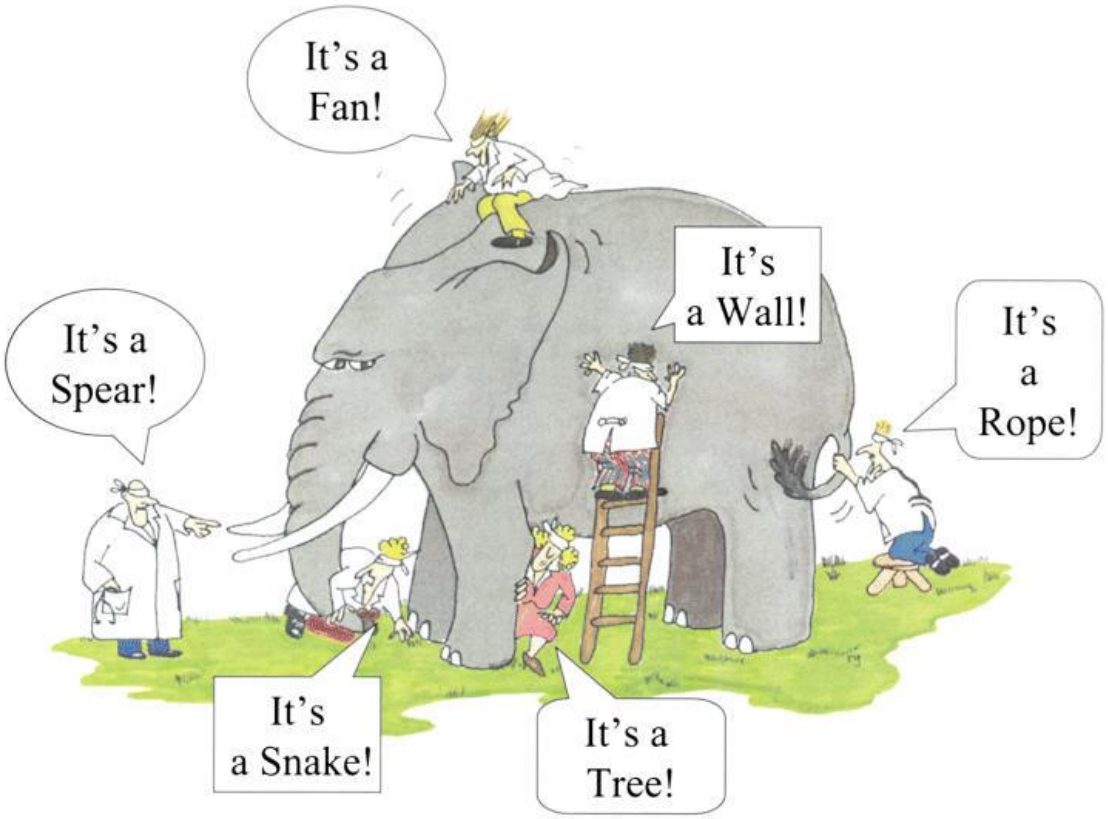
CONFORMATION OF THE INTERDISCIPLINARY TEAM "KILLALAB" AS A TOOL FOR ASTROBIOLOGY EXPERIMENTS

Ruth E. Quispe Pilco , Sofía Rodríguez Venturo , Rómulo Leoncio Cruz Simbrón, Jeffrey Ramírez Gramber , Víctor Vásquez Ortiz , Carlos Leonardo Julián, Julio Valdivia Silva, H. Saul Pérez-Montaño .

SCIENTIFIC SOCIETY OF ASTROBIOLOGY OF PERU

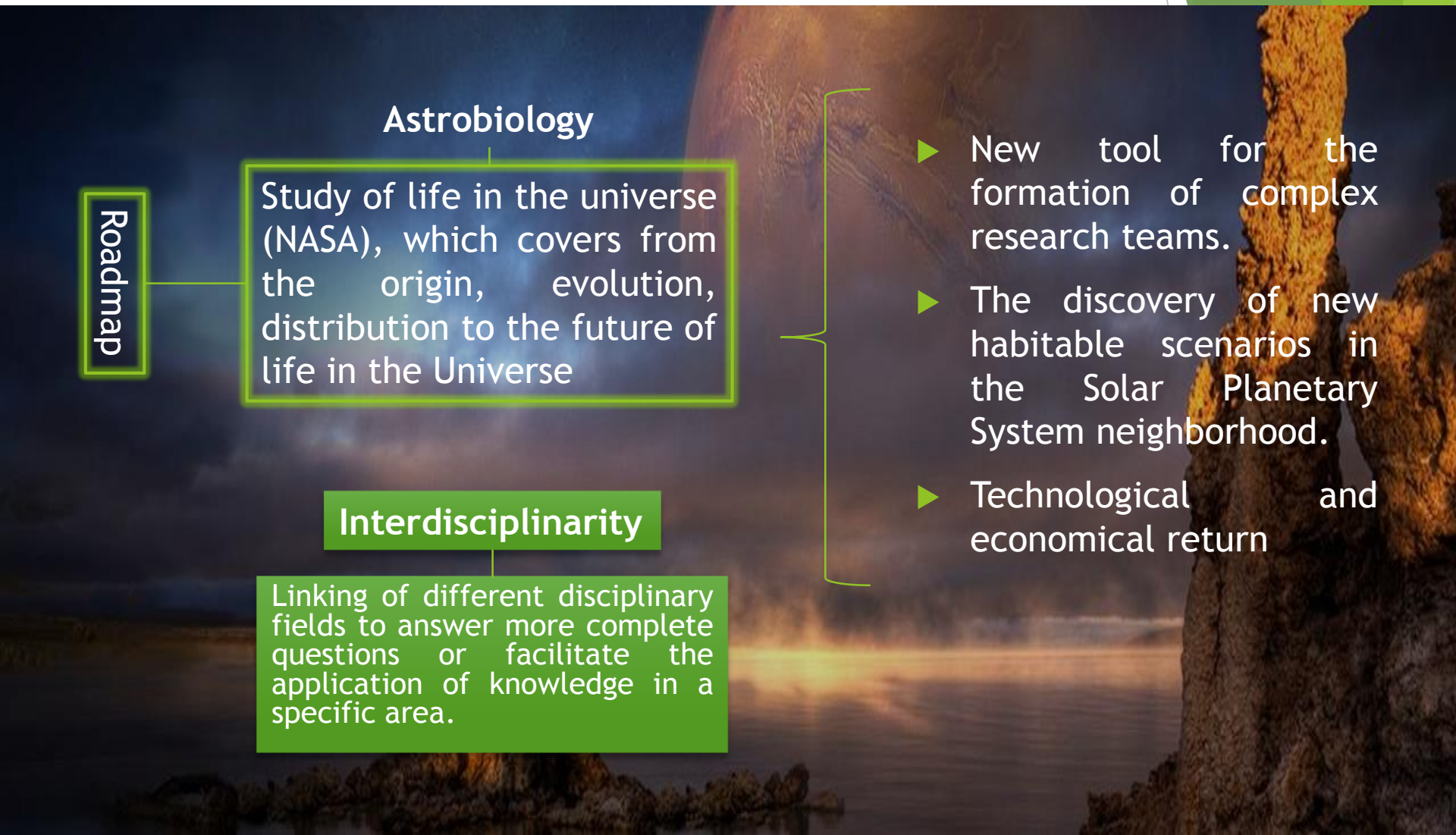
SCAP
SOCIEDAD CIENTÍFICA DE ASTROBIOLOGÍA DEL PERU
EXPLORACIÓN E INVESTIGACIÓN PARA LA CIENCIA EN EL PERÚ

