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| **Document Guidelines**   * Please make every attempt to write text in present tense where applicable. * **[IDRD]** indicates the field is required for the Increment Definition and Requirements Document Annex 5: Payload Tactical Plan, Table 3.0. * ***Please note: After Baseline, a CEF must be submitted in order to change an [IDRD] field.*** * **[nasa.gov]** indicates the field appears on the website <http://www.nasa.gov/iss-science/>. * To check a box: double click > default value = checked > ok. * Submit completed form to the RPWG. |

**Investigation/Research Common Data**

**(Required for All Investigations)**

**Investigation Name [IDRD] [nasa.gov]:** NanoRacks – Duchesne- Plant Growth Chamber

**Investigation Title [nasa.gov]:** NanoRacks –Duchesne – The effects of Microgravity and Light Wavelength on plant growth in an Ardulab

**OpNom [nasa.gov]:** NanoRacks Module-

**Principal Investigator:** If there are additional Principal Investigators, please copy, paste, and fill in for each Principal Investigator.

* **First Name [nasa.gov]:** Kathy
* **Last Name [nasa.gov]:** Duquesnay
* **Email:** kathy.duquesnay@duchesne.org
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* **Mailing Address:** 10202 Memorial Dr., Houston, Tx 77024
* **Credentials (M.D., Ph.D., M.S., etc.) [nasa.gov]:** M. Ed.
* **Institution [nasa.gov]:** Duchesne Academy of the Sacred Heart
* **Investigator Location [nasa.gov]:** TX, USA
* **Institution Type:**

Academia

Government

Industry

Military

Nonprofit

Space Agency

**Co-Investigator/Collaborator:** If there are additional Co-Investigators/Collaborators, please copy, paste, and fill in for each Co-Investigator/Collaborator.

* **First Name [nasa.gov]:**
* **Last Name [nasa.gov]:**
* **Email:**
* **Phone [(###) ###-####]:**
* **Mailing Address:**
* **Credentials (M.D., Ph.D., M.S., etc.) [nasa.gov]:**
* **Institution [nasa.gov]:**
* **Investigator Location [nasa.gov]:**
* **Institution Type:**

Academia

Government

Industry

Military

Nonprofit

Space Agency

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| --- | --- |
| **Person publically credited as source of this** | Kathy Duquesnay |
| **information:** | **First Name Last Name** |

**Contact:**

* **Primary Contact responsible for scientific content of this form:**
  + **First Name:** Kathy
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  + **Email:** kathy.duquesnay@duchesne.org
  + **Phone [(###) ###-####]:** 713-468-8211 ext 286
* **Secondary Contact**:
  + **First Name:**
  + **Last Name:**
  + **Email:**
  + **Phone [(###) ###-####]:**

**Developer(s) [nasa.gov]:** NanoRacks LLC, Houston, TX 77058, USA.

**Sponsoring Space Agency [IDRD] [nasa.gov]:** Space agency responsible for the implementation of the investigation.

Canadian Space Agency (CSA)

European Space Agency (ESA)

Japan Aerospace Exploration Agency (JAXA)

National Aeronautics and Space Administration (NASA)

Roscosmos

**Sponsoring Organization [nasa.gov]:** *NASA Investigations Only -* Official name of the NASA organization responsible for sponsoring the research for flight.

Human Exploration and Operations Mission Directorate (HEOMD)

Italian Space Agency (ASI)

NASA Education (EDU)

National Laboratory (NL)

National Laboratory - Department of Defense (NL-DoD)

National Laboratory - Department of Energy (NL-DOE)

National Laboratory - National Institute of Standards and Technology (NL-NIST)

National Laboratory - National Institutes of Health (NL-NIH)

National Laboratory - National Science Foundation (NL-NSF)

National Laboratory - U.S. Agency for International Development (NL-USAID)

National Laboratory - U.S. Department of Agriculture (NL-USDA)

National Laboratory Education (NLE)

Science Mission Directorate (SMD)

Technology Demonstration Office (TDO)

**Research Benefits [nasa.gov]:** Does the research have potential benefits in the following areas? (Choose all that apply.)

