



**Genoscope sequences the genome of *Kuenenia stuttgartiensis*,
a major player in the nitrogen cycle
(*Nature*, april 6, 2006)**

Evry, April 6, 200—The genome of the bacterium, *Kuenenia stuttgartiensis*, has just been sequenced from a bacterial community from the environment. This result, which is published in the *Nature* issue of April 6, 2006, is the fruit of a long collaboration between scientists from Genoscope (Genopole, Evry)* and groups from the universities of Nijmegen**, Munich*** and Vienna****. *Kuenenia stuttgartiensis* is the prototype of the anammox group of bacteria. This group carries out the “anammox” chemical reaction by oxidizing ammonia to nitrogen in the absence of oxygen. This characteristic makes this group a major player in the regeneration of atmospheric nitrogen. The use of this bacterium is being tested industrially as a means of simplifying, accelerating and reducing the cost of treatment of waste water.

The composition of atmospheric gases is regulated by an ensemble of complex processes, called biogeochemical cycles, which depend largely on the microorganisms in our environment. The nitrogen cycle, which has been studied since the latter part of the 19th century, has not yet yielded all its secrets. Thus it has recently been observed that ammonia (a degradation product of biologic origin) could be oxidized by anaerobic bacteria from the anammox group. Like the majority of bacteria from the environment, they cannot be isolated, and genomic approaches are needed to study them.

***Kuenenia stuttgartiensis*, a bacterium from the anammox group**

The bacteria which perform anaerobic oxidation of ammonia, called anammox for “anaerobic ammonium oxidation”, belong to the division Planctomycetes, a poorly understood group of bacteria which have been ignored by microbiologists for a long time, but which includes numerous species with unique and unusual characteristics.

The anammox reaction, which transforms ammonia and nitrites into nitrogen gas under anaerobic conditions, is a major element of the nitrogen cycle. It has been estimated at present that it contributes to more than 50% of the transformation of nitrogen in the oceans. This transformation produces hydrazine as an intermediate, a substance which is highly toxic. The bacterial cells must protect themselves from it by confining it in a vesicle called an “anammoxosome”, which has been identified as the seat of the chemical reactions. The membrane of this vesicle, which is perfectly impermeable, is mainly composed of specific lipids, the ladderanes, which have been discovered recently and for which the biosynthetic pathway is unknown.

Sequencing of the anammox genome

Kuenenia stuttgartiensis is a bacterium which divides very slowly (one division every 2-3 weeks) and which has not yet been isolated in pure culture. The Genoscope scientists used DNA from populations of bacteria cultivated in a bioreactor for one year. The reconstitution of the genome of *K. stuttgartiensis* has led to the identification of the genes responsible for the biosynthesis of ladderanes, as well as for the process of anaerobic oxidation of ammonia. The genome of this bacterium has proven to be much more vast than what was believed, and includes a very large repertoire of metabolic pathways which notably permit the use of carbon dioxide to perform these biosyntheses.

Systematics of Planctomycetes

Analysis of the genome of *K. stuttgartiensis* has also made it possible to settle the controversy about the evolutionary origin of the Planctomycetes group. It turns out that they have more genes in common with the Chlamydiae than with any other group, and therefore descent from the same common ancestor as the Chlamydiae.

An environmental application: waste water treatment

The utilization of anammox for the treatment of waste water is currently being studied experimentally. It presents numerous advantages in comparison with the classical method of nitrification/denitrification by permitting a simplification of the procedure, acceleration of treatment and a considerable reduction in cost, notably by economy of energy. The supply of oxygen to the basin can be reduced because the anammox bacteria do not need organic carbon for growth and produce less biomass, which reduces the mass of the sludge to be eliminated.

The sequencing of the genome of an anammox bacterium and the identification of its metabolic potential were especially difficult, and are the result of the efforts of a European consortium. This is one of the first successful examples of the reconstruction of a bacterial genome from a complex community. This clearly illustrates the importance of producing more environmental sequences in order to explore diversity and complete the inventory of still-unknown enzymatic activities.

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GENOSCOPE (Centre National de Séquençage)

The first large French biological institute created in 1997, Genoscope is dedicated to the sequencing of genomes and to the analysis of the sequences produced within the framework of large international projects (human genome, Arabidopsis, rice, etc.) or internal projects. The species studied are of fundamental, medical or economic interest.

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