In 2004, the Hubble Space Telescope took a million-second exposure of a small part of the sky to detect as many galaxies as possible. Here's what they saw!
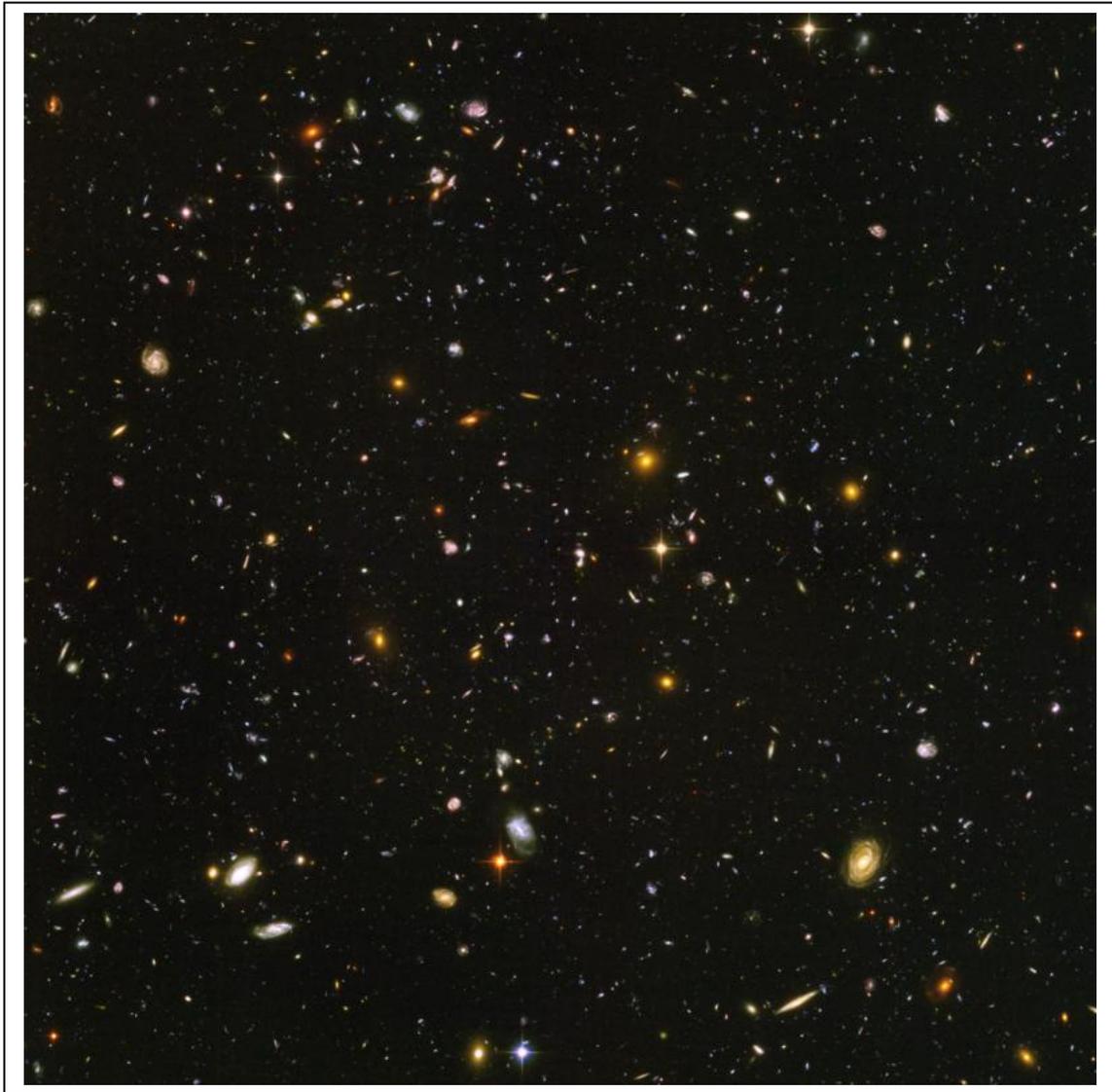
Problem 1 – Divide the field into 16 equal areas. Label the grids alphabetically from A to P starting from the top left cell. Count the number of 'smudges' in four randomly selected cells. What is the average number of galaxies in of one of the cells in the picture? What uncertainties can you identify in counting these galaxies?

Problem 2 – One square degree equals 3,600 square arcminutes. If Hubble Ultra Deep Field picture is 3 arcminutes on a side, what is the area of one of your cells in square degrees?

Problem 3 – There are 41,250 square degrees in the sky, about how many galaxies are in the full sky as faint as the faintest galaxy that Hubble detected in the Deep Field image?

Answer Key

Problem 1 – Divide the field into 16 equal areas. Count the number of 'smudges' in four randomly selected cells. What is the average number of galaxies in an area of the sky equal to the size of one of the cells in the picture? What uncertainties can you identify in counting these galaxies?

Answer: Students counting will vary depending on how many 'spots' they can easily see. There should be vigorous discussions about which smudges are galaxies and which ones are photocopying artifacts. Note that, depending on the quality of the laser printer used, the number of galaxies will vary considerably.

The full image is about 145 millimeters wide, so the cells should measure about 145/4 = 36 millimeters wide. For a typical photocopy quality, here are some typical counts in 4 cells: D=160, F=170; K=112; M=164. The average is (160+170+112+164)/4 = 151 galaxies/cell. Students estimates may vary depending on the number of galaxies they could discern in the photocopy of the Hubble Ultra-Deep Field image. A reasonable range is from 50 – 200 galaxies per cell on average.

Problem 2 – One square degree equals 3,600 square arcminutes. If the Hubble Ultra Deep Field picture is 3 arcminutes on a side, what is the area of one of your cells in square degrees?

Answer: The field is 3 arcminutes wide, so one cell is 3 / 4 = 0.75 arcminutes on a side. Since there are 60 arcminutes in one degree, this equals 0.75 x 1/60 = 0.0125 degrees. The area of the cell is 0.0125 x 0.0125 = 0.000156 square degrees.

Problem 3 – There are 41,250 square degrees in the sky, about how many galaxies are in the full sky as faint as the faintest galaxy that Hubble detected in the Deep Field image?

Answer: The number of these cells in the full sky is   41,250 square degrees/0.000156 square degrees = 264 million. Since there are on average 151 galaxies per cell, the total number of galaxies in the sky is   151 galaxies/cell x 264 million cells/full sky = 39.4 billion galaxies.

Note, astronomers using the original image data counted an average of 625 galaxies in each cell, for an estimated total of 165 billion galaxies in the full sky.