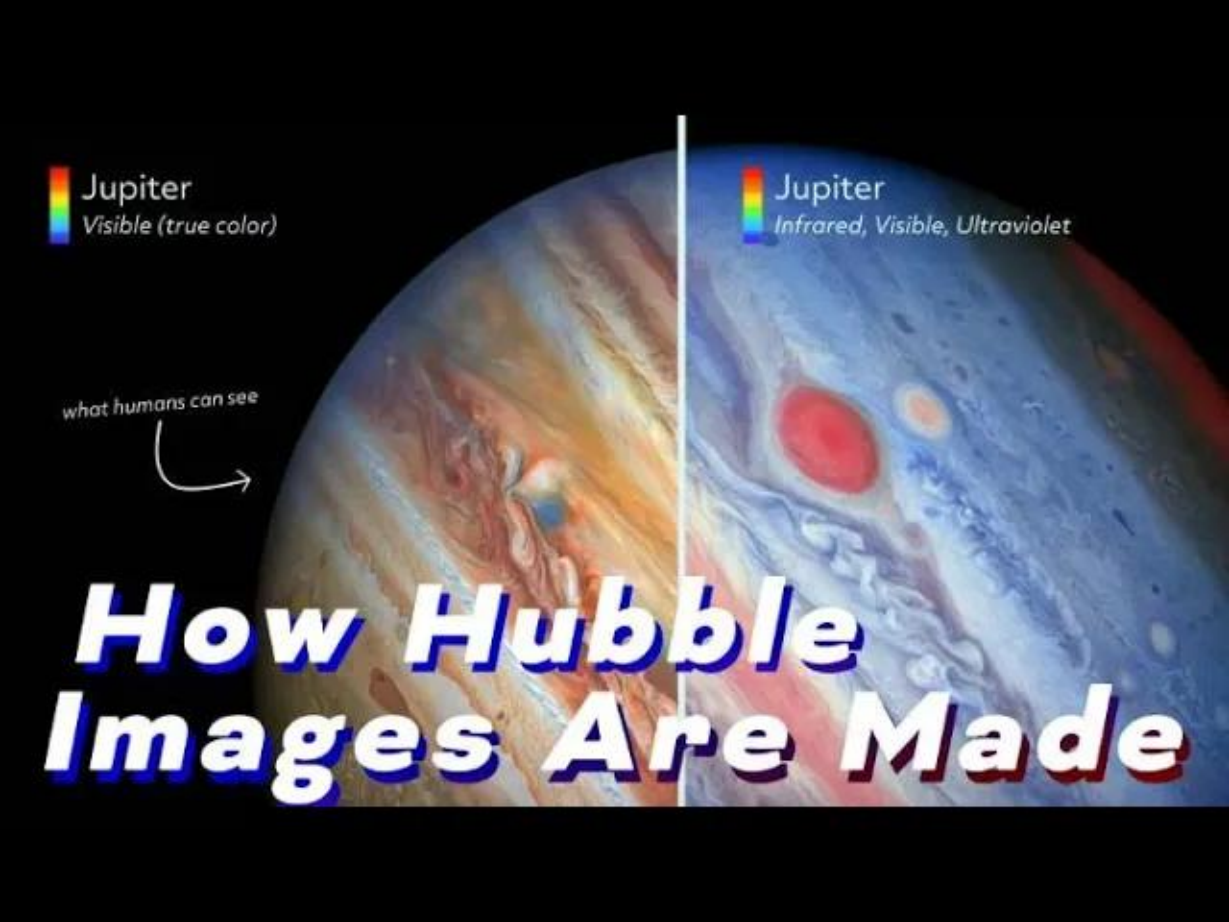
Jupiter
Visible (true color)
what humans can see
Jupiter
Infrared, Visible, Ultraviolet
How Hubble Images Are Made

