MARS 2020

Dr. Justin I. Simon
Return Sample Scientist
NASA Johnson Space Center
Why do scientists explore Mars?

- Mars has geologic features similar to Earth.
- Water once flowed on Mars.
- We want to know if Mars could have once supported ancient life forms (and how we could live there).
How do scientists study planetary objects in our Solar System?

Put your answers in the chat.

Credit: NASA
How do scientists study planetary objects in our Solar System?

- Observations from telescopes on Earth
- Measurements from orbiters ('spacecraft')
- Measurements from robotic landers and rovers
- Collect and study meteorites
- Robotic geologists and astronauts collect and return samples

Credit: NASA
Where do meteorites come from?

Primitive meteorites come from → asteroid belt

Martian meteorites are knocked off from the impact of these objects.

Real images of asteroids

Which after floating around fall to Earth

Credit: NASA

Painting by Don Davis. Copyright SETI Institute, 1994
Meteorites fall lots of places on Earth, but we’ve had a lot of success finding dark rocks on light ice.
Softball-sized carbonaceous chondrite ("protoplanetary disk sediment")

Meteor Crater, Arizona

Images = Cascadia Meteorite Laboratory

4.56 billion years old

Many martian meteorites have less clear ages... this one ranges from 0.2 to 1.3 billion years old

8 kg (17 lbs) martian meteorite found in Antarctica

Credit: NASA
We have found many meteorites & learned a lot from them, but their travels to Earth can be pretty rough!

Antarctic Martian Meteorite

“Sheared” black outer fusion crust from atmospheric entry

Mixture of primitive meteorite +/- sedimentary martian surface rock (and altered on Earth too before collection)

Each photomicrograph is 2.8 mm across.

Cut surface

Credit: NASA
If we want more pristine rock samples we have to go get them...!
Apollo Missions to the Moon

Apollo 17, Dec. 1972

Credit: NASA
OSIRIS-REx
Asteroid Bennu
2023 (planned)
Regolith

Bennu, a carbon-bearing asteroid, is \( \sim 0.48 \text{ km} \) in diameter

This is an artist’s rendition

This is real (Aug. 11th dress rehearsal ~ to our successful sample collection Oct. 21\textsuperscript{st}, 2020)

Credit: NASA
The Three-Mission Mars Sample Return Campaign

Sample Collection (Mars 2020)

These are artists’ renditions

we are here

Mars Ascent Vehicle (MAV) launches Orbiting Sample (OS)

Mars Orbiter captures OS and brings it back to Earth

Credit: NASA
Introducing the Mars 2020 Rover Perseverance, our Scientific Adventure Begins
Mars 2020
Perseverance

GOALS:

• Identify past environments capable of supporting microbial life
• Seek signs of possible past microbial life in those habitable environments
• Collect rock core and “soil” samples and store them on the martian surface
• Test oxygen production from the martian atmosphere

This is an artist’s rendition of a real event!

Credit: NASA
Terrestrial Biological Time Line

Mars climate change here

First Familiar "fossils"

credit: Wikimedia commons
Modern Stromatolites: Shark Bay
BASIC NEEDS OF A LIVING ORGANISM

Water, energy, nutrients, and clement environment (e.g., reasonable temperature)

Likely geological places to find life:
• Near or in bodies of water
• Near volcanoes and other geothermal heat sources
• In partially melted subsurface ices

EVIDENCE OF PAST LIFE ON EARTH

On Mars we would be looking for evidence of past life... looking for evidence in data such as... (see next slide!)
How might we detect ancient, possibly non-Earthlike life?

- **Organic molecules**
  - $^{13}\text{C}/^{12}\text{C}$
  - $^{18}\text{O}/^{16}\text{O}$

- **Physical & chemical structures in rocks**

- **Biominerals**
Where should Mars 2020 go...?

4 Landing Site Selection Workshops
1st in 2014: many landing sites
2nd in 2015: >20 landing sites
3rd in 2017: 8 landing sites
4th in 2018: 3 final landing sites

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### Top three landing sites...

#### 1st in 2014: many landing sites

- Columbia Hills
- NE Syrtis
- Eberswalde
- SW Melas
- Nili Fossae Trough (N)
- Nili Fossae Carbonate
- Mawrth
- Holden Crater
- Mclnlaughlin
- Hypanis
- Nili Fossae Trough (S)
- Ladon Valles
- E. Margaritifer
- Coprates Chasma
- Oyama Crater
- Eridania
- Nili Patera
- Oxia Planum
- Sabrina/Magong Crater
- Hadriacus Palus

#### 2nd in 2015: >20 landing sites

#### 3rd in 2017: 8 landing sites

#### 4th in 2018: 3 final landing sites

#### Landing Site Scientific Selection Criteria

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**Choice 1: Jezero Crater**
- Data indicates this area once had river channels and lakes filling the now "dry" crater.

