oceans themselves is still open.

Questions

1. Why did most early thinkers believe rivers could not be fed by rain alone?

A. Rain seemed too fitful and small to explain rivers that kept flowing
B. They had measured the rain and found too little
C. Rivers only flowed in winter

2. What did Perrault's calculation for the upper Seine show?

A. The river carried six times more water than the rain supplied
B. Only about one-sixth of the yearly rain was needed to account for the river's flow
C. The river was fed by seawater from underground

3. In this book, what does "discharge" mean?

A. Being fired from a job
B. The amount of rain in a year
C. The volume of water passing a point in a river each second

4. How did Halley's work complete the picture that Perrault and Mariotte began?

A. He showed evaporation from a sea was enough to supply the rivers flowing into it
B. He proved that caverns make water

C. He measured rain on the Seine more exactly

5. What did the 2024 re-check of Perrault's catchment conclude?

A. His proof was a fake

B. His numbers were less certain than textbooks suggest

C. The Seine has dried up

6. Why does the book say the ledger for the oceans is still open?

A. Nobody has ever measured ocean water

B. Perrault left his book unfinished

C. Scientists have strong clues but have not settled where Earth's water first came from

Words to know

catchment: river's drainage area
discharge: river flow volume
infiltration: soaking into ground
aquifers: water-holding rock
latent: hidden, stored
deuterium: heavy hydrogen

Answer key: The Tax Collector's Rain

1. A. Rain seemed too fitful and small to explain rivers that kept flowing
2. B. Only about one-sixth of the yearly rain was needed to account for the river's flow
3. C. The volume of water passing a point in a river each second
4. A. He showed evaporation from a sea was enough to supply the rivers flowing into it
5. B. His numbers were less certain than textbooks suggest
6. C. Scientists have strong clues but have not settled where Earth's water first came from