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Opening Extract from...

Seveneves

Written by Neal Stephenson

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seveneves

Neal Stephenson

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Part One

The Age of the One Moon

THE MOON BLEW UP WITHOUT WARNING AND FOR NO APPARENT reason. It was waxing, only one day short of full. The time was 05:03:12 UTC. Later it would be designated A+0.0.0, or simply Zero.

An amateur astronomer in Utah was the first person on Earth to realize that something unusual was happening. Moments earlier, he had noticed a blur flourishing in the vicinity of the Reiner Gamma formation, near the moon's equator. He assumed it was a dust cloud thrown up by a meteor strike. He pulled out his phone and blogged the event, moving his stiff thumbs (for he was high on a mountain and the air was as cold as it was clear) as fast as he could to secure the claim to himself. Other astronomers would soon be pointing their telescopes at the same dust cloud—might be doing it already! But—supposing he could move his thumbs fast enough—he would be the first to point it out. The fame would be his; if the meteorite left behind a visible crater, perhaps it would even bear his name.

His name was forgotten. By the time he had gotten his phone out of his pocket, his crater no longer existed. Nor did the moon.

When he pocketed his phone and put his eye back to the eyepiece of his telescope, he let out a curse, since all he saw was a tawny blur. He must have knocked the telescope out of focus. He began to twiddle the focus knob. This didn't help.

Finally he pulled back from the telescope and looked with his naked eyes at the place where the moon was supposed to be. In that moment he ceased to be a scientist, with privileged information, and became no different from millions of other people around the Americas, gaping in awe and astonishment at the most extraordinary thing that humans had ever seen in the sky.

In movies, when a planet blows up, it turns into a fireball and ceases to exist. This is not what happened to the moon. The Agent (as people came to call the mysterious force that did it) released a very large amount of energy, to be sure, but not nearly enough to turn all the moon's substance into fire.

The most generally accepted theory was that the puff of dust observed by the Utah astronomer was caused by an impact. That the Agent, in other words, came from outside the moon, pierced its surface, burrowed deep into its center, and then released its energy. Or that it simply kept on going out the other side, depositing enough energy en route to break up the moon. Another hypothesis stated that the Agent was a device buried in the moon by aliens during primordial times, set to detonate when certain conditions were met.

In any case, the result was that, first, the moon was fractured into seven large pieces, as well as innumerable smaller ones. And second, those pieces spread apart, enough to become observable as separate objects—huge rough boulders—but not enough to continue flying apart from one another. The moon's pieces remained gravitationally bound, a cluster of giant rocks orbiting chaotically about their common center of gravity.

That point—formerly the center of the moon, but now an ab-

straction in space—continued to revolve around the Earth just as it had done for billions of years. So now, when the people of Earth looked up into the night sky at the place where they ought to have seen the moon, they saw instead this slowly tumbling constellation of white boulders.

Or at least that is what they saw when the dust cleared. For the first few hours, what had been the moon was just a somewhat-greater-than-moon-sized cloud, which reddened before the dawn and set in the west as the Utah astronomer looked on dumbfounded. Asia looked up all night at a moon-colored blur. Within, bright spots began to stand out as dust particles fell into the nearest heavy pieces. Europe and then America were treated to a clear view of the new state of affairs: seven giant rocks where the moon ought to have been.

BEFORE THE LEADERS OF THE SCIENTIFIC, MILITARY, AND POLITICAL worlds began using the word "Agent" to denote whatever had blown up the moon, that word's most common interpretation, at least in the minds of the general public, had been in the pulp-fiction, B-movie sense of a secret agent or an FBI agent. Persons of a more technical mind-set might have used it to mean some sort of chemical, such as a cleaning agent. The closest match for how the word would be used forever after was the sense in which it was used by fencers and martial artists. In a sword-fighting drill, where one participant is going to mount an attack and the other is to respond in some way, the attacker is known as the agent and the respondent is known as the patient. The agent acts. The patient is passive. In this case an unknown Agent acted upon the moon. The moon, along with all the humans living in the sublunary realm, was the passive recipient of that action. Much later, humans might rouse themselves to take action and be agents once again. But now and for long into the future they would be nothing more than patients.

The Seven Sisters

RUFUS MACQUARIE SAW IT ALL HAPPEN ABOVE THE BLACK RIDGELINE OF the Brooks Range in northern Alaska. Rufus operated a mine there. On clear nights he would drive his pickup truck to the top of a mountain that he and his men had spent the day hollowing out. He would take his telescope, a twelve-inch Cassegrain, out of the back of the truck and set it up on the summit and look at the stars. When he got ridiculously cold, he would retreat into the cab of his truck (he kept the engine running) and hold his hands over the heater vents until his fingers regained feeling. Then, as the rest of him warmed up, he would put those fingers to work communicating with friends, family, and strangers all over the world.

