SAMPLE

Solar System Missions: Hayabusa2

Sampling Ryugu

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Free sample: Introduction & Chapter 1

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This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

In December 2020, a small fireball crossed the Australian night sky, and inside its scorched capsule, wrapped in a heat shield and riding a parachute, was a quantity of black grit weighing less than a coin: the first sample of a carbon-rich asteroid ever returned to Earth. The spacecraft that delivered it had spent six years flying to a spinning, diamond-shaped rock named Ryugu, dropping hopping robots onto its surface, firing a copper ball into it to expose its buried layers, touching it twice to gather its dust, and then flying home with its treasure sealed in a container that never touched the Earth's air until it was safely in a laboratory. The mission was Hayabusa2, the Japanese state space agency's second asteroid-sampling craft, and it stands among the most successful planetary expeditions ever flown.

This book tells the story of that mission for the general reader, from the troubled first flight whose scars shaped the second one's design, through the six-year voyage and the eighteen months of close operations at Ryugu, to the laboratory findings that followed and the extended journey the spacecraft is still flying today. The chapters need no technical background. They follow the mission's own arc: the building of the craft, the survey of the asteroid, the robots on its surface, the two dramatic sample collections, the artificial crater, the homecoming, the science of the returned grains, and the new targets the falcon is chasing in the late 2020s and beyond.

The story rewards the telling because Hayabusa2's subject is, at bottom, the oldest one there is: where the water and the chemistry of life came from. Ryugu is a fossil, a survivor of the solar system's construction phase, and its grains, untouched by Earth's air and water for four and a half billion years, carry the chemistry of the beginning. What the mission found inside them, the wet minerals, the organic molecules, the traces of ancient ice, is the closest science has come to reading the recipe from which worlds like ours were made, and the reader who finishes these chapters will know how such a reading was obtained, and why the little falcon is still flying.

A note on the road ahead, for readers planning a route. The first three chapters build the mission from its predecessor's scars, follow the flight to arrival, and introduce the Dragon Palace itself; the fourth reads the spinning top's clockwork; the fifth through eighth carry the surface war, the hoppers, the two gentle touchdowns, and the homecoming of the capsule; the ninth reads the grains in the laboratory and the tenth seats them among their comet kin; the eleventh follows the treasure into the world's hands; and the last four carry the falcon's second flight, the sibling mission's comparisons, the reasons the samples matter, and the closing account of what came home. Each

chapter keeps its own feet; the route runs straight; and the reader who wants the ending first may read the final chapter and then return to the scars where the story begins.

A word on the book's method before the tale begins. The account asks no technical background of the reader, uses no equations, and reports the mission's people and instruments by their work rather than by the acronyms the flight logs use; every number that matters is given in the plain scales of everyday life, and every result the laboratories reported is described as the laboratories described it, with the caution that the science of the samples continues, the vaults still yielding, and the reader who checks the latest findings will find the tale of this book sound in its facts and, in its closing chapters, deliberately open at the edges, where the next instruments are still at work.

Chapter 1: A Sequel With a Harder Promise

The mission that returned Ryugu's dust exists because the mission before it nearly failed. The first Hayabusa, launched in 2003 toward the tiny asteroid Itokawa, was a triumph in the end, returning the first asteroid grains ever collected in 2010, but it achieved its success through a shipwreck of setbacks: ion engines that stalled, a fuel line that ruptured, a mini-lander that missed the asteroid entirely, a sampling mechanism that fired at the wrong moment, and a spin so violent at one stage that the craft lost contact with Earth for seven weeks. The engineers coaxed the crippled probe home across three billion kilometers of space, and the grains it returned were microscopic, sub-millimeter flecks picked up almost by accident when the sampler's projectile failed to fire and the craft's own descent stirred dust into the horn. The achievement was genuine, and the lessons were recorded in exacting detail.

Those lessons became the specification for the sequel. In 2010, the year the first Hayabusa's capsule came home, the Japanese space agency obtained approval to begin development of a second asteroid sample-return mission, this one aimed not at a rocky S-type object like Itokawa but at a carbonaceous asteroid, the class richest in water-bearing minerals and organic chemistry, and therefore the class with the most to say about the origins of water and life on Earth. The target chosen was Ryugu, a near-Earth object roughly nine hundred meters across, dark as charcoal, and classified at the time as a C-type, the most primitive category in the asteroid zoo. Where the first mission had improvised its way to a clutch of dust, the second was designed from the start to bring back grams, from multiple sites, including one below the surface, sealed and unexposed.

The design inherited the first craft's proven bones and hardened everything that had broken. The second Hayabusa, six hundred kilograms with its fuel, kept the same boxy frame, the same sample horn on its belly, and the same ion-engine propulsion that had limped home so heroically; but the engines were rebuilt for redundancy, the reaction wheels were doubled in number and redesigned, the sampling system was revised so that its bullet-firing mechanism worked even after long cold soak, and the communications package added a Ka-band antenna for high-rate data. The craft also shipped four small robots to ride along: three hopping rovers of Japanese make and a European lander, so that the asteroid could be studied from its own surface while the mothership hovered above. A small carry-on impactor, a device for making an artificial crater, completed the payload, because a mission that promises material from beneath the surface must carry a way of exposing it.

The promise, in plain terms, was threefold: bring back a sample, bring back

more of it, and bring back the right kind. Carbonaceous material, unlike the stony Itokawa grains, can carry water locked in its crystal structure and organic molecules assembled in the solar system's youth, and such material is vanishingly rare on Earth, since the planet's own chemistry has long since processed away its primitives; the few carbonaceous meteorites in collections have all been altered by their fiery arrival and their years on the ground. A sample sealed in a container, caught in space, from an object that never entered the atmosphere, would be something no laboratory on Earth had ever held: a piece of the beginning, clean. Building the machine that could deliver such a thing, on the budget of a state agency's medium-size program, with the memory of the near-failure fresh in every engineer's notebook, is the story the next chapters tell.

The program's scale deserves a sentence of honest accounting, because the mission's economy is part of its meaning. Developed for a budget reported at roughly sixteen billion yen, on the order of one and a half hundred million dollars at approval, the second Hayabusa delivered planetary-science results that flagship-scale programs have chased for decades, and the discipline of the small budget, reuse the first craft's frame, inherit its proven engines, buy no capability that the mission does not need, is visible in every subsystem. The partners came cheap and early too: the German and French agencies built the surface lander, the American deep-space network helped track the craft through its critical passages, and the international arrangements that later moved grains between laboratories were signed while the mission was still flying, not improvised afterward. Small budgets and early friendships, the mission's managers like to say, are the two forms of fuel nobody counts in the tankage tables, and this mission ran rich on both.

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.