Bacteria, One and Many

One of the great complicating factors in biology is the individuality of its units of study. All organisms, including those who are genetically identical, are in practice different from each other, especially when the influence of the environment is considered. This is in contrast to the physical sciences, where all units in a given class (such as atoms of a particular element) are considered, for practical purposes, to be identical. A good example of this aspect of biological theory is given by the problems associated with the concept *species*.

The modern definition of a species is that of a natural population of individuals that is reproductively and genetically isolated from other populations. Each species has its own gene pool, and the individuals are the transitory keepers of the gene pool.

While this definition serves for the higher forms of life, the Metazoa, it breaks down when considering the single-celled bacteria. Bacteria cannot be so neatly classified into species because the occasional exchange of genetic material between different types defeats the definition. While most bacteria can be grouped into similar types, not all such groups are genetically isolated from each other.

Escherichia coli, a form of bacteria which inhabits the human gut, although reproducing asexually by binary fission, also come together and transfer genetic material in a process known as sexual conjugation. A bacterium with a sex factor F+ will transfer this sex factor to another *E. coli* bacterium possessing the F- factor via a microtubule joining the two cells. Along with the F factor, part or all of the bacterium's circular chromosome may also be transferred. In this way genes are passed between different strains of *E. coli*.

Exchange of genes also occurs between 'species'. *E. coli* can infect *Shigella* species with the F factor, along with portions of its chromosomes. A *Shigella* bacterium may then transfer the F factor back into other *E. coli* cells, along with those chromosome portions, by acting as the male conjugant. Similar relationships exist between *E. coli* and other species, such a *Pasteurella pestis* (bubonic plague), and *Salmonella* species. *Salmonella* may transfer the F factor, along with part or all of the bacterial chromosome, to other *Salmonella*, *Shigella* or *E. coli*. bacteria. Genes conferring resistance to antibiotics can be transferred within and between bacterial species in this way.

The movement of genes between different types of bacteria occurs by a variety of other means, including transformation and transduction. In transformation, extracellular DNA is taken up by recipient cells and transferred across the cell membrane. Special receptor sites on the cell wall capture free DNA in the surrounding medium. After entering the cell, the DNA may undergo recombination with the circular chromosome of the cell.

Transduction is the transfer of DNA from a donor cell to a recipient cell through the agency of bacteriophages, viruses that infect bacteria and take over the genetic processes of the infected cell as part of their reproductive cycle. As new viruses are produced within the cell, some genetic material from the bacterial host may be picked up by these viruses, and later be passed to other strains of bacteria, enabling them to use new energy sources, or to resist antibiotics.

Since the means of gene transfer between different types of bacteria are manifold, these micro-organisms might be thought of as constituting a single large gene pool, rather than a series of isolated gene pools.

This idea was taken up some years ago by two Canadian researchers, Sorin Sonea and Maurice Paniset, who proposed a revolutionary interpretation of bacteria as forming a 'planetary bacterial clone', whose genes collectively make up a single enormous potential genome. On this view, all bacteria would be seen as a single species, the individuals of which maintain a common gene pool.

Indeed, this planetary bacterial clone might be thought of as a single individual, since in theory the whole gene pool is universally accessible by all its agents. In association with their fast reproductive rate, this gene pool bestows immense evolutionary versatility on its bacterial guardians, as advantageous mutations in one strain are passed to others.

The idea of a common gene pool for all types of bacteria highlights the difficulties of the conventional definition of species. It also reminds us of the great adaptive power of bacteria, whose presence is universal, and whose challenge to our own species remains as forceful as ever.

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