

An astronaut in a white spacesuit is shown in a dynamic, mid-air pose against a hazy, orange-red Martian landscape. The astronaut's arms are extended forward, and their legs are bent, suggesting movement or a fall. The background features rolling hills and a bright, hazy sky, creating a sense of isolation and vastness.

THE MARTIAN

ANDY WEIR

A NOVEL

The Martian

Andy Weir



Chapter 1

LOG ENTRY: SOL 6

I'm pretty much fucked.

That's my considered opinion.

Fucked.

Six days in to what should be a greatest two months of my life, and it's turned in to a nightmare.

I don't even know who'll read this. I guess someone will find it eventually. Maybe a hundred years from now.

For the record... I didn't die on Sol 6. Certainly the rest of the crew thought I did, and I can't blame them. Maybe there'll be a day of

national mourning for me, and my Wikipedia page will say "Mark Watney is the only human being to have died on Mars."

And it'll be right, probably. Cause I'll surely die here. Just not on Sol 6 when everyone thinks I did.

Let's see... where do I begin?

The Ares program. Mankind reaching out to Mars to send people to another planet for the very first time and expand the horizons of

humanity blah, blah, blah. The Ares 1 crew did their thing and came back heroes. They got the parades and fame and love of the world.

Ares 2 did the same thing, in a different location on Mars. They got a firm handshake and a hot cup of coffee when they got home.

Ares 3. Wel. That was my mission. Wel, not *mine* per se. Commander Lewis was in charge. I was just one of her crew. Actually, I

was the very lowest ranked member of the crew. I would only be “in command” of the mission if I were the only remaining person.

What do you know? I’m in command.

I wonder if this log will be recovered before the rest of the crew die of old age? I presume they got back to Earth all right. Well, guys, if you’re reading this: It wasn’t your fault. You did what you had to do. In your position I would have done the same thing. I don’t blame you, and I’m glad you survived.

I guess I should explain how Mars missions work, for any layman who may be reading this. We got to earth orbit the normal way,

through an ordinary ship to Hermes. All the Ares missions use Hermes to get to and from Mars. It’s really big and cost a lot so NASA only

built one.

Once we got to Hermes, four additional unmanned missions brought us fuel and supplies while we prepared for our trip. Once

everything was a go, we set out for Mars. But not very fast. Gone are the days of heavy chemical fuel burns and trans-Mars injection

orbits.

Hermes is powered by ion engines. They throw Argon out the back of the ship really fast to get a tiny amount of acceleration. The thing

is, it doesn't take much reactant mass, so a little Argon (and a nuclear reactor to power things) let us accelerate constantly the whole way there. You'd be amazed at how fast you can get going with a tiny acceleration over a long time.

I could regale you with tales of how we had great fun on the trip, but I won't. We did have fun, but I don't feel like reliving it right now.

Suffice it to say we got to Mars 124 days later without strangling each other.

From there, we took the MDV (Mars Descent Vehicle) to the surface. The MDV is basically a big can with some light thrusters and

parachutes attached. Its sole purpose is to get six humans from Mars orbit to the surface without killing any of them.

And now we come to the real trick of Mars exploration: Having all our shit there in advance.

A total of 14 unmanned missions deposited everything we would need for surface operations. They tried their best to land all the supply

vessels in the same general area, and did a reasonably good job. Supplies aren't nearly so fragile as humans and can hit the ground really hard. But they tended to bounce around a lot.

Naturally, they didn't send us to Mars until they'd confirmed all the supplies had made it to the surface and their containers weren't

breached. Start to finish, including supply missions, a Mars mission takes about 3 years. In fact, there were Ares 3 supplies en route to Mars while the Ares 2 crew were on their way home.

The most important piece of the advance supplies, of course, was the MAV. The "Mars Ascent Vehicle." That was how we would get

back to Hermes after surface operations were complete. The MAV was soft-landed (as opposed to the balloon bounce-fest the other

supplies had). Of course, it was in constant communication with Houston, and if there were any problems with it, we would pass by Mars

and go back to Earth without ever landing.

The MAV is pretty cool. Turns out, through a neat set of chemical reactions with the Martian atmosphere, for every kilogram of

hydrogen you bring to Mars, you can make 13 kilograms of fuel. It's a slow process, though. It takes 24 months to fill the tank. That's why they sent it long before we got here.

You can imagine how disappointed I was when I discovered the MAV was gone.

It was a ridiculous sequence of events that led to me almost dying. Then an even more ridiculous sequence that led to me surviving.

The mission is designed to handle sandstorm gusts up to 150 km/hr. So Houston got understandably nervous when we got whacked

with 175 km/hr winds. We all got in our suits and huddled in the middle of the Hab, just in case it lost pressure. But the Hab wasn't the problem.

The MAV is a spaceship. It has a lot of delicate parts. It can put up with storms to a certain extent but it can't just get sandblasted

forever. After an hour and a half of sustained wind, NASA gave the order to abort. Nobody wanted to stop a month-long mission after

only six days but if the MAV took any more punishment we'd all get stranded down here.

We had to go out in the storm to get from the Hab to the MAV. That was going to be risky, but what choice did we have?

Everyone made it but me.

Our main communications dish, which relayed signals from the Hab to Hermes, acted like a parachute, getting torn from its foundation

and carried with the torrent. Along the way, it crashed through the reception antenna array. Then one of those long thin antennae slammed in to me end first. It tore through my suit like a bullet through butter and I felt the worst pain of my life as it ripped open my side. I vaguely remember suddenly having the wind knocked out of me (puled out of me, really) and my ears popping painfully as the pressure of my suit

escaped.

The last thing I remember was seeing Johanssen hopelessly reaching out toward me.

I awoke to the oxygen alarm in my suit. A steady, obnoxious beeping that eventually roused me from a deep and profound desire to

just fucking die.

The storm had abated; I was face down, almost totally buried in sand. As I groggily came to, I wondered why I wasn't more dead.

The antenna had enough force to punch through the suit and my side, but then it got stopped by my pelvis. So there was only one hole

in the suit (and a hole in me, of course).

I had been knocked back quite a ways and roled down a steep hil. Somehow I landed face down, which forced the antenna to a

strongly oblique angle that put a lot of torque on the hole in the suit. It made a weak seal.

Then, the copious blood from my wound trickled down toward the hole. As the blood reached the site of the breach, the water in it

quickly evaporated from the airflow and low pressure, leaving only a gunky residue behind. More blood came in behind it and was also

reduced to gunk. Eventually, the blood sealed the gaps around the hole and reduced the leak to something the suit could counteract.

The suit did its job admirably. Seeing the drop in pressure, it constantly flooded itself with air from my nitrogen tank to equalize. Once the leak became manageable, it only had to trickle new air in slowly the relieve the air lost.

After a while, the CO₂ (carbon dioxide) absorbers in the suit were expended. That's realy the limiting factor to life support. Not the

amount of oxygen you bring with you, but the amount of CO₂ you can remove. In the Hab, we had the Oxygenator, a large piece of

equipment that could break CO₂ apart and give the oxygen back. But the spacesuits had to be portable, so they used a simple chemical

absorption process with expendable filters. I'd been asleep long enough that my filters were useless.

The suit saw this problem and moved in to an emergency mode the engineers call “bloodletting”. Having no way to separate out the

CO₂, the suit deliberately vented air to the Martian atmosphere, then back-filled with nitrogen. Between the breach and the bloodletting, it quickly ran out of nitrogen. All it had left was my oxygen tank.

So it did the only thing it could to keep me alive. It started back-filing with pure oxygen. I now risked dying from oxygen toxicity, as the excessively high amount of oxygen threatened to burn up my nervous system, lungs, and eyes. An ironic death for someone with a leaky space suit: too much oxygen.

Every step of the way would have had beeping alarms, alerts, and warnings. But it was the high-oxygen warning that woke me.

The sheer volume of training for a space mission is astounding. I spent a week back on Earth practicing emergency space suit drills. I

knew what to do.

