MISSION HAWKING

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REQUEST FOR PROPOSAL

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1.1 Function and Infrastructure

1.1.1 Part 1

1. Terrain

Land Fertility:

Land fertility is highly dependant of the soil chemistry of the planet. If you take many samples of the comparisons of soil fertility on various locations on Earth, its main factor is climate. The climate directly correlated with the topsoil depth, because drier climates force water to undergo calcification, that brings up more minerals from the deeper levels of the crust. This in turn makes a thicker topsoil, that is more suitable to growing crops. Wetter climates force leeching to occur, which creates large amounts of water to leach through the topsoil down into the bedrock levels. This water leaching takes away essential soluble nutrients, creating a non-desirable environment.

Since the extreme conditions of temperature will be difficult to work around, we plan on conducting soil pH testings and take soil samples to see nutrient levels/concentrations. The nutrients we will be testing for will include, but are not limited to: nitrogen, phosphorus, potassium, calcium, and iron. If these tests prove positive, we will have a window of opportunities to grow crops in a controlled environment on the planet, inside the base.

Soil Chemistry:

The three major nutrients that we will be looking for in the chemistry will be nitrogen, phosphorus, and potassium. These macronutrients are some of the key essential nutrients that vegetation require. However, on top of all this, a pH test will be vital as it determines the solubility of certain compounds, nutrients, and the availability of micro-organism interaction.

We will be referring to Laboratory Methods of Soil Analysis (Manitoba link) to conduct our experiments, that will all be done in the set research base on the planet. These collection of methods include, but are not limited to: the Kjeldahl method of contained nitrogen in ammonia and organic substances, analysis for Ca, Mg, Na and K ions using NH_4OAc, potentiometric methods to determine pH levels[3], automated pH titration for determining HCO_3^- and CO_3^- ions, potentiometric titration for determining Cl^- and SO_4^- ions, and redox titration for determining organic carbon.

Water Content:

Miniature mass spectrometry machines will be used. If water content is observed to be in range for plant growth and the other soil characteristics match, we may be able to use the soil from the planet to grow food. However, this is highly unlikely. If there is a significant amount of water in the soil or we land near a deposit of water, possibly in the form of ice due to the low atmospheric pressure, we can utilize pressure to pull the water out of the soil. This water can then be used for other vital needs in our base, or to supplement water recycling.

Capacity for Vegetation:

The capacity for vegetation in the planet's natural environment will heavily depend on natural vegetation and soil quality. If natural vegetation is found, then we will send samples back to Earth on manned missions, and be analyzed in a better lab facility to see its nutrient values and potential contributions to the daily diet. We will also monitor these plants in the facilities to study their species.

If said soils can produce environments for plants, then we shall experiment to see if they can grow known species of flora back on Earth.

Mineral Surface Composition:

There are few minerals in particular that we would like to check for. Oxides and carbonates can help contribute to carbon dioxide scrubbing. To test for oxides and carbonates, we can first dissolve as much soil into water as possible. We then use a potentiometric pH meter to detect the pH of the solution. If it is basic, that means there are soluble metal oxides in the soil. We may then boil down the solution and add it to our carbon dioxide scrubbing mixture. If neutral or acidic then the soil likely does not contain any usable metal oxides and this method of replenishing carbon dioxide scrubbers is not viable.

2. Energy

Solar:

Our usage of solar energy will be variant depending on the path of the storm, and its proximity to the poles. If the storm is near the poles, we can easily set up solar arrays near the equatorial areas, which will be prone to more sunlight. The temporary silt and dust created by the passing storms should not then affect said solar arrays, as it would follow the jetstream.

If it is the contrary, the locations of the panels must be modified to accustom the tilt of the planet and its seasonal changes, to maximize efficiency. This depends on which hemisphere we decide to land, and how close our base will be to the storm pathing. The main caution we will exercise is the shading sensitivity, as the PV solar panels are very sensitive to shading, because its series circuits can be easily disrupted with small amounts of shading. Calculations to see best locations that aren't interfered with the planetary rings will be done.

Wind:

Wind turbines are very volatile, because of its sheer size of turbines that conflict with transport. If we do happen to have budget costs to have transport of big wind turbines, we will plant them in an area where the power of the storm can be maximized. Wind will also be our primary source of power, because it is much more efficient than solar arrays.

