



SCIENTIFIC OBJECTIVES AND REQUIREMENTS

PSI#5:
SEARCH FOR LIFE

SCIENTIFIC INVESTIGATIONS

PSIs#5 are focused on the local scale to search for evidence of a potential biosphere within Europa

Science on the surface/subsurface

All JEM investigations that require surface measurements should be coordinated with the NASA Lander TM (this case is different to other PSIs that can be achieved from remote observations)



SCIENTIFIC INVESTIGATIONS

From Hand presentation, August 2016

(OPAG update)

Goal	Investigation
Search for evidence of life on Europa	Detect and characterize any organic indicator of past or present life
	Identify and characterize morphological and textural indicators of life
	Detect and characterize any inorganic indicator of past and present life
	Determine the provenance of sampled material
	Determine if living organisms persist in sampled materials (Not part of the threshold)
Assess the habitability of Europa via in situ techniques uniquely available to a lander mission	Characterize the non-ice composition of Europa's near-surface material and determine whether there are indicators of chemical disequilibrium and other components essential for life.
	Determine the proximity to liquid water at the lander's location
	Detect whether Europa is active today and characterize any observable surface exchange processes to support sample context.
Characterize surface properties at the scale of the lander to support future exploration	Characterize the biosignature preservation potential (BPP) of accessible surface materials at the landing site
	Characterize the surface dynamics of Europa at the landing site in all 3D
	Characterize the material properties of Europa at the landing site

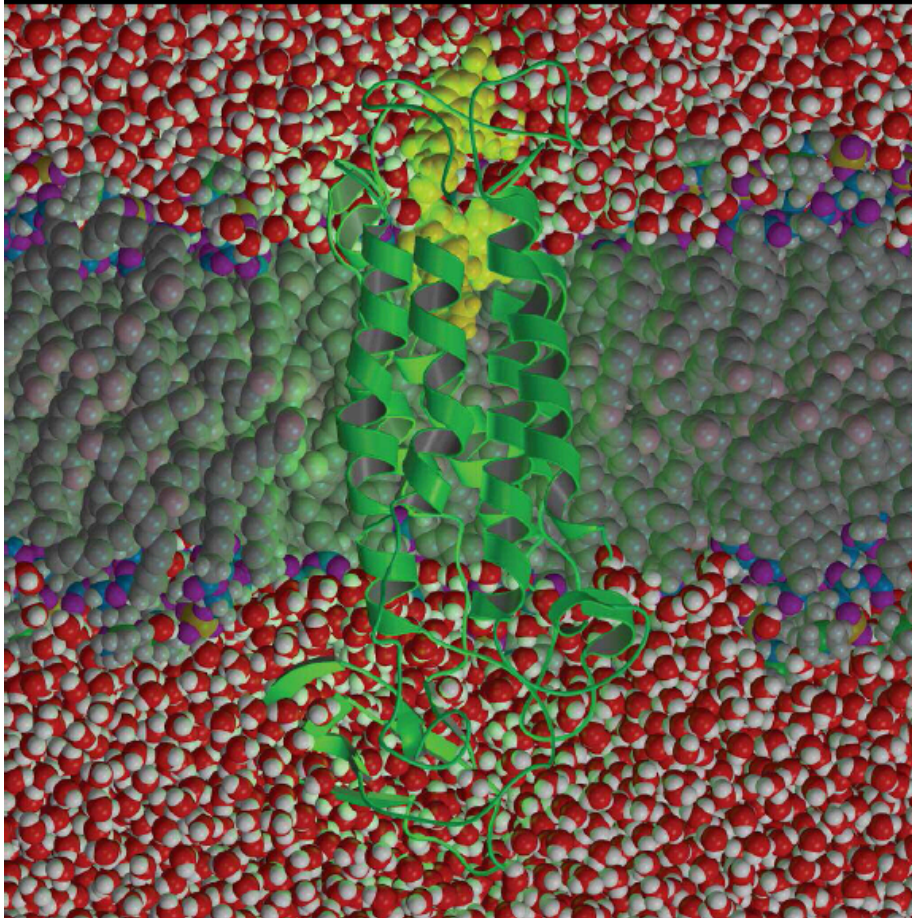
S
O
S
P S
SOP

Substance Object Pattern

FROM FORMATION TO SEARCH FOR LIFE

From Des Marais concepts applied to Mars

Lipid biosignature features & functions



Compound class
fatty acids **S**
membranes, cells **O**
M.W. distribution
n-C16 to n-C18 **P**
isoprenoids **S**
permeability
Complex molecules **S**
enhanced functions
Stable isotopes **P**
metabolism
ecology