**Choice 2: Columbia Hills, Gusev Crater**
- Previously explored by the Mars Spirit Rover.
- Evidence of past hot springs.

**Choice 3: NE Syrtis**
- Associated with past volcanic activity.
- Evidence of past hot springs, surface ice melting, layered terrain.

What makes each of these sites good landing sites for the Mars 2020 Rover?

*Put your answers in the chat.*
Isidis impact basin (~3.9 billion years ago)

Jezero Crater

Nili Fossae

Syrtis Major (3.5-3.8 billion years old)

Hargraves crater

Utopia Planitia

Jezero crater

Isidis impact basin (~3.9 billion years ago)

Credit: NASA
Anatomy of Jezero crater and its deposits

- Lower inlet valley
- Outlet channel
- Jezero crater (Ancient Lake?)

Credit: NASA
Delta Deposit Inside Jezero Crater

HRSC topography overlain on CTX mosaic

Modified from T. Goudge LSW3

Credit: NASA
River deltas are environments teeming with microbial life
We launched July 30th, 2020; land on Mars Feb 18th, 2021; return samples 2026
I named the rover Perseverance
-Alex

Total cameras: 23
Engineering cameras: 9
Science cameras: 7
Entry, descent and landing cameras: 7
“Ingenuity” Helicopter

I named the Mars Helicopter - Vaneeza

Credit: Rupani Family

Image from NASA Article.
Image Credit: Rupani Family

4 lb
4 ft rotor, 2400 RPM
Solar-powered
2 cameras

NASA/JPL
MARS 2020 ROVER

NEW LANDING TECHNIQUE

1. Take descent photos
2. Compare to orbital map
3. Divert if necessary

Landing February 18, 2021

mars.nasa.gov
Mobility System

Perseverance is the fastest rover to date and we need this to have enough time to find and collect samples

CURIOSITY  PERSEVERANCE

Credit: NASA
Mastcam-Z

MAIN JOB:
Take high-definition video, panoramic color & 3D images of the surface & more!

Credit: NASA
SuperCam

MAIN JOB:

Identify the chemical composition of the rocks and soils including their atomic & molecular makeup.

Credit: NASA
Planetary Instrument for X-ray Lithochemistry (PIXL)

MAIN JOB:
Measure the chemical makeup of rocks at a very fine scale. (sub-mm scales)

Credit: NASA
Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals (SHERLOC)

MAIN JOB:
Fine-scale detection of minerals, organic molecules, and potential biosignatures.

Credit: NASA
MAIN JOB:
Camera that will take close-up pictures of rock textures. Will work closely with the SHERLOC instrument.
SHERLOC, WATSON, and PIXL Work Together

**SHERLOC**
- Context
- Chert Organics Dolomite

**PIXL**
- Fe intensity
- Ti Si Ca intensity

2.72 Ga Stromatolites (Fortescue Gp., Western Australia)
Above: outcrop. Below: cut slab

Credit: NASA
Radar Imager for Mars' Subsurface Experiment (RIMFAX)

MAIN JOB:
To see geologic features under the surface with ground-penetrating radar.

Credit: NASA
Mars Environmental Dynamics Analyzer (MEDA)

MAIN JOB:
To measure weather (such as wind speed & direction, temperature, humidity) and monitor dust in the atmosphere.

Credit: NASA
Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE)

MAIN JOB:

To produce oxygen from the Martian carbon-dioxide atmosphere.

Credit: NASA
If you were a Mars scientist, which instrument would you be most interested to work with & why?

Put your answers in the chat.
Sampling and Caching

MARS 2020 ROVER
Depot Caching Strategy

- Landing Site
- Region of Interest
- Sample Tube
- Primary Mission
- Extended Mission

Credit: NASA
Flight sample tube handling during TVAC testing

Credit: NASA
Rover will drill core samples to be returned to Earth
These extraterrestrial samples are curated by NASA. But studied by scientists all over the world!
Fun Fact: Well-known “secret”

A rover traverse outside the Jezero to Midway would allow us explore much of the 3rd landing site.

Choice 3: NE Syrtis

Figure 1: Region and suggested extended mission rover paths outside Jezero crater. Color coding indicate 3 paths that afford high priority science and sampling objectives in Nili Planum. After exiting

Credit: NASA
Fun Fact: Career path of Dr. Abigail Fraeman from high school to Deputy Project Scientist (MER Mission)