And off it.

After the moon blew up, and he convinced himself that what he was seeing was real, he fired up an app that showed the positions of various natural and man-made celestial bodies. He checked the position of the International Space Station. It happened to be swinging across the sky 260 miles above and 2,000 miles south of him.

He pulled a contraption onto his knee. He had made it in his little machine shop. It consisted of a telegraph key that looked to be about 150 years old, mounted on a contoured plastic block that strapped to his knee with hook-and-loop. He began to rattle off dots and dashes. A whip antenna was mounted to the bumper of his pickup truck, reaching for the stars.

Two hundred sixty miles above and two thousand miles south of him, the dots and dashes came out of a pair of cheap speakers zip-tied to a conduit in a crowded, can-shaped module that made up part of the International Space Station.

BOLTED TO ONE END OF THE ISS WAS THE YAM-SHAPED ASTEROID called Amalthea. In the unlikely event that it could have been brought gently to Earth and laid to rest on a soccer field, it would have stretched from one penalty box to the other and completely covered the center circle. It had floated around the sun for four and a half billion years, invisible to the naked eye and to astronomers' telescopes even though its orbit had been similar to that of the Earth. In the classification system used by astronomers, this meant that it was called an Arjuna asteroid. Because of their near-Earth orbits, Arjunas had a high probability of entering the Earth's atmosphere and slamming into inhabited places. But, by the same token, they were also relatively easy to reach and latch on to. For both those reasons, bad and good, they drew the attention of astronomers.

Amalthea had been noticed five years earlier by a swarm of telescope-wielding satellites sent out by Arjuna Expeditions, a Seattle-based company funded by tech billionaires for the express purpose of asteroid mining. It had been identified as dangerous, with a 0.01 percent probability of striking the Earth within the next hundred years, and so another swarm of satellites had been sent up to drop a bag over it and drag it into a geocentric (Earth- rather than sun-centered) orbit, which had then been gradually matched with that of the ISS.

In the meantime, the planned expansion of the ISS had plodded onward. New modules—inflatables and air-filled tin cans sent up on rockets—had been added to the space station at both ends. At the forward end—the space station's nose, if you thought of it as a vaguely bird-shaped object flying around the world—a home was prepared for Amalthea and for the asteroid mining research project that was planned to grow up around it. Meanwhile, at the aft end, a torus—a donut-shaped habitat about forty meters in diameter—was constructed and made to spin like a merry-go-round, creating a small amount of simulated gravity.

At some point during these improvements, people had stopped calling it the International Space Station, or ISS, and begun referring to the old girl as Izzy. Coincidentally or not, this moniker had become popular around the time that each of the station's two ends had come under the management of a woman. Dinah MacQuarie, the fifth child and only daughter of Rufus, was responsible for much of what went on in Izzy's forward end. Ivy Xiao had overall command of ISS and tended to operate out of the torus at its "stern."

During most of Dinah's waking hours, she was at the forward end of Izzy, in a small workspace ("my shop") where she could look out a small quartz window at Amalthea ("my girlfriend"). Amalthea was nickel and iron: heavy elements that had probably sunk to the hot center of an ancient planet long since blown apart by some primordial catastrophe. Other asteroids were made of lighter materials. In the same way that Amalthea's Earth-like orbit had made her both a dire threat and a promising candidate for exploitation, her dense metallic constitution had made her a bitch to move around the solar system, but a rewarding object of study. Some asteroids were made largely of water, which could be hoarded for consumption by humans or split into hydrogen and oxygen to fuel rockets. Others were rich in precious metals that could be returned to Earth and sold.

A lump of nickel and iron like Amalthea could be smelted into structural materials for the construction of orbiting space habitats.

Doing so on anything more than a small pilot scale would require the development of new technology. Using human miners was out of the question, since sending them up to orbit and keeping them alive was expensive. Robots were the obvious solution. Dinah had been sent up to Izzy to lay groundwork for a robot laboratory that would eventually host a staff of six. The budget wars in Washington had reduced that number to one.

Which was how she actually liked it. She had grown up in remote places, following her father, Rufus; her mother, Catherine; and her four brothers to a series of hard rock mines in places like the Brooks Range of Alaska, the Karoo Desert of South Africa, and the Pilbara of western Australia. Her accent betrayed traces of all those places. She'd been home-schooled by her parents and a series of tutors they'd flown in, none of whom had lasted more than a year. Catherine had taught her the finer points of piano playing and napkin folding, and Rufus had taught her mathematics, military history, Morse code, bush piloting, and how to blow things up, all by the age of twelve, when, by family voice vote over dinner, she had been deemed too smart and too much of a handful for life at the minehead. She had been sent off to boarding school on the East Coast of the United States. For her family—though she'd never had an inkling of it until then—was well off.

