DEPARTMENT OF MOLECULAR BIOLOGY
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KEEP IT SIMPLE: SYMBIOSIS IN PLANTS GOES BACK TO BASICS

Media release

A new discovery of a simpler single-cell infection mechanism may improve our understanding of how legumes control infection by the beneficial bacteria called *Rhizobium* and build root nodules in which the bacteria fix atmospheric nitrogen which can be used by the plants. This discovery may lead to the development of sustainable agriculture with reduced use of artificial fertilisers.

Scientists from The Danish National Research Foundation's CARB Centre (Centre for Carbohydrate Recognition and Signalling) at the Department of Molecular Biology, Aarhus University, have used the model legume *Lotus japonicus* to reveal how legume plants use three different mechanisms to control infection by symbiotic bacteria. Like other organisms, plants have mechanisms to fight pathogenic bacterial infection, but in this beneficial symbiotic interaction, entry of the bacteria is accepted. The bacteria are accommodated inside the plant cells where they convert atmospheric nitrogen into ammonium, which is used by the plant as a nitrogen source. Consequently, this symbiotic interaction enables legumes to grow without nitrogen fertiliser (Figure 1).

Figure 1.

Lotus japonicus plants **with** (left) and **without** (right) nitrogen fixing root nodules, showing the growth improvement caused by symbiosis with the *Rhizobia* bacteria.

High-resolution photos:

Fig. 1a

Fig. 1b

Most cultivated crop legumes will normally allow a stringently controlled, sophisticated entry of bacteria through their root hair infection threads to infect the root tissue during the development of nitrogen fixing root nodules (Figure 2). The new research reveals a simpler single-cell infection mechanism that may be the first mechanism evolved for symbiosis in primitive legumes at the evolutionary emergence of the legume plant familiy. A detailed understanding of this simple single-cell infection therefore serves to understand the evolution of symbiotic nitrogen fixation and facilitates a step by step approach in future biotechnological strategies investigating the possibilities for transferring symbiotic nitrogen fixation to for example cereals. In the long-term perspective, this could conserve the reserves of fossile fuels and contribute to sustainable agriculture with less use of expensive nitrogen fertiliser.

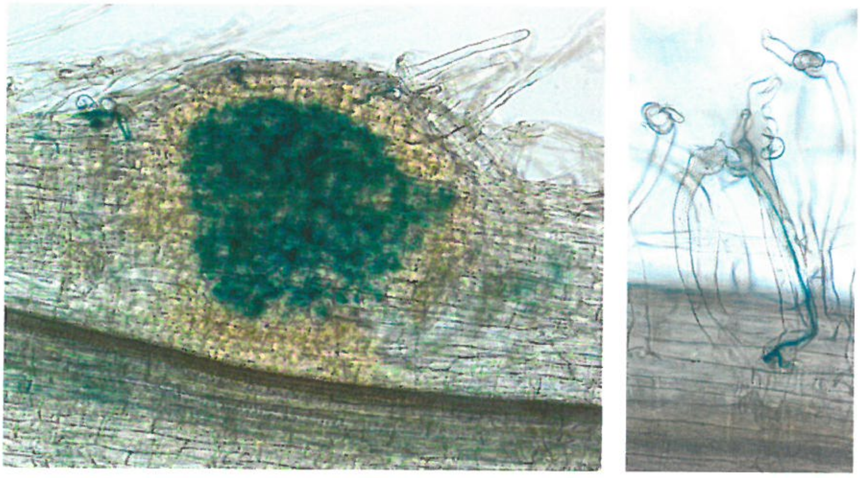


Figure 2.

Left:
Cross section of a root nodule showing the *Rhizobia* bacteria (blue) accommodated inside the nodule.

Right:
Close-up of a root hair with an infection thread containing bacteria (blue) progressing towards the root nodule cells.Fotoer i høj opløsning:

High-resolution photos:
Fig. 2a

Fig. 2b

Goes online with Nature

The results by the CARB Centre scientists have just been published in *Nature Communications*, a new journal launched by *Nature Publishing Group*. *Nature Communications* is the first of the classical high impact journals to skip the paper print and represents a new concept for online-only publication of biological, physical and chemical sciences. The first online issue of 12 April 2010 features the work presented here.