Earth Benefits

Scientific Discovery

Space Exploration

**Increment(s) [IDRD] [nasa.gov]:** Inc 39/40

**Number of Investigations:** (*Increment Specific*) One.

**PAO Summary (“Research Objectives” in IDRD) [IDRD] [nasa.gov]:** This experiment will test the effect of combinations of red and blue wavelengths of electromagnetic radiation on a small fast growing plant such as pea or broccoli shoots. We can start these plants from seeds and they will be placed in a 10 cubic centimeter Ardulab and grown in a microgravity environment.

**Research Overview [nasa.gov]:** Bulleted list slightly more detailed than the PAO summary, written on the 8th grade level. The Research Overview should highlight why the research is needed, what the research accomplishes, and what the impact of the research is. Information is used in the Research and Planning Working Group (RPWG) Planning process and Crew Briefings.

* This experiment uses a standard 1.0 U (10 cm x 10 cm x 10 cm) ArduLab in a NanoRacks Module containing red and blue LED lights, 2 cameras, broccoli and pea seeds in Phytoblend agar with nutrients as the growth media
* The payload is automated; it will utilize the standard NanoRacks Platform plug-n-play operations for power and data.
* *NASA has used white, green, and red lights in the past; this is one of the reasons we have decided on these colors. Red LED lights have been proven by NASA to cause the plants to have a “higher concentration of anthocyanin, an antioxidant that can combat some of the effects of cosmic radiation” (LED Lights Used in Plant Growth Experiments for Deep Space Missions). Another NASA study concluded that green lights are also beneficial to plants. NASA believes the light is important because of the positive effects, like an increase of antioxidants, can have on the plants.*
* *A space experiment called VEGGIE, short for plant growing system about the size of a microwave oven, to be sent onto the ISS on Dec. 9 2013. The experiment called for red and blue LED lights for photosynthesis to take place and to make experiments. LED lights are being used because of their long lifetime.*
* *From October 2009 to September 2010, scientists grew a garden of thale cress on ISS in an experiment called ADSVAC, which tested the Advanced Astroculture Plant Growth Chamber. Scientists genetically modified these plants to under how stress in a zero gravity environment was affecting the plants. When they genetically modified the plants, it allowed them to glow when they were unhappy. This was helpful because it meant they could examine the plant without dissecting it.*
* *In 2010, the ISS was sent plants called Arabidopsis thaliana or Thale Cress. These plants were used to study how plant roots developed in a weightless environment. These plants were grown on a nutrient-rich gel in clear petri plates. These plants showed familiar root growth patterns where roots slant progressively as they branch out. Researchers have always thought that direction of growth was the result of gravity's effects on root tip growth. Others think that in microgravity, other factors take over that enable the plant to direct its roots away from the seed and light-seeking shoot. Those factors could include moisture, nutrients, and light.*

**Space Applications [nasa.gov]:** This experiment will be important so that plants with high nutrition can be effectively and rapidly grown on the ISS and on future long duration flight. We propose to identify the combination red and blue LEDs that will induce the most rapid growth.

**Earth Applications [nasa.gov]:** This experiment will have the potential of helping to understand how to grow nutritious vegetables using minimal light energy, nutrients, and space. These results can be put to use in various locations throughout the world.

**Category [IDRD] [nasa.gov]:** The investigation is classified within **one** research category.

**Subcategory [nasa.gov]:** The investigation is classified within **one** research subcategory.

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|  | **Biology and Biotechnology** | | |
|  |  | Animal Biology – Invertebrates | Microbiology |
|  |  | Animal Biology – Vertebrates | Microencapsulation |
|  |  | Cellular Biology | Plant Biology |
|  |  | Macromolecular Crystal Growth | Vaccine Development |

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|  | **Earth and Space Science** | | |
|  |  | Astrobiology | Earth Remote Sensing |
|  |  | Astrophysics | Heliophysics |

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|  | **Educational Activities and Outreach** | | |
|  |  | Classroom Versions of ISS Investigations | Educational Demonstrations |
|  |  | Commercial Demonstrations | Engineering Education |
|  |  | Cultural Activities | Student-Developed Investigations |
|  |  | Educational Competitions |  |

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|  | **Human Research** | | |
|  |  | Bone and Muscle Physiology | Human Microbiome |
|  |  | Cardiovascular and Respiratory Systems | Immune System |
|  |  | Crew Healthcare Systems | Integrated Physiology and Nutrition |
|  |  | Dental Health | Nervous and Vestibular Systems |
|  |  | Habitability and Human Factors | Radiation Impacts on Humans |
|  |  | Human Behavior and Performance | Vision |