Interdisciplinarity



- Is the integration of information, data, techniques, tools, perspectives, concepts and / or theories of two or more specialized disciplines to advance in the understanding of complex problems whose solutions are beyond the scope of a single research discipline.

The interdisciplinarity of astrobiology



Roadmap

Astrobiology

Study of life in the universe (NASA), which covers from the origin, evolution, distribution to the future of life in the Universe

Interdisciplinarity

Linking of different disciplinary fields to answer more complete questions or facilitate the application of knowledge in a specific area.

- New tool for the formation of complex research teams.
- The discovery of new habitable scenarios in the Solar Planetary System neighborhood.
- Technological and economical return

The interdisciplinarity of astrobiology

- At the beginning of 1988, astrobiology was not considered an interdisciplinary science.

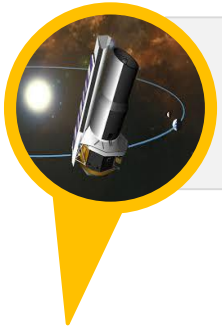
- SPACE MISSIONS: The interdisciplinarity of astrobiology has become known as inherent since it requires at least the conjunction of biologists, chemists, astronomers and engineers to address experiments that answer questions such as:

Can terrestrial microorganisms survive? the conditions of deep space?

The interdisciplinarity of astrobiology

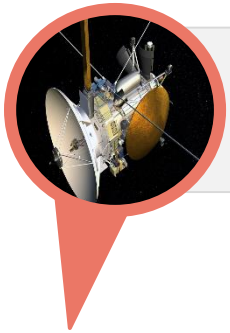
Start of the Viking I and II mission with the aim of searching for life on Mars.

1976



Launch of the Spitzer Space Telescope.

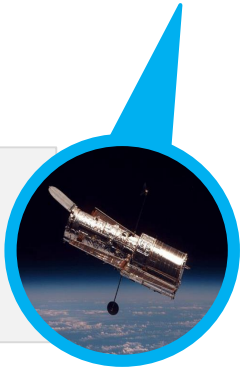
2003



Arrival of the Cassini probe to Titan. Interest in Titan's hydrocarbon oceans grows.

2005

1990

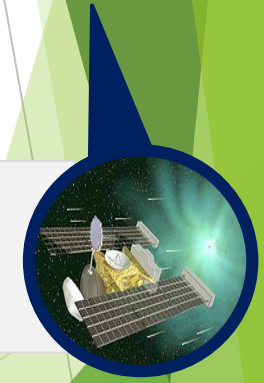


Hubble launch to Earth orbit and first photograph.

2004

Arrival of the Spirit and Opportunity rovers to Mars to study their possibility of harboring water..

2009



Return of a sample from an asteroid, Stardust mission.

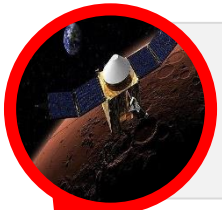
MULTIDISCIPLINARITY

INTERDISCIPLINARY EXECUTION

The interdisciplinarity of astrobiology

Discovery of the 1st planet Earth type Kepler-186f in a zone of habitability.

Amartizaje del Curiosity (Mars Science Laboratory)



Arrival of MAVEN to the orbit of Mars to study the past and present of its atmosphere.

Despertar de la Misión Awakening of the Rosette Mission upon reaching the asteroid with the Philae probe.

2011

2014

2019

2020

First observations of the ALMA observatory (Atacama Large Milimeter Array).