1
00:00:05,390 --> 00:00:02,990
as a cosmic photographer NASA's Hubble

2
00:00:08,030 --> 00:00:05,400
Space Telescope has taken over a million

3
00:00:11,629 --> 00:00:08,040
snapshots documenting the universe

4
00:00:14,150 --> 00:00:11,639
these images illustrate explain and

5
00:00:15,829 --> 00:00:14,160
Inspire us with their Grandeur but may

6
00:00:16,910 --> 00:00:15,839
not match what we'd see with our own

7
00:00:19,070 --> 00:00:16,920
eyes

8
00:00:21,529 --> 00:00:19,080
that's because Hubble sees light beyond

9
00:00:24,470 --> 00:00:21,539
our sensitivity

10
00:00:25,970 --> 00:00:24,480
our eyes only sense a small fraction of

11
00:00:28,370 --> 00:00:25,980
the universe's light

12
00:00:30,710 --> 00:00:28,380
this tiny band of wavelengths called the

13
00:00:33,709 --> 00:00:30,720

visible spectrum holds every color in

14
00:00:35,810 --> 00:00:33,719
the rainbow light outside that span with

15
00:00:38,330 --> 00:00:35,820
longer or shorter wavelengths is

16
00:00:40,430 --> 00:00:38,340
invisible to our eyes but those

17
00:00:43,490 --> 00:00:40,440
invisible wavelengths can tell us so

18
00:00:45,590 --> 00:00:43,500
much more about the universe Hubble

19
00:00:47,150 --> 00:00:45,600
House's six scientific instruments that

20
00:00:49,369 --> 00:00:47,160
observe at different wavelengths

21
00:00:52,490 --> 00:00:49,379
together they expand our vision into

22
00:00:54,470 --> 00:00:52,500
infrared and ultraviolet light

23
00:00:57,529 --> 00:00:54,480
that doesn't mean Hubble can show us

24
00:00:59,689 --> 00:00:57,539
never before seeing colors in fact the

25
00:01:01,850 --> 00:00:59,699
telescope can only see the universe in

26
00:01:03,830 --> 00:01:01,860
Shades of Gray

27
00:01:05,870 --> 00:01:03,840
seeing in black and white allows Hubble

28
00:01:08,510 --> 00:01:05,880
to detect subtle differences in the

29
00:01:10,490 --> 00:01:08,520
light's intensity if one wavelength is

30
00:01:12,050 --> 00:01:10,500
brighter than another that tells us

31
00:01:12,969 --> 00:01:12,060
something about the science of that

32
00:01:16,010 --> 00:01:12,979
object

33
00:01:18,469 --> 00:01:16,020
but because color helps humans interpret

34
00:01:20,870 --> 00:01:18,479
what we see NASA Specialists work to

35
00:01:23,710 --> 00:01:20,880
process and colorize publicly available

36
00:01:26,450 --> 00:01:23,720
Hubble data into more accessible images

37
00:01:28,730 --> 00:01:26,460
when Hubble snaps a photo it puts a

38
00:01:31,070 --> 00:01:28,740

filter in front of its detector allowing

39
00:01:33,770 --> 00:01:31,080
specific wavelengths to pass through

40
00:01:34,609 --> 00:01:33,780
Broadband filters let in a wide range of

41
00:01:37,010 --> 00:01:34,619
light

42
00:01:39,649 --> 00:01:37,020
narrowband filters are more selective

43
00:01:42,830 --> 00:01:39,659
isolating light from Individual elements

44
00:01:45,289 --> 00:01:42,840
like hydrogen oxygen and sulfur

45
00:01:47,870 --> 00:01:45,299
Hubble observes the same object multiple

46
00:01:49,969 --> 00:01:47,880
times using different filters image

47
00:01:52,190 --> 00:01:49,979
processors then assign those images a

48
00:01:54,230 --> 00:01:52,200
color based on their filtered wavelength

49
00:01:56,749 --> 00:01:54,240
the longest wavelength becomes red

50
00:01:59,030 --> 00:01:56,759
medium becomes green and the shortest

51
00:02:00,410 --> 00:01:59,040
blue corresponding to the light sensors

52
00:02:02,810 --> 00:02:00,420
in our eyes

53
00:02:05,149 --> 00:02:02,820
combining them gives us a color image

54
00:02:07,789 --> 00:02:05,159
showcasing characteristics we can't make

55
00:02:10,309 --> 00:02:07,799
out in black and white

56
00:02:12,410 --> 00:02:10,319
adding color reveals the underlying

57
00:02:14,449 --> 00:02:12,420
science in every image

58
00:02:17,390 --> 00:02:14,459
it's like translating words into another

59
00:02:18,650 --> 00:02:17,400
language making sure no information is

60