By satellite mapping of the storm route patterns, we can potentially set up wind farms along the paths, where there will be a balance between energy production and safety. The types of models we will be using are HAWT (horizontal axis wind turbines) that are equipped with 3 blades. This blade configuration will spread the torque evenly along the blades, reducing chances of break and failure when receiving large winds. This also makes use of all portions of one cycle, meaning we will have maximum efficiency.

Geothermal heat:

The usage of geothermal heat will primarily be for the temperature maintenance of the facilities. Direct geothermal heating can come from circulating heat pumps. We will also be taking advantage of the Peltier[1] effect, to create thermoelectric cooling and heating. This method will not consume electricity that can be used for other things. Since the method can be instantaneously switched from cooling to heating, it will be fitting to the drastic temperature drops both the storm and the average climate can bring.

These devices that use the Peltier effect will be put in through the walls and various locations that will provide even temperature within the facilities. The Peltier effect isn't the most efficient in terms of heating options, however, it will still be more advantageous because of its factor of little maintenance and little moving parts. The setup will be easy for the researchers.

3. Atmosphere

Air Composition:

To first study the atmospheric composition, we can use a spectrometer to detect certain light frequencies that have not been reflected back to Earth. Using certain light signatures, we can then detect the elements that are composed in the atmosphere and land. Along with this, we can also determine what the immediate surface of the planet will have, using similar methods with a spectrometer. This will all be done using satellites and other machinery from Earth and imagery sent from initial satellites in phase 1 (refer timeline).

Gas Chemistry:

Using a GC/MS[2], otherwise known as Gas Chromatography Mass Spectrometry, we can determine the exact composition of the atmosphere to very precise amounts.

Weather and Climate:

Using geostationary weather satellites that are deployed in orbit before actual landing onto the planet, we can observe the patterns of the storm while also using thermal sensors to find areas of warm and cold on the planet.

We can also detect ammonium hydrosulfide using GC/MS techniques to see when a storm is coming. We will likely use Miniature Mass Spectrometers to detect ammonium.

Solar Storm Shielding:

Main protection from solar storms will come from Planet XVIII's own magnetic field. However, in such cases there will be a thin lead layer in the shells of the base.

1.1.2 Part 2

1. Life Supporting Systems

Air

Air will likely be generated and recycled using carbon dioxide scrubbers and oxygen releasers, an example of which is Lithium peroxide. It can capture CO_2 and release oxygen making it very mass efficient in terms of oxygen content. Cheaper alternatives that may supplement this include sodium hydroxide or calcium oxide. If calcium oxides are present in the soil, they may be used to scrub carbon dioxide as well. Generally, there should be shipments of new lithium peroxide every 6 weeks if water cannot be found in the soil. If water can be found in the soil, we can efficiently utilize electrolysis to extract oxygen from it. Humidity control will also be in place, with AWGs capturing water that escapes from the human breath.

After the greenhouse has been constructed, the plants can conduct photosynthesis and contribute to air recycling.

Foods

Most of the preliminary foods for the researchers will all be pre packaged and sent on supply missions to the site on Planet XVIII. However, after a transition period of 1-2 years, the researchers will have then created necessary crop environments for raising their own crops. Before these growable crop seeds are sent, our facilities on Earth will genetically modify simple and efficient foods to grow in gravity-variant environments, such as on board the now-expanded ISS. On the journey and on the ground, researchers will ingest vitamin and mineral supplements such as vitamin D, calcium, and protein powder. Freeze dried foods will also be sent.

Once arable soils and a greenhouse has been built, we shall send these seeds to observe their growth in their new environments. While this is happening, researchers on the planet will determine if new vegetation are edible and can contribute to the human diet. To ideally create an environment, we will use methods such as nitrogen fixation and UV lighting to have optimal growing areas.

Preliminary goals of food farming will involve potatoes, and creating an artificial atmosphere inside the greenhouse to be moist air.

Water

To ensure that the first couple of weeks will go on without water complications 440 pounds of water will be brought along on the trip.

Since we cannot know from the given if there is good water conditions on the planet, this section will focus primarily on the methods of recycling and purification. Many of the following techniques will already come from the working-processes in the ISS.

