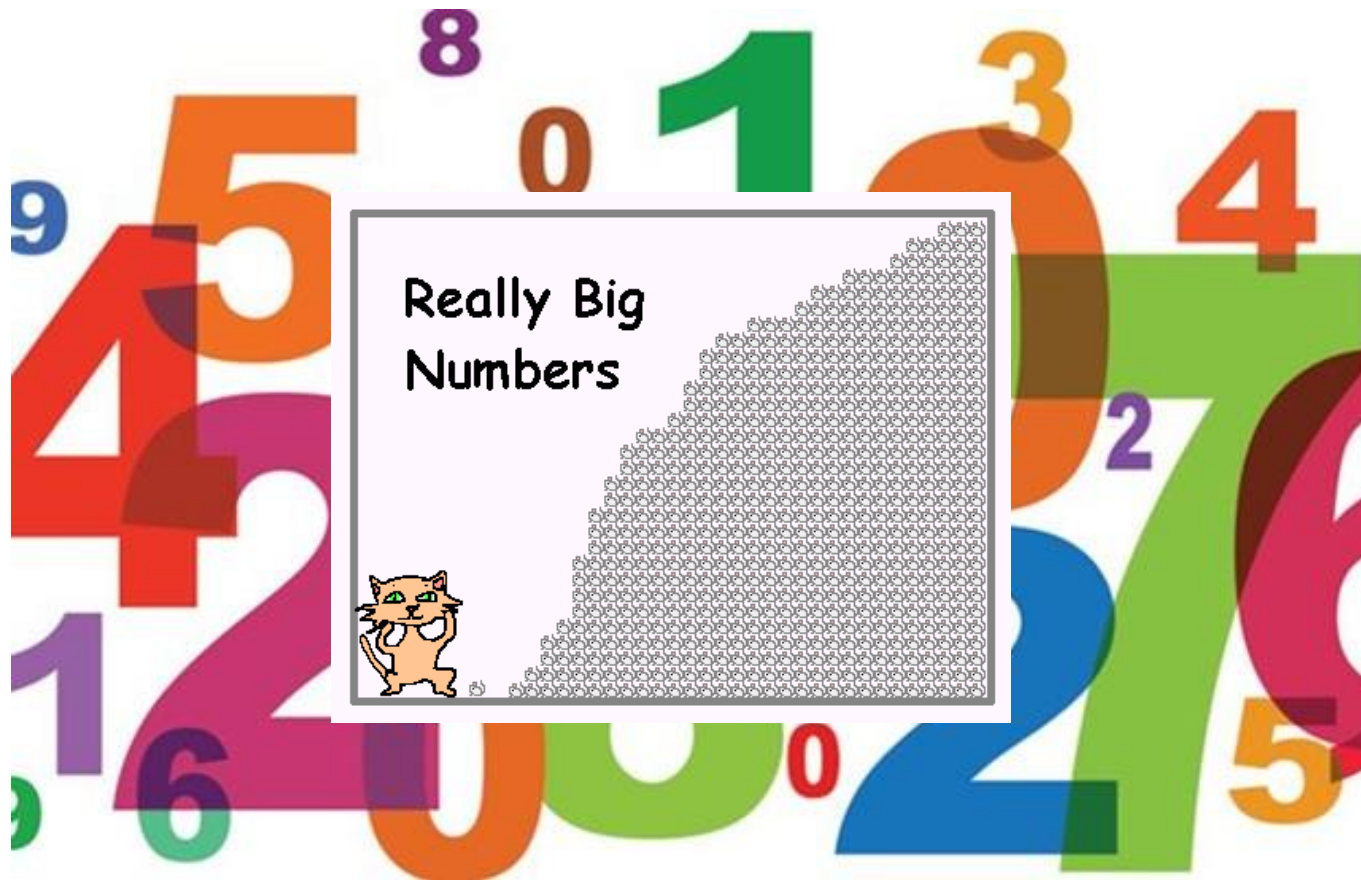


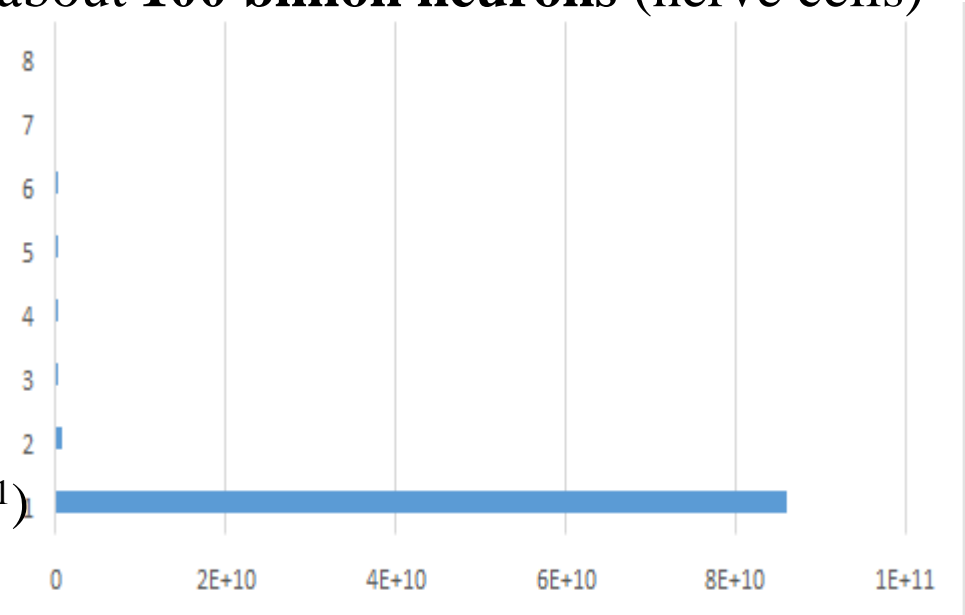
Question

- What's your favorite big number?

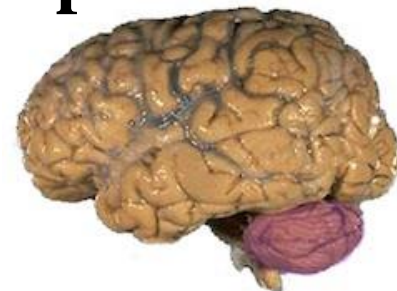


Cells

- The average human brain has about **100 billion neurons** (nerve cells)
 - Jellyfish: 800
 - Snail: 11,000
 - Fruit Fly: 100,000
 - Ant: 250,000
 - Honey Bee: 960,000
 - Rat: 200,000,000
 - Cat: 760,000,000
 - Human: 86,000,000,000 (10^{11})



- The average human brain has about **10^{15} synapses**
 - Rat: 10^{11}
 - Cat: 10^{13}
 - Human: 10^{15}





Stars

- Stars in the Milky Way: 200 billion stars
- Galaxies in the Universe: 100 billion galaxies





Of Humans, Galaxies and Atoms

- Atoms in the Universe: $\sim 10^{80}$
 - Only accounts only for the observable universe which reaches 46 billion light years in any direction, and is based on where the expansion of space has taken the most distant objects observed
 - Within this observable universe, this matter is spread homogeneously throughout space, at least when averaged over distances longer than 300 million light-years
 - On smaller scales, however, matter is observed to form into the clumps of hierarchically-organized luminous matter that we are all familiar with