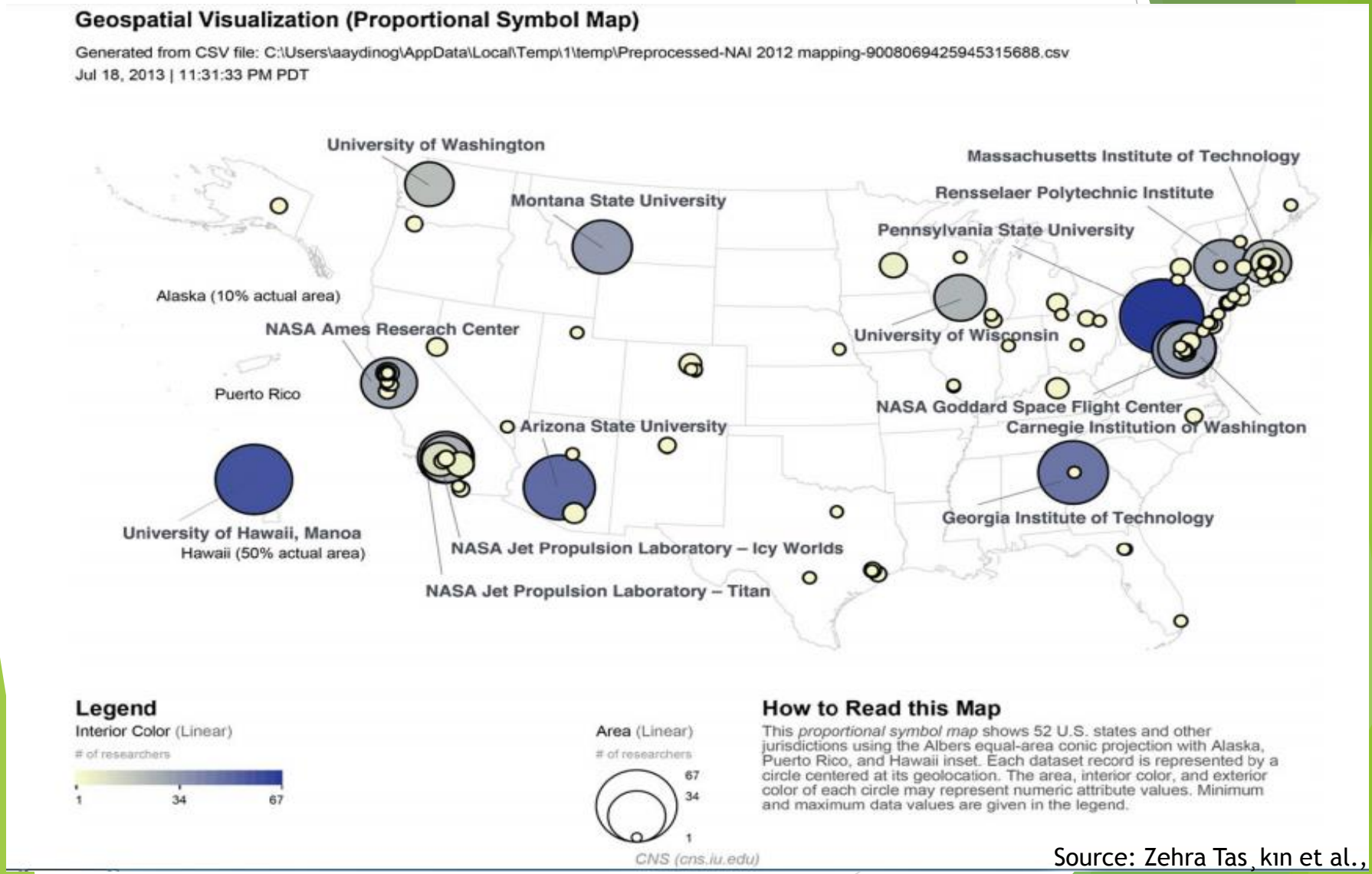
Launch of the James Webb Space Telescope to study the physical and chemical properties of planetary systems and investigate the potential of these systems.

Launch of the Mars 2020 mission to study its climatic and geobiological past

INTERDISCIPLINARY EXECUTION

The interdisciplinarity of astrobiology

NAI, as a representative institution of astrobiology and its interdisciplinary relations with other institutions



Source: Zehra Taş¸kın et al., 2014
Link: https://link.springer.com/article/10.1007/s11192-015-1576-8

IMPORTANCE OF INTERDISCIPLINARITY

Illustration by Dean Trippe.
Nature special: Interdisciplinarity

- The purpose of interdisciplinary research is to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single field of research practice.
- Applied to solve the great challenges facing society: energy, water, climate, food, health.
- Interdisciplinary collaboration has contributed to the evolution of new disciplines such as materials science in the 1980s, astrobiology and synthetic biology in the current decade (Lyall et al., 2012).

