EDITORIAL

Microbiology by numbers

The scale of life in the microbial world is such that amazing numbers become commonplace. These numbers can be sources of inspiration for those in the field and used to inspire awe in the next generation of microbiologists.

In science, numbers can become so complicated that their meaning becomes lost. To provide relevance to these unimaginable quantities, it is often useful to draw a comparison with other large (but more manageable) numbers, and nowhere is it more appropriate to do this than in the field of microbiology, in which mind-blowing numbers are to be found wherever one looks. Here, we draw together some awe-inspiring numbers that are found in microbiology, sourced from our followers on Twitter (@NatureRevMicro). The examples below are mostly based on 'back of the envelope' calculations and should therefore be viewed as they were intended: ballpark figures aiming to inspire. Perhaps somewhat aptly, the number of words that will fit on this page has precluded the inclusion of references, but those that were provided can be found in Supplementary information S1 (box).

Astronomy is a field that is used to dealing with large numbers, but these can be dwarfed when compared with life on the microbial scale. For instance, if all the 1×10^{31} viruses on earth were laid end to end, they would stretch for 100 million light years. Furthermore, there are 100 million times as many bacteria in the oceans (13×10^{28}) as there are stars in the known universe. The rate of viral infection in the oceans stands at 1×10^{23} infections per second, and these infections remove 20–40% of all bacterial cells each day. Moving onto dry land, the number of microorganisms in a teaspoon of soil (1×10^{9}) is the same as the number of humans currently living in Africa. Even more amazingly, dental plaque is so densely packed that a gram will contain approximately 1×10^{11} bacteria, roughly the same number of humans that have ever lived. Not quite so densely packed but impressive all the same, the bacteria present in the average human gut weigh about 1 kilogram, and a human adult will excrete their own weight in faecal bacteria each year. The number of genes contained within this gut flora outnumbers that contained within our own genome 150-fold, and even in our genome, 8% of the DNA is derived from remnants of viral genomes.

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Microbiological numbers can also span enormous scales in space and time. For instance, the largest known contiguous fungal mycelium covered an area of 2,400 acres (9.7 square kilometres) at a site in eastern Oregon, USA. At the other end of the scale, there are 958,980 atoms in a single Simian virus 40 (SV40) virion. On the temporal scale, microorganisms can become dormant or form spores and survive for great lengths of time. For example, some viable bacteria extracted from amber were estimated to be 34,000–170,000 years old.

Perhaps the scariest numbers in microbiology relate to pathogenic microorganisms. Worldwide, 16 million people die from infectious disease every year, and many of these deaths are preventable. Approximately one in every 12 individuals, or 500 million people worldwide, is living with chronic viral hepatitis, and the estimated number of new chlamydial infections per year is approximately 50 million, more than the population of South Korea. The bacterium *Clostridium botulinum* produces a toxin so potent that 3 grams would be enough to kill the population of the United Kingdom and 400 grams would kill everyone on the planet.

In total, there are ~1,400 known species of human pathogens (including viruses, bacteria, fungi, protozoa and helminths), and although this may seem like a large number, human pathogens account for much less than 1% of the total number of microbial species on the planet. On this point, ignoring questions about what actually constitutes a species, estimates for the total number of microbial species vary wildly, from as low as 120,000 to tens of millions and higher. Part of the reason for this large range is that we have only sequenced 1×10^{-22}% of the total DNA on Earth (although the Earth Microbiome Project should improve this dramatically to 1×10^{-20}% in the next 3 years). This means that the fraction of microbial diversity that we have sampled to date is effectively zero, a nice abstract entity to end on.

These examples barely scratch the surface of the wondrous world of microbiology, and we encourage readers to continue to help us build a list of the numbers that inspire interest in the field. Post your examples on Twitter to @NatureRevMicro and include the hashtag #microbiologybynumbers.

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