The primary water output that will be recycled is urine. The urine will be recycled by using a low pressure distillation method to compensate for the low atmospheric pressure, and the lower gravity on the planet. After this distillation process, other wastewater from humidity and outside sources will come in and go into treatment. This treatment will catch physical unwanted objects and go through a series of filters. The water that then comes out is exposed to high heat and UV sterilization, which will then be available for the researchers to consume.

These filters that will be sent will be the ones that are in current use in space shuttles and stations currently. We may send more, depending on how much treatment is needed for the outside water.

If water is in the atmosphere, extraction and purification will be done using multiple Zvezda modules modified for surface usage. During the storm, the modules will be lowered into the ground and covered with a plastic sheet cover nailed to the ground. During that time water stored in backup tanks will be used. Furthermore, the water will be filtered using several material filters and a catalytic oxidation reactor. This method will be also used with the ventilation system to filter out excess humidity and sweat inside the base.

Physical & Mental Healthcare

Personnel attending the base will be under a strict exercise schedule to reduce the effects of muscle degradation. There will be an exercise facility that is composed of several aerobic machines along with several anaerobic facilities such as a sprinting track. Additionally, there will be several strength machines that will reduce the effect of the muscle atrophy the researchers suffere. In addition to the machines, when the researchers first arrive they will all be required to wear a posture correcting device to ensure that the effect of the journey to the planet will be reversed as quickly as possible. The training schedule when the researchers first arrive would be to strengthen their legs while also using a suit to help them cope with the gravity on the planet. During the majority of the mission the researchers will be subjected to many aerobic exercises such as running on treadmills or stationary biking. The anaerobic exercises will mainly focus on strengthening the muscles using weights, machines, and sprints.

To treat bacterial and viral infections on the base. There will be a quarantined area that will be dedicated to treating the sick. At all times there will be at least one surgeon on the base along with antibiotics and sophisticated natural medicines. There will also be quarantine suits to enter and exit the quarantine area. This area will contain surgery equipment, and other equipment.

In order to lower the chances of psychological damage on personnel stationed at the base the resource shipments from earth will include comfort items such as chocolate and magazines. They will have access to media downloaded by NASA personnel. To combat feuds on the base there will always be at least 1 researcher who has a degree in psychology to help work things out and calm people down. In order to reduce the feelings of isolation the researchers will be split up into groups. These groups will be encouraged to eat together, elect group leaders, and have meetings at the end of each week to address issues and productivity. Researchers that are in a relationship with each other will have priority to be the in the first group on the planet. Before couples are sent to the planet, they will be asked to fill out a questionnaire if they would be willing to use contraceptives on board the base if they would engage in sexual activities. If they were to reply in the negative, there will be strict rules on sexual interactions. Condoms will be worn at all time for sexual interactions as sexually transmitted infections native to the planet may infect them. Originally, there will be 10 people, those 10 people will be people that have developed good relations while they were training. After that, every 2 years a new population of 10 people will be added to the base population allowing for people to get to know new people thus reducing the feeling of isolation.

2. Infrastructure and Navigation Systems

Housing

The housing of the researchers will be connected dome-like structures that are made of many layers. The first major layer will act as a protection against the outside environment. This will be mainly composed of a sublayer of titanium nitride covering a thinner layer of titanium plating. Between this layer and the second layer there will be a layer of X-Flex wallpaper to reinforce the first layer and second layer. The second major layer will be mainly composed of radiation proofing material such as lead and demron.

The third layer will be insulation which will mainly compose of mylar and kevlar. The next layer will have many Peltier plates that will help regulate temperatures inside the rooms. Inner layers will have insulators that will help trap heat, and the last layer will be composed of plastic with ventilation vents every couple of metres.

For heating, we can use the thermal battery and peltier plates. As the temperature is significantly different from night to day, it is possible to store thermal energy in the battery and then release it when necessary. This cannot satisfy all the thermal needs, but it can supplement the peltier system.

The construction will primary be done all at once, with cargo depositing missions occuring before we send the researchers into the planet. This construction will be conducted by the drones and rovers that can be controlled back from planet Earth.

