

DNA-Stable Isotope Probing Technology (DNA-SIP)

Background

[DNA-stable isotope probing technology](#) (DNA-SIP) is a molecular ecology technology that uses stable isotopes to trace the genomic DNA of microorganisms in complex environments. Making use of stable isotopes to trace microbial genomic DNA in complicated environments can realize the transformation of research from single microbial physiological process to physiology and ecology of microbial community, and directional exploration of important microbial resources at a higher and more complex level, promoting microbial physiological ecology and biotechnology development.

Technical Principle

DNA-SIP technology mainly targets microbial communities and reveals microbial actors involved in the metabolic process of labeled substrates in complex environments. With the exception of phosphorus, almost all biologically significant elements have 2 or more stable isotopes. Generally, compounds composed of heavy isotopes or light isotopes have the same physicochemical and biological properties, so microorganisms can utilize stable heavy isotopes to grow and reproduce. Carbon and nitrogen are fundamental elements of life, so environmental samples are often cultured with [stable isotopes](#) such as ^{13}C -labeled substrates. Environmental microbial cells that utilize the labeled substrate continuously divide, grow, reproduce and synthesize ^{13}C -DNA. Subsequently, the total DNA of environmental microbial genomes was extracted and separated from ^{13}C -DNA and ^{12}C -DNA by ultra-high-speed density gradient centrifugation, and then ^{13}C -DNA was analyzed by molecular biology techniques.

This method enables the identification of microbial actors in complex environmental samples that assimilate labeled substrates. By combining specific material metabolism processes with the species composition of complex environmental microbial communities, it is possible to discover important functional genes at the microbial community level, and then reveal the molecular mechanisms of microorganisms in important physiological and metabolic processes in complex environments.

Technical Applications

DNA-SIP technology has received extensive attention in the study of the earth's key elements in the geochemical cycle and the microbial degradation of pollutants. It is an important means to study the molecular mechanism of microbial physiological and ecological processes in complex environments. For example, it is applicable for exploring the microbial physiological metabolism process of single-carbon compounds (such as methane) in forest soil and lake sediment, the

microbial degradation process of pollutants, the microbial-mediated soil material and energy cycling process, and the microbial assimilation and utilization process of plant photosynthetic products.

In recent years, the application field of DNA-SIP technology has also been continuously expanded, and it has important application prospects in the physiological and ecological processes of intestinal microorganisms and health medicine, the discovery of important functional genes of microorganisms, the high-throughput screening of biologically active substances, and the synthesis of active biocatalysts.

The combination of DNA-SIP and metagenomics can link the characteristics of certain microorganisms to their special metabolism, not only can detect low-level microorganisms from metagenomic libraries, but also accelerate the development of new enzymes and other biologically active substances. This technology is expected to solve the urgent need for new enzyme preparations in the industry, and can significantly improve the success rate of gene detection and greatly reduce the cost of finding new enzymes.