At school she had developed into a gifted soccer player and parlayed this talent into an athletic scholarship to Penn. During her sophomore year she had blown out her right ACL, terminating her serious athletic career, and turned her attention in a more serious way to the study of geology. That, plus a three-year relationship with a boy who liked to build robots, combined with her background in the mining industry, had made her into a perfect candidate for the job she had now. Working hand in glove with robot geeks on terra firma—a mixture of university researchers, freelance members of the hacker/maker community, and paid Arjuna Expeditions staff—she programmed, tested, and evaluated a menagerie of robots, ranging

in size from cockroach to cocker spaniel, all adapted for the task of crawling around on the surface of Amalthea, analyzing its mineral composition, cutting bits off, and taking them to a smelter that, like everything else up here, was specially adapted to work in the environment of space. The ingots of steel that emerged from this device were barely large enough to serve as paperweights, but they were the first such things made off-world, and right now they were weighing down important papers on billionaires' desks all over Silicon Valley, worth far more as conversation pieces and status symbols than as commodities.

Rufus, a die-hard ham radio enthusiast who still communicated in Morse code with a dwindling circle of old friends all over the world, had pointed out that radio transmission between the ground and Izzy was actually rather easy, given that it was line-of-sight (at least when Izzy happened to be passing overhead) and that the distance was nothing by ham radio standards. Since Dinah lived and worked in a robot workshop, surrounded by soldering gear and electronics workbenches, it had been a simple matter for her to assemble a small transceiver following specifications provided by her dad. Zip-tied to a bulkhead, it dangled above her workstation, making a dim static hiss that was easily drowned out by the normal background roar of the space station's ventilation systems. Sometimes it would beep.

A spacewalker gazing at Dinah's end of Izzy, a few minutes after the Agent had fractured the moon, would have seen, first of all, Amalthea: a huge, gnarled twist of metal, still dusty in some places with space debris that had fallen into its evanescent gravitational field over the aeons, gleaming in others where it had been rubbed clean. Scurrying over its surface was a score of different robots, belonging to four distinct "species": one that looked like a snake, one that picked its way along like a crab, one that looked like a sort of rolling geodesic dome, and another that looked like a swarm of insects. These provided sporadic illumination from the blue and white LEDs that Dinah used to track them, from the lasers with which they scanned Amalthea's

surface, and from the blinding arcs of purplish light with which they would sometimes slice into it. Izzy was then in Earth's shadow, on the night side of the planet, and so all was dark otherwise, except for white light spilling out from the little quartz window beside Dinah's workstation. This was barely large enough to frame her head. She had straw-colored hair cut short. She had never been especially appearance conscious; back at the minehead her brothers had mocked her to shame whenever she had experimented with clothes or cosmetics. When she'd been described as a tomboy in a school yearbook she had interpreted it as a sort of warning shot and had gone into a somewhat more girly phase that had run its course during her late teens and early twenties and ended when she had started to worry about being taken seriously in engineering meetings. Being on Izzy meant being on the Internet, doing everything from painstakingly scripted NASA PR interviews to candid Facebook shots posted by fellow astronauts. She had grown tired of the pouffy floating hair of zero gravity and, after a few weeks of clamping it down with baseball caps, had figured out how to make this shorter cut work for her. The haircut had spawned terabytes of Internet commentary from men, and a few women, who apparently had nothing else to do with their time.

As usual, she was focused on the screen of her computer, which was covered with lines of code governing the behavior of her robots. Most software developers had to write code, compile it into a program, and then run the program to see whether it was working as intended. Dinah wrote code, beamed it into the robots scurrying around on Amalthea's surface a few meters away, and stared out the window to see whether it was working. The ones closest to the window tended to get most of her attention, and so there was a kind of natural selection at work, in that the robots that huddled closest to their mother's cool blue-eyed gaze acquired the most intelligence, while the ones wandering around loose on the dark side never got any smarter.

At any rate her focus was either on the screen or on the robots, and so it had been for many hours. Until a string of beeps came out of the

hissing speaker zip-tied to the bulkhead, and her eyes went momentarily out of focus as her brain decoded the dots and dashes into a string of letters and numbers: her father's call sign. "Not now, Pa," she muttered, with a guilty daughter's glance at the brass-and-oak telegraph key he had given her—a Victorian relic purchased at great price on eBay, during a bidding war that had placed Rufus into pitched battle against a host of science museums and interior decorators.

