1
00:00:17,660 --> 00:00:25,270
In 1923, Hermann Oberth, a German scientist,
in a book entitled The Rocket Into Interplanetary

2
00:00:25,270 --> 00:00:27,980
Space, put forward a dream.

3
00:00:27,980 --> 00:00:34,590
If we could look at the heavens with an astronomical
telescope in orbit, unhindered by the shielding

4
00:00:34,590 --> 00:00:40,290
sea of atmosphere that blankets the Earth,
think of the discovers we would make, the

5
00:00:40,290 --> 00:01:21,800
clear vision of the universe we would have
in quiet space.

6
00:01:21,800 --> 00:01:26,820
The telescope, an instrument for collecting
more light than would normally enter the human

7
00:01:26,820 --> 00:01:28,229
eye.

8
00:01:28,229 --> 00:01:35,290
For over 300 years, light, optics, and the
human imagination have sculptured our perception

9
00:01:35,290 --> 00:01:38,330
of the universe.

10
00:01:38,330 --> 00:01:46,280
Today, large telescopes such as those at Palomar
Mountain and Kitt Peak carry out detailed

11
00:01:46,280 --> 00:01:54,970
investigations of very faint objects at the

limits of perception.

12
00:01:54,970 --> 00:01:59,360
The naked eye has been replaced by spectroscopes,

13
00:01:59,360 --> 00:02:00,760
photographic plates,

14
00:02:00,760 --> 00:02:02,060
computers.

15
00:02:02,060 --> 00:02:12,340
Yet, a fundamental challenge, a length between
past and present, remains ever constant:

16
00:02:12,340 --> 00:02:18,670
the quest for more light, to see fainter and
more distant objects, to construct better

17
00:02:18,670 --> 00:02:20,720
light collectors.

18
00:02:20,720 --> 00:02:31,110
“This is a photograph of the galaxy Messier
33, a nearby galaxy, a rather common type,

19
00:02:31,110 --> 00:02:38,290
and quite illustrative of the type of image
that we obtain with telescopes that are based

20
00:02:38,290 --> 00:02:42,030
on the surface of the Earth.

21
00:02:42,030 --> 00:02:52,521
This type of information, together with spectra
like the plate that I am holding here, form

22
00:02:52,521 --> 00:02:59,510
the largest part of the information obtained

and used by ground-based astronomers.

23
00:02:59,510 --> 00:03:06,310
It’s quite god, but nowhere as good as it
might be.

24
00:03:06,310 --> 00:03:12,590
Astronomers themselves, and many in the lay
public, don’t appreciate, at times, the

25
00:03:12,590 --> 00:03:17,160
enormous distances that they’re dealing
with.

26
00:03:17,160 --> 00:03:25,260
When we look at the photograph of a cluster
of galaxies like this, it’s hard to appreciate

27
00:03:25,260 --> 00:03:34,590
that these images that we obtain now are from
galaxies that are probably a billion lightyears

28
00:03:34,590 --> 00:03:36,569
away.

29
00:03:36,569 --> 00:03:43,220
With the space telescope, we’ll be able
to look to much great distances and therefore

30
00:03:43,220 --> 00:03:46,850
much further back into time.

31
00:03:46,850 --> 00:03:53,810
In fact, much closer to the creation of the
universe itself.

32
00:03:53,810 --> 00:04:01,450
In order to understand how the Space Telescope
works, we really need to understand how the

33
00:04:01,450 --> 00:04:10,520
astronomer and the astrophysicists work with
light.”

34
00:04:10,520 --> 00:04:15,790
Almost all the information we have about the
universe reaches us in the form of electromagnetic

35
00:04:15,790 --> 00:04:21,299
radiation, which objects either radiate, absorb,
or reflect.

36
00:04:21,299 --> 00:04:27,240
The spectrum disperses this radiation into
its separate colors, visible light, infrared

37
00:04:27,240 --> 00:04:34,710
radiation, radio waves at one end to X-rays
and gamma rays at the other.

