Exploring the Planets-
How we use robots to learn about them

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My Very Educated Mother Just Served Us Nibbles
Rocky planets
Gas giants
planets can have moons
earth’s moon
Earth's moon

Craters (planets can have them too)

Mercury
Moons

daphnis

pan
gas giants can have **rings**
saturn
rocky planets can have volcanoes & ice caps
Olympus Mons
polar ice cap
volcano
mars

Olympus Mons
How do we learn about the planets?
The Naked Eye
Telescopes

Galileo discovered four of Jupiter’s moons
Spacecraft!
Unmanned, or robotic missions
• Allow us to get a closer view

• Get *in-situ*, or in place, measurements
Flight Operations

**MESSENGER**
MErcury Surface, Space ENvironment, GEochemistry, and Ranging

- **Launch**
- **Cruise**
- **Encounter**
  - Flyby
  - Orbit
  - (Land)
- **Data return**
Voyager I & II
Flying by the Outer Solar System

Launched in 1977 (and still going!)
Voyager I & II
Flying by the Outer Solar System

Visited Jupiter, Saturn, Uranus & Neptune
Voyager I & II

Flying by the Outer Solar System

Science Instruments

Magnetometers
Radio/Plasma Wave Antenna
Cosmic Ray Plasma
Photopolarimeter
Spectrometers (UV/IR)
Imaging (WA/NA)
discovery:

jupiter has **rings**
discovery:

proteus
(neptune)

more **moons**

3 - jupiter
3 - saturn
10 - uranus
6 - neptune

**volcanic activity** on io
discovery:

storms on neptune
Not fare well,
But fare forward, Voyagers.
– T. S. Eliot, *The Dry Salvages*
Cassini-Huygens
Orbiting Saturn, Landing on Titan
Cassini-Huygens
Orbiting Saturn, Landing on Titan
Cassini-Huygens

Orbiting Saturn, Landing on Titan

gavity assist to get there

maneuvering to stay there
Cassini
Orbiting Saturn
Phoebe

Voyager II
4 Sept 1981
2.2 million km away

Cassini
11 June 2004
2000 km away
Multi-Wavelength Observations

The Electromagnetic Spectrum

- Gamma Rays
- X-Rays
- UV
- Visible
- Infrared
- Radio

Wavelength vs. Frequency

- Shorter wavelength
- Longer wavelength

Images:
- X-Ray: ROSAT
- UV: ASTRO-2 UIT
- Visible: Color: Galileo
- Near Infrared: Galileo
- Mid Infrared: MSX
- Radio: NRAO VLA
a view from the ultraviolet

Ultraviolet (UV) image displays brightness variations. UV spectra confirm presence of water frost on surface.
a view from the infrared - temperature

day night variation

made of loose dust and ice particles
a view from the infrared - mineral distribution

originated in the kuiper belt
Huygens

Landing on Titan

- Imager
- Measure winds using radio
- Analyze the atmosphere
- Measure titan’s surface
descent unto Titan
descend unto Titan

[Movie with images and sounds from the Huygens probe landing on Titan]

wind - from the furthest sounds in the Solar System
drainage channels

hills

pebbles

hydrocarbon rain & flows
Mars Exploration Rovers
Roving the Red Planet
getting there in one piece
can update and set science goals daily

use current data to plan next moves
Mars Exploration Rovers
Roving the Red Planet

Remote Sensing Package
Pancam
Mini-TES

In-Situ Package
Microscopic Imager
Alpha Particle X-Ray Spectrometer
Mössbauer Spectrometer
Rock Abrasion Tool

Magnetic properties experiment
RAT hole

water?
water?

dissolved crystals

voids

blueberries

sulphates and standing water

different, rippled layers

flows

evaporation from a salty brine
beyond the solar system

extrasolar planets
Conduct advanced telescope searches for Earth-like planets and habitable environments around other stars.
the learning continues...