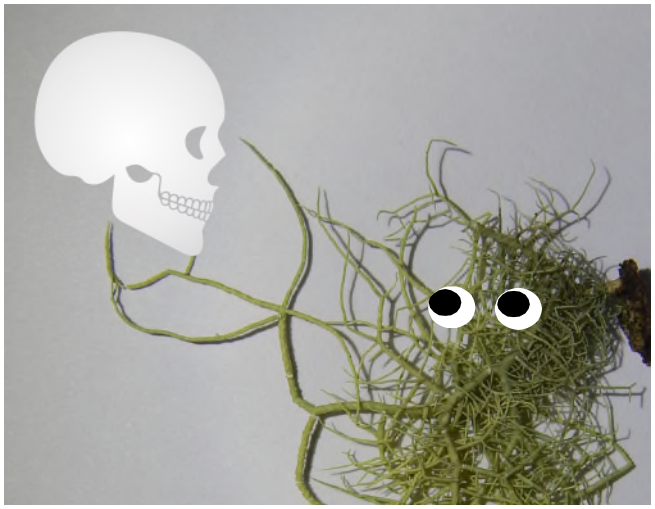
Naturhistoriska riksmuseet

~the 7th Sweden-Japan Academic Network seminar~

To be or not to be a lichen?

Using genomics to interpret lifestyles in fungi



Mieko Kono

The Royal Swedish Academy of Sciences
01.02.2019

~ Aug. 2018

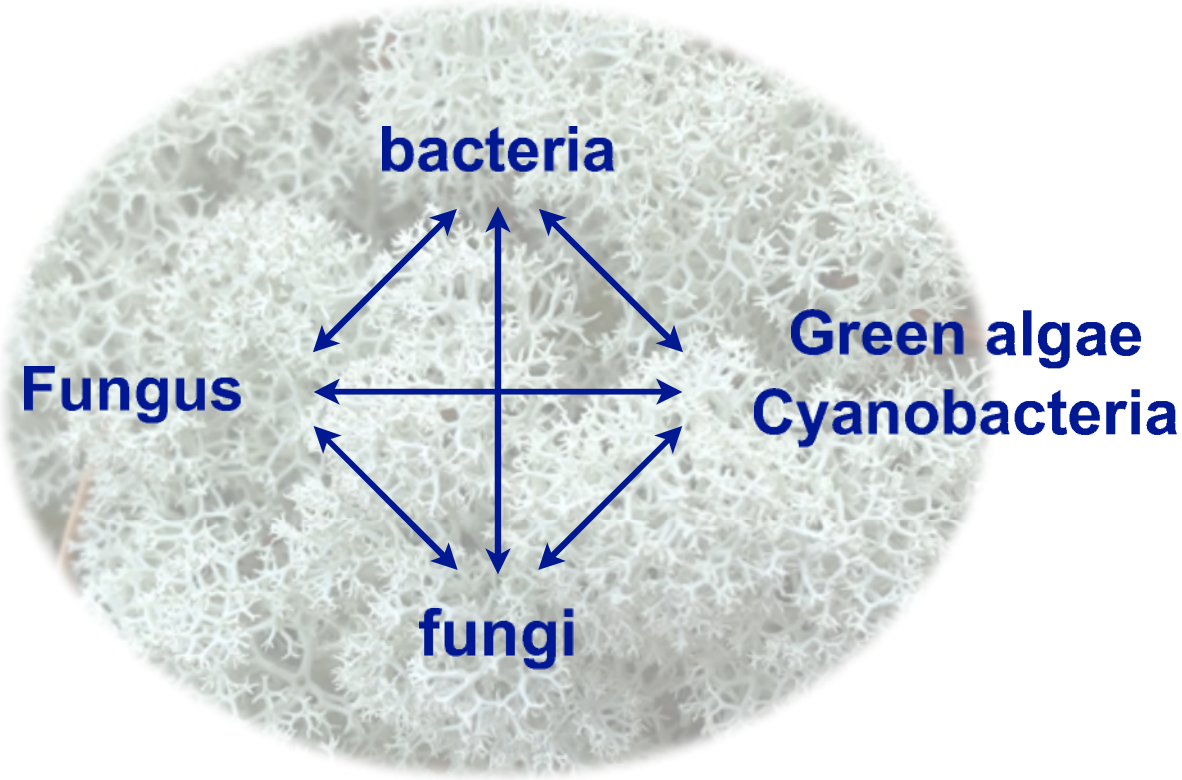
SOKENDAI

The Graduate University for Advanced Studies

Sept. 2018~

Naturhistoriska riksmuseet

What are lichens?