LOOK AT THE MOON

"Not now, Pa, I know the moon's pretty, I'm right in the middle of debugging this method . . ."

OR WHAT USED TO BE IT

"Huh?"

And then she brought her face close to the window and twisted her neck to find the moon. She saw what used to be it. And the universe changed.

HIS NAME WAS DUBOIS JEROME XAVIER HARRIS, PH.D. THE FRENCH first name came from his Louisiana ancestors on his mother's side. The Harrises were Canadian blacks whose ancestors had come up to Toronto during slavery. Jerome and Xavier were the names of saints—two of them, just to be on the safe side. The family straddled the border in the Detroit-Windsor area. Inevitably, he had been dubbed Doob by his friends at school when they had still been too young to understand that "doobie" was slang for a marijuana cigarette. The overwhelming majority of people called him Doc Dubois now, because he was on TV a lot, and that was how the talk show hosts and the network anchormen introduced him. His job on TV was to explain science to the general public and, as such, to act as

a lightning rod for people who could not accept all the things that science implied about their worldview and their way of life, and who showed a kind of harebrained ingenuity in finding ways to refute it.

In academic settings, such as when he was keynoting astronomical meetings and writing papers, he was, of course, Dr. Harris.

The moon blew up while he was attending a fund-raising reception in the courtyard of the Caltech Athenaeum. At the beginning of the evening it was a fiercely cold bluish-white disk rising above the Chino Hills. Lay observers would fancy it a good night for moon watching, at least by Southern California standards, but Dr. Harris's professional eye saw a thin border of fuzz around its rim and knew that aiming a telescope at it would be pointless. At least if the objective were to do science. Public relations was another matter; operating more in his Doc Dubois persona, he occasionally organized star parties where amateur astronomers would set their telescopes up in Eaton Canyon Park and aim them at crowd-pleasing targets such as the moon, the rings of Saturn, and the moons of Jupiter. Tonight would be a fine night for that.

But that wasn't what he was doing. He was drinking good red wine with rich persons, mostly from the tech industry, and being Doc Dubois, the affable science popularizer of television and of four million Twitter followers. Doc Dubois knew how to size up his audience. He knew that self-made tech zillionaires liked to argue, that Pasadena aristocracy didn't, and that society wives liked to be lectured to, as long as the lectures were brief and funny. And he knew that his job was to charm these people, nothing more, so that they could later be handed off to professional fund-raisers.

He was going back to the bar for another glass of the pinot noir, fully in the Doc Dubois persona, slapping shoulders and bumping fists and exchanging grins, when a man gasped. Everyone looked at him. Doob was afraid that the poor guy had been struck by a stray bullet or something. He was frozen, poised on one leg, gazing up. A woman followed his gaze and screamed.

And Doob became one of perhaps a few million people around the dark half of the planet all looking up into the sky, in a state of shock so profound as to shut off the parts of the brain responsible for higher functions like talking. His first thought, given that they were in Greater Los Angeles, was that they were looking at a black projection screen that had been stealthily hoisted into the air above the neighboring property, and were seeing a Hollywood special effect thrown onto it by a concealed projector. No one had informed him that any such stunt was under way, but perhaps it was some incredibly bizarre fund-raising gambit, or part of a movie production.

When he came to his senses, he was aware that a large number of telephones were singing their little electronic songs. Including his. The birth cry of a new age.

IVY XIAO WAS IN OVERALL COMMAND OF IZZY AND SPENT ALMOST all of her time in the torus, partly because her office was there and partly because she was more susceptible to space sickness than she liked to admit. That physical separation—Ivy back in the torus, Dinah up in the forward end, close to Amalthea—was symbolic, in many people's minds, of a difference between them that didn't really exist. Other contrasts were obvious enough, beginning with the physical: Ivy was four inches taller, with long black hair that she kept under control usually by braiding it and trapping the braid under the collar of her jumpsuit. She had the build of a volleyball player. Raised in Los Angeles, the only child of high-strung parents, Ivy had SATed, science faired, and spiked her way to Annapolis, then followed that up with a Ph.D. in applied physics from Princeton. Only then had the navy demanded the years of service that she owed it in return for her tuition. After learning how to pilot helicopters, she had spent most of that time in the astronaut program, in whose ranks she had risen quickly. Unlike most astronauts, who were mission specialists—scientists or engineers carrying out specific tasks

after the launch vehicle had reached orbit—Ivy, with her training as a pilot, was a flight specialist as well, meaning that she knew how to fly rockets. The days of the Space Shuttle were long over, so there was no need to joystick a winged vehicle back to a runway. But docking and maneuvering spacecraft in orbit was a good clean match for someone with the motor control of a chopper pilot and the mathematical mind of a physicist.