Biosignature type: **Object** **Pattern** **Substance**

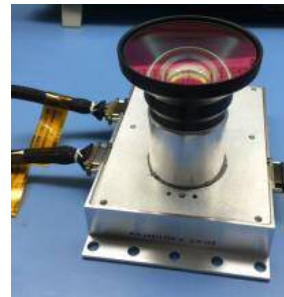
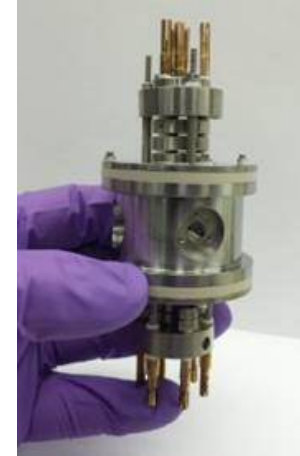
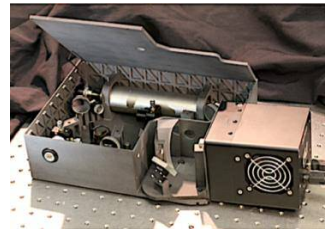


SCIENTIFIC INVESTIGATIONS

From Pappalardo presentation, March 2016

Model Payload (Total Mass 35 kg MEV)

- Centerpiece Instruments for Astrobiology
 - **GCMS**: VCAM GC + Ion Trap MS, 8.3 kg CBE
 - **Raman**: SHERLOC 5.4 kg CBE
- Auxiliary Instruments
 - **Context LanderCams (x2)**, 0.5 kg each CBE
 - **Microscopic SampleCam**, 0.5 kg CBE
- Baseline Instrument (not included in Threshold)
 - **3-axis Geophone**, 0.8 kg



SCIENTIFIC INVESTIGATIONS

CONSIDERATIONS

- Attributes of signs of life: Selectivity of organic molecules
- Scenarios: concentration, environment properties
- Validate biological origin of degraded signatures

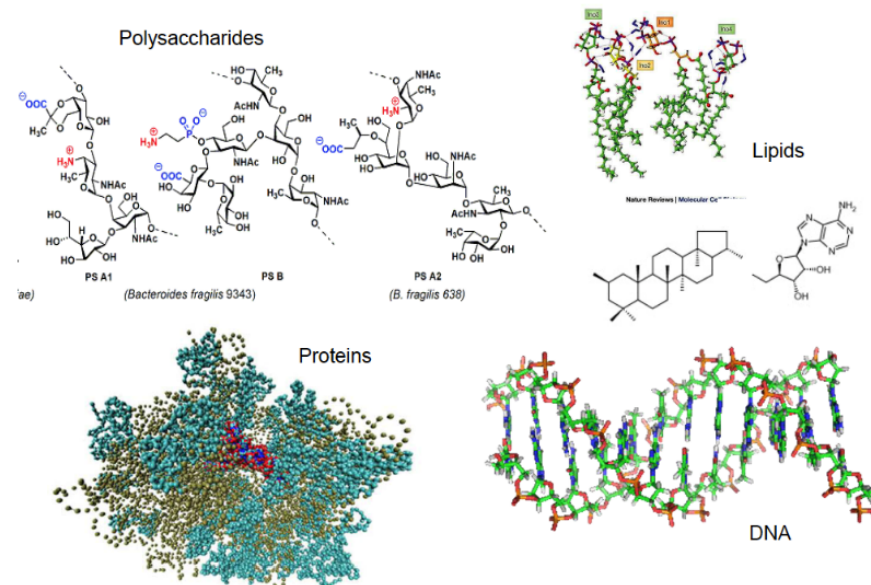
DEFINITIONS

- Biosignature is an object, substance and/or pattern whose origin specifically requires a biological agent

...be careful with ambiguous signatures!!

- Biomarker (or molecular biosignature) is an organic compound with a specific biological source. They are indisputable evidence of life.