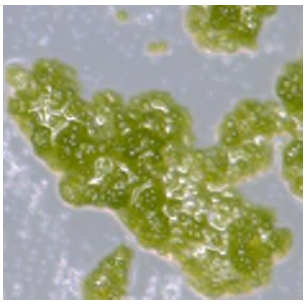


How are they genetically organized?

Symbiosis-specific genes?

Usnea hakonensis

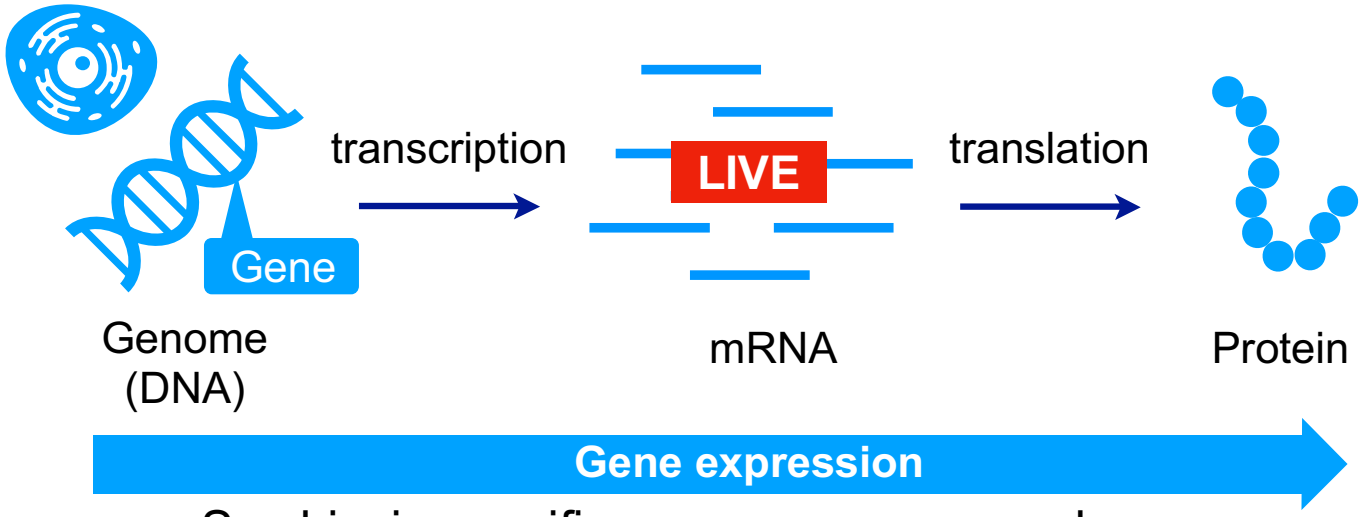
Fungus



Alga

Symbiotic lifestyle requires morphological, physiological, biochemical changes

How can we identify symbiosis-specific genes?

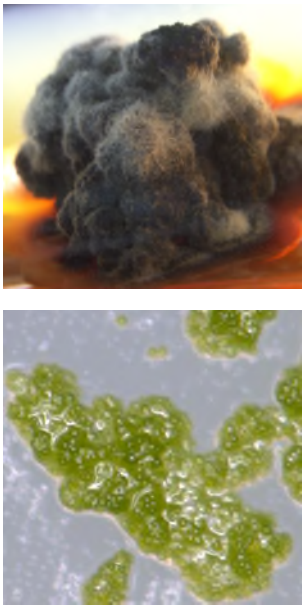


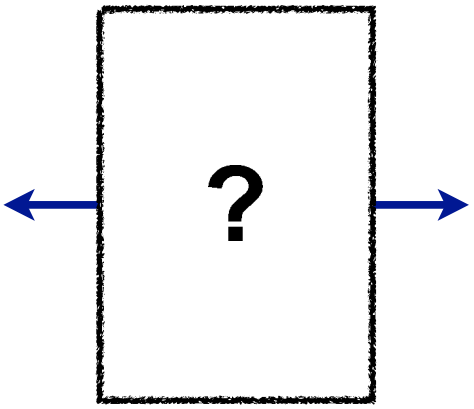
Symbiosis-specific genes are expressed more abundantly in the symbiotic state

Compare the gene expression between **before** and **after** the symbiosis

Compare the gene expression between…?

in the lab | in the lab | in the field





Usnea hakonensis

Thalli in the field are expose to complex environment distinct from the culture condition in the lab.

Can we reproduce lichens in the lab?