EXAMPLE OF BIBLIOMETRIC ANALYSIS

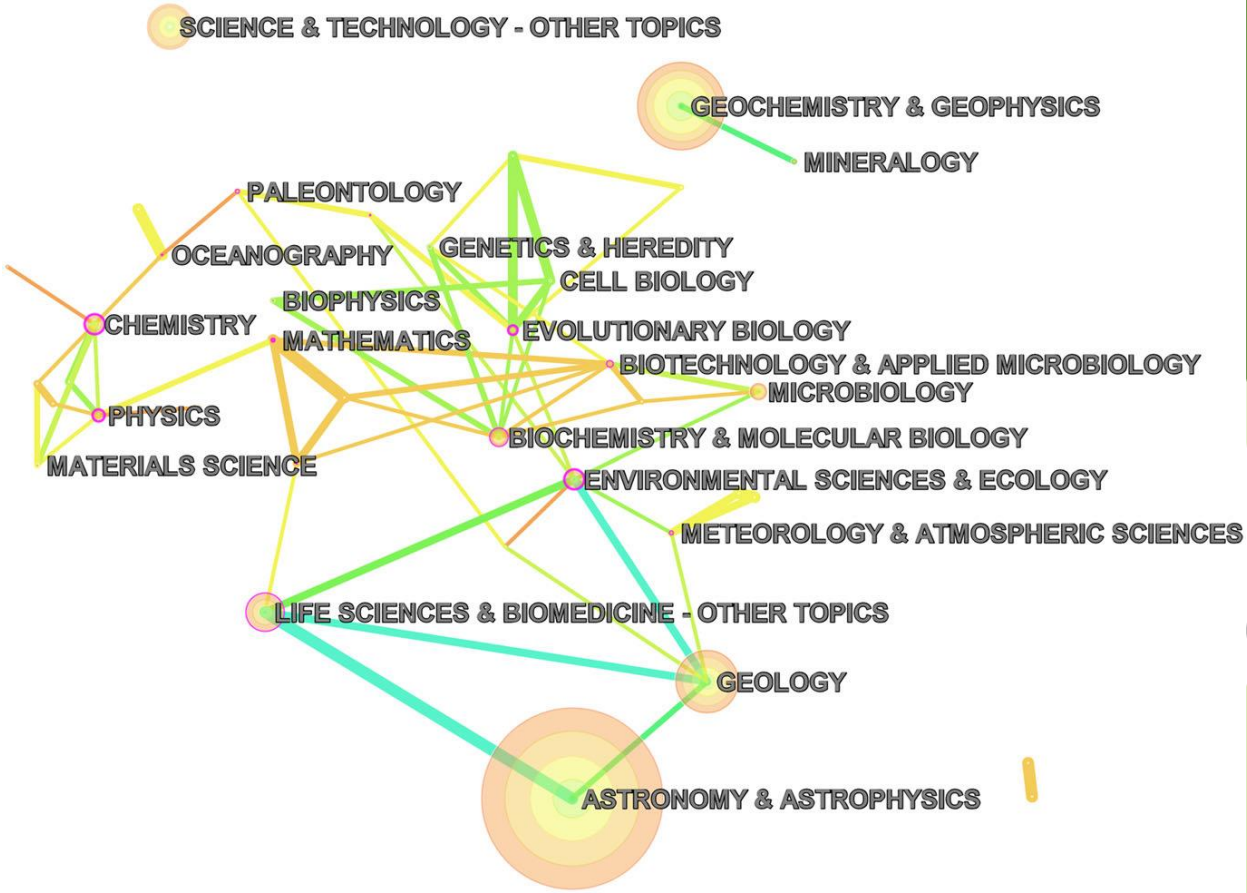
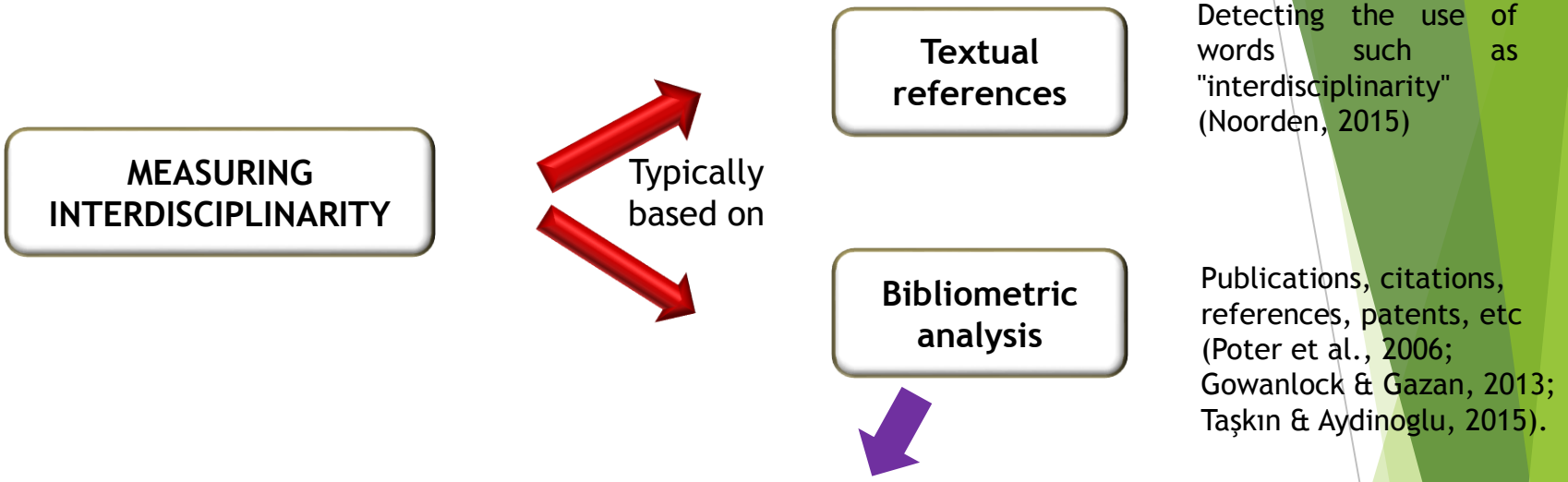