Carefully reaching to the side of my helmet, I got the breach kit. It’s nothing more than a funnel with a valve at the small end, and an

unbelievably sticky resin on the wide end. The idea is you have the valve open and stick the wide end over a hole. The air can escape

through the valve, so it doesn’t interfere with the resin making a good seal. Then you close the valve and you’ve sealed the breach.

The tricky part was getting the antenna out of the way. I pulled it out as fast as I could, wincing as the sudden pressure drop dizzied me and made the wound in my side scream in agony.

I got the breach kit over the hole and sealed it. It held. The suit back-filled the missing air with yet more oxygen. Checking my arm

readouts, I saw the suit was now at 85% oxygen. For reference, Earth’s atmosphere is about 21%. I’d be ok, so long as I didn’t spend too much time like that.

I stumbled up the hill back toward the Hab. As I crested the rise, I saw something that made me very happy and something that made

me very sad: The Hab was intact (yay!) and the MAV was gone (boo!).

Right that moment I knew I was screwed. But I didn't want to just die out on the surface. I limped back to the Hab and fumbled my

way in to an airlock. As soon as it equalized, I threw off my helmet.

Entering the Hab, I doffed the suit and got my first good look at the injury. It would need stitches. Fortunately, all of us had been

trained in basic medical procedures, and the Hab had excellent medical supplies. A quick shot of local anesthetic, irrigate the wound, 9

stitches and I was done. I'd be taking antibiotics for a couple of weeks, but other than that I'd be fine.

I knew it was hopeless, but I tried firing up the communication array. No signal, of course. The primary satellite dish had broken off,

remember? And it took the reception antennae with it. The Hab had secondary and tertiary communication systems, but they were both just

for talking to the MAV, which would use its much more powerful systems to relay to Hermes. Thing is, that only works if the MAV is still

around.

I had no way to talk to Hermes. In time, I could locate the dish out on the surface, but it would take weeks for me to rig up any repairs, and that would be too late. In an abort, Hermes would leave orbit within 24 hours. The orbital dynamics made the trip safer and shorter the earlier you left, so why wait for no reason just to make the trip take longer?

Checking out my suit, I saw the antenna had plowed through my bio-monitor computer. When on an EVA, all the crew's suits are

networked so we can see each other's status. The rest of the crew would have

seen the pressure in my suit drop to nearly 0, followed

immediately by my bio-signs going flat. Add to that I was sent tumbling down a hill with a spear through me in the middle of a sandstorm...

yeah. They thought I was dead. How could they not?

They may have even had a brief discussion about recovering my body, but regulations were clear. In the event a crewman died on

Mars, he stayed on Mars. Leaving his body behind reduced weight for the MAV on the trip back. That meant more disposable fuel and a

larger margin of error for the return thrust. No point in giving that up for sentimentality.

So that's the situation. I'm stranded on Mars. I have no way to communicate with Hermes or Earth. Everyone thinks I'm dead. I'm in a

Hab designed to last 31 days.

If the Oxygenator breaks down, I'll suffocate. If the Water Reclaimer breaks down, I'll die of thirst. If the Hab breaches, I'll just kind

of explode. If none of those things happen, I'll eventually run out of food and starve to death.

So yeah. I'm fucked.

Chapter 2

LOG ENTRY: SOL 7

Ok, I've had a good night's sleep, and things don't seem as hopeless as they did yesterday.

Today I took stock of supplies, and did a quick EVA to check up on the external equipment. Here's my situation:

The surface mission was supposed to be 31 days. For redundancy, the supply probes had enough food to last the whole crew 56 days.

That way if one or two probes had problems, we'd still have enough food to complete the mission.

We were six days in when the helmet broke loose, so that leaves enough food to feed six people for 50 days. I'm just one guy, so it'll last

me 300 days. And that's if I don't ration it. So I've got a fair bit of time.

The Hab stood up to the storm without any problems. Outside, things aren't so rosy. I can't find the satellite dish; it probably got blown kilometers away.

The MAV is gone, of course. My crewmates took it up to Hermes. Though the bottom half (the landing stage) is still there. No reason

to take that back up when weight is the enemy. It includes the landing gear, the fuel plant, and anything else NASA figured it wouldn't need for the trip back up to orbit.

The MDV is on its side and there's a breach in the hull. Looks like the storm ripped the cowling off the reserve chute (which we didn't

have to use on landing). Once the chute was exposed it dragged the MDV all over the place, smashing it against every rock in the area.

Not that the MDV would be much use to me. Its thrusters can't even lift its own

weight. But it might have been valuable for parts. Might still be.

Both rovers are half-buried in sand, but they're in good shape otherwise. Their pressure seals are intact. Makes sense. Operating

procedure if a storm hits is to stop motion and wait for the storm to pass. They're made to stand up to punishment. I'll be able to dig them out with a day or so of work.

I've lost communication with the weather stations, placed a kilometer away from the Hab in 4 directions. They might be in perfect

working order for all I know. The Hab's communications are so weak right now it probably can't even reach a kilometer.

The solar cell array was covered in sand, rendering it useless (hint: solar cells need sunlight to make electricity). But once I swept

them off, they returned to full efficiency. Whatever I end up doing, I'll have plenty of power for it. 200 square meters of solar cells, with hydrogen fuel cells to store plenty of reserve. All I need to do is sweep them off every few days.

Things indoors are great, thanks to the Hab's sturdy design.

I ran a full diagnostic on the Oxygenator. Twice. It's perfect. If anything goes wrong with it, there is a short-term spare I can use. But it's solely for emergency use while repairing the main one. The spare doesn't actually pull CO₂ apart and recapture the oxygen. It just

absorbs the CO₂ the same way the spacesuits do. It's intended to last 5 days before it saturates the filters, which means 30 days for me (just one person breathing, instead of six). So there's some insurance there.

The Water Reclaimer is working fine, too. The bad news is there's no backup. If it stops working, I'll be drinking reserve water while I

rig up a primitive distillery to boil piss. Also, I'll lose half a liter of water per day to breathing until the humidity in the Hab reaches its maximum and water starts condensing on every surface. Then I'll be licking the walls. Yay. Anyway, for now, no problems with the Water

Reclaimer.

So yeah. Food, water, shelter al taken care of. I'm going to start rationing food right now. Meals are pretty minimal already, but I think I can eat a 3/4 portion per meal and stil be al right. That should turn my 300 days of food in to 400. Foraging around the medical area, I found the main bottle of vitamins. There's enough multivitamins there to last years. So I won't have any nutritional problems (though I'l stil starve to death when I'm out of food, no matter how many vitamins I take).

The medical area has morphine for emergencies. And there's enough there for a lethal dose. I'm not going to slowly starve to death, I'l

tel you that. If I get to that point, I'l take an easier way out.

Everyone on the mission had two specialties. I'm a botanist and mechanical engineer. Basicaly, I was the mission's fix-it man who

played with plants. The mechanical engineering might save my life if something breaks.

I've been thinking about how to survive this. It's not completely hopeless. There'l be humans back on Mars in about four years when

Ares 4 arrives (assuming they didn't cancel the program in the wake of my "death").

Ares 4 wil be landing at the Schiapareli Crater, which is about 3,200km away from my location here in the Acidalia Planitia. No way

for me to get there on my own. But if I could communicate, I might be able to get a rescue. Not sure how they'd manage that with the

resources on hand, but NASA has a lot of smart people.

So that's my mission now. Find a way to communicate with Earth. If I can't manage that, find a way to communicate with Hermes

when it returns in 4 years with the Ares 4 crew.

Of course, I don't have any plan for surviving 4 years on 1 year of food. But one thing at a time here. For now, I'm well fed and have a purpose: "Fix the damn radio".

LOG ENTRY: SOL 10

Well, I've done three EVAs and haven't found any hint of the communication dish.

I dug out one of the rovers and had a good drive around, but after days of wandering I think it's time to give up. The storm probably

blew the dish far away and then erased any drag-marks or scuffs that might have led to a trail. Probably buried it, too.

I spent most of today out at what's left of the communication array. It's really a sorry sight. I may as well yel toward Earth for all the good that damned thing will do me.

I could throw together a rudimentary dish out of metal I find around the base, but this isn't some walkie-talkie I'm working with here.