The pedigree was intimidating, even off-putting to people who were impressed by such things. Dinah, who wasn't, cared little one way or the other. Her informal behavior toward Ivy was interpreted by some observers as disrespectful. Two very different women in conflict with each other made for a more dramatic story than what was actually true. They were continually bemused by the efforts made by Izzy personnel, and their handlers on the ground, to heal the nonexistent rift between them. Or, what was a lot less funny, to exploit it in the pursuit of byzantine political schemes.

Four hours after the moon blew up, Dinah and Ivy and the other ten crew members of the International Space Station had a meeting in the Banana, which was what they called the longest uninterrupted section in the spinning torus. Most of the torus was chopped up into segments short enough that the brain could talk the eye into believing that the floor was flat and that gravity always pointed in the same direction. But the Banana was long enough to make it obvious that the floor was in fact curved through about fifty degrees of arc from one end to the other. "Gravity" at one end of it was aimed in a different direction from that at the other end. Accordingly, the long conference table that ran down its length was curved too. People entering into one end looked "uphill" to the opposite end, but experienced no sensation of climbing as they moved toward it. New arrivals tended to expect that anything placed elsewhere on the table would roll and slide down toward them.

The walls were pale yellow. The usual collection of malfunctioning audiovisual equipment purported to show live video streams of

people on the ground, in theory enabling them to teleconference with colleagues in Houston, Baikonur, or Washington.

When the meeting began at A+0.0.4 (zero years, zero days, and four hours since the Agent had acted upon the moon), nothing was working, and so the occupants of Izzy had a few minutes to talk among themselves while Frank Casper and Jibran Haroun wiggled connectors, typed commands into computers, and rebooted everything. Relatively new arrivals to Izzy, Frank and Jibran had made the mistake of letting on that they were good at that sort of thing, so they always got saddled with it. Both of them were more comfortable with it anyway than with making chitchat.

"Primordial singularity" were the first words Dinah heard upon gliding into the room. Gravity here was only one-tenth of that on Earth, and "walking" wasn't the right word for how people moved around—it was halfway between that and flying, a sort of long, bounding gait.

The words had been spoken by Konrad Barth, a German astronomer. It was clear from how the others reacted that Ivy, who was sitting directly across the table from him, was the only other person in the Banana who had the faintest idea what he was talking about.

"And that is?" Dinah asked, since that sort of thing had become her role. Others tended to be so worshipful of Ivy, or so reluctant to show ignorance, that they wouldn't ask.

"A small black hole."

"Why 'primordial'?"

"Most black holes are formed when stars collapse," Ivy said. "But there's a theory that some of them were created shortly after the Big Bang. The universe was lumpy. Some of the lumps might have been dense enough to undergo gravitational collapse. They could form black holes that instead of weighing what a star weighs could be a lot smaller."

"How small?"

"I don't think there's a lower limit. But the point is that one

of them could zip through space invisibly and punch all the way through a planet and out the other side. There used to be a theory that the Tunguska event was caused by one, but it's been disproved."

Dinah knew about that, because her dad liked to talk about it: a huge explosion in Siberia, a hundred years ago, that had knocked down millions of trees out in the middle of nowhere.

"That was a big deal," Dinah said, "but not enough to blow up the moon."

"To blow up the moon would take a bigger one, going faster," Ivy said. "Look, it's just a hypothesis."

"But it's gone now?"

"It would be long gone now. Like a bullet through an apple."

It struck Dinah as odd that they were talking about such an event so matter-of-factly. But there was no other way to address it. Emotions were not large enough to encompass such a thing. Besides, it was just a visual effect so far, like something seen in a movie with the sound turned off.

"Is it going to affect the tides?" asked Lina Ferreira. As a marine biologist, Lina would naturally be somewhat concerned about the tides. "Since those are caused by the moon's gravity?"

"And by the sun's," Ivy added with a nod and a little smile. Which was why she was in charge of Izzy and Dinah wasn't. She was willing to correct a Ph.D. marine biologist in front of a roomful of people, but she could carry it off in a way that didn't sting. "But the answer is, probably surprisingly little. The moon's mass is still all there, close to where it was before. It's just spread out a little. But the pieces still have the same collective center of gravity, still in the same orbit as the moon had before. Your tide tables will still pretty much work."

Dinah's facial expression was blank, but she was enjoying Ivy's ability to talk about science with a kind of little-nerd-girl sense of wonder even in spite of the disturbing subject matter. This was why Ivy always got the media interviews, while Dinah had to be dragged out of her den of robots and told, over and over again, to smile. The

tone of voice was the giveaway; when Ivy was giving orders or reading PowerPoint slides, she went clipped and military, but when she talked about science her face opened up and her voice went into a vaguely Mandarin singsongy lilt.

