SAMPLE

Earth's Dynamic Systems: The Atmosphere

Layers of Air

Aira Astralis

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Introduction

The air is the most familiar object in the world and one of the least examined. Everyone has lived inside it every moment of their life; almost nobody could say, without looking it up, what it is made of, how much it weighs, how high it goes, or why the sky is blue rather than any other color. It has no surface to touch and no edge to see, and so it escapes the attention that the sea and the land and the stars receive; yet it is a physical object of enormous size and complexity, five quadrillion tons of gas pressed against the planet by its own weight, a machine of layers and currents and chemistry that has been running, under successive managements, through the whole four-billion-year span of the planet's habitable age, and the only known object in the universe in which anything has ever breathed.

This book is an account of that object. It opens with the air's discovery as a substance, the seventeenth-century experiments that turned an invisible nothing into a measurable something; it follows the census of what air contains, the stack of layers it forms, its weight and pressure, its ozone shield and its electrically charged upper floors; it watches the light that plays through it, the blue days and red evenings, the rainbows and the mirages; it counts the meteors it catches and the lightning it makes; it tells the life story of the whole envelope, from the planet's first steam to the oxygen age and the balancing act that keeps it breathable; and it closes with the atmosphere's slow leak to space and its current, rapid, human-prompted changes. The story is told in plain prose, with no mathematics, and it asks of the reader only the willingness to notice a thing they have never once seen.

The reason to bother is simple: the air is where all the weather is, all the climate is, all the breathing is, and most of the beauty of the sky is. The books beside this one in the series take up the winds and the storms; this one takes up the medium itself, the substance those books move in, and it aims to leave the reader with the strange and satisfying picture of a planet wearing a deep, layered, living coat of gas, a coat that is mostly nitrogen, one-fifth oxygen, a wisp of carbon dioxide with the whole climate in it, and not one still yard in its whole five-quadrillion-ton bulk.

A note on neighbors, before the account begins: the atmosphere is a shared subject, and this book has its own plot. The series' books on the winds, the storms, the jet streams, and the climate tell the air's motion and its moods; this book tells the air itself, the substance they move in. The reader will find no long accounts of fronts or cyclones here, and only such weather as the medium's own story requires; what stands in these pages instead is the stuff: what it is made of, how it got that way, how it weighs, how it is stacked, how it

handles the light and the stones, and how it is being changed. Think of it as the biography of a substance, and the weather as one chapter of the life, which is the honest proportion.

Chapter 1: The Discovery of Air

For most of history the air was not a thing but an absence. The old philosophies listed it among the four or five elements, the pure principle of which the actual wind was an impure sample, and this way of thinking, for all its elegance, made the air unexaminable: a pure principle cannot be weighed, bottled, or squeezed, and so for two thousand years nobody tried. The breakthrough came in the seventeenth century, and it came not from the air's defenders but from the vacuum's: the artisans and philosophers of the Italian cities, working with the era's newly refined glass tubes, discovered that a column of mercury in a sealed tube would stand at a height of about three feet and no more, leaving an empty space above it, and the argument over that empty space, whether it was real, whether nature really abhorred it, turned the air suddenly into a mechanical question, a thing with a pressure, a limit, and a weight.

The barometer was the air's birth certificate as an object. The tube's standing mercury column, first demonstrated in the 1640s, holds up because the atmosphere presses on the mercury pool below, and the column's height is a direct measure of that pressure: about three feet of mercury balancing the whole five-quadrillion-ton press of the sky. The demonstration traveled fast: within a few years a French philosopher carried a barometer up a mountain and found the column shortening as he climbed, the air's press thinning with altitude exactly as a blanket thins toward its top, and the readers of the account understood, many for the first time, that the atmosphere is a finite garment wrapped around a round world, stacked in layers that press down hardest at the bottom.

The vacuum pump, built in the same decades, completed the discovery: air could be removed from a vessel, and in the removed air's absence candles guttered, birds fainted, bells fell silent, and the air outside pressed inward on the vessel with a force that crushed it; the nothing, examined, turned out to be a something with habits, effects, and a weight of about a kilogram pressing on every square centimeter of the ground.

The census came last, and it completed the air's conversion from principle to substance. Late in the eighteenth century the chemists, now able to bottle and handle the airs, found the atmosphere to be a mixture: one part in five a gas that feeds fire and life, the oxygen; the rest almost entirely a quiet, unreactive gas, the nitrogen, named for its deadness; a small portion of a gas that turns limewater cloudy and feeds the plants, the carbon dioxide; and a scattering of others, including a heavy, lazy gas identified a century later from the leftover fraction, the argon.

The discovery that the air is not an element but a brew, four-fifths one thing and one-fifth another with a pinch of the rest, was among the century's most consequential findings: the breathing of animals and the burning of fires and the growth of plants were all suddenly understood as exchanges with the mixture, and the atmosphere entered the modern age as what it is, the planet's great shared reservoir of gases, continually stirred, continually spent and refilled.

The chapter's closing thought belongs to the reader's own lungs: every breath takes a scoop of the same mixture the seventeenth century first measured, and the press of the whole sky's weight, which the barometer reads as three feet of mercury, is what drives the scoop in. The air's discovery as an object is barely four centuries old; the breathing of it is as old as animals; and the book's remaining chapters are, in effect, the longer census that followed the discovery, the account of what else the object turned out to be: layered, weighted, tinted, charged, shielded, and alive.

The discovery's human texture deserves one more paragraph, because the seventeenth century's air experiments were among the first great public sciences. The vacuum demonstrations were theater: birds fainting in evacuated jars, the crushed spheres teams of horses could not pull apart, the barometer carried up the mountain with a reading taken at every stop, the results published and argued in the new journals and the letters of the republic of science; the air's conversion from principle to object happened, in large part, in front of audiences, and the century's engravers sold the pictures. The reader's modern intuition, that air is a real heavy stuff that can be pumped and weighed, is thus inherited, not obvious: it was won in a few decades of showmanship and argument, and the fact that schoolchildren now meet it in a single sentence should not hide how strange it was when it was new.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.