Genomics throws species definition in question for microbes

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Until a decade ago, scientists categorized microorganisms almost exclusively by their physical characteristics: how they looked, what they ate, and the by-products they produced. With the advent of genomic sequencing and genetic analysis in the 1990s, our understanding of the relationships between different microorganisms fundamentally changed. In light of this new knowledge, what exactly is the definition of a microbial species, and how should microbiologists be categorizing microorganisms?

These questions are the focus of a new report released by the American Academy of Microbiology (AAM) entitled Reconciling Microbial Systematics and Genomics.

"It is clear that the current system for designating microbial species is somewhat functional, but inadequate in many ways. It is unclear whether this system should be replaced or renovated," says Richard Roberts of New England Biolabs, one of the authors of the report.

The report is the result of a colloquium convened by the AAM in September 2006. Participants with expertise in microbial taxonomy, systematics, ecology, physiology and other areas described the history of microbial taxonomy, the state of the field today, and how work in the field should proceed in the future. The report is a record of their comments and recommendations.

In the late 1800s, in order to make sense of the vast diversity of

microbiological organisms, microbial taxonomists developed a system of placing microorganisms into categories in which each organism was granted a "genus" and "species" designation. At the time, physical (or phenotypic) properties were the only means of describing microorganisms, so the system was based on measurable and observable characteristics of the organisms, not genetic traits.

In the late 20th century, molecular biology uncovered the genetic relationships between microorganisms, and some of the secrets of microbes that had yet to be cultured in the lab (and hence phenotypically characterized) were revealed.

"Much of this new knowledge was incorporated into species descriptions, but difficulties in classification persisted and novel issues arose," says Roberts. "Conflicts exist between phenotypic and phylogenetic information, the means for classifying non-cultured microbes are limited under the current paradigm, and microbial species do not always demonstrate the phenotypic or genetic cohesiveness expected of them. For these reasons and others it has become clear that the species classification framework in use today is not capable of fully portraying and organizing microbial diversity."

The report contains an in-depth review of the myriad issues and conflicts involved in the classification of microbes in the post-genomic era, including a discussion on the definition of the term "species." It ends with a set of specific recommendations including, but not limited to:

-- The establishment of a subcommittee within the International Committee on Systematics of Prokaryotes to consider a paradigm shift in the species definition.

-- The need for more thorough study of the mechanisms of speciation before a more meaningful and practical species theory can be developed.

-- The need for more comprehensive and systematic data to uncover whether microorganisms are organized into robust, definable, biologically meaningful clusters that adhere to the concept of species.

-- The acquisition of draft-quality genome sequences for all type strains to help advance the integration of genomic information into our understanding of microbial diversity and enable researchers to map phenotypes to genomes.

Source: American Society for Microbiology