1 Scales of the living organisms

The smallest living organism are those which contain a single cell, assuming that viruses are not regarded as living. The typical size of a bacterium is about one micrometer. The cells of more advanced organisms are usually larger. So The size of the smallest living organism is about one micrometer, that is $(10^{-6}\,\mathrm{m})$. If viruses are regarded as living as well, this lower limit for the size if further decreases by about one order of magnitude, to about $(100\,\mathrm{n\,m})$, which is $(10^{-7}\,\mathrm{m})$.

The wavelength of the visible part of the electromagnetic waves (more commonly called *light*) is a few hundred nanometers, from about $(450\,\mathrm{n\,m})$ for the far violet, to nearly $(800\,\mathrm{n\,m})$ for the far red. A light microscope can detect (*see*) objects which are larger that the wavelength of the light used in the microscope. So bacteria are almost at the threshold of visibility by light microscopes, and viruses cannot be seen by light microscopes.

The volumes corresponding to typical viruses and bacteria are $(10^{-21}\,\mathrm{m}^3)$ and $(10^{-18}\,\mathrm{m}^3)$, respectively. As the densities of theses things are essentially the same as the density of water, $(10^3\,\mathrm{k\,g\,m}^{-3})$, the masses of typical viruses and bacteria are $(10^{-18}\,\mathrm{k\,g})$ and $(10^{-15}\,\mathrm{k\,g})$, respectively.

The typical length size of a cell of more advanced organisms, say humans, is about ten times that of a typical bacterium. So the size of a typical cell inside our bodies is about $(10\,\mu\,\mathrm{m})$, or $(10^{-5}\,\mathrm{m})$. The volume of such a cell is then $(10^{-15}\,\mathrm{m}^3)$, and its mass is $(10^{-12}\,\mathrm{k\,g})$. The mass of a typical adult human is of the order of $(100\,\mathrm{k\,g})$. (I agree, most of us have a mass smaller than that, but the order of magnitude is correct.) This means that the body of each of us contains 10^{14} cells.

The largest animal which presently lives on the land, is the elephant. It can reach a mass of perhaps up to seven tons. Let's round to ten tons. That mass, $(10^4\,\mathrm{k\,g})$ is about a hundred times the mass of each of us. But the typical size of the cells in an elephant is about the same as the that of our cells. So an elephant can have about 10^{16} cells.

The largest animal on the earth is the blue whale. The blue whale (like other whales) actually lives in the ocean, not on the land. By the *earth*, it was meant the planet and not the land. A typical adult blue whale has a mass of about a hundred tons, that is $(10^5\,\mathrm{k\,g})$, one thousand times our mass. Again, the cell sizes aren't much different from ours. So a blue whale has about 10^{17} cells.

The blue whale seems to be the largest animal which has ever lived on the earth. It is larger than the dinosaurs the fossils of which have been discovered. We have the honor of sharing the earth with the largest animal ever lived on it. But the blue whale is not the largest living organism on the earth. That position belongs to a plant, not an animal. The largest plant on the earth is about one order of magnitude more massive than the blue whale. There are trees with a mass of about a thousand tons, or even more. The plant cells are of roughly the same size of animal cells, perhaps slightly larger. So a tree of a mass one thousand tons, that is $(10^6\,\mathrm{k\,g})$, has about 10^{18} cells.

Regarding the number of cells, on a logarithmic scale, midway between the

bacteria (which have a single cell) and those giant trees is something with 10^9 cells. The typical mass of each cell of such an organism has a mass of about $(10^{-12}\,\mathrm{k\,g})$, like our cells, not bacteria. So such an organism should have a mass of about $(10^{-3}\,\mathrm{k\,g})$, which is one gram. This is of the order of the masses of the smallest mammals and birds.