Power Sources

Our primary sources of power will be coming from solar arrays and wind, for electric equipment. Heating and temperature regulation will come from peltier plates that utilize the temperature difference outside to heat, and other methods such as geothermal batteries and geothermal heat pumps. Power will be stored in diamond batteries[4] , because they last longer than that of the conventional nickel-cadmium and lithium-ion ones. Those battery cells will be powered by decaying nuclear waste. This nuclear waste will not be harmful, as it only releases beta rays. A standard diamond battery will output around 15.8MJ, and will be used for all backup and emergency equipment. It will also be used when wind and solar are not available for usages. However, we will still use lithium-ion rechargeable batteries as our main power source.

Waste Management

Urine will be recycled through distillation systems, as well as other waste waters from oral hygiene, and showers. This was further explained in the water sections of this document.

Feces will be stored into containers, where the gases will be extracted and the feces will be stored in bags that have no air. Gas extraction can then go to filters that can help contribute to the inside environment. This waste will then be stored later for fertilization uses and other biodegrade uses.

Human waste combined with outside water sources will also be used to create hydrogen gas[5], through processes that use electrochemical reactors. This reactor will break down both water and human excretes to output hydrogen gas and fertilizer- an idea presented by Professor Hoffmann, Professor of Environmental Sciences at Caltech. Using his method, we can store hydrogen gas in fuel rods for return journeys by spacecraft. This can even help create more water, by accessing potentially existent oxygen within the atmosphere.

Transportation

Our entire trip will consist of six phases.

Phase 1 and 2 will be about gathering as much data as possible without manned missions, as long as the delivery of the main resources to construct a base. The location of base will be dependant on storm pathing and patterning, which can all be observed from satellites. Following in suit of Tesla's new Falcon Models of reusable rockets, we plan to send equipment to Planet XVIII and have the ships return via swing by of the planet. This will save resources and further lower the budget.

Phase 3, 4, 5, and 6 will begin the gradual introduction of humans into the base. These will have a staggered introduction system, with 10 people each year being added. Since it is the year 2150, we can assume that we will have a reliable, low cost way to get into orbit, so we will decrease the costs for getting into orbit.

As for local transportation, there will be a garage of rovers that are available to the researchers. All the domes of the hub will be interconnected, by a central main chamber. All movement of equipment and people will be recorded in a cloud drive log that can be both accessed by the researchers and the team back on Earth.

Payload Materials

Let's assume that One rocket will approximately be able to deliver 140 tons of cargo. This leaves lots of room for phase 1 to deliver drones and other form of robotics. These robots will be equipped with other raw material, including framework, power collecting devices, and recycling devices that are pre-created in our facilities. The second rocket delivery for phase 1 will include more specialized robotics to better craft and finish up the pressure chambers and other digging/construction for the base. Before this, there will be a launch wave of satellites that will map out climate and other patterns of features, and determine best possible landing spot.

The second phase payloads will contain human transport and more research equipment. Food, water, and oxygen will all be included in this part of phase 2.

The next phases will supply the rockets with samples, bring back samples, modified GMOs, and other products that the researchers need for research and healthcare.

3. Telecommunications Systems

Necessary Satellites

Reconnaissance Orbiting Satellites will be sent along through phase 1. Following models that have been used to explore other planets of similar size, our models will be based off of the MAVEN space probe and other JPL supervised satellites.

For recon, we can use the Planet ™ satellites, which are cheap and can image the surface of the planet to spot storms and viable landing sites.

Communication on Planet XVIII

Communication throughout the hub can be done using a Wi-Fi like approach, with several routers linked up together throughout the hub system allowing for full access to the network. This network allows the crew members to see current conditions outside, observe crucial machinery, and control things such as humidity, temperature, and pressure. It also allows for real time communications to other crew members.

Communication back to Earth

Transmissions can first be transmitted to orbiting satellites. They will then be able to use ultra high frequency transmitters to send the information to Earth. The frequency can be expected at around 1GHz.