 - most atoms are condensed into stars, most stars are condensed into galaxies, most galaxies into clusters, most clusters into superclusters and, finally, into the largest-scale structures like the Great Wall of galaxies



Big Numbers

Million (Mega): 10^6 ← *A book of zeroes* (400 pages with 50 lines per page and 50 zeroes per line)

- Billion (Giga): 10^9 ← *Neurons in a human brain/Stars in the Milky Way*
- Trillion (Tera): 10^{12} ← *How many \$ greeks owe/Your Wikipedia Lab*
How many \$ americans owe
- Quadrillion (Peta): 10^{15}
- Quintillion (Exa): 10^{18}
- Sextillion (Zeta): 10^{21} ← *Human neurons on Earth*
- Septillion (Yotta): 10^{24} ← *Stars in the Universe*
- Googol: 10^{100} ← *Atoms in the Universe*
← *10,001st Primonacci number*
- Googolplex: 10^{googol}

Golden Ratio

- Historically, the number can be seen in the architecture of many ancient creations, like the *Great Pyramids* and the *Parthenon*
 - In the Great Pyramid of Giza, the length of each side of the base is 756 feet with a height of 481 feet. The ratio of the base to the height is roughly 1.5717, which is close to the Golden ratio
- These numbers can be applied to the proportions of a rectangle, called the Golden rectangle. This is known as one of the *most visually satisfying of all geometric forms*