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|  | **Physical Science** | | |
|  |  | Combustion Science | Fundamental Physics |
|  |  | Complex Fluids | Materials Science |
|  |  | Fluid Physics |  |

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|  | **TBD: To Be Defined Based on Selected Science Objectives** |

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|  | **Technology Development and Demonstration** | | |
|  |  | Air, Water and Surface Monitoring | Power Generation/Distribution Systems |
|  |  | Avionics and Software | Propulsion Systems |
|  |  | Characterizing Experiment Hardware | Radiation Measurements and Shielding |
|  |  | Communications and Navigation | Repair and Fabrication Technologies |
|  |  | EVA Systems | Robotics |
|  |  | Fire Suppression and Detection | Small Satellites and Control Technologies |
|  |  | Food and Clothing Systems | Space Structures |
|  |  | Imaging Technology | Spacecraft and Orbital Environments |
|  |  | Life Support Systems and Habitation | Spacecraft Materials |
|  |  | Microbial Populations in Spacecraft | Thermal Management Systems |
|  |  | Microgravity Environment Measurement |  |

**Hardware Description [IDRD]:** (*Increment Specific*) NanoRacks Module-41 P/N NRP-10041, S/N 1001: a 10 x 10 x 10 cm module for standard power/data interface with the NanoRacks Platform for USB power and data transfer. Utilizes a ArduLab structure and electronic interface

**Unique Payload Constraints [IDRD]:** (*Increment Specific*) The experiment needs plugged into the NanoRacks Platform and powered-up for 30 days of operations (+/- week) before return.

**Imagery [nasa.gov]:** Submit images, drawings, and graphical data separately in a high resolution (1MB or larger) .jpg format with the completed Investigation Summary Form. Image caption should have a detailed description of the image contents, activity occurring in the image, a NASA number if available, names of the individuals in the image, and image credit information. The primary image is used for communication projects. Images of the investigation on the ISS will be added following operation.

**Primary Image Caption:** Diagram of NanoRacks Module-

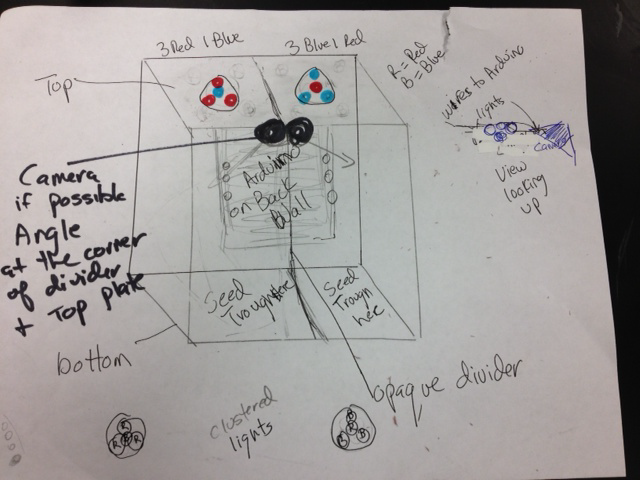
**Additional Image Caption 1:** 

Diagram of the experiment design

**Additional Image Caption 2:**

**Additional Image Caption 3:**

**Operations Location:** Indicates where the investigation is performed.

Ascent Only

Descent Only

ISS Internal

ISS External – Attached

ISS External – Deployed

Pre/Postflight

Sortie

**Brief Research Operations:** Brief bulleted summary of the operations and activities used to perform the investigation. Information is used in the Research and Planning Working Group (RPWG) Planning process and Crew Briefings. No more than 10 sentences.

* Destow
* Plug into one of the NanoRacks Frame-1 or 2 Module ports as soon after destowing as possible.
* Power up the Frame
* Operate for minimum 30 days (+/- week)\*
* Downlink data 3 times a week
* Destow from NanoRacks Platform Frame to pack for return to Earth on Space X5 (can we have it packed at 4 degrees Celsius for the return?

\*NOTE: This payload can be left in the active Frame and executed as long as needed until standard time to pack for return (i.e. no hard constraint for deactivation time).

**Previous Missions [nasa.gov]:** None

**Additional Information and Publications**

**(Optional for non-US Sponsored Investigations)**

**Detailed Research Description [nasa.gov]:** Provides a place for a more technical description of the objectives of an investigation aimed at an interdisciplinary scientific audience. Several paragraphs may be used. Technical terminology should be defined to ensure readability. This field may also include a brief description of hardware and any previous names associated with the investigation.