Communicating from Mars to Earth is a pretty big deal, and requires extremely specialized equipment. I won't be able to whip something up with tinfoil and gum.

I need to ration my EVAs as well as food. The CO2 filters are not cleanable. Once they're saturated, they're done. The mission

accounted for a 4-hour EVA per crewmember per day. Fortunately, CO2 filters are light and small so NASA had the luxury of sending

more than we needed. Al told, I have about 1500 hours worth of CO2 filters. After that, any EVAs I do will have to be managed with bloodletting the air.

1500 hours may sound like a lot, but I'm faced with spending at least 4 years

here if I'm going to have any hope of rescue, with a

minimum of several hours per week dedicated to sweeping off the solar array. Anyway. No needless EVAs.

In other news, I'm starting to come up with an idea for food. My botany background may come in useful after all.

Why bring a botanist to Mars? After all, it's famous for not having anything growing here. Well, the idea was to figure out how well

things grow in Martian gravity, and see what, if anything, we can do with Martian soil. The short answer is: quite a lot... almost. Martian soil has the basic building blocks needed for plant growth, but there's a lot of stuff going on in Earth soil that Mars soil doesn't have, even when it's placed in an Earth-atmosphere and given plenty of water. Bacterial activity, certain nutrients provided by animal life, etc. None of that is happening on Mars. One of my tasks for the mission was to see how plants grow here, in various combinations of Earth or Mars soil and atmosphere.

That's why I have a small amount of Earth soil and a bunch of plant seeds with me.

I can't get too excited, however. It's about the amount of soil you'd put in a window planter-box, and the only seeds I have are a few

species of grass and ferns. They're the most rugged and easily grown plants on earth, so NASA picked them as the test subjects.

So I have two problems: not enough dirt, and nothing edible to plant in it.

But I'm a botanist, damn it. I should be able to find a way to make this happen. If I don't, I'll be a really hungry botanist in about a

year.

LOG ENTRY: SOL 11

I wonder how the Cubs are doing.

LOG ENTRY: SOL 14

I got my undergrad degree at the University of Chicago. Half the people who studied botany were hippies who thought they could

return to some natural world system. Somehow feeding 7 billion people through pure gathering. They spent most of their time working out

better ways to grow pot. I didn't like them. I've always been in it for the science, not for any New World Order bullshit.

When they made compost heaps and tried to conserve every little ounce of living matter, I laughed at them. "Look at the silly hippies!" I would scoff. "Look at their pathetic attempts to simulate a complex global ecosystem in their back yard."

Of course now I'm doing exactly that. I'm saving every scrap of biomatter I can find. Every time I finish a meal, the leftovers go to the compost bucket. As for other biological material...

The Hab has sophisticated toilets. Shit is usually vacuum-dried, then accumulated in sealed bags to be discarded on the surface.

Not any more!

In fact, I even did an EVA to recover the previous bags of shit from before the crew left. Being completely desiccated, this particular

shit didn't have bacteria in it anymore, but it still had complex proteins and would serve as useful manure. Adding it to water and active bacteria would quickly get it inundated, replacing any population killed by the Toilet Of Doom.

I found a big container and filled it with a bit of water, then added the dried shit. Since then, I've added my own shit to it as well. The worse it smells, the more successful things are going. That's the bacteria at work!

Once I get some Martian soil in here, I can mix in the shit and spread it out. Then I can sprinkle the Earth soil on top. You might not

think that would be an important step, but it is. There are dozens of species of

bacteria living in Earth soil, and they're critical to plant growth. They'll spread out and breed like... well, like a bacterial infection..

Within a week, the Martian soil will be ready for plants to germinate in. But I won't plant yet. I'll spread it out over a doubled area. It'll

"infect" the new Martian soil. After another week, I'll double it again. And so on. Of course, all the while, I'll be adding all new manure to the effort.

My asshole is doing as much to keep me alive as my brain.

This isn't a new concept I just came up with. People have speculated on how to make crop soil out of Martian dirt for decades. I'll just

be putting it to the test for the first time.

I searched through the food supplies and found all sorts of things that I can plant. Peas, for instance. Plenty of beans, too. I also found several potatoes. If **any** of them can still germinate after their ordeal, that'll be great. With a nearly infinite supply of vitamins, all I need are calories of any kind to survive.

The total floor-space of the Hab is about 92 square meters. I plan to dedicate all of it to this endeavor. I don't mind walking on dirt.

It'll be a lot of work, but I'm going to need to cover the entire floor to a depth of 10 cm. That means I'll have to transport 9.2 cubic meters of Martian soil in to the Hab. I can get maybe 1/10th of a cubic meter in through the airlock at a time, and it'll be backbreaking work to collect it. But in the end, if everything goes to plan, I'll have 92 square meters of croppable soil.

Well yeah I'm a botanist! Fear my botany powers!

LOG ENTRY: SOL 15

Ugh! This is backbreaking work!

I spent 12 hours today on EVAs to bring dirt in to the Hab. I only managed to cover a small corner of the base, maybe 5 square

meters. At this rate it'll take me weeks to get all the soil in. But hey, time is one

thing I've got.

The first few EVAs were pretty inefficient; me filing small containers and bringing them in through the airlock. Then I got wise and just put one big container in the airlock itself and filled that with small containers till it was full. That sped things up a lot because the airlock takes about 10 minutes to get through.

I ache all over. And the shovels I have are made for taking samples, not heavy digging. My back is killing me. I foraged in the medical

supplies and found some Vicodin. I took it about 10 minutes ago. Should be kicking in soon.

Anyway, it's nice to see progress. Time to start getting the bacteria to work on these minerals. After lunch. No 3/4 ration today. I've

earned a full meal.

LOG ENTRY: SOL 16

One complication I hadn't thought of: Water.

Turns out being on the surface of Mars for a few million years eliminates all the water in the soil. My master's degree in botany makes

me pretty sure plants need wet dirt to grow in. Not to mention the bacteria that has to live in it first.

Fortunately, I have water. But not as much as I want. To be viable, soil needs 40 liters of water per cubic meter. My overall plan calls

for 9.2 cubic meters of soil. So I'll eventually need 368 liters of water to feed it.

The Hab has an excellent Water Reclaimer. Best technology available on Earth. So NASA figured "why send a lot of water up there?"

Just send enough for an emergency." Humans need 3 liters of water per day to be comfortable. They gave us 50 liters each. There are 300

liters total in the Hab.

Looks like I won't be able to cover the whole surface of the Hab with fertile soil. I'm willing to dedicate all but an emergency 50 liters to the cause. That means I can feed 62.5 square meters at a depth of 10cm. About 2/3 of the Hab's floor. It'll have to do. Anyway, I've

only got a paltry 5 square meters covered at the moment.

After that, things got disgusting. I spent three hours spreading shit on Martian sand. I didn't have to do it with my hands, at least.

I spread the sand out in a corner of the Hab, about 10cm thick. I wadded up a few blankets and uniforms from my departed

crewmates to serve as one edge of a planter box (with the curved walls of the Hab being the rest of the perimeter). Then I sacrificed 20

liters of precious water to the dirt gods.

5 square meters was about right for the amount of manure I had handy. I dumped my big container o' shit on to the soil and nearly

puked from the smell.

That smell's going to stick around for a while, too. It's not like I can open a window. Still, you get used to it. I mixed this soil and shit together with a shovel, and spread it out evenly again. Then I sprinkled the Earth soil on top. Get to work, bacteria. I'm counting on you.

In other news, today is Thanksgiving. My family will be gathering in Chicago for the usual feast at my parent's house. My guess is it

won't be much fun, what with me having died 11 days ago. Hell, they probably just got done gathering for my funeral.

I wonder if they'll ever find out what really happened.

LOG ENTRY: SOL 22

Wow. Things really came along.

I got all the sand in and ready to go. 2/3 of the base is now dirt. And today I executed my first dirt-doubling. It's been a week, and the former Martian soil was rich and lovely. Two more doublings and I will have covered the whole field.

All that work was great for my morale. It gave me something to do. But after things settled down a bit, and I had dinner while listening

to Johanssen's Beatles music collection, I got depressed again.