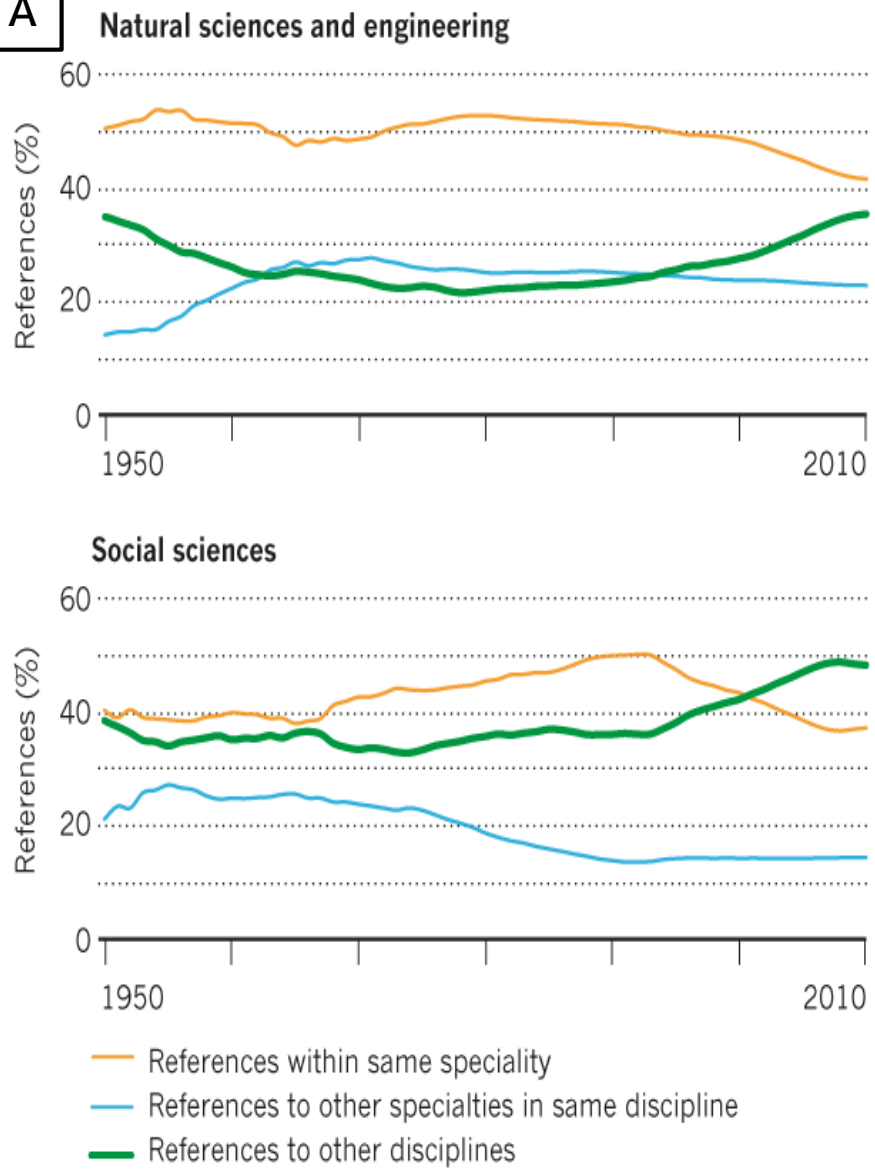
Fig. Network topology of journal categories based on NAI-funded publications [colors represent the year of publication or connection (orange 2012, yellow 2011, green 2010, light blue 2009, dark blue 2008). This work is an example of a bibliometric analysis and the production of interaction network maps. (Taşkın & Aydinoglu, 2015).

MEASURING INTERDISCIPLINARITY



EXAMPLE OF TEXTUAL REFERENCES

A

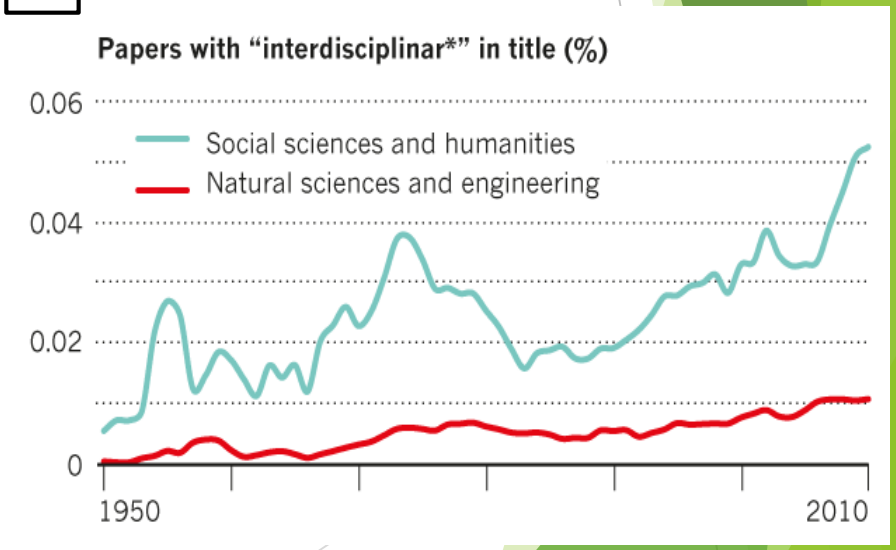


Interdisciplinary research is on the rise

A. The analysis shown used journal names to assign more than 35 million papers in the Web of Science to 14 major conventional disciplines (such as biology or physics) and 143 specialities. The fraction of paper references that point to work in other disciplines is increasing in both the natural and the social sciences.

B. The fraction of papers that mention interdisciplinarity in their title has fluctuated, perhaps reflecting the priorities of funders, but the twenty-first century saw that proportion reach an all-time high..

B



Source: V. Larivière & Y. Gingras in Beyond Bibliometrics (eds B. Cronin & C. R. Sugimoto) 187–200 (MIT Press, 2014)

Measuring interdisciplinarity in Astrobiology

KillaLAB

(Quechua Word Killa: Moon)