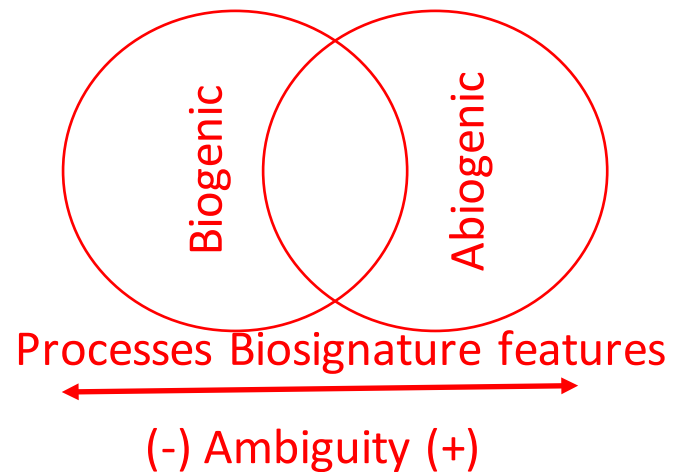
EPS, DNA, pigments, FAME



SCIENTIFIC INVESTIGATIONS

Categories of biosignatures can include the following:

- cellular and extracellular morphologies
- biogenic fabrics in rocks
- bio-organic molecular structures
- chirality
- biogenic minerals
- biogenic stable isotope patterns in minerals and organic compounds
- atmospheric gases
- biomolecules



From NASA Astrobiology Roadmap

SCIENTIFIC INVESTIGATIONS

Modified from Hand's presentation, August 2016

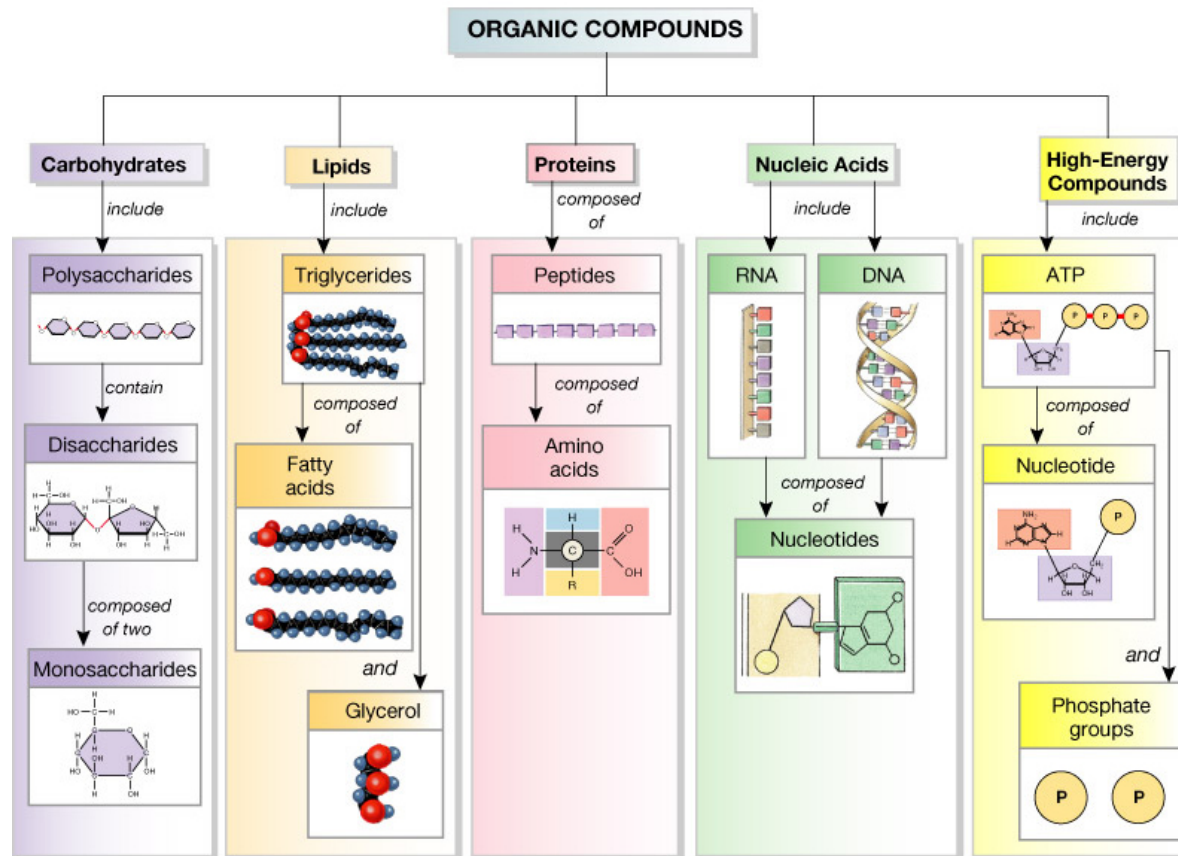
Goal	Investigation
Search for evidence of life on Europa	Detect and characterize any organic indicator of past or present life Detect general biomarkers**
	Identify and characterize morphological and textural indicators of life
	Detect and characterize any inorganic indicator of past and present life
	Determine the provenance of sampled material
	Determine if living organisms persist in sampled materials (Not part of the threshold)**
Assess the habitability of Europa via in situ techniques uniquely available to a lander mission	Characterize the non-ice composition of Europa's near-surface material and determine whether there are indicators of chemical disequilibrium and other components essential for life
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SCIENTIFIC INVESTIGATIONS