Doing the math, this won't keep me from starving.

My best bet for making calories is potatoes. They grow prolifically and have a reasonable caloric content (770 calories per kg). I'm

pretty sure the ones I have will germinate. Problem is I can't grow enough of them. In 62 square meters, I could grow maybe 150kg of

potatoes in 400 days (the time I have before running out of food). That's a grand total of 115,500 calories, a sustainable average of 288

calories per day. With my height and weight, if I'm willing to starve a little, I need 1500 calories per day.

Not even close.

So I can't just live off the land for ever. But I can extend my life. The potatoes will last me 76 days.

Potatoes grow continually, so in those 76 days, I can grow another 22,000 calories of potatoes, which will tide me over for another 15

days. After that, it's kind of pointless to continue the trend. All told it buys me about 90 days.

So now I'll start starving to death on Sol 490 instead of Sol 400. It's progress, but any hope of survival rests on me surviving until Sol 1412, when Ares 4 will land.

There's about a thousand days of food I don't have. And I don't have a plan for

how to get it.

Shit.

Chapter 3

LOG ENTRY: SOL 25

Remember those old math questions you had in Algebra class? Where water is entering a container at a certain rate and leaving at a

different rate and you need to figure out when it'll be empty? Well, that concept is critical to the "Mark Watney doesn't die" project I'm working on.

I need to create calories. And I need enough to last four years. I figure if I don't get rescued by Ares 4, I'm dead anyway. So that's my target: four years.

I have plenty of multivitamins; over double what I need. And there's five times the minimum protein in each food pack, so careful

rationing of portions takes care of my protein needs for at least four years. My general nutrition is taken care of. I just need calories.

I need 1500 calories every day. I have 400 days of food to start off with. So how many calories do I need to generate per day along

the entire time period to stay alive for 1400 days total (the time til Ares 4 arrives)?

I'll spare you the math. The answer is a cool 1000. I need to create 1000 calories per day with my farming efforts to survive until Ares

4 gets here. Actually, a little more than that, because it's sol 25 right now and I haven't actually planted anything yet.

With my 62 square meters of farmland, I'll be able to create about 288 calories per day. I need to bring that up to 1000. I need four

times my current plan's production to survive.

I need more surface area for farming, and I need water to hydrate the soil. So let's take the problems one at a time.

How much farmland can I really make?

There are 92 square meters in the Hab. Let's say I could make use of all of it.

Also, there are five unused bunks. Let's say I put soil in on them, too. They're 2 square meters each, giving me 10 more square meters.

So we're up to 102.

The Hab has three lab tables, each about 2 square meters. I want to keep one for my own use, leaving two for the cause. That's

another four square meters, bringing the total to 106.

I have two Martian rovers. They have pressure seals, allowing the occupants to drive in ease, without spacesuits, as they spent long

periods traversing the surface. They're too cramped to plant crops in, and I want to be able to drive them around anyway. But both rovers have an emergency pop-tent.

There are a lot of problems with using pop-tents as farmland, but they have 10 square meters of floor space each. Presuming I can

overcome the problems, they net me another 20 square meters, bringing my farmland up to 126.

126 square meters of farmable land. That's something to work with. Not nearly enough water to moisten the soil, but like I said, one

thing at a time.

The next thing to consider is how efficient I can be in growing potatoes. I based my crop yield estimates on the potato industry back on Earth. But potato farmers aren't in a desperate race for survival like I am. Can I get a better yield?

For starters, I can give attention to each individual plant. I can trim them and keep them healthy and not interfering with each other.

Also, as their flowering bodies breach the surface, I can replant them deeper,

then plant younger plants above them. For normal potato

farmers, it's not worth doing because they're working with literally millions of potato plants.

Also, this sort of farming annihilates the soil. Any farmer doing it would turn their land into a dust bowl within 12 years. It's not

sustainable. But who gives a shit? I just need to survive four years.

I estimate I can get 50% higher yield by using these tactics. And with the 126 square meter farmland (just over double the 62 square

meters I have) it works out to be over 900 calories per day.

That's real progress. I'd still be in danger of starvation, but it gets me in the range of survival. I might be able to make it by nearly starving but not quite dying. I could reduce my caloric use by minimizing manual labor. I could set the temperature of the Hab higher than normal, meaning my body expends less energy keeping its temperature. I could cut off an arm and eat it, gaining me valuable calories and reducing my overall caloric need.

No, not really.

So let's say I could clear up that much farmland. Seems reasonable. Where do I get the water? To go from 62 to 126 square meters of

farmland at 10cm deep, I'll need 6.4 more cubic meters of soil (more shoveling, whee!) and that'll need over 250 liters of water.

The 50L I have is for me to drink if the Water Reclaimer breaks. So I'm 250L short of my 250L goal.

Bleh. I'm going to bed.

LOG ENTRY: SOL 26

It was a back-breaking yet productive day.

I was sick of thinking, so instead of trying to figure out where I'll get 250L of

water, I did some manual labor. I need to get a whole assload more soil in to the Hab, even if it is dry and useless right now.

I got a cubic meter in before getting exhausted.

Then, a minor dust-storm dropped by for an hour and covered the solar collectors with crap. So I had to suit up *again* and do

another EVA. I was in a pissy mood the whole time. Sweeping off a huge field of solar cels is boring and physicaly demanding. But

once the job was done, I came back to my Little Hab on the Prairie.

It was about time for another dirt-doubling, so I figured I may as wel get it over with. It took an hour. One more doubling and the

usable soil wil al be good to go.

Also, I figured it was time to start up a seed crop. I'd doubled the soil enough that I could afford to leave a little corner of it alone. I had 12 potatoes to work with.

I am one lucky son-of-a-bitch they aren't freeze-dried or mulched. Why did NASA send 12 whole potatoes, refrigerated but not

frozen? And why send them along with us as in-pressure cargo rather than in a crate with the rest of the Hab supplies? Because

Thanksgiving was going to happen while we were doing surface operations, and NASA's shrinks thought it would be good to make a meal

together. Not just to eat it, but to actualy prepare it. There's probably some logic to that, but who cares?

I cut each potato in to 4 pieces, making sure each piece had at least 2 eyes. The eyes are where they sprout from. I let them sit for a

few hours to harden a bit, then planted them, wel spaced apart, in the corner. God speed, little taters. My life depends on you.

Normally, it takes 90 days to yield full sized potatoes. But I can't wait that long. I'll need to cut up all the potatoes from this crop to

seed the rest of the field.

By setting the Hab temperature to a balmy 25.5C, the plants will grow quicker. Also, the internal lights will provide plenty of "sunlight"

and I'll make sure they get lots of water (once I figure out where to get water). There will be no foul weather, or any parasites to hassle them, or any weeds to compete with for soil or nutrients. With all this going for them, they should yield healthy, sproutable tubers within 40

days.

I figured that was enough being Farmer Mark for one day.

A full meal for dinner. I'd earned it. Plus, I'd burned a ton of calories and I wanted them back.

I rifled through Commander Lewis's stuff until I found her personal data-stick. Everyone got to bring whatever digital entertainment

they wanted, and I was tired of listening to Johanssen's Beatles Albums for now. Time to see what Lewis had.

Crappy TV shows. That's what she had. Countless entire runs of TV shows from forever ago.

Well. Beggars can't be choosers. "Three's Company" it is.

LOG ENTRY: SOL 29

Over the last few days, I got all the dirt in that I'd need. I prepped the tables and bunks for holding the weight of soil, and even put the dirt in place. There's still no water to make it viable, but I have some ideas. Really bad ideas, but they're ideas.

Today's big accomplishment was setting up the pop-tents.

The problem with the rovers' pop-tents is they weren't designed for frequent use.

The idea was you'd throw out a pop-tent, get in, and wait for rescue. The airlock is nothing more than valves and two doors. Equalize

the airlock with your side of it, get in. equalize with the other side, get out. This means you lose a lot of air each use. And I'll need to get in there at least once a day. The total volume of each pop tent is pretty low, so I can't afford to lose air from it.

I spent *hours* trying to figure out how to attach a pop-tent airlock to a Hab airlock. I have three airlocks in the Hab. I'd be willing to dedicate two to pop-tents. That would have been awesome.