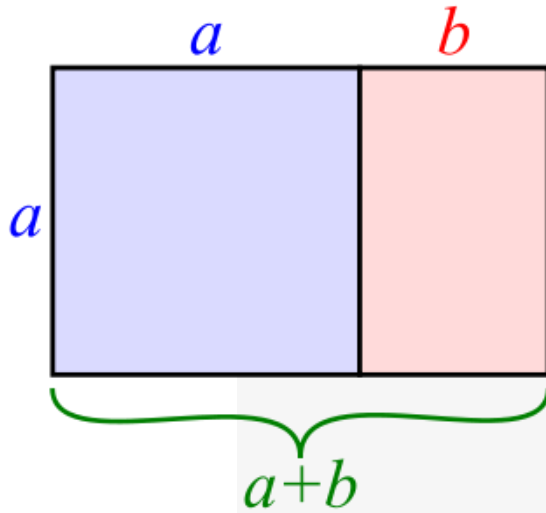




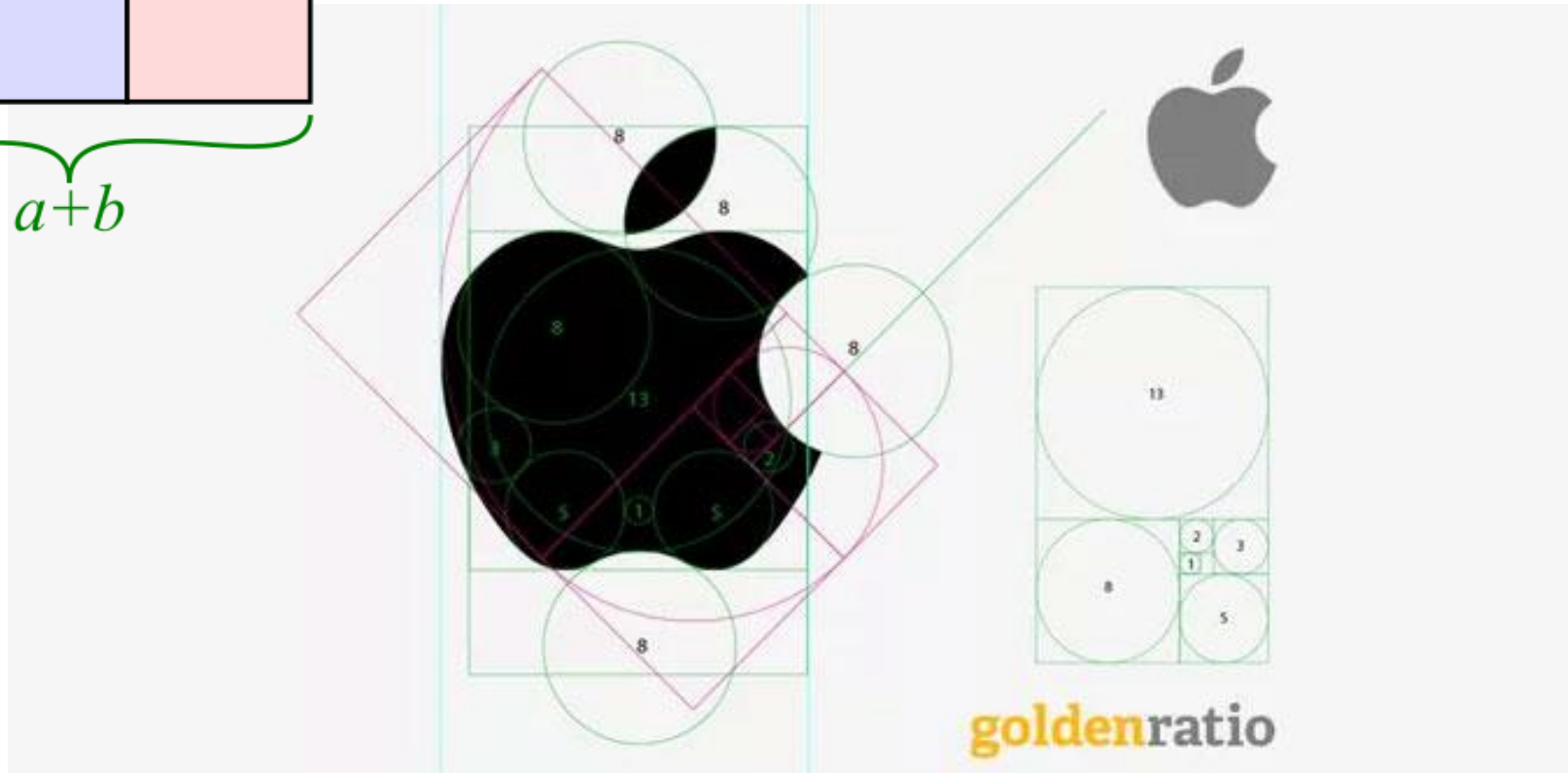
Golden Ratio

- Two quantities are in the golden ratio if their ratio is the same as the ratio of their sum to the larger of the two quantities

Golden Ratio in Design



- $a/b = (a+b)/a$





Golden Ratio in nature

- The number of petals on some flowers or seeds in sunflowers follows the Fibonacci sequence..
 - It is believed that in Darwinian processes, each petal is placed to allow for the best possible exposure to sunlight and other factors
 - The measurement of the human navel to the floor and the top of the head to the navel is the Golden ratio
 - <http://io9.gizmodo.com/5985588/15-uncanny-examples-of-the-golden-ratio-in-nature>

Golden Ratio in nature



Golden Ratio and Fibonacci



- Dividing each Fibonacci number by the previous number gives: $1 / 1 = 1$, $2 / 1 = 2$, $3 / 2 = 1.5$, and so on up to $144 / 89 = 1.6179....$
 - The resulting sequence is:
 - 1, 2, 1.5, 1.666..., 1.6, 1.625, 1.615..., 1.619..., 1.6176..., 1.6181..., 1.6179...
- Do you notice anything about those numbers? Perhaps the fact that they keep oscillating around and getting tantalizingly closer and closer to 1.618?—the value of phi: the golden ratio!
- Completely unbeknownst to Fibonacci, his solution to the rabbit population growth problem has a deep underlying connection to the golden ratio that artists and architects have used for thousands of years