38
00:04:34,710 --> 00:04:42,430
Now, each element in nature has a characteristic
spectral signature, a fingerprint of light,

39
00:04:42,430 --> 00:04:43,680
if you will.

40
00:04:43,680 --> 00:04:48,690
Because common Earthly elements have been
found in the Sun and stars, we can determine

41
00:04:48,690 --> 00:04:55,910
through a star’s own unique stellar spectrum
the speed of an object, its temperature, density,

42
00:04:55,910 --> 00:04:58,260
chemical composition.

43
00:04:58,260 --> 00:05:09,620

Each band of light becomes a window unto the
universe with a unique view.

44
00:05:09,620 --> 00:05:15,000
But many wavelengths are permanently inaccessible
to astronomers using Earth-bound telescopes.

45
00:05:15,000 --> 00:05:19,840
Due to the Earth’s atmosphere, which in
shielding us from most of the biologically

46
00:05:19,840 --> 00:05:26,810
harmful radiations, allows only visible light
and varying amounts of ultraviolet, infrared,

47
00:05:26,810 --> 00:05:31,660
and radio to reach the ground.

48
00:05:31,660 --> 00:05:36,560
We are given a very incomplete picture of
the universe in these wavelengths.

49
00:05:36,560 --> 00:05:41,240
Our stellar fingerprint is difficult to analyze.

50
00:05:41,240 --> 00:05:45,150
The atmosphere also frustrates ground-based
optical observations.

51
00:05:45,150 --> 00:05:52,050
One hundred miles deep, it is filled with
dust particles, water vapor, and other obscuring

52
00:05:52,050 --> 00:05:53,900
materials.

53
00:05:53,900 --> 00:06:01,290
Constantly shifting layers of air of different
densities bend light back and forth.

54
00:06:01,290 --> 00:06:05,740
Atmospheric turbulence imposes a fundamental
limitation on a telescope’s ability to see

55
00:06:05,740 --> 00:06:09,470
clearly two objects close together in the
sky.

56
00:06:09,470 --> 00:06:20,389
At times of bad seeing, stellar images waver
like candle flames in a gentle breeze.

57
00:06:20,389 --> 00:06:25,580
The space telescope will be out where the
images are completely quiet, where the full

58
00:06:25,580 --> 00:06:30,910
spatial and wavelength resolution powers of
the telescope can be used.

59
00:06:30,910 --> 00:06:36,750
It will peer far into the ultraviolet and
infrared regions of the spectrum.

60
00:06:36,750 --> 00:06:45,830
A galaxy seen through the Earth’s atmosphere
as a big shimmering fuzz ball in space will

61
00:06:45,830 --> 00:06:51,800
be brought into sharp, clear, and steady view
for study and analysis.

62
00:06:51,800 --> 00:06:54,970
We will see it ten times clearer than we see
it now.

63
00:06:54,970 --> 00:07:00,910
We will see fifty time further into the universe
than the best ground-based telescopes can

64
00:07:00,910 --> 00:07:02,480
see.

65
00:07:02,480 --> 00:07:07,310
All this from a telescope no different in
principle than the reflecting telescope of

66
00:07:07,310 --> 00:07:10,320
Newton and his descendants.

67
00:07:10,320 --> 00:07:15,490
“Every optical telescope operates in essentially
the same manner.

68
00:07:15,490 --> 00:07:20,830
It gathers a part of a light produced by or
reflected from an object, concentrates this

69
00:07:20,830 --> 00:07:29,000
light in a single area, a focal plane, and
then magnifies the image formed there.”

70
00:07:29,000 --> 00:07:38,900
So, in space, as on Earth, we must begin with
a mirror.

71
00:07:38,900 --> 00:07:44,920
In this case, polished within one half a millionth
of an inch of accuracy.

72
00:07:44,920 --> 00:07:49,780
As light enters from space, something must
catch the reflection of our primary mirror.

73
00:07:49,780 --> 00:07:53,510
A secondary mirror is set into place.