The frustrating part is pop-tent airlocks *can* attach to other airlocks! You might have injured people in there, or not enough space

suits. You need to be able to get people out without exposing them to the Martian atmosphere.

But the pop-tents were designed for your crewmates to come rescue you in a *rover*. The airlocks on the Hab are much larger and

completely different than the airlocks on the rovers. When you think about it, there's really no reason to attach a pop-tent to the Hab.

Unless you're stranded on Mars and everyone thinks you're dead and you're in a desperate fight against time and the elements to stay

alive. But, you know, other than that edge case there's no reason.

So I finally decided I'd just take the hit. I'll be losing some air every time I enter or exit a pop-tent. The good news is each pop-tent

has an air feed valve on the outside. Remember, these are emergency shelters. The occupants might need air, and you can provide it from a rover by hooking up an air line. It's nothing more than a tube that equalizes the rover's air with the pop-tent's.

The Hab and the rovers use the same valve and tubing standards, so I was able to

attach the pop tents directly to the Hab. That'l

automatically replenish the air I lose with my entries and exits (what we NASA folk call ingress and egress).

NASA was not fucking around with these emergency tents. The moment I pushed the panic button in the rover, there was an ear-

popping whoosh as the pop-tent fired out, attached to the rover airlock. It took about two seconds.

I closed the airlock from the rover side and ended up with a nice, isolated pop-tent. Setting up the equalizer hose was trivial (for once I'm using equipment the way it was designed to be used). Then, after a few trips through the airlock (with the air-loss automatically

equalized by the Hab) I got the dirt in.

I repeated the process for the other tent. Everything went really easily.

Sigh... water.

In high school, I played a lot of Dungeons and Dragons. (You may not have guessed this Botanist / Mechanical Engineer was a bit of a

nerd in high school, but indeed I was). In the game I played a Cleric. One of the magic spells I could cast was "Create Water". I always

thought it was a really stupid spell, and it never came up. Boy what I wouldn't give to be able to do that in real life right now.

Anyway. That's a problem for tomorrow.

For tonight, I have to get back to "Three's Company." I stopped last night in the middle of the episode where Mr. Roper saw

something and took it out of context.

LOG ENTRY: SOL 30

I have an idiotically dangerous plan for getting the water I need. And boy do I

mean *dangerous*. But I don't have much choice. I'm

out of ideas and I'm due for another dirt-doubling in a few days. When I do the final doubling, I'll be doubling on to all that new soil I've brought in. If I don't wet it first, it'll just die.

There isn't a lot of water here on Mars. There's ice at the poles, but they're too far away. If I want water I'll have to make it from

scratch. Fortunately, I know the recipe: Take hydrogen. Add oxygen. Burn.

Let's take them one at a time. I'll start with oxygen.

I have a fair bit of O₂ reserves, but not enough to make 250 liters of water. Two high-pressure tanks at one end of the Hab are my

entire supply (plus the air in the Hab of course). They each contain 25 liters of liquid O₂. The Hab would only use them in an emergency; it has the Oxygenator to balance the atmosphere. The reason the O₂ tanks are here is to feed the spacesuits and rovers.

Anyway, the reserve oxygen would only be enough to make 100L of water (50L of O₂ makes 100L of molecules that only have one

O each). That would mean no EVAs for me, and no emergency reserves. And it would make less than half the water I need. Out of the

question.

But oxygen's easier to find on Mars than you might think. The atmosphere is 98% CO₂. And I happen to have a machine whose sole

purpose is liberating oxygen from CO₂. Yay Oxygenator!

One problem: The atmosphere is very thin. About 1/90th the pressure on Earth. So it's hard to collect. Getting air from outside to

inside is nearly impossible. The whole purpose of the Hab is to keep that sort of thing from happening. The tiny amount of Martian

atmosphere that enters when I use an airlock is laughable.

That's where the MAV fuel plant comes in.

My crewmates took the MAV away weeks ago. But the bottom half of it stayed behind. NASA is not in the habit of putting

unnecessary shit in to orbit. It left the landing gear, ingress ramp, and fuel plant behind. Remember how the MAV made its own fuel with help from the Martian atmosphere? Step one of that is to collect CO₂ and store it in a high pressure vessel. Once I get that hooked up to the Hab's power, it'll give me half a liter of liquid CO₂ per hour, indefinitely. After 5 days it'll have made 125L of CO₂, which will make 125L of O₂ after I feed it through the Oxygenator.

That's enough to make 250L of water. So I have a plan for oxygen.

The hydrogen will be a little trickier.

I considered raiding the hydrogen fuel-cells, but I need those batteries to maintain power at night. If I don't have that, it'll get too cold.

I could bundle up, but the cold would kill my crops. And each fuel cell only has a small amount of H₂ anyway. It's just not worth sacrificing so much usefulness for so little gain. The one thing I have going for me is that energy is not a problem. I don't want to give that up.

So I'll have to go a different route.

I often talk about the MAV. But now I want to talk about the MDV.

During the most terrifying 23 minutes of my life, four of my crewmates and I tried not to shit ourselves while Martinez piloted the MDV

down to the surface. It was kind of like being in a tumble-dryer.

First, we descended from Hermes, and decelerated our orbital velocity so we could start falling properly. Everything was smooth until

we hit the atmosphere. If you think turbulence is rough in a jetliner going 720kph, just imagine what it's like at 28,000kph.

Several staged sets of chutes deployed automatically to slow our descent, then Martinez manually piloted us to the ground, using the

thrusters to slow descent and control our lateral motion. He'd trained for this for years, and he did his job extraordinarily well. He

exceeded all plausible expectations of landings, putting us just nine meters from the target. The guy just plain owned that landing.

Thanks, Martinez! You may have saved my life!

Not because of the perfect landing, but because he left so much fuel behind. Hundreds of liters of unused Hydrazine. Each molecule of

Hydrazine has four hydrogen atoms in it. So each liter of Hydrazine has enough hydrogen for **two** liters of water.

I did a little EVA today to check. The MDV has 292L of juice left in the tanks. Enough to make almost 600L of water! Way more

than I need!

There's just one catch: Liberating hydrogen from Hydrazine is... well... it's how rockets work. It's really, really hot. And dangerous. If

I do it in an oxygen atmosphere, the heat and newly liberated hydrogen will explode. There'll be a lot of H₂O at the end, but I'll be too

dead to appreciate it.

At its root, Hydrazine is pretty simple. The Germans used it as far back as World War II for rocket-assisted fighter fuel (and

occasionally blew themselves up with it).

All you have to do is run it over a catalyst (which I can extract from the MDV engine) and it will turn in to nitrogen and hydrogen. I'll

spare you the chemistry, but the end result is that 5 molecules of Hydrazine becomes 5 molecules of harmless N₂ and 10 molecules of

lovely H₂. During this process, it goes through an intermediate step of being ammonia. Chemistry, being the sloppy bitch it is, ensures

there'll be some ammonia that doesn't react with the Hydrazine, so it'll just stay ammonia. You like the smel of ammonia? Wel it'll be

prevalent in my increasingly helish existence.

The chemistry is on my side. The question now is how do I actualy make this reaction happen slowly and how do I colect the

hydrogen? The answer is: I don't know.

I suppose I'll think of something. Or die.

Anyway, much more important: I simply can't abide the replacement of Chrissie with Cindy. "Three's Company" may never be the

same after this fiasco. Time wil tel.

Chapter 4

LOG ENTRY: SOL 32

So I ran in to a bunch of problems with my water plan.

My idea is to make 600L of water (limited by the hydrogen I can get from the Hydrazine). That means I'll need 300L of liquid O₂.

I can create the O₂ easily enough. It takes 20 hours for the MAV fuel plant to fill its 10L tank with CO₂. The Oxygenator can turn it in

to O₂, then the Atmospheric Regulator will see the O₂ content in the Hab is high, and pull it out of the air, storing it in the main O₂ tanks.

They'd fill up, so I'd have to transfer O₂ over to the rovers' tanks and even space suit tanks as necessary.