KILLALAB
Lab2Moon Peruvian Team

- ***Research settings:***

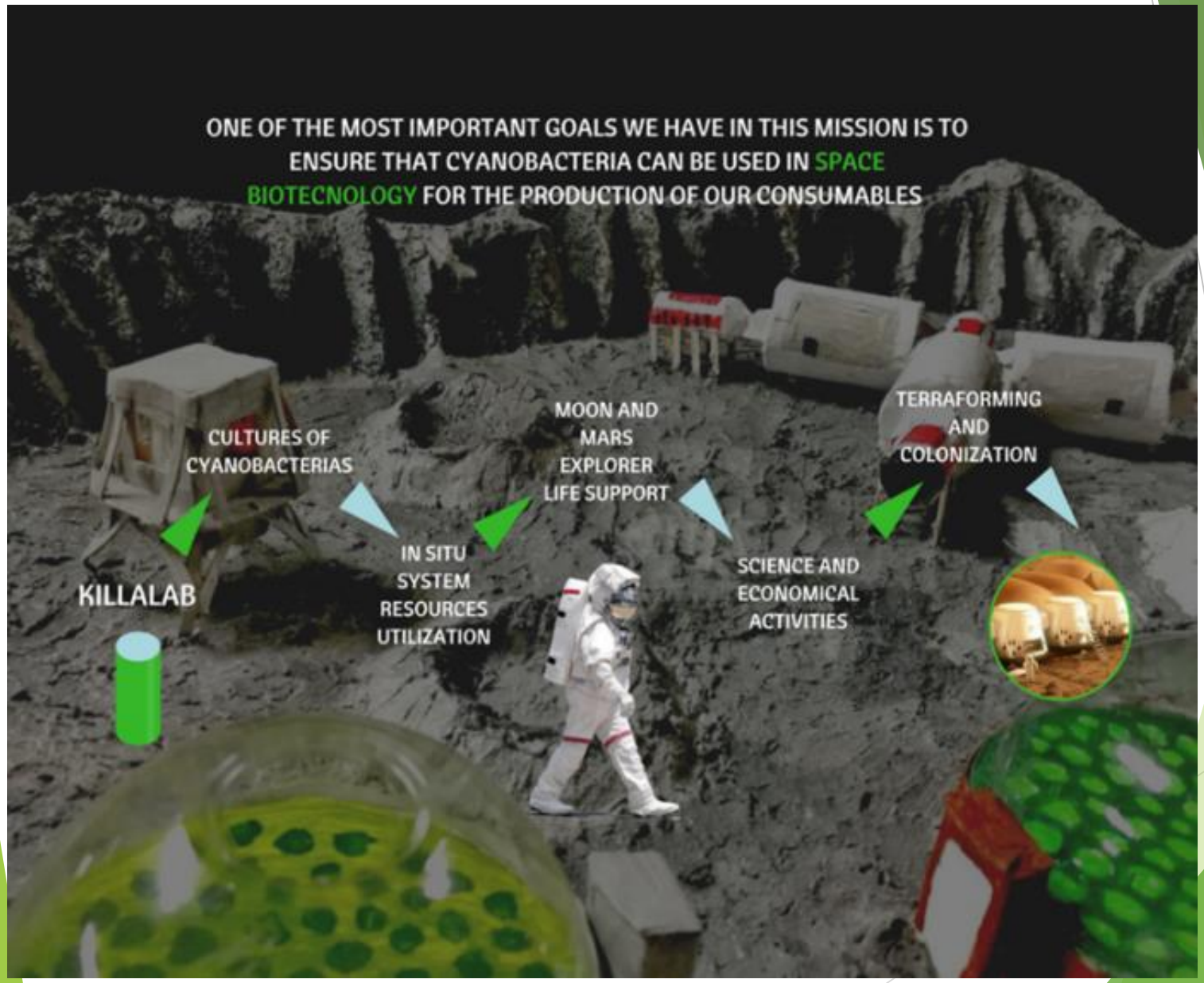
The Team Killalab, which develops a project in astrobiology, had to use techniques and processes from different disciplines to address the following goal: ¨To study the effects of radiation from the outer space environment on cyanobacterial biofilms isolated from the Peruvian high Andean ecosystems using an autonomous aerospace minilaboratory¨. The conformation of the team had the following considerations:

SCAP
SOCIEDAD CIENTÍFICA DE ASTROBIOLOGÍA DEL PERÚ
EXPLORACIÓN E INVESTIGACIÓN PARA LA CIENCIA EN EL PERÚ

1. **Team Killalab disciplines conformation:**

-Masters and PhD researchers and young graduates who some of them made their thesis with specific objectives from the general proposal.
- Chemistry, biology, physics, electronic engineering, mechanical engineering and computer science. The team was constituted with 13 members.
- Principal investigator (PI), whose function is to direct the team members to establish common specific objectives to the research by disciplines. The PI for interdisciplinary research can come from any discipline as long as it possesses the required experience relevant to the research objectives. In Killalab team, the PI came from science.
- Team meetings, important tool for communication and knowledge exchange. The maintenance of the approach and the execution were complemented with the establishment of deadlines for the research milestones.

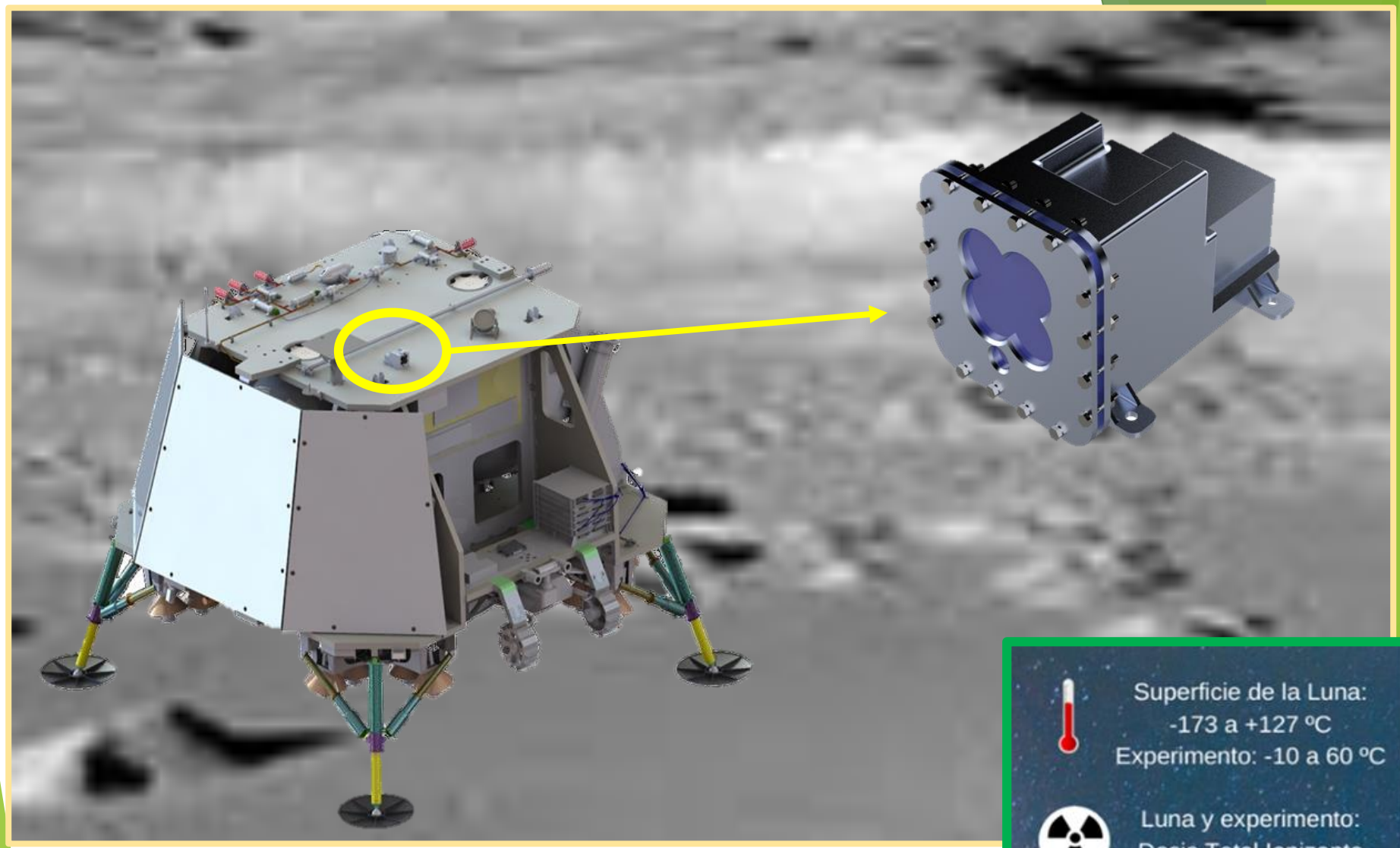
Perspective and context of Killalab research team