1.2 Timeline

Jan 2151- Start of mission

Mar 2151- Satellites arrive and survey the planet for good landing spot

Apr 2151- First drones land and observe atmospheric and soil conditions, check for resources

Jan 2152- Basic life support and habitation is complete

June 2152- All systems have been built and the base can now support all 50 people

Jan 2153- First 10 people arrive, along with shipments to support them for 2 years (water, oxygen, food, seeds), people arrive to plant seeds in hydroponic chambers

Jan 2154- Conduct experiments on planet which they want to do

2155- 10 more people arrive to the base

2156- Expand plant base and resource management. Expand base to accommodate 10 more people

2157- 10 more people are added to base

2158- Expand plant base and resource management. Expand base to accommodate 10 more people

2159- 10 more people are added to base

2160- Expand base to fit last group of 10 people

2161- Last group of 10 people arrive, will be staying for 1 year

1.3 Technical Risks

There are a couple of priorities when it comes to risk trade off. Main essential parts of the operation involves power sources, storm protection, food growth, and missions timing.

We chose to have our primary source of power from wind over solar, because it is the most reliable and least variant in its efficiency. However, the efficiency of these wind turbines will be variant with storm pathing. But, wind will almost be guaranteed throughout the entire day because of the jetstream that the storm will follow. This is why our solar arrays will act as our secondary source. Solar will be effective, as the solar panels can be placed in such a way so that the dust from the storms will have minimal effect. The base will be positioned in a location where solar arrays will not be affected, while still taking advantage of the storms geothermal capacities. Solar is a familiar and progressed technology so we decided to use it. Solar array demands have also been so high in 2150 that the prices were very low.

Storm protection would be mainly provided by the architectural designs of the base. The base will be composed of partial underground segments, that will not receive direct wind from storms. We chose to have an underground facility rather than a ground level one, because it would be economically advantageous for repairs and amounts of material that is needed to be brought.

Food growth will be given around 8 years to completely self-sustain. The first 5 years or so, there will be constant shipments from Earth containing foods and further-modified GMO seeds. By year 8, there should be a sustaining greenhouse facility. The primary risk is that the seeds will not grow in its new environment. However, we are confident that 8 years of clinical time will be enough to create a sustaining greenhouse full of arable crops.

Mission timing and launch deadlines will be met with alterable speeds on our main cruiser. We are confident in our ability to match our calculations.

2.0 Finance

2.1 Mission Budget

~**80** billion for construction

~**25** billion for human missions

~**2** billion for “robot” and “unmanned” missions

~**1** billion for satellites

~**5** billion annually per ten people for follow up, **150** billion over 10 years