But I can't create it very quickly. At 1/2L of CO₂ per hour, it will take 25 days to make the oxygen I need. That's longer than I'd like.

Also, there's the problem of storing the hydrogen. The air tanks of the Hab, the rovers, and all the space suits add up to exactly 374L

of storage. To hold all the materials for water, I would need a whopping 900L of storage.

I considered using one of the rovers as a "tank". It would certainly be big enough, but it just isn't designed to hold in that much

pressure. It's made to hold (you guessed it) one atmosphere. I need vessels that can hold 50 times that much. I'm sure a rover would burst.

The best way to store the ingredients of water is to make them be water. So what's what I'll have to do.

The concept is simple, but the execution will be incredibly dangerous.

Every 20 hours, I'll have 10L of CO₂ thanks to the MAV fuel plant. I'll vent it in to the Hab via the highly scientific method of

detaching the tank from the MAV landing struts, bringing it in to the Hab, then opening the valve until it's empty.

The Oxygenator will turn it in to oxygen in its own time.

Then, I'll release Hydrazine, VERY SLOWLY, over the iridium catalyst, to turn it in to N₂ and H₂. I'll direct the hydrogen to a small

area and burn it.

As you can see, this plan provides many opportunities for me to die in a fiery explosion.

Firstly, Hydrazine is some serious death. If I make any mistakes, there'll be nothing left but the "Mark Watney Memorial Crater" where

the Hab once stood.

Presuming I don't fuck up with the Hydrazine, there's still the matter of burning hydrogen. I'm going to be setting a fire. In the Hab. On purpose.

If you asked every engineer at NASA what the worst scenario for the Hab was, they'd all answer "fire." If you asked them what the

result would be, they'd answer "death by fire."

But if I can pull it off, I'll be making water continuously, with no need to store hydrogen or oxygen. It'll be mixed in to the atmosphere

as humidity, but the Water Reclaimer will pull it out.

I don't even have to perfectly match the Hydrazine end of it with the fuel plant CO₂ part. There's plenty of oxygen in the Hab, and

plenty more in reserve. I just need to make sure not to make so much water I run myself out of O₂.

I hooked up the MAV fuel plant to the Hab's power supply. Fortunately they

both use the same voltage. It's chugging away, collecting CO₂ for me.

Half-ration for dinner. All I accomplished today was thinking up a plan that'll kill me, and that doesn't take much energy.

I'm going to finish off the last of "Three's Company" tonight. Frankly, I like Mr. Furley more than the Ropers.

LOG ENTRY: SOL 33

This may be my last entry.

I've known since Sol 6 there was a good chance I'd die here. But I figured it would be when I ran out of food. I didn't think it would

be this early.

I'm about to fire up the Hydrazine.

Our mission was designed knowing that anything might need maintenance, so I have plenty of tools. Even in a space-suit, I was able to

pry the access panels off the MDV and get at the six Hydrazine tanks. I set them in the shadow of a rover to keep them from heating up

too much. There's more shade and a cooler temperature near the Hab, but fuck that. If they're going to blow up, they can blow up a rover, not my house.

Then I pried out the reaction chamber. It took some work and I cracked the damn thing in half, but I got it out. Lucky for me I don't

need a proper fuel reaction. In fact, I really, super-duper don't want a proper fuel reaction.

I brought all the Hydrazine and reaction chamber in. I briefly considered only having one tank in at a time to reduce risk. But some

back-of-the-napkin math told me even one tank was enough to blow the whole Hab up, so why not bring them all in?

The tanks have manual vent valves. I'm not 100% sure what they're for. Certainly we were never expected to use them. I think they're

there to release pressure during the many quality checks done during construction and before fueling. Whatever the reason, I have valves to work with. All it takes is a wrench.

I liberated a spare water hose from the Water Reclaimer. With some thread torn out of a uniform (Sorry, Johanssen), I attached it to

the valve output. Hydrazine is a liquid, so all I have to do is lead it to the reaction chamber (more of a "reaction bowl" now).

Meanwhile, the MAV fuel plant is still working. I've already brought in one tank of CO₂, vented it, and returned it for refiling.

So there are no more excuses. It's time to start making water.

If you find the charred remains of the Hab, it means I did something wrong. I'm copying this log over to both rovers so it's more likely it'll survive.

Here goes nothin'

LOG ENTRY: SOL 33 (2)

Well, I didn't die.

First thing I did was put on the inner lining of my EVA suit. Not the bulky suit itself, just the inner clothing I wear under it, including the gloves and booties. Then I got an oxygen mask from the medical supplies and some lab goggles from Vogel's chem kit. Almost all of my

body was now protected and I would be breathing canned air.

Why? Because Hydrazine is very toxic. If I breathe too much of it I'll get major lung problems. If I get it on my skin, I'll have chemical burns for the rest of my life. I wasn't taking any chances.

I turned the valve until a trickle of Hydrazine came out. I let one drop fall in to the iridium bowl.

It un-dramatically sizzled and disappeared.

But hey, that's what I wanted. I just freed up hydrogen and nitrogen. Yay!

One thing I have in abundance here is bags. They're not much different than kitchen trash bags, though I'm sure they cost \$50,000

because NASA.

In addition to being our commander, Lewis was also the geologist. She was going to collect rock and soil samples from all over the

operational area (10 km radius). Weight limits restricted how much she could actually bring back, so she was going to collect first, then sort out the most interesting 50kg to take home. The bags are to store and tag the samples. Some are smaller than a Ziploc, while others are as big as a Hefty lawn and leaf bag.

Also, I have duct tape. Ordinary duct tape, like you buy at a hardware store. Turns out even NASA can't improve on duct tape.

I cut up a few Hefty sized bags and taped them together to make a sort of tent. Really it was more of a super-sized bag. I was able to

cover the whole table where my Hydrazine mad scientist set-up was. I put a few knickknacks on the table to keep the plastic out of the

iridium bowl. Thankfully, the bags are clear, so I can still see what's going on.

Next, I sacrificed a spacesuit to the cause. I needed an air hose. I have a surplus of space suits, after all. A total of seven; one for each crewmember and one spare. So I don't mind murdering one of them.

I cut a hole in the top of the plastic and duct taped the hose in place. Nice seal, I think.

With some more string from Johannsen's clothing, I hung the other end of the hose from the top of the Hab's dome by two angled

threads (to keep them well clear of the hose opening). Now I had a little chimney. The hose was about 1cm wide. Hopefully a good

aperture.

The hydrogen will be hot after the reaction, and it'll want to go up. So I'll let it go up the chimney, then burn it as it comes out.

Then I had to invent fire.

NASA put a lot of effort in to making sure nothing here can burn. Everything is made of metal or flame retardant plastic and the

uniforms are synthetic. I needed something that could hold a flame, some kind of pilot light. I don't have the skills to keep enough H₂

flowing to feed a flame without killing myself. Too narrow a margin there.

After a search of everyone's personal items (hey, if they wanted privacy, they shouldn't have abandoned me on Mars with their stuff) I

found my answer.

Martinez is a devout catholic. I knew that. What I didn't know was he brought along a small wooden cross. I'm sure NASA gave him

shit about it, but I also know Martinez is one stubborn son-of-a-bitch.

I chipped his sacred religious item into long splinters using a pair of pliers and a screwdriver. I figure if there's a God, He won't mind, considering the situation I'm in.

Ruining the only religious icon I have leaves me vulnerable to Mars Vampires. I'll have to risk it.

There were plenty of wires and batteries around to make a spark. But you can't just ignite wood with a small electric spark. So I

collected ribbons of bark from local palm trees, then got a couple of sticks and rubbed them together to create enough friction to...

No not really. I vented pure oxygen at the stick and gave it a spark. Fucker lit up like a match.

With my mini-torch in hand, I started a slow Hydrazine flow. It sizzled on the iridium and disappeared. Soon I had short bursts of flame sputtering from the chimney.

The main thing I had watch was the temperature. Hydrazine breaking down is extremely exothermic. So I'd do it a bit at a time,

constantly watching the readout of a thermocouple I'd attached to the iridium chamber.

Point is, the process worked!