Interrelations between subjects of the Killalab interdisciplinary team.

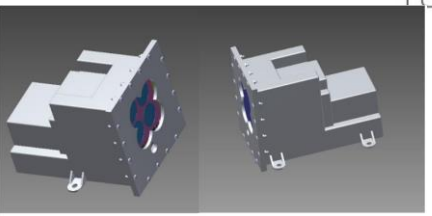
Discipline	Specific Goals
Biology	Study of the survival of cyanobacteria to the extreme conditions of space
Chemistry	Study of the chemical modification of the protective pigments of cyanobacteria
Physics	Evaluate physical conditions of the payload that can resist the total components
Electronic engineering	Design of the electronics of the payload (minilaboratory)
Mechanical engineering	Design the mechanics of the payload (minilaboratory).
Computer science	Get data from simulations and real ultraviolet radiation exposure in outer space.

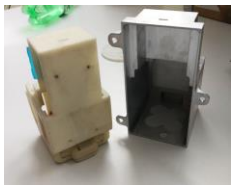
Table 1: Specific goals from each discipline involved in the team Killalab.



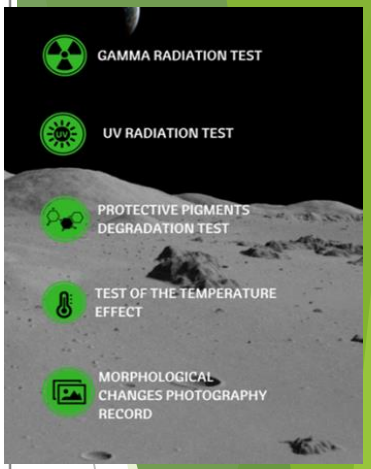
Space exposition (Enviromental conditions) to consider for each discipline

Interrelations between disciplines tasks of the Killalab interdisciplinary team.





MECHANICS	SCIENCES	ELECTRONICS	COMPUTER SCIENCE
	CONCEPT OF MISSION		
	PHASE A-DEVELOPMENT OF CONCEPT		
	Materials		
(M-1) Analysis of structural, thermal properties and machinability of materials	(S-1) Definition of environmental conditions of the mission from start to finish. (S-2) Analysis of biocompatibility, release of gases and chemical resistance of materials and biological samples. (S-3) A proposal for operating time.	(E-1) Proposal of materials for electronic components and thermal regulation requirements	
	Meeting for general approval		
	(Integrated Plan 1) Plan for the use of structural materials, support materials and the sample compartment		
	Sensors		
(M-2) Proposal for the design and evaluation of the compartment for sensors, biological samples and structural support.	(S-4) Selection of sensors for UV radiation, temperature (T) and humidity (H), ionizing radiation, DRIFT spectrophotometry, microimages. Conditions of use and optimal positioning of the sensors	(E-2) Review of processing limitations and electrical consumption of sensors. (E-3) Proposal of electronic components for PCBs. (E-4) Proposal of a circuit diagram.	(P-1) Determination of the communication protocol between sensors.
	General review for approval		
	(Integrated Plan 2) Plan for the use of sensors and various electronic components for the Killalab experiment		
	PHASE B-PRELIMINARY DESIGN		
	Sample compartment		
(M-3) Redesign of the sample compartment. (M-4) Hermetic seal design and mechanical interface.	(S-5) Sensor operation test	(E-5) Redesign of sensor board (UV and RADFET sensors).	(P-2) Data for UV exposure simulation
	Tests and vibroacoustic qualification		
(M-5) Thermal and vibration simulations in ANSYS and redesign of structural supports. (M-6) Environmental simulations of termovacio and radiation of mechanical components	(S-6) Experiment flowchart proposal (vibration ranges, detailed operation times, environmental conditions during the experiment.	(E-6) Resizing of sensor plates. (E-7) Test of operation of electronic components.(M-6) Environmental simulations of thermovance and radiation of electronic components.	(P-3) Proposal for programming the sensors.
	General review of operation		
	(Integrated plan 3) Manufacturing and assembly plan for mechanical and electronic components. Detailed operation plan of the mission.		
	PHASE C-FINAL DESIGN		
	FLIGHT MODEL		



- The tasks interactions that had the greatest impact on the realization of this stage were science-mechanics and mechanics-electronics followed by electronic-computer science. Likewise, it is important to mention that identifying all the areas of study and the related sciences and engineering allowed the focus on the main objective of the team and the experiment.

