The Sombrero Galaxy (a.k.a Messier-104 and NGC-4594) is a spiral galaxy located 28 million light years from the Milky Way in the direction of the constellation Virgo, and contains over 800 billion stars. It is the most massive galaxy in the Virgo Cluster, which itself contains over 2,000 galaxies spanning a volume of space 10 million light years in diameter. M-104 is about the same age as the Milky Way (~12 billion years), but instead of only having about 130 globular clusters, M-104 has over 2,000; each cluster contains about 100,000 stars. Its diameter is about 50,000 light years. The infrared and optical photographs below were taken with the Spitzer Infrared Telescope (main) and the Hubble Space Telescope (inset). The optical image shows mainly the locations of stars (whitish haze) and absorption of starlight by the dust disk. The infrared image shows mainly the dust (colored red) heated by starlight (colored blue), and can penetrate deeper into the interior of a galaxy that visible light.

Question 1 – What is the scale of the image in light years per millimeter?
Question 2 – What is the radius of the stellar (blue) component to the galaxy in light years?
Question 3 – What is the inner and outer radius of the ring of dust in light years?
Question 4 - What is the thickness of the dust disk in light years?
Question 5 – What is the radius of the faint inner disk in light years?
Question 6 – What is the diameter of the bright nuclear core containing the black hole?
Question 7 – How many globular star clusters (the star-like spots) can you count in this image?
Question 8 - How big, in light years, is the smallest dust cloud you can see in the outer disk?
Question 9 – Compare the infrared and optical photographs, and describe their similarities and differences. Why would an astronomer want to study the infrared photograph?

You can obtain much higher resolution (and gorgeous!!!) images of M-104 from the Spitzer website

http://www.spitzer.caltech.edu/Media/releases/ssc2005-11/release.shtml

and from Hubble website

http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/28/image/a

The following answers are relevant to the large 'Spitzer' image. Note, the smallest detail you can reliably measure with a millimeter ruler will be about 0.5 mm or 330x0.5 = 160 light years across. The above, enlarged photos will let you see features less than 50 light years (about 2 image pixels) across.

Question 1 – What is the scale of the image in light years per millimeter? **Answer:** Galaxy diameter 50,000 lys = 150 mm so the scale is about 330 light years per millimeter.

Question 2 – What is the radius of the stellar (blue) component to the galaxy in light years?
Answer: Depending on the quality of your laser printer, the distance from center to the outer edge of the blue haze (stars!!) will be about 40 to 60 mm, for a radius of 40x330 = 13,000 ly to 60x330 = 19,800 light years. The distance from our sun to the center of the Milky Way is about 25,000 light years.

Question 3 – What is the inner and outer radius of the ring of dust in light years?
Answer: The inner radius is about 45mm or 15,000 light years. The outer radius is about 70mm or 23,000 light years.

Question 4 - What is the thickness of the dust disk in light years?
Answer: The thickness of the dust disk can be estimated from the smallest width of the ring which is near the center of the picture. This width is about 3 mm or 1,000 light years. This is similar to the width of the disk of the Milky Way.

Question 5 – What is the radius of the faint inner disk in light years?
Answer: It may be difficult to see this inner disk depending on the quality of the photocopy. Its radius is about 25 mm or 8,000 light years.

Question 6 – What is the diameter of the bright nuclear core containing the black hole?
Answer: This is the star-like bright spot at the center of the Spitzer image. It is about 3 mm in diameter or 1,000 light years across. This is similar to the inner core region of our Milky Way which also contains a massive black hole. In both cases, the black hole size is 0.0001 light years and cannot be seen in photographs like this.

Question 7 – How many globular star clusters can you count in this image?
Answer: This may depend on the quality of the photocopy. Students should count all the star-like spots in the photo that are 'faint'. There are a few bright stars in the field, like the one in the lower right corner. Answers may range from 100 to 300. More can be seen in higher quality data.

Question 8 - How big, in light years, is the smallest dust cloud you can see in the outer disk?
Answer: Look in the dust ring and find the smallest 'blob'. You should be able to see interstellar clouds only 0.5 millimeters across or 160 light years. As a comparison, the Orion Nebula is about 40 light years across.

Question 9 – Compare the infrared and optical photographs, and describe their similarities and differences. Why would an astronomer want to study the infrared photograph? **Answer:** Both show stars, but the infrared image shows the dust ring more clearly, including a clearer view of the core region and inner disk. The optical photo shows the globular star clusters more clearly, and also the details inside the dust ring, which appear black. Astronomers would want the infrared photo because it lets them see more details in the dust clouds, especially when looking deep inside a galaxy where the stars would usually 'white out' the entire field and hide these details. Optical instruments can resolve finer details, so these images give better views of star clusters and the outsides of dust clouds.