Each Hydrazine tank holds a little over 50L, which would be enough to make 100L of water. I'm limited by my oxygen production, but

I'm al excited now, so I'm wiling to use half my reserves. Long story short, I'll stop when the tank is half-empty, and I'l have 50L or

water at the end!

LOG ENTRY: SOL 34

Wel that took a realy long time. I've been at it al night with the Hydrazine. But I got the job done.

I could have finished faster, but I figured caution's best when setting fire to rocket fuel in an enclosed space.

Boy is this place a tropical jungle now, I'l tel ya.

It's almost 30C in here, and humid as al hel. I just dumped a ton of heat and 50L of water in to the air.

During this process, the poor Hab had to be the mother of a messy toddler. It's been replacing the oxygen I've used, and the Water

Reclaimer is trying to get the humidity down to sane levels. Nothing to be done about the heat. There's actualy no air-conditioning in the Hab. Mars is cold. Getting rid of excess heat isn't something we expected to deal with.

I've now grown accustomed to the alarms that are blaring at al times. The fire alarm has finally stopped, now that there's no more fire.

The low oxygen alarm should stop soon. The high humidity alarm wil take a little longer. The Water Reclaimer has its work cut out for it today.

For a moment, there yet another alarm. The Water Reclaimer's main tank was ful. Booyah! That's the kind of problem I want to have!

Remember the spacesuit I vandalized yesterday? I hung it on its rack and carried buckets of water to it from the reclaimer. It can hold

an atmosphere of air in. It should be able to handle a few buckets of water.

Man I'm tired. Been up al night and it's time to sleep. But I'l drift off to dreamland in the best mood I've been in since Sol 6.

Things are finally going my way. In fact, they're going great! I have a chance to live after al!

LOG ENTRY: SOL 37

I am fucked and I'm gonna die!

Ok, calm down. I'm sure I can get around this.

I'm writing this log to you, dear future Mars archeologist, from Rover 2. You may wonder why I'm not in the Hab right now. Because I

fled in terror, that's why! And I'm not sure what the hel to do next.

I guess I should explain what happened. If this is my last entry, you'l at least know why.

Over the past few days, I've been happily making water. It's been going swimmingly. (See what I did there? "swimmingly")

I even beefed up the MAV fuel plant compressor. It was very technical (I increased the voltage to the pump). So I'm making water

even faster now.

After my initial burst of 50L, I decided to settle down and just make it at the rate I get O₂. I'm not willing to go below a 25L reserve.

So when I dip too low, I stop dicking with Hydrazine until I get the O₂ back up to well above 25L.

Important note: When I say I made 50L of water, that was an assumption. I didn't *reclaim* 50L of water. The additional soil I'd filed

the Hab with was extremely dry and greedily sucked up a lot of the humidity. That's where I want the water to go anyway, so I'm not

worried, and I wasn't surprised when the reclaimer didn't get anywhere near 50L.

I get 10L of CO₂ every 15 hours now that I souped up the pump. I've done this process four times. My math tells me that, including

my initial 50L burst, I should have 130L of water added to the system.

Well my math is a damn liar!

I've gained 70L in the water regulator and the spacesuit-now-watertank. There's plenty of condensation on the walls and domed roof,

and the soil is certainly absorbing its fair share. But that doesn't account for 60L of missing water. Something was wrong.

That's when I noticed the other O₂ tank.

The Hab has two reserve O₂ tanks. One on each side of the structure, for safety reasons. The Hab can decide which one to use

whenever it wants. Turns out it's been topping off the atmosphere from Tank 1. But when I add O₂ to the system (via the Oxygenator), the Hab evenly distributes the gain among the two tanks. Tank 2 has been slowly gaining oxygen.

That's not a problem, it's just doing its job. But it does mean I've been gaining O₂ over time. Which means I'm not consuming it as fast as I thought.

At first, I thought “Yay! More oxygen! Now I can make water faster!” But then a more disturbing thought occurred to me.

Follow my logic: I’m gaining O₂. But the amount I’m bringing in from outside is constant. So the only way to “gain” it is to be using less than I thought. But I’ve been doing the Hydrazine reaction with the assumption that I was using all of it.

The only possible explanation is I haven’t been burning all the released hydrogen.

It’s obvious now, in retrospect. But it never occurred to me that some of the hydrogen just wouldn’t burn. It got past the flame, and

went on its merry way. Dammit, Jim, I’m a botanist, not a chemist!

Chemistry is messy, so there’s unburned Hydrogen in the air. All around me. Mixed in with the oxygen. Just... hanging out. Waiting for a

spark so it can *blow the fucking Hab up!*

Once I figured this out, and composed myself, I got a Ziploc-sized sample bag and waved it around a bit, then sealed it.

Then, a quick EVA to a rover, where we keep the atmospheric analyzers. Nitrogen: 22%. Oxygen: 9%. Hydrogen: 64%.

I’ve been hiding here in the rover ever since.

It’s Hydrogenville in the Hab.

I’m very lucky it hasn’t blown. Even a small static discharge would have led to “Oh the humanity!”

So, I’m here in Rover 2. I can stay for a day or two, tops, before the CO₂ filters from the rover and my spacesuit fill up. I have that

long to figure out how to deal with this.

The Hab is now a bomb.

Chapter 5

LOG ENTRY: SOL 38

I'm still cowering in the rover, but I've had time to think. And I know how to deal with the hydrogen.

I thought about the Atmospheric Regulator. It pays attention to what's in the air and balances it. That's how the excess O₂ I've been

importing ends up in the tanks. Problem is, it's just not built to pull hydrogen out of the air.

The regulator uses freeze-separation to sort out the gasses. When it decides there's too much oxygen, it starts collecting air in a tank

and cooling it to 90 kelvin. That makes the oxygen turn to liquid, but leaves the nitrogen (condensation point: 77K) still gaseous. Then it stores the O₂.

But I can't get it to do that for hydrogen, because hydrogen needs to be below 21K to turn liquid. And the regulator just can't get

temperatures that low. Dead end.

Here's the solution:

Hydrogen is dangerous because it can blow up. But it can only blow up if there's oxygen around. Hydrogen without oxygen is

harmless. And the regulator is all about pulling oxygen out of the air.

There are four different safety interlocks that prevent the regulator from letting the Hab's oxygen content get too low. But they're

designed to work against technical faults, not deliberate sabotage (bwa ha ha!).

Long story short, I can trick the regulator into pulling all the oxygen out of the Hab. Then I can wear a spacesuit (so I can breathe) and do whatever I want

without fear of blowing up. Yay!

I'll use an O2 tank to spray short bursts of oxygen at the hydrogen, and make a spark with a couple of wires and a battery. It'll set the

hydrogen on fire, but only until the small bit of oxygen is used up.

I'll just do that over and over, in controlled bursts, until I've burned off all the hydrogen.

One tiny flaw with that plan: It'll kill my dirt.

The dirt is only viable soil because of the bacteria growing in it. If I get rid of all the oxygen, the bacteria will die. I don't have 100

billion little spacesuits handy.

It's half a solution anyway.

Time to take a break from thinking.

Commander Lewis was the last one to use this rover. She was scheduled to use it again on Sol 7, but she went home instead. Her

personal travel kit's still in the back. Rifling through it, I found a protein bar and a personal USB, probably full of music to listen to on the drive.

Time to chow down and see what the good Commander brought along for music.

LOG ENTRY SOL 38 (2)

Disco. God damn it, Lewis.

LOG ENTRY: SOL 39

Well I think I've got it.

Soil bacteria are used to winters. They get less active, and require less oxygen to survive. I can lower the Hab temperature to 1C, and

they'll nearly hibernate. This sort of thing happens on Earth all the time. They can

survive a couple of days this way. If you're wondering how bacteria survive long periods of cold on Earth, the answer is they don't. Bacteria further underground where it was warmer breed

upward to replace the dead ones.

They'll still need some oxygen, but not much. I think a 1% content will do the trick. That leaves a little in the air for the bacteria to

breathe, but not enough to maintain a fire. So the hydrogen won't blow up.

But that leads to yet another problem. The potato plants won't like the plan.