74
00:07:53,510 --> 00:08:00,010
An image must now be fed into a variety of

auxiliary instruments, so we provide a package

75
00:08:00,010 --> 00:08:05,759
of five major scientific instruments which
will convert telescope images into useful

76
00:08:05,759 --> 00:08:07,330
data.

77
00:08:07,330 --> 00:08:13,110
The scientific instruments and optical assembly
must then be encased in a shell, which protects

78
00:08:13,110 --> 00:08:20,610
them from dangers in the space environment
such as stray light or micrometeoroids.

79
00:08:20,610 --> 00:08:27,400
To power our telescope, we turn to the Sun
for energy and attach solar array panels.

80
00:08:27,400 --> 00:08:32,820
In the Earth's shadow, we will power our
telescope by batteries.

81
00:08:32,820 --> 00:08:38,909
Finally, we must have a means of communicating
with our telescope, so we obtain two high

82
00:08:38,909 --> 00:08:40,449
gain antennas.

83
00:08:40,449 --> 00:08:48,930
Data which these antennas beam back to Earth
will be converted to pictures.

84
00:08:48,930 --> 00:08:57,740
"Two earliest telescopes here at Palomar
in California is only about twice as big as

85
00:08:57,740 --> 00:09:02,470
the space telescope will be, yet it is very
much more massive because, of course, it has

86
00:09:02,470 --> 00:09:04,339
to work in the Earth's gravity.

87
00:09:04,339 --> 00:09:09,879
However, all telescopes, including this one
and Space Telescope, are essentially the same.

88
00:09:09,879 --> 00:09:13,589
They gather light so we can analyze it with
various instruments.

89
00:09:13,589 --> 00:09:15,800
The space telescope will have five such instruments.

90
00:09:15,800 --> 00:09:21,670
There will be two wide field cameras which
take pictures of the sky, one over a wide

91
00:09:21,670 --> 00:09:25,199
region and another over a smaller region.

92
00:09:25,199 --> 00:09:31,529
The smaller region camera will have a much
higher resolution than the other.

93
00:09:31,529 --> 00:09:35,830
There will also be two spectrographs aboard
Space Telescope, one will be used on fairly

94
00:09:35,830 --> 00:09:42,339
bright objects and take the highest resolution
spectra, the other will be used for quite

95
00:09:42,339 --> 00:09:46,720
faint objects such as galaxies and far away

quasi-stellar sources.

96
00:09:46,720 --> 00:09:52,029
There will also be on Space Telescope an instrument
that utilizes the fine guidance system of

97
00:09:52,029 --> 00:09:53,029
the telescope.

98
00:09:53,029 --> 00:09:57,920
This is the system that keeps the telescope
pointed quite accurately at the stars during

99
00:09:57,920 --> 00:09:59,429
an exposure.

100
00:09:59,429 --> 00:10:03,720
This instrument will allow us to measure the
distance between stars quite accurately on

101
00:10:03,720 --> 00:10:08,399
the sky and also their motions over a short
period of time."

102
00:10:08,399 --> 00:10:17,119
The space telescope, due to be launched in
the 1980s, will be hoisted into orbit some

103
00:10:17,119 --> 00:10:20,690
500 miles above the Earth by the space shuttle.

104
00:10:20,690 --> 00:10:26,679
Fitting into the shuttle's cargo bay, the
telescope will be latched to a tilting mechanism

105
00:10:26,679 --> 00:10:30,990
and rotated into a ninety degree position
for checkout.

106

00:10:30,990 --> 00:10:36,529
It will then be placed in a vertical angle,
released, and its power and communication

107
00:10:36,529 --> 00:10:42,529
systems deployed.

108
00:10:42,529 --> 00:10:47,829
The periodic revisit of the shuttle will allow
for the replacement of components and routine

109
00:10:47,829 --> 00:10:49,339
maintenance.

110
00:10:49,339 --> 00:10:55,220
Every five years, the telescope will be returned
to Earth for major ground refurbishment.