JEM contribution on search for evidence of life:

Search for biomarkers, specifically biological polymers, e.g. like polysaccharides, lipids, proteins, or some form of information transmitting molecule similar to DNA.



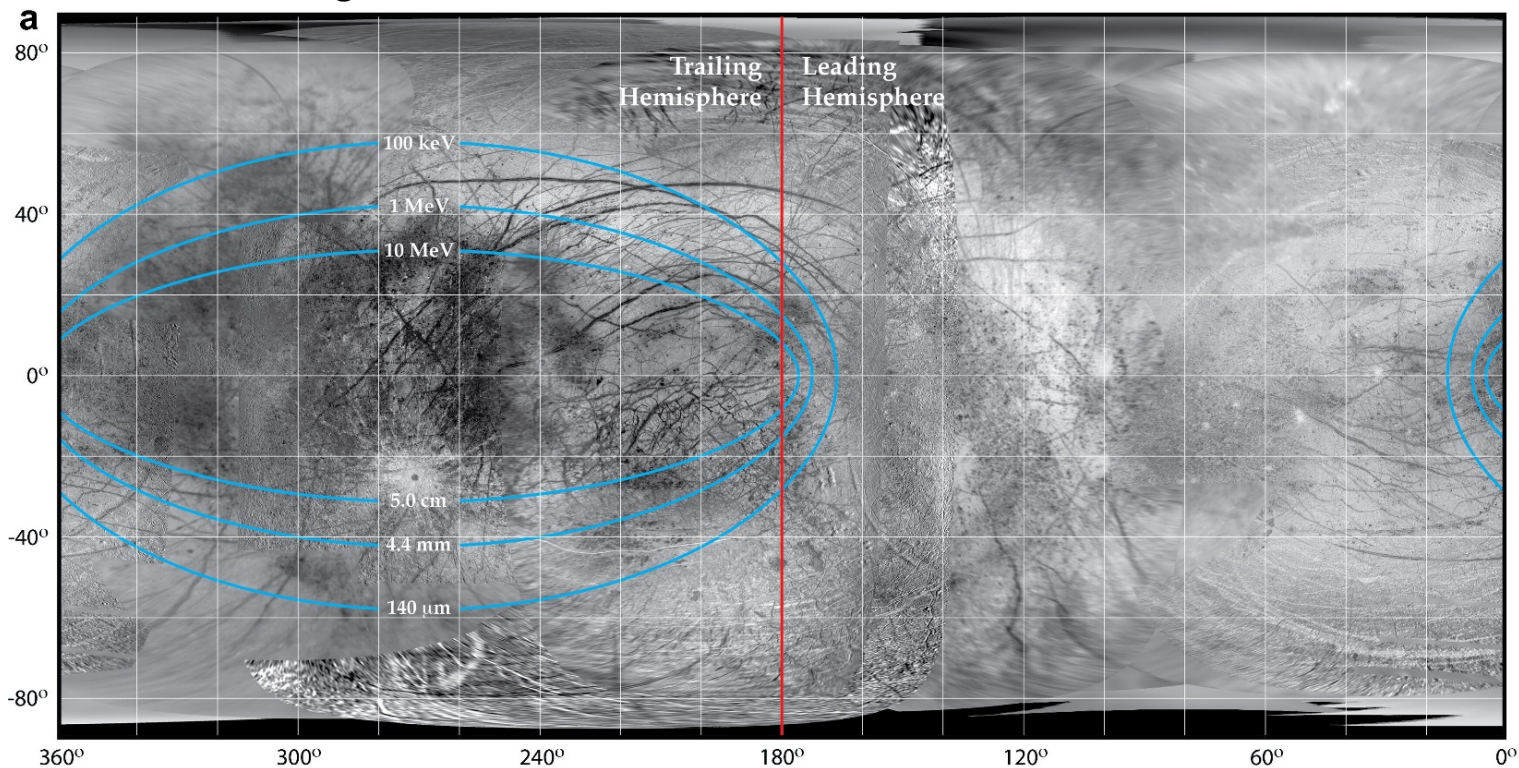
SCIENTIFIC INVESTIGATIONS

Class	Examples	Significance
Conserved and deeply rooted biomolecules that are ubiquitous in the tree of life	DNA; 8-oxoguanine; Thymine dimer; Lipid A, peptidoglycan and its derivatives (NAG-NAM)	DNA is the most stable of the informational polymers and constitutes the ultimate repository of information in Earth life
Protein domains that are involved in deeply rooted and widespread metabolic pathways	N fixation (NifH, NifD), sulfate reduction (DsrA, DsrB), methanogenesis (McrB), hydrogenases (HupL), perchlorate reduction (Pcr, Cld), nitrate reduction (NtrA)	Used as biomarkers of extant life. Highly conserved biomolecules that play a central role in ancient metabolic pathways
Structural components of cell walls (proteins and polysaccharides) of broad prokaryotic group	Peptidoglycan, Exopolysaccharides, Lipopolysaccharides, Lipid A, Lipoteichoic acids, Pigments for protecting against radiation	They are ubiquitous in the cell wall of taxonomic-related microorganisms within suprageneric groups (e.g. Archaea, a-, b-, g-, d- proteobacteria, Firmicutes, Actinobacteria, Cyanobacteria)
Phylogenetically conserved structural proteins and storage compounds under stress (e.g. Nutritional of water availability) of broad prokaryotic groups	GroEL, FtsZ, Histon-like, Phycobiliproteins (pigments), Cyanophycin (polypeptide), Bacterial Glycogen, Bacterioferritins and related proteins for iron storage.	They are ubiquitous in large taxonomic-related microorganisms within suprageneric groups (e.g. Archaea, a-, b-, g-, d- proteobacteria, Firmicutes, Actinobacteria, Cyanobacteria)