They don't mind the lack of oxygen but the cold will kill them. So I'll have to pot them (bag them, actually) and move them to a rover.

They haven't even sprouted yet, so it's not like they need light.

It was surprisingly annoying to find a way to make the heat stay on when the rover's unoccupied. But I figured it out. After all, I've got nothing but time in here.

So that's the plan. First, bag the potato plants and bring them to the rover (make sure it keeps the damn heater on). Then drop the Hab

temperature to 1C. Then reduce to O2 content to 1%. Then burn off the hydrogen with a battery, some wires, and a tank of O2.

Yeah. This all sounds like a great idea with no chance of catastrophic failure.

That was sarcasm, by the way.

Well, off I go.

LOG ENTRY: SOL 40

Things weren't 100% successful.

They say no plan survives first contact with implementation. I'd have to agree. Here's what happened:

I summoned up the courage to return to the Hab. Once I got there, I felt a little more confident. Everything was how I'd left it (what did I expect? Martians looting my stuff?)

It would take a while to let the Hab cool, so I started that right away by turning the temperature down to 1C.

I bagged the potato plants, and got a chance to check up on them while I was at it. They're rooting nicely and about to sprout. One

thing I hadn't accounted for was how to bring them from the Hab to the rovers.

The answer was pretty easy. I put al of them in Martinez's spacesuit. Then I dragged it out with me to the rover I'd set up as a

temporary nursery.

Making sure to jimmy the heater to stay on, I headed back to the Hab.

Buy the time I got back, it was already chily. Down to 5C already. Shivering and seeing my breath condense in front of me, I threw on

extra layers of clothes. Fortunately I'm not a very big man. Martinez's clothes fit over mine, and Vogel's fit over Martinez's. These shitty clothes were designed to be worn in a temperature-controlled environment. Even with three layers, I was stil cold. I climbed in to my bunk and under the covers for more warmth.

Once the temperature got to 1C, I waited another hour, just to make sure the bacteria in the dirt got the memo that it was time to take it slow.

The next problem I ran in to was the regulator. Despite my swaggering confidence, I wasn't able to outwit it. It *really* does not want to pul too much O2 out of the air. The lowest I could get it to was 15%. After that, it flatly refused to go lower, and nothing I did mattered. I had al these plans about getting in and reprogramming it. But the safety protocols turned out to be in ROMs.

I can't blame it. Its whole purpose is to *prevent* the atmosphere from becoming lethal. Nobody at NASA thought "Hey, let's alow a fatal lack of oxygen that wil make everyone drop dead!"

power to the regulator.

I may not be able to reprogram the regulator, but I can turn the bastard off completely.

The Hab has emergency flashlights in many locations in case of critical power failure. I tore the L.E.D. bulbs out of one and left the two frayed power wires very close together. Now when I turned it on I got a small spark.

Taking a canister of O₂ from Vogel's suit, I attached a strap to both ends and slung it over my shoulder. Then I attached an air line to the tank and crimped it with my thumb. I turned on a very slow trickle of O₂; a small enough that it couldn't overpower the crimp.

Standing on the table with a sparker in one hand and my oxygen line in the other, I reached up and gave it a try.

And holy hell it worked! Blowing the O₂ over the sparker, I flicked the switch on the flashlight and a wonderful jet of flame fired out of the tube. The fire alarm went off, of course. But I'd heard it so much lately I barely noticed it any more.

Then I did it again. And again. Short bursts. Nothing flashy. I was happy to take my time.

I was elated! This was the best plan ever! Not only was I clearing out the hydrogen, I was making more water!

Everything went great right up to the explosion.

One minute I was happily burning hydrogen; the next I was on the other side of the Hab and a lot of stuff was knocked over. I

stumbled to my feet and saw the Hab in disarray.

My first thought was "My ears hurt like hell!"

Then I thought "I'm dizzy," and fell to my knees. Then I fell prone. I was *that* dizzy. I groped my head with both hands, looking for a head-wound I desperately hoped would not be there. Nothing seemed to be amiss.

But feeling all over my head and face revealed the true problem. My oxygen mask had been ripped off in the blast. I was breathing

nearly pure nitrogen.

The floor was covered in junk from all over the Hab. No hope of finding the medical O2 tank. No hope of finding anything in this mess

before I passed out.

Then I saw Lewis's suit hanging right where it belonged. It hadn't moved in the blast. It was heavy to start with and had 70L of water in it.

Rushing over, I quickly cranked on the O2 and stuck my head into the neck-hole (I'd removed the helmet long ago, for easy access to

the water). I breathed a bit until the dizziness faded, then took a deep breath and held it.

Still holding my breath, I glanced over to the spacesuit and Hefty bag I'd used to outsmart the regulator. The bad news is I'd never

removed them. The good news is the explosion removed them. Eight of the nine intakes for the regulator were still bagged, but this one

would at least tell the truth.

Stumbling over to the regulator, I turned it back on.

After a two second boot process (it was made to start up fast for obvious reasons) it immediately identified the problem.

The shrill low-oxygen alarm blared throughout the Hab as the regulator dumped pure oxygen in to the atmosphere as fast as it safely

could. *Separating* oxygen from the atmosphere is difficult and time consuming, but *adding* it is as simple as opening a valve.

I clambered over debris back to Lewis's spacesuit and put my head back in for more good air. Within three minutes, the regulator had

brought the Hab oxygen back up to par.

I noticed for the first time how burned my clothing was. It was a good time to be wearing three layers of clothes. Mostly the damage

was on my sleeves. The outer layer was gone. The middle layer was singed and burned clean through in places. The inner layer, my own

uniform, was in reasonably good shape. Looks like I lucked out again.

Also, glancing at the Hab's main computer, I see the temperature rose to 15C. Something very hot and very explodey happened, and I

wasn't sure what. Or how.

And that's where I am now. Wondering what the hell happened.

After all that work and getting blown up, I'm exhausted. Tomorrow I'll have to do a million equipment checks and try to figure out

what blew up, but for now I just want to sleep.

I'm in the rover again tonight. Even with the hydrogen gone, I'm reluctant to hang out in a Hab that has a history of exploding for no

reason. Plus, I can't be sure there isn't a leak.

This time, I brought a proper meal, and something to listen to that isn't disco.

LOG ENTRY: SOL 41

I spent the day running full diagnostics on every system in the Hab. It was incredibly boring, but my survival depends on these

machines, so it had to be done. I can't just assume an explosion did no long-term damage.

I did the most critical tests first. Number one was the integrity of the Hab canvas. I felt pretty confident it was in good shape, cause I'd spent a few hours asleep in the rover before returning to the Hab, and the pressure was still good. The computer reported no change

So I had to use more a more primitive plan.

The regulator uses a different set of vents for air sampling than it does for main air separation. The air that gets freeze-separated comes in through a single large vent on the main unit. But it samples the air from nine small vents that pipe back to the main unit. That way it gets a good average of the Hab, and prevents one localized imbalance from throwing it off.

I taped up eight of the intakes, leaving only one of them active. Then I taped the mouth of a Hefty-sized bag over the neck-hole of a

spacesuit (Johanssen's this time). In the back of the bag, I poked a small hole and taped it over the remaining intake.

Then I inflated the bag with pure O₂ from the suit's tanks. "Holy shit!" the regulator thought, "I better pull O₂ out right away!"

Worked great!

I decided I not to wear a space suit after all. The atmospheric pressure was going to be fine. All I needed was oxygen. So I grabbed an

O₂ canister from the medical bay. That way, I had a hell of a lot more freedom of motion. It even had a rubber band to keep it on my face!

Though I did need a spacesuit to monitor the actual Hab oxygen level (The Hab's main computer was convinced it was 100% O₂).

Each spacesuit knew how to monitor its own internal air, of course.

Let's see... Martinez's spacesuit was in the rover. Johanssen's was outwitting the regulator. Lewis's was serving as a water-tank. I

didn't want to mess with mine (hey, it's custom fitted!). That left me three spacesuits to work with.

I grabbed Vogel's suit and activated the internal air sensors while leaving the helmet off. Once the oxygen dropped to 12% I put the

breather mask on. I watched it fall further and further. When it reached 1% I cut