"Where are you getting all this?" Dinah asked, drawing startled or disapproving glances from a few who worried that she was being too brusque with the boss. "It's only been, what, four hours?"

"There's a lot of noisy comment thread traffic, as you'd expect, and a few ad hoc email lists sort of congealing out of that," Ivy explained.

A blue screen appeared on the lightweight monitor stretched above one end of the long table, and was replaced by a NASA logo. "Okay, got it," muttered Jibran, who made a sideways bound toward a chair.

Then they were looking at the familiar environs of the ISS Flight Control Room, which was at Johnson Space Center in Houston. The director of mission operations was sitting in front of the camera stroking his iPad. He didn't seem to be aware that the camera was on. A few moments later they heard a door open off camera. The DMO, who was ex-military, stood up out of habit. He reached out and shook hands with a woman who entered from stage right: NASA's deputy administrator, the number two person in the whole org chart and a rare sight at such meetings. She was a retired astronaut named Aurelia Mackey, dressed for business in the environment of D.C., where she spent most of her time.

"Are we on?" she asked someone off camera.

"Yes," said several people in the Banana.

Aurelia looked a little startled by that. Both she and the DMO were looking a little stunned to begin with, of course.

"How are you all today?" Aurelia said, in an absolutely rote, businesslike voice, as if nothing had happened. Running on autopilot while her brain caught up with events.

"Fine," said some people in the Banana, mixed in with a few nervous chuckles.

"I'm sure you are all aware of the event."

"We have a good view of it," Dinah said. Ivy shot her a warning look.

"Of course you do," Aurelia admitted. "I would love to have an extended conversation with you all about what you have seen and what you are experiencing. But this is going to have to be brief. Robert?"

The DMO peeled his eyes off the iPad and sat forward in his chair. "We're expecting an increase in the number of rocks floating around up there." He meant loose chunks of the moon. "Not huge because most will be gravitationally bound. But some may have escaped. So other missions are suspended while you batten down the hatches. Make preparations for impacts."

Everyone in the Banana listened silently, thinking about what that would mean for them. They would tighten precautions, dividing Izzy up into separate compartments so that damage to one wouldn't suck the air from all. They would review procedures. Lina's biology experiments might take a hit. Dinah's robots would enjoy a holiday.

Aurelia spoke into the camera. "All spaceflight operations are suspended until further notice. No one is coming up and no one is going down."

Everyone in the Banana looked at Ivy.

AS SOON AS THEY GOT INTO IVY'S TINY OFFICE, WHERE SHE FELT IT was okay to let tears come into her eyes, they slipped into their Q code.

Q codes were ham radio slang. Dinah had learned them from Rufus. They were three-letter combinations, beginning with Q. To save time in Morse code transmissions, they were substituted for frequently used phrases such as "Would you like me to change to a different frequency?"

Dinah and Ivy's Q codes didn't actually begin with Q. But some of them were three-letter combinations.

Uppity Little Shitkicker was a name that had been hung on Dinah when she had first arrived at private school and, during a soccer scrimmage, intercepted a pass meant for a girl from New York.

Straight Arrow Bitch had been bestowed on Ivy at Annapolis when she had declined to take part in a drinking game during a tailgate party.

The ULS/SAB dynamic was a thing that Dinah and Ivy exploited in meetings, even having meetings-before-meetings to plan how to use it.

Good Looks Wasted had found its way to Dinah in the aftermath of her new haircut, as the result of an improbable chain of "Reply to All" mishaps. She had brought it to Ivy, breathless with excitement, and they had enshrined "GLW" in their private codebook.

"I forgot," when spoken in a breathy, little-girl voice, was a shorthand way of saying "I forgot to put on my makeup," quoted verbatim from a NASA PR flack.

SAR was from a tart exchange between Ivy and a NASA administrator who, upon reading one of her reports, had criticized her for having an "almost pathological predilection for unnecessary abbreviations." This had struck Ivy as a bit odd, given that every other word in NASA prose was an acronym. When Ivy had asked for clarification, she had been told that her abbreviations were "schoolgirlish and recondite."

Space Camp (which both Ivy and Dinah had attended as teens, though at different times) was what they called not just Izzy, but the whole subculture of NASA manned spaceflight.

"What are you going to say to the Maternal Organism?" Dinah asked, as Ivy rummaged in the back of a storage bin for her bottle of tequila.

Ivy stiffened for a moment, then pulled out the bottle and swung

it toward Dinah's head like a club. Dinah didn't flinch, just watched it glide to a halt above her head. "What?"