Total : 257 billion USD

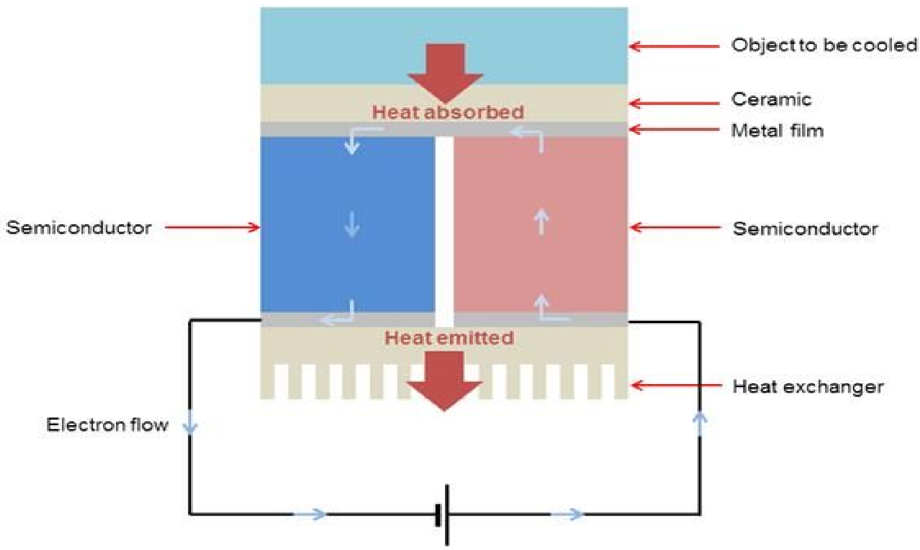
2.2 Budget Justification

The first portion of the budget is the cost of establishing the base. The **80** billion comes from creating the framework of the base, excavating the site, building the different portions of the base, accomodations for research facilities and stations, water/waste/power systems, life support/food systems, and living quarters and recreational areas. Significant impacts from design decisions is that the researchers who arrive are setting up for permanent residence instead of preparing to return to Earth. However, the extended time, and the fact that the base must accommodate for 50 people also impact the cost. The **25** billion comes from the human missions and research. This accounts for the cost of training the researchers, wages, and the cost of sending the researchers to the planet. The **2** billion comes from unmanned, robot missions. This accounts for the cost of building and designing the robots and sending them to the planet to survey. The **1** billion comes from the cost of building the survey satellite and the communication satellite as well as sending them into space. In addition, we also accounted for **5** billion per person per year, to cover the cost of further follow up missions and maintenance. We based the estimations of the costs off current estimations of missions to send people to space, such as the Mars One mission.

3.0 Appendix

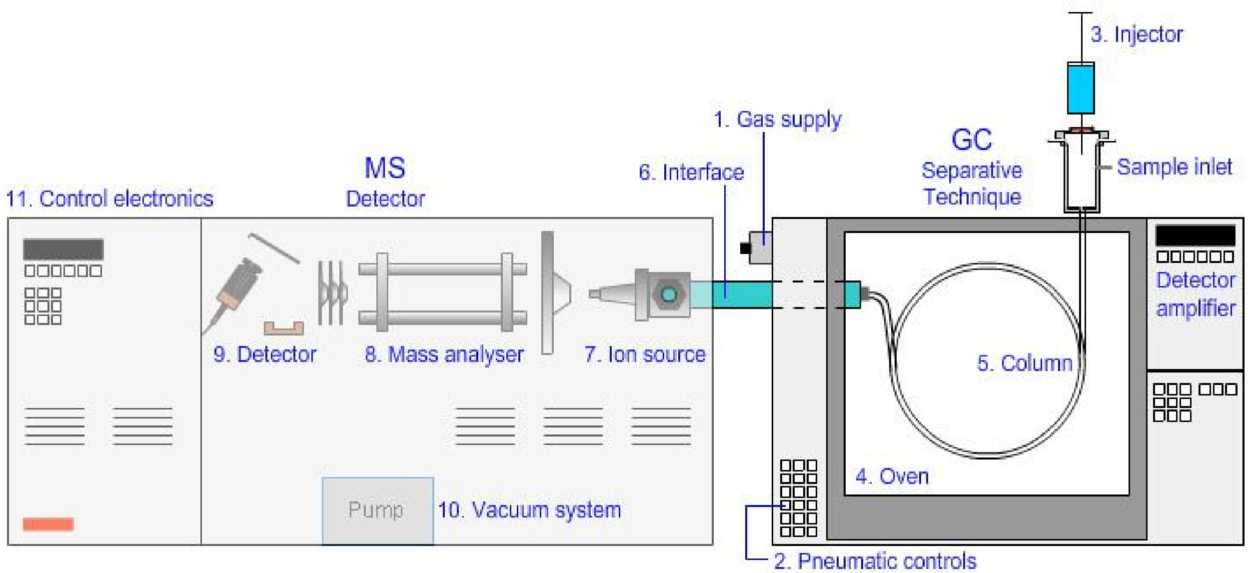
1. Peltier effect

Source: Website designed and developed by Zarr - http://www.zarr.com. (n.d.). The Peltier effect – a 'cool technology' for thermal desorption. Retrieved from https://www.markes.com/blog/The-Peltier-effect-a-cool-technology-for-thermal-desorption.aspx



A typical Peltier cooling 'couple'. Many of these are arranged side-by-side to form a Peltier cooler.