SCIENTIFIC REQUIREMENTS

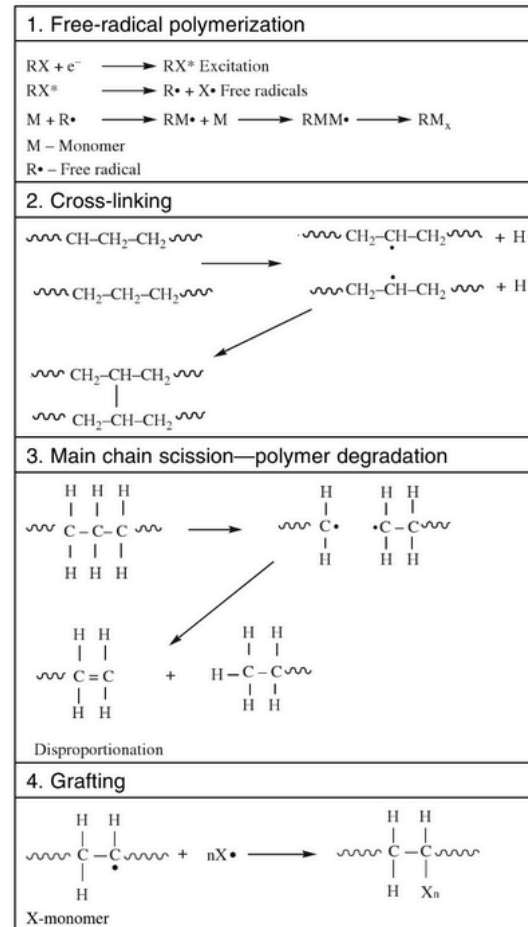
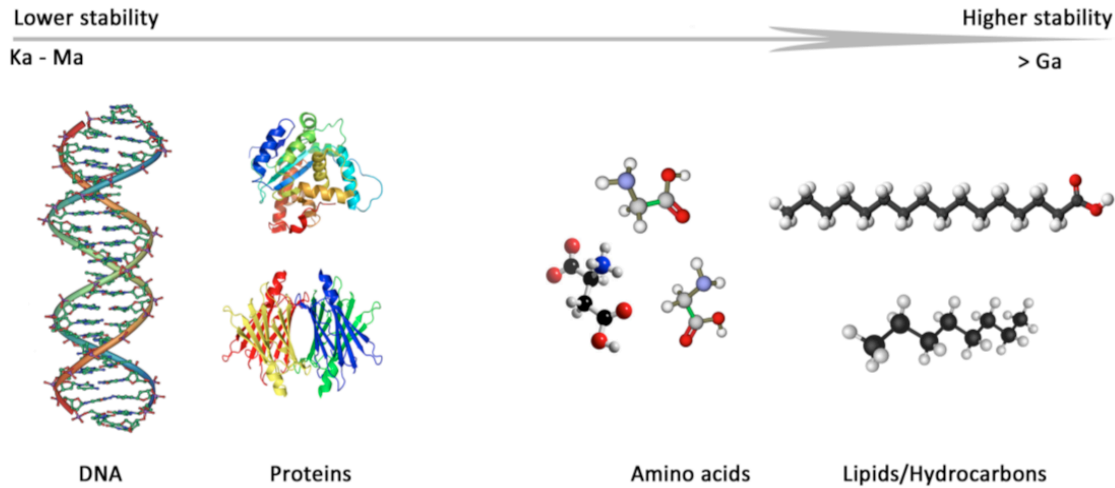
How to achieve this investigation:

- Surface science is imperative due to the low concentration and the in situ analytical techniques that must be used
- Multiarray immunoassay detector
- Sampling the subsurface of Europa in order to measure fresh materials. Materials preserved from radiation and other destruction processes
- Selection of the landing site to minimize the risk, and maximize the options to search for life.
- Multisite sampling to multiply opportunities of detection. Avoid potential contamination/alteration due to landing



SCIENTIFIC REQUIREMENTS

- Biosignature Preservation Potential (BPP)
Destruction by radiation, ultravacuum, oxidants



SCIENTIFIC REQUIREMENTS

Goal	Investigation	Requirement	Instrument
Search for evidence of life on Europa	Detect potential biomolecules	Identify biomolecules such as: D/L aromatic aa PAHs Short peptides Anti-freezing peptides and sugars EPS from psychrophilic microbes Cold shock proteins (Concentration <10ppb)	Multiarray immunoassay detector

SCIENTIFIC REQUIREMENTS

NASA soft lander platform	European institutes interested to contribute/collaborate	National agencies
GCMS*	LATMOS-CNES, University of Bern, Max Plank Institute	NASA, France, Switzerland, Germany
Raman spectroscopy*	IRAP, INTA/CSIC-UVA	NASA, France, Spain
PanCam/microscope *	DLR, MSSL/UCL, Space Exploration Institute, CNRS	NASA, Germany, UK, Switzerland, France
Geophone*	Imperial College London, IPG-Paris-CNES-ISAE	NASA, UK, France
Additional payload (to be considered)		
Microarray immunoassay detector	CAB-CSIC-INTA	Spain
Wet chemistry lab	CAB-CSIC-INTA	Spain
Thermogravimeter	IAPS	Italy
Ice properties package (gravimeter, tiltmeter, radio transponder, heat sensors)	Univ. Roma La Sapienza	Italy
Magnetometer	Imperial College London	UK
Radiometer	DLR	Germany

SCENARIOS

Scenarios to seek for signs of life:

-if plumes exists (and their material are from the habitable zone)*

- Fresh material

- Subsurface origin: potentially an aqueous reservoir

- Detection with no risk

- Detection limit of MS very low

-if plumes does not exist → landing (soft or hard)

