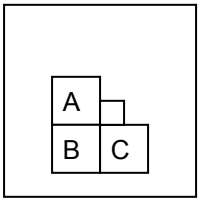
The Most Distant Galaxies

Is the Sky Empty?
The "Hubble Deep Field" image is a special very long time exposure view of a very dark area of space, where no galaxies or stars appear when observed for a short time. So the objects in the field of view are very faint (and therefore very likely very far away). Instead of the view being empty, though, the field is full of galaxies (and a few nearby faint stars).

Hubble Images:
On the next page is an image of the Hubble Deep Field, a very long observation of one small patch of sky. By making such a long time exposure, it was possible to detect some of the most distant objects seen so far in our Universe.

The image consists of 4 touching pieces, three large and a smaller one in the top right. Each one was made using a separate CCD imager on Hubble. The one in the top right covers a smaller area of the sky with the same number of "pixels" in the CCD. That one therefore has better "spatial resolution", and can be "blown up" to show more detail. Do not use that one for the following questions! *(NOTE: the new Hubble images taken with the new Advanced Camera for Surveys will not have this odd shape – each quadrant will have the same resolution, better than each of these!)*



Your Challenge:
Select any two of the three quadrants, note which ones you are using, and answer the following:

a) The region studied was deliberately chosen to lie out of the plane of our Milky Way Galaxy, so that almost everything in this picture is a distant galaxy. However, a few stars from our Milky Way Galaxy are present. These can be picked out because they have artificial X-shaped spikes. How many of these stars are there in the quadrants you selected?

b) Count the number of galaxies in your quadrants that have a size larger than 3 millimeters.
Use the largest length for those that are not circular. Estimate the number of galaxies in your quadrants that have a size smaller than 3 millimeters. Would you say that most of the galaxies are nearby or far away?

c) Spiral galaxies such as our Milky Way have well-defined spiral arms. Ellipticals are spherical or football-shaped balls with no structure. Irregulars have haphazard structure. Look at the "Galaxies" sections of Astronomy Update for examples. For the larger galaxies in your quadrants, determine which are likely to be spirals, ellipticals, and irregulars.

d) Objects that are red in this image can be this color either because they mostly contain old stars, or because they are at large distances and their light has been red-shifted by the expansion of the Universe. Conversely, blue objects either contain many young stars, or they are relatively nearby.
Look at both the bright and faint objects in your quadrants. Are they predominantly red or blue?
Are there any trends in color versus type of galaxy (spiral/elliptical)? Are there any trends in color versus size of galaxy?

e) Compare your answers to (b), (c), and (d) for the two different quadrants. Are your answers basically the same for the two quadrants, or radically different? Does this mean that the distant Universe is relatively uniform, or significantly clumped?

f) (Advanced) The galaxies stand out as being bright dots on a black background (the very faint "background glow" is mostly an artifact). If the Universe were infinite in size, would you expect to get this result? If the Universe has a finite size or finite age, would you expect to get this result?