2. GC/MS



Source:

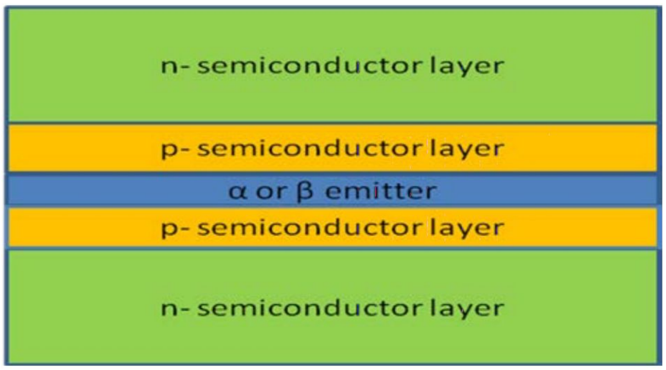
http://www.chromacademy.com/resolver-november2010_understanding_gcms_part_1.html

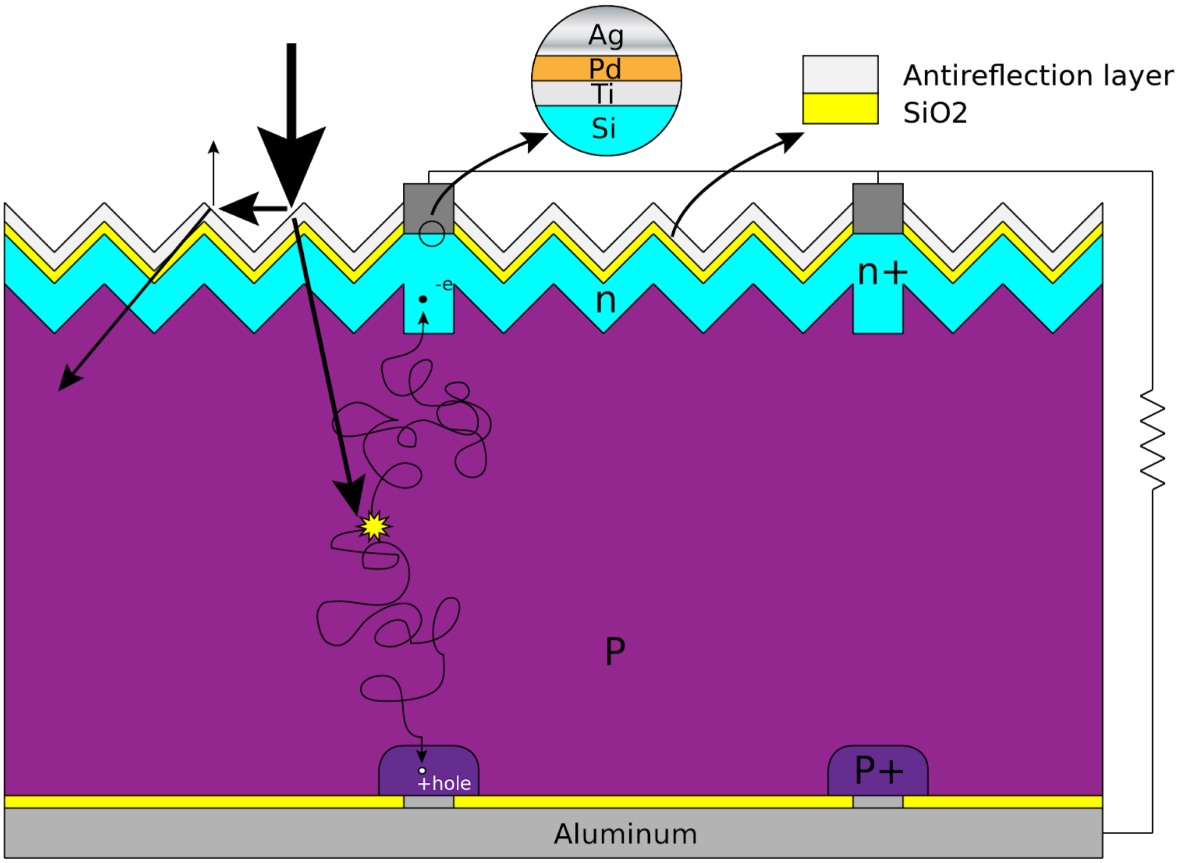
3. NH_4Ac extraction

   http://sis.agr.gc.ca/cansis/publications/manuals/1984-30/84-005-extractable-Ca-Mg-K.pdf

4. Diamond Batteries

   http://large.stanford.edu/courses/2017/ph241/lanham2/





5. Hydrogen Gas from Feces

Source:

https://www.youtube.com/watch?gl=US&hl=en&client=mv-google&v=eVQaMsvBLb8&nomobile=1

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