Background

Nitrogen fixing symbiosis between legumes and the soil bacteria *Rhizobium* is established as a non-pathogenic bacterial infection of cells of the developing root nodule organ. This developmental process is controlled by the host legume, which has a genetic programme that synchronises two processes running in parallel: organ formation and bacterial infection. For the experimental scientists, this coordination has made separation of the molecular mechanisms underlying these two very different plant developmental processes difficult and has especially limited the assignment of the specific role of plant genes governing the bacterial infection and organ formation.

Genetic dissection of symbiosis

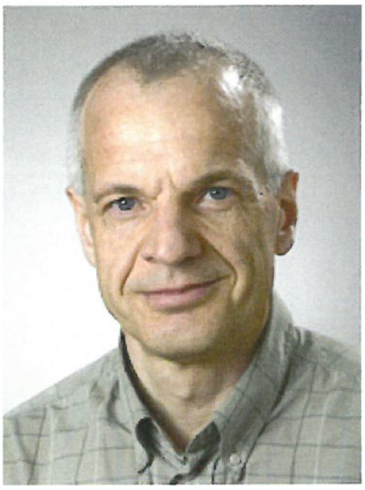
The use of genetics has now made it possible to make a synthesis of a decade of gene discoveries identifying legume genes required for symbiosis. Altogether the mechanistic role of sixteen receptors and signal transduction components has been brought together in a functional framework coordinating infection and root nodule organ formation. Broadening this genetic approach further by asking for the role of individual genes in the infection process revealed how the legume plant possesses three different mechanisms for controlling bacterial infection. The simplest and least effective version is an intercellular invasion followed by single-cell endocytosis, and this mechanism is proposed to be the ancient entry mechanism which founded symbiosis in the legume plants. The identification of the gene-set regulating single-cell infection may be the key to "the biotechnological jewel in the crown": design of symbiosis in plants like cereals that are currently unable to interact with rhizobial bacteria. The central questions that can now be addressed are: how many genes does the legume plant use to host the symbiotic bacteria, and what is the minimum gene-set needed to build a primitive symbiotic system in a non-legume plant?

These questions will be addressed by the CARB scientist in future studies.

Title of the article: The molecular network governing nodule organogenesis and infection in the model legume *Lotus japonicus*

Authors: Lene H. Madsen, Leïla Tirichine, Anna Jurkiewicz, John T. Sullivan, Anne B. Heckmann, Anita S. Bek, Clive W. Ronson, Euan K. James and Jens Stougaard

More information



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SYMBIOSE

Symbiose - 16 geners rolle kortlagt

Af Inga C. Bach, redaktør
Indlæg oprettet d. 14.04.10 kl. 10:31

Forskere fra Grundforskningscenteret CARB (Centre for Carbohydrate Recognition and Signalling) ved Molekylærbiologisk Institut, Aarhus Universitet, har i samarbejde med forskere fra New Zealand og Storbritannien fundet nye vigtige brikker i det molekylære netværk, der styrer dannelse af rodknolde og infektion med symbiotiske *Rhizobium*-bakterier. Detaljerede studier af mutanter af japansk kællingetand (*Lotus japonicus*) har afsløret, hvordan bælgplanter bruger tre forskellige mekanismer til at kontrollere bakteriernes infektion.

Man har nu et samlet billede af et funktionelt netværk med hele 16 receptorer og signaltransduktions-proteiner i bælgplanter og deres rolle i samspillet med kvælstoffikserende *Rhizobium*-bakterier.

De seneste resultater blev publiceret i Nature Communications den 12. april 2010. Titel på artikel: The molecular network governing nodule organogenesis and infection in the model legume Lotus japonicus. Forfattere: Lene H. Madsen, Leïla Tirichine, Anna Jurkiewicz, John T. Sullivan, Anne B. Heckmann, Anita S. Bek, Clive W. Ronson, Euan K. James and Jens Stougaard

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