00:02:21,350 --> 00:02:18,660
lost

61
00:02:22,970 --> 00:02:21,360
some words have an exact counterpart the

62
00:02:25,369 --> 00:02:22,980
meaning Remains the Same when you swap

63
00:02:28,369 --> 00:02:25,379

them couple's true color photos are like

64
00:02:32,030 --> 00:02:28,379
that they are a direct translation using

65
00:02:34,430 --> 00:02:32,040
broad filters and wavelengths we can see

66
00:02:37,550 --> 00:02:34,440
other words can't be translated directly

67
00:02:39,770 --> 00:02:37,560
when we use narrowband filters or peer

68
00:02:41,930 --> 00:02:39,780
outside the visible spectrum it's like

69
00:02:45,110 --> 00:02:41,940
translating words with no one word

70
00:02:46,850 --> 00:02:45,120
replacement easily done but requires

71
00:02:48,949 --> 00:02:46,860
more work

72
00:02:51,770 --> 00:02:48,959
narrowband images highlight the

73
00:02:54,050 --> 00:02:51,780
concentration of important elements

74
00:02:56,809 --> 00:02:54,060
infrared images are like heat Maps

75
00:02:59,750 --> 00:02:56,819
helping us spot newborn stars in dark

76
00:03:01,550 --> 00:02:59,760
Dusty clouds and peer further back in

77
00:03:04,430 --> 00:03:01,560
time and space

78
00:03:06,890 --> 00:03:04,440
in ultraviolet we uncover active aurorae

79
00:03:09,350 --> 00:03:06,900
on Jupiter and learn how young massive

80
00:03:12,350 --> 00:03:09,360
stars develop

81
00:03:14,330 --> 00:03:12,360
image processors also clean up artifacts

82
00:03:16,790 --> 00:03:14,340
signatures in an image that aren't

83
00:03:19,490 --> 00:03:16,800
produced by The observed Target as

84
00:03:22,250 --> 00:03:19,500
sensors age some pixels become imperfect

85
00:03:24,009 --> 00:03:22,260
returning too much electrical charge or

86
00:03:27,229 --> 00:03:24,019
not enough

87
00:03:29,290 --> 00:03:27,239
artifacts can leave behind odd shapes or

88
00:03:31,910 --> 00:03:29,300

return images without any true black

89
00:03:33,770 --> 00:03:31,920
these effects can be calibrated and

90
00:03:36,229 --> 00:03:33,780
removed

91
00:03:37,970 --> 00:03:36,239
other artifacts come from the dynamic

92
00:03:39,649 --> 00:03:37,980
environment of space

93
00:03:41,990 --> 00:03:39,659
even the best photographers get

94
00:03:44,809 --> 00:03:42,000
photobombed in Hubble's case the

95
00:03:47,449 --> 00:03:44,819
culprits are asteroids spacecraft or

96
00:03:50,570 --> 00:03:47,459
debris trails and high energy particles

97
00:03:53,030 --> 00:03:50,580
called cosmic rays by combining and

98
00:03:55,430 --> 00:03:53,040
aligning multiple observations image

99
00:03:58,369 --> 00:03:55,440
processors can identify them and piece

100
00:04:00,770 --> 00:03:58,379
together an artifact free image

101
00:04:03,050 --> 00:04:00,780
without processing many Hubble images

102
00:04:05,930 --> 00:04:03,060
would be divided down the middle

103
00:04:08,869 --> 00:04:05,940
this line called a chip Gap is the tiny

104
00:04:10,670 --> 00:04:08,879
space between some camera sensors Hubble

105
00:04:13,070 --> 00:04:10,680
moves slightly with each observation

106
00:04:15,470 --> 00:04:13,080
allowing image processors to fill the

107
00:04:18,229 --> 00:04:15,480
Gap and replace faulty pixels

108
00:04:20,990 --> 00:04:18,239
this process is called dithering

109
00:04:23,810 --> 00:04:21,000
and because there's no natural up or

110
00:04:27,050 --> 00:04:23,820
down in space processors decide how to

111
00:04:29,870 --> 00:04:27,060
rotate and frame the image

112
00:04:32,450 --> 00:04:29,880
it's a time consuming procedure simple

113
00:04:34,610 --> 00:04:32,460

images take about a week while large

114
00:04:39,650 --> 00:04:34,620
mosaics stitch together from many

115
00:04:45,230 --> 00:04:42,230
Hubble images may not be what we'd see

116
00:04:47,030 --> 00:04:45,240
firsthand instead they are tools for

117
00:04:49,610 --> 00:04:47,040
understanding science at a glance

118
00:04:52,990 --> 00:04:49,620
shedding light on otherwise invisible