"I can't believe that the Morg has so taken over my wedding that the first thing that comes into your mind is how *she's* going to react."

Dinah looked mildly sick.

"Don't worry about it," Ivy said, "you forgot." *To put on your makeup*.

"Sorry, baby. I was just thinking . . . you and Cal are still going to get married, and have a great life, no matter what."

"But the Morg is going to take the hit," Ivy said, nodding, as she poured tequila into a pair of small plastic cups. "Having to reschedule everything."

"Sounds like she's kind of in her element doing that, though," Dinah said. "Not to minimize it or anything."

"Totally."

"To the Morg."

"The Morg." Dinah and Ivy tapped their plastic cups together and sipped at the tequila. One of the fringe benefits that came of being in the torus was that you could drink normally instead of sucking everything through tubes. The lower gravity took some getting used to, but they were old hands at it by now.

"What's up with your family? Did you hear from Rufus?" Ivy asked.

"My father desires raw data files from Konrad's Wide-Field Infrared Observation Platform, which he has read about on the Internet, so that he can satisfy his personal curiosity about the thing that hit the moon."

"You going to Morse code those down to him?"

"His Internet is working. He has already created an empty Dropbox folder. As soon as I provide him with the files, he'll go back to his usual grousing about how his taxes are too high and the federal government needs to be scaled back to a size where he can personally stomp it to death with steel-toed boots."

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WHAT ASTRONOMERS DIDN'T KNOW OUTWEIGHED, BY AN ALMOST infinite ratio, what they did. And for persons used to a more orderly system of knowledge, with everything on Wikipedia, this created a certain perception of incompetence, or at least failure to perform, on the part of the astronomical profession whenever weird things happened in the sky.

Which was every day, actually. But most of them could be seen only by astronomers and so they were able to keep them a sort of trade secret. Blatantly obvious events such as meteorite strikes caused Doc Dubois's phone to sing. The singing usually portended a series of appearances on talk shows where, among other things, he would be asked to explain why astronomers hadn't predicted this. Why hadn't they seen the meteor coming? Wasn't it just the case that they were a bunch of good-for-nothing propellerheads?

A little bit of humility seemed to go a long way, and if the pundits didn't cut him off too soon he was frequently able to work in a plea for more government support of science. For members of the general public might not care about Wolf-Rayet stars in the Quintuplet Cluster, but they definitely saw why having hot rocks fall on one's head was a good thing to avoid.

He always called it the breakup of the moon. Not the explosion. The term began to gain traction on Twitter, with hashtag #BUM. Whatever you called it, it was an infinitely bigger deal than a single meteor strike. So it seemed to demand more explanation. But there was no way to explain it, yet. Meteors were easy: space was full of rocks too small and dark to be seen through telescopes, and some of them snagged on the atmosphere and fell to ground. But the breakup of the moon could not have been caused by any normal astronomical phenomenon. So Doc Dubois—who spent most of the next week on camera—got out in front of that issue at every chance, always lead-

ing with a frank statement that neither he nor any other astronomer knew the cause. That was the pitch, straight down the middle. Then he added the spin: This is absolutely fascinating. It is, as a matter of fact, the most fascinating scientific event in human history. It looks scary and upsetting, but the fact is that no one has been killed by it, save for a few drivers who swerved off roads, or rear-ended stopped traffic, while rubbernecking.

At A+0.4.16 (four days and sixteen hours after the breakup of the moon), he had to amend "no one has been killed" when a meteorite, almost certainly a chunk of moon rock, entered the atmosphere over Peru, shattered windows along a twenty-mile track, and smashed into a farmstead, obliterating a small family.

But the message remained the same: let's look at this as a scientific phenomenon and start with what we know. His friend was a video streaming site called astronomicalbodiesformerlyknownasthemoon .com, which kept a high-resolution feed of the rubble cloud running around the clock. As soon as possible in the interview, Doc Dubois would get that up on the screen and then begin making observations about the cloud. Because making observations calmed people down. The moon had broken up into seven large pieces, which inevitably became known as the Seven Sisters, and an uncountable number of smaller ones. Gradually the big ones acquired names. Doc Dubois was responsible for many of these. He gave them descriptive names that wouldn't scare people. It wouldn't do to call them Nemesis or Thor or Grond. So instead it was Potatohead, Mr. Spinny, Acorn, Peach Pit, Scoop, Big Boy, and Kidney Bean. Doc Dubois would point those out and then draw attention to the way they moved. This was governed entirely by Newtonian mechanics. Each piece of the moon attracted every other piece more or less strongly depending on its mass and its distance. It could be simulated on a computer quite easily. The whole rubble cloud was gravitationally bound. Any shrapnel fast enough to escape had done so already. The rest was drifting around in a loose huddle of rocks. Sometimes they banged into one

another. Eventually they would stick together and the moon would begin to re-form.

