

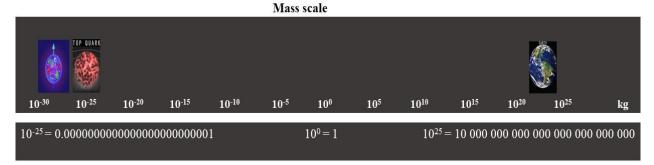
Can you play nature's scale?

The universe is a big place and getting bigger, but there is a whole world of small objects, like cells, atoms and quarks, which can't be seen with the naked eye. Scientists invented different tools, such as microscopes, telescopes and accelerators, to observe very small and very large objects in our universe. Scientists at Fermilab study elementary particles—the basic building blocks of matter. They build particle accelerators and detectors to observe them. Neutrinos, quarks, and electrons are the smallest pieces of matter known to scientists. **How small are they?**

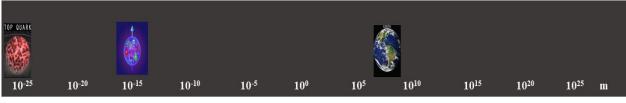
Materials: Color cardboard sheets, plastic meter stick to make mass and size scales with powers of 10

Activity: Cut cardboard and make 2" x 3" cards. Label cards: top quark, proton, mosquito, bison, planet earth, Milky Way Galaxy, universe; add other objects too, if you like. Make your guess and arrange these objects in ascending order from quarks to galaxies onto the mass and size scales. Now, use the attached chart (or the links attached) and look up the mass and size for each object. Make sure your arrangement is correct.

Questions to ask: What tool do you need to see a galaxy? (a cell, a quark...)? How small is an atom compared to a mosquito? How small is a proton compared to the Earth?



Size scale



| $10^{-25} = 0.0000000000000000000000000000000000$ | $10^0 = 1$ | $10^{25} = 10\ 000\ 000\ 000\ 000\ 000\ 000\ 000$ |
|---|------------|---|
| | | |

| Object | Size in m | Mass in kg |
|------------------|-----------|------------|
| Top quark | < 10-18 | 10-25 |
| Proton | 10-15 | 10-27 |
| Mosquito | 10-3 | 10-6 |
| Bison | 100 | 102 |
| Planet Earth | 107 | 1024 |
| Milky Way Galaxy | 1021 | 1042 |
| Universe | 1024 | 1052 |

Useful links:

https://en.wikipedia.org/wiki/Orders of magnitude (mass) https://en.wikipedia.org/wiki/Orders of magnitude (length) https://www.youtube.com/watch?v=8Are9dDbW24 https://ed.fnal.gov/lsc_exhibits/list.html https://www.liveworksheets.com/id/bz39940qp