*The selection process for a nutritional, rapidly growing plant that could be easily grown from seeds led us to several vegetables commonly eaten as shoots. In their early stages of life, peas, popcorn shoots, broccoli shoots, and bamboo could be used as test subjects to observe the speed of growth under different wavelengths of light. Pea shoots contain high amounts of Vitamin A, B, C, E, calcium, chlorophyll, iron, magnesium, niacin, phosphorus, potassium, amino acids, and protein up to 25%. In additional to their nutritional values, they are also low in sodium, fat, and sugar. They can be harvested after only two to four weeks of growth, and have a seed shelf life of four to five years. Popcorn shoots also contain Vitamin A, B, C, E, calcium, chlorophyll, iron, lecithin, magnesium, pantothenic acid, phosphorus, potassium, trace elements, and around 30% protein. However, popcorn seeds only take between eight to twelve days to sprout. In addition to pea and popcorn shoots, bamboo shoots are also highly beneficial. Studies show that bamboo can prevent the production of cancerous cells, improve appetite and digestion, aid weight loss, and treat hypertension and hyperglycemia. The main nutrients include high levels of protein, amino acids, healthy fats and sugars, salt, and water contents. Broccoli sprouts are known for their antioxidant properties. They contain especially high amounts of sulfuraphane.*

*We are planning to use a combination of red and blue LED lights. According to our research, a mixture of red and blue lights provides the optimal wavelength to induce favorable plant growth.*

*Professor Allen Barker at University of Massachusetts Amherst stated that 450 and 650 nanometers are required for photosynthesis, and red light has wavelengths between 622 and 780 nm. Blue light has between 455 to 492 nm, and violet light has between 390 and 455 nm. Also between 650 and 730 nm wavelengths allow the plant to flower by influencing the phytochrome plant pigment.*

**Operational Requirements [nasa.gov]:** Defines constraints and requirements necessary to complete the investigation (number of subjects or observations, spacing of observations, downlink of data, return of samples, etc.).

Our largest constraint was the size 1 U (10cm x 10 cm x 10 cm) size of the Ardulab. We were also limited to the power provided by one USB connection. We were also limited by providing enough growth media for the seeds that they would thrive for the 30 days and not need to be watered during the experiment.

We will have data downlinked 3 times a week. The data will consist of 2 photographs( 1 per side since we have divided the Arulab in half) every 12 hours one taken just after the lights turn on and one taken just before the lights turn off.

We will need the samples returned so we can observe additional data that the photographs were unable to capture and compare the data to our concurrently running experiment here on Earth.

**Operational Protocols [nasa.gov]:** Descriptive overview of the investigation on orbit procedures.

Not sure if this is what you want

Destow

Plug into one of the NanoRacks Frame-1 or 2 Module ports as soon after destowing as possible.

Power up the Frame

Have the crew take one digital photograph of the Ardulab every 7 days as a back up to the data gathered by the cameras inside the Ardulab. These photos can be emailed or posted on a NASA web site for us to observe.

**Educational Impact:**

Will this investigation involve students (K-12, Undergraduate, Graduate), teachers, or schools?

Yes  No

**Educational Activities:**

Defines educational activities associated with the investigation and a brief description of student involvement.

The students have been the co-investigators, they did the back ground research included in this document. They used numerous design matrices and designed the experiment, they programmed the lights and cameras, they ran the practice experiments, and they determined the best way to gather the data. They have written summaries of the progress. They have designed a mission patch. They have acted both as the scientists and the engineers for this project and have learned first-hand what is involved in a project of this magnitude and importance.

**Websites [nasa.gov]:** www.ndcpilot.weebly.com

**Related Investigations:** Provide Investigation Names for current or past ISS investigations that have similar objectives.

*ADSVAC*

*LED Lights Used in Plant Growth Experiments for Deep Space Missions*

*VEGGIE*

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| **Project Type:** *NASA Investigations Only* - Indicates the primary source of project funding. | | |
|  | CASIS | NASA Research Announcement |
|  | Commercial | NASA Station Detailed Test Objective (SDTO) |
|  | Government Agency (non-NASA) | NASA Supplemental Medical Objective (SMO) |
|  | NASA Detailed Supplementary Objective (DSO) | Nonprofit |

**Grant Number:** If applicable, please provide the grant number.