Or at least that was the theory until the star party that they threw in the middle of the Caltech campus at A+0.7.0, exactly one week after the event.

Normally they held the star parties up in the hills, where the seeing was better, but seeing giant rocks close to the Earth was so easy that there was no need to go to the trouble of driving up into the mountains. It would have undercut the purpose of the event, which was to get as many members of the general public as possible out in a parklike atmosphere to peer through telescopes and make observations. The Beckman Mall was lined with yellow school buses, interspersed here and there with vans from local and network television, their masts deployed so that they could relay live video downtown. Their reporters stood in pools of light, using as backdrop an open green strewn with telescopes of various types and sizes. Little seven-card decks were handed out, each card depicting a different fragment of the moon from various angles and identifying it by its name. Kids were given the assignment to identify each of the rocks through the eyepiece of a telescope, check it off on a homework sheet, and write down an observation about it. Most of the scopes, obviously, were pointed at the Seven Sisters, but one contingent was looking at a darker part of the sky with binoculars or just their naked eyes, expecting to see meteorites. By Day 7, several hundred of these had entered the atmosphere. Or at least, several hundred large enough to be noticed. Most had burned up before hitting the ground. There had been about a score of incidents in which they drew arc-light trails across the sky, illuminating the ground below with freaky bluish radiance and producing huge sonic booms. Half a dozen had struck the ground, doing greater or lesser amounts of damage. The death toll, though, was still far beneath the statistical ground clutter of shark attacks and lightning strikes.

The evening went fine. Doob, who had raised three children to adulthood, had figured out a long time ago that any event largely organized by elementary school teachers was likely to come off extremely well from a logistical and crowd-control standpoint. So he was able to relax and be Doc, autographing Seven Sisters cards for kids and occasionally slipping into Dr. Harris mode for a discussion with a fellow astronomer.

As he wandered about the place, he had three different chance encounters with the same elementary school teacher, one Ms. Hinojosa, and fell in love with her. This was unusual. He had not been in love with anyone in twelve years. He had been divorced for nine. He found it nearly as shocking in its own way as the breakup of the moon. He tried to deal with it in the same way: by making scientific observations of the phenomenon. His working hypothesis was that the breakup of the moon had made Doob young again, exfoliating layers of emotional callus from his soul and leaving a pink shiny impressionable heart just waiting to be colonized by the first appealing woman who came along.

He was talking to Amelia—for that, as it turned out, was her first name—when a buzz moved slowly over the quad, like a gentle breeze, and caused everyone to look up.

Two of the larger pieces—Scoop and Kidney Bean—were headed right for each other. It would not be the first such collision. They happened all the time. But seeing two big chunks heading right for each other with high closing velocity was unusual, and promised a good show. Doob tried to quiet an unsettled feeling in his chest, which might have been caused by what was happening with Amelia, or by the natural trepidation that any sane person would feel upon seeing two enormous pieces of rock getting ready to smash into each other directly overhead. The good news was that people were beginning to treat the evolution of the swarm as a kind of spectator sport, to see it as fascinating and fun, not terrifying.

Scoop's sharper edge slammed into the divot that gave Kidney Bean its name and split it in half. It all happened, of course, in quiet super-slow motion.

"And then there were eight!" Amelia said. Instinctively she had turned away from Doob and toward her brood of twenty-two students. "What just happened to Kidney Bean?" she was asking, in that teacherly way, scanning for upraised hands, looking for a kid to call on. "Can anyone tell me?"

The kids were silent and vaguely sick looking.

Amelia held up her Kidney Bean card and tore it in half.

Dr. Harris was walking toward his car. His phone rang, so startling him that he almost swerved into a school bus. What was wrong with him? His scalp was tingling, and he realized it was his hairs trying to stand up on his head. He checked the screen of the phone and saw that the call was from a colleague in Manchester. He declined to answer it and found himself looking at a new contact that he had been creating for Amelia: a snapshot of her face, just a silhouette in profile against a bank of TV lights, and her phone number. He tapped the Done button.

He had felt that tingling in the scalp once before, on a safari in Tanzania, and had turned around to see that he was being watched, interestedly, by a group of hyenas. The thing that had scared him hadn't been the hyenas themselves. Those, and even more dangerous animals, were all over the place. Rather, it was the sudden awareness that he had let his guard down, that he had been focusing his attention on the wrong thing while the real danger had been circling around behind him.

He had wasted a week on the fascinating scientific puzzle of "What blew up the moon?"

That had been a mistake.