111
00:10:55,220 --> 00:11:00,449
This ability to service the telescope through
human care will extend its lifespan up to

112
00:11:00,449 --> 00:11:02,670
twenty years.

113
00:11:02,670 --> 00:11:10,720
“It will orbit above our murky atmosphere
and obtain images of objects that are incredible

114
00:11:10,720 --> 00:11:17,009
distances away, perhaps of galaxies fourteen
billion lightyears distance.

115
00:11:17,009 --> 00:11:24,489
So far away that when the light first set
out towards us, there was no Earth, no Sun,

116
00:11:24,489 --> 00:11:26,369
no Milky Way galaxy.

117
00:11:26,369 --> 00:11:31,750
We will be probing the time of the earliest
history of the universe.

118
00:11:31,750 --> 00:11:36,959
Space Telescope is, in a way, a little like
Galileo's first telescope.

119
00:11:36,959 --> 00:11:41,649
Wherever Galileo pointed his telescope, he
made major new discoveries.

120
00:11:41,649 --> 00:11:43,989
Look at the Moon, you find mountains and craters.

121
00:11:43,989 --> 00:11:45,620
Look at Saturn, you find rings.

122
00:11:45,620 --> 00:11:51,989
Look at the Milky Way, you find it is littered
and composed of stars.

123
00:11:51,989 --> 00:11:55,279
Every one of these discoveries, things that
people had not known before.

124
00:11:55,279 --> 00:12:01,749
I think it's going to be very similar with
the space telescope, yet will illuminate celestial

125
00:12:01,749 --> 00:12:04,120
objects that we know about.

126
00:12:04,120 --> 00:12:08,230
It will discover celestial objects never before
guessed.

127
00:12:08,230 --> 00:12:15,179
It will provide insights into the most important

questions such as stellar evolution, such

128
00:12:15,179 --> 00:12:23,290
as the search for planets going around other
stars, and the grandest cosmological questions

129
00:12:23,290 --> 00:12:26,939
of the origin, nature, and fate of the universe.

130
00:12:26,939 --> 00:12:36,089
Space Telescope is a kind of grand intellectual
adventure for all of us, which will cast light

131
00:12:36,089 --> 00:12:39,589
not just on the cosmos, but also on ourselves."

132
00:12:39,589 --> 00:12:50,010
"It's impossible to predict what Space
Telescope will bring in terms of its results,

133
00:12:50,010 --> 00:12:53,910
but we do know the results will be exciting.

134
00:12:53,910 --> 00:12:58,839
When the first radio telescopes were built,
we did not know that we'd find quasars and

135
00:12:58,839 --> 00:13:00,749
pulsars.

136
00:13:00,749 --> 00:13:06,850
Or when the first X-ray telescopes were built,
we did not know that we would discover X-ray

137
00:13:06,850 --> 00:13:08,000
stars.

138
00:13:08,000 --> 00:13:13,160
With Space Telescope, we will find many new

things, we'll find exciting things."

139
00:13:13,160 --> 00:13:24,830
Stretching the mind of humankind to the very
beginning and end of space and time, the space

140
00:13:24,830 --> 00:13:31,029
telescope may tell us at last whether the
universe will expand forever or whether that

141
00:13:31,029 --> 00:13:43,939
expansion is slowing.

142
00:13:43,939 --> 00:13:48,990
It may help us learn more about the violent
events of the universe,

143
00:13:48,990 --> 00:13:51,309
pulsars,

144
00:13:51,309 --> 00:13:53,639
quasars,

145
00:13:53,639 --> 00:14:06,649
the gravitational implosions that produce
black holes.

146
00:14:06,649 --> 00:14:14,370
It may also tell us how the universe began
and how it will end.

147
00:14:14,370 --> 00:14:23,129
Ultimately, as is the case with all voyages
of discovery, it's greatest contribution

148
00:14:23,129 --> 00:14:29,989
will be the unexpected breakthrough that brings
completely new knowledge.

149

00:14:29,989 --> 00:14:38,889
But with the space telescope, we will shake
loose of the Earth, of its murky and oblique