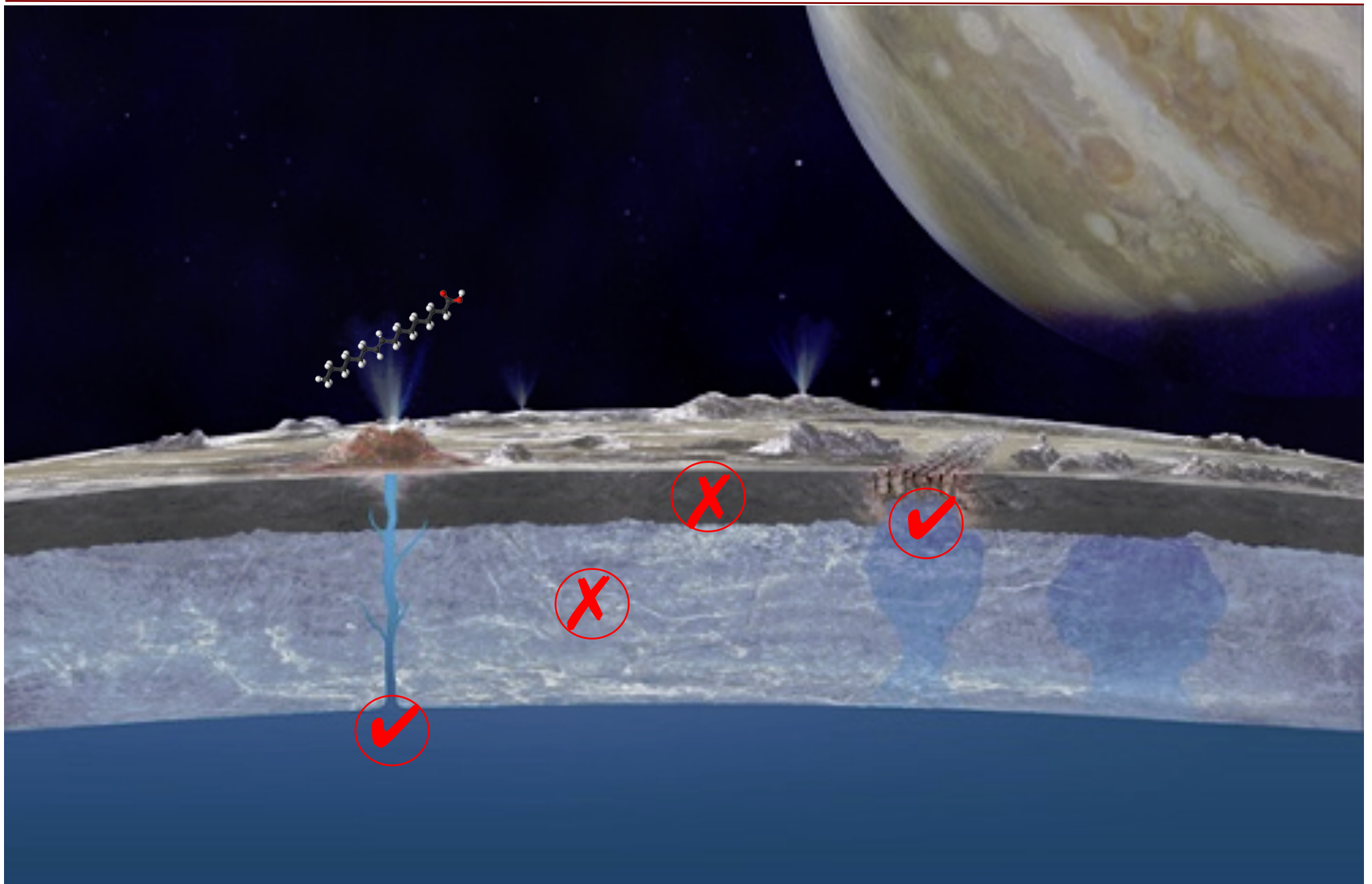
- Sampling in situ

- Selection of site: recently active, shielded,
linked with the ocean

- Risk on soft landing

- Sample concentration. Diverse payload

SOURCE OF THE PLUMES



QUESTION

What if there is no evidences of life?

UNSUCCESSFUL MISSION ?