The 21st Century:
The Century of Biology on Earth and Beyond

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Universidad Autonoma De Madrid
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Dr. Jill Tarter – Emeritus Chair for SETI Research, SETI Institute
Life Beyond Earth

• Discover it
  – In situ biomarkers
  – Remote biosignatures
Life Beyond Earth

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  – In situ biomarkers
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• Communicate with it
  – Technosignatures
  – Serendipitous observations
Life Beyond Earth

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• Communicate with it
  – Technosignatures
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• Export it
  – Moon, Mars, Asteroids
  – Breakthrough StarShot, 100 Year Starship Study, Icarus
“…strong indications of life beyond Earth in a decade and definitive evidence within 10 to 20 years.”

Ellen Stofan
former NASA Chief Scientist
“…we are currently on a journey to Mars”

John Grunsfeld
AA NASA’s SMD (ret’d)
GAME CHANGERS
FROM THE 20TH CENTURY

Exoplanets and Exomoons
“SNOTTITE” IMAGE COURTESY OF DR. KENNETH INGHAM / TARDIGRADE IMAGE COURTESY OF DAIKI HORIKAWA, NASA AMES RESEARCH CENTER
There are more planets than stars in the Milky Way.

There is more potentially habitable real estate than we imagined.

slide from Fergal Mullally
SUPER EARTH’S and MINI-NEPTUNES
Period
Semi-major axis
Radius
or Mass or both  => Density
SEVEN EXOPLANETS ABOVE THE FOLD
TRAPPIST-1 DISCOVERY
The Richest Set of Earth-sized Planets Ever Found
HERE and NOW
Plano de la Universidad Autónoma de Madrid

Campus de Cantoblanco
Ctra. Complutense km 13 - 28049 MADRID

Campus de Medicina
Ctra. Moncloa km 6 - 28040 MADRID

Edificio Accessible
Edificio No Accesible
Anchuras de los caminos
HERE
Credit: NASA/GSFC/Dana Berry
IT TAKES A COSMOS TO MAKE A HUMAN
BIOSIGNATURES
TECHNOSIGNATURES
RADIO: NATURAL VS. ENGINEERED

Center Freq: 8439.757867 MHz  Subband: 0659  BW: 533.3 Hz  #Half Frames: 0256  Actld: 3151
Prof. Philip Morrison

SETI IS THE ARCHEOLOGY OF THE FUTURE
The Number of civilizations in our galaxy with which communication is possible

\[ N \approx L \]

The average length of time such civilizations survive and continue to send communications.
THE ATA- 42
THE ATA-42
20,000 RED DWARF SURVEY
BREAKTHROUGH LISTEN

$100 M OVER 10 YEARS FROM YURI MILNER
$100\ M\ OVER\ 10\ YEARS\ FROM\ YURI\ MILNER

• All $43$ stars within 5 parsecs
• 1000 stars of all spectral types within 50 parsecs
• One million nearby stars
• Center regions of at least 100 nearby galaxies,
  • Exotic Objects
$100 M+ OVER 10 YEARS FROM YURI MILNER
BREAKTHROUGH LISTEN $100 M OVER 10 YEARS FROM YURI MILNER
BREAKTHROUGH LISTEN
THE FUTURE

JWST and then ???

IMAGING / BIOSIGNATURES

WFIRST

HabEx or LUVOIR
ExoLife Finder

If Proxima b were an Earth twin, this is what ELF would see.

And we’d know if anything lives there!
On a finite world, a cosmic perspective isn’t a luxury; it is a necessity.

Caleb Scharf (2014)