Interdisciplinarity of team Killalab.

Computer science

Physics

Microelectronics

Biophysics

Astrophysics

Programming

Vacuum environment

Microscopy

Mathematical modeling

Space radiation

Spectroscopy

Dynamics

Limits of Life

Electronic engineering

Biocompatibility

Bioprospecting

Robotics

Material science

Biochemistry

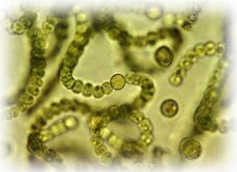
Microbiology

Mechanical engineering

Chemistry

Biology

Astrobiology



CONCLUSION AND REMARKS

- Astrobiology, which by its nature needs several disciplines, facilitated the formation of the Killalab interdisciplinary team that focused on solving how biofilms of microorganisms were affected after space conditions.
- The use of subject categories as a boundary discipline helped to identify the communication and interaction between the disciplines of team members in the framework of this qualitative research.
- The conformation characteristics of the team, such as communication through meetings to resolve knowledge gaps between disciplines, the respect between them and the order to establish the specific objectives and tasks of each discipline can help improve the implementation and effectiveness of interdisciplinary research or educational programs.

REFERENCIAS

1. Mazzocchi, F. (2019). Scientific research across and beyond disciplines: Challenges and opportunities of interdisciplinarity. *EMBO reports*, e47682.
2. Bililign, S. (2013). The need for interdisciplinary research and education for sustainable human development to deal with global challenges. *International Journal of African Development*, *1*(1), 8.
3. Stopar, K., Drobne, D., Eler, K., & Bartol, T. (2016). Citation analysis and mapping of nanoscience and nanotechnology: identifying the scope and interdisciplinarity of research. *Scientometrics*, *106*(2), 563-581.
4. Gowanlock, M., & Gazan, R. (2013). Assessing researcher interdisciplinarity: A case study of the University of Hawaii NASA Astrobiology Institute. *Scientometrics*, *94*(1), 133-161.
5. Lungeanu, A., Huang, Y., & Contractor, N. S. (2014). Understanding the assembly of interdisciplinary teams and its impact on performance. *Journal of informetrics*, *8*(1), 59-70.
6. Sephton, M. A. (2014). Astrobiology can help space science, education and the economy. *Space Policy*, *30*(3), 146-148.
7. Richter, D. M., & Paretti, M. C. (2009). Identifying barriers to and outcomes of interdisciplinarity in the engineering classroom. *European Journal of Engineering Education*, *34*(1), 29-45.
8. National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. 2005. Facilitating Interdisciplinary Research. Washington, DC: The National Academies Press
9. Aboelela, S. W., Larson, E., Bakken, S., Carrasquillo, O., Formicola, A., Glied, S. A., ... & Gebbie, K. M. (2007). Defining interdisciplinary research: Conclusions from a critical review of the literature. *Health services research*, *42*(1p1), 329-346.
10. Cornell, J. W. (2014). Mapping disciplinary relationships in Astrobiology: 2001-2012.

REFERENCIAS

11. Fischer, A. R., Tobi, H., & Ronteltap, A. (2011). When natural met social: a review of collaboration between the natural and social sciences. *Interdisciplinary Science Reviews*, *36*(4), 341-358.
12. Tobi, H., & Kampen, J. K. (2018). Research design: the methodology for interdisciplinary research framework. *Quality & quantity*, *52*(3), 1209-1225.
13. D. Des Marais, J. Nuth, L. Allamandola, A. Boss, J. Farmer, T. Hoehler, B. Jakosky, V. Meadows, A. Pohorille, B. Runnegar and A. Spormann, "The NASA Astrobiology Roadmap", Astrobiology, vol. 8, no. 4, pp. 715-730, 2008
14. Taşkın, Z., & Aydinoglu, A. U. (2015). Collaborative interdisciplinary astrobiology research: a bibliometric study of the NASA Astrobiology Institute. *Scientometrics*, *103*(3), 1003-1022.
15. Grotzinger, J. P., Crisp, J., Vasavada, A. R., Anderson, R. C., Baker, C. J., Barry, R., ... & Gellert, R. (2012). Mars Science Laboratory mission and science investigation. *Space science reviews*, *170*(1-4), 5-56.
16. Vasavada, A. R., Grotzinger, J. P., Arvidson, R. E., Calef, F. J., Crisp, J. A., Gupta, S., ... & Wiens, R. C. (2014). Overview of the Mars Science Laboratory mission: Bradbury landing to Yellowknife Bay and beyond. *Journal of Geophysical Research: Planets*, *119*(6), 1134-1161.
17. Yin, R. K. (2003). Case study research: Design and methods (Vol. 5).
18. Nielsen-Pincus, M., Morse, W. C., Force, J. E., & Wulfhorst, J. D. (2007). Bridges and barriers to developing and conducting interdisciplinary graduate-student team research. *Ecology & Society*.
19. Naiman, R. J. (1999). A perspective on interdisciplinary science. *Ecosystems*, *2*(4), 292-295.
20. Koch, L. C., & Rumrill Jr, P. D. (1998). The working alliance: An interdisciplinary case management strategy for health professionals. *Work*, *10*(1), 55-62.
21. VanWormer, A., Lindquist, R., Robiner, W., & Finkelstein, S. (2012). Interdisciplinary collaboration applied to clinical research: an example of remote monitoring in lung transplantation. Dimensions of Critical Care Nursing, 31(3), 202.

gracias