Stage 1: Pre-contact

Stage 2: Contact

Stage 3: Growth together

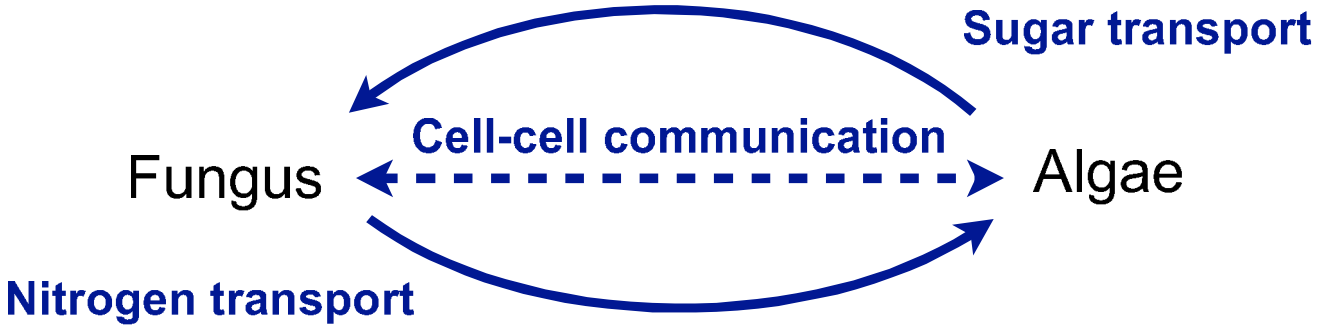
Stage 4: Incorporation of symbionts into a common matrix

Stage 5: Thallus differentiation

Many attempts have been made but…

Predicted functions of symbiosis-specific genes

Stage 1 & 2	*Cladonia grayi*	Joneson *et al.* (2011) *Mycologia*
Stage 1	*Endocarpon pusillum*	Wang *et al.* (2014) *BMC Genomics*

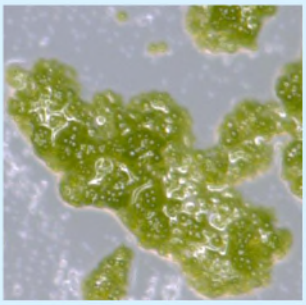


What kind of genes are expressed in the later stages and in the natural habitat?

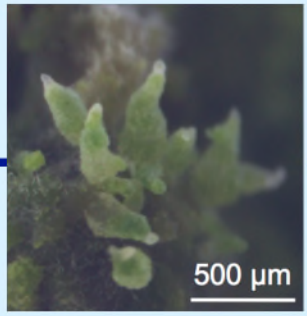
Symbiotic model of *Usnea hakonensis*

in the lab

Usnea hakonensis



Trebouxia sp.



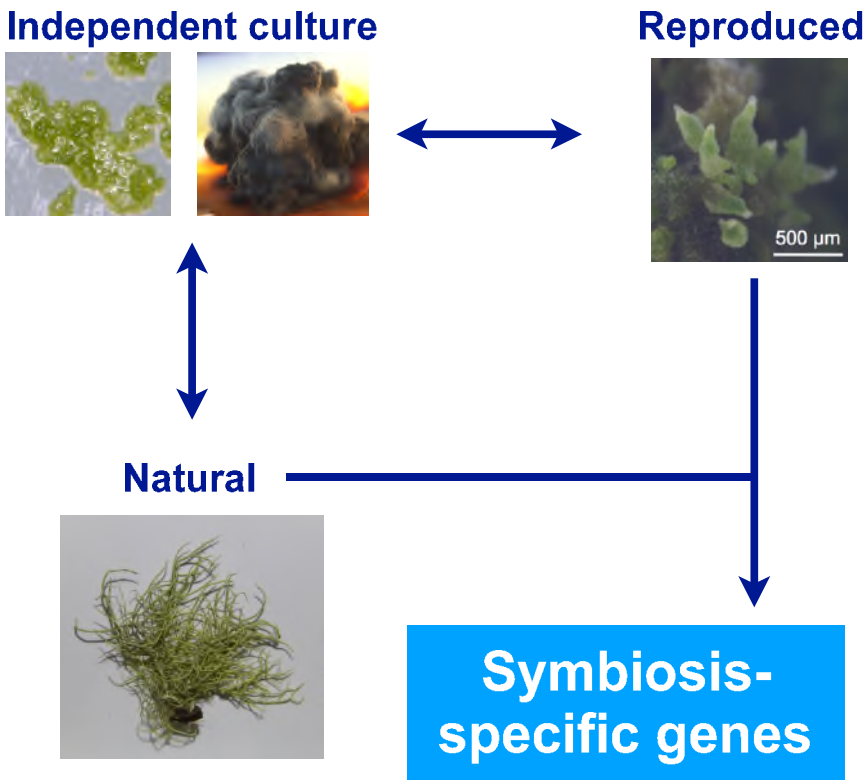
Stage 5

Thallus differentiation

Usnea hakonensis

Established by Dr. Yoshiaki Kon

Searching for symbiosis-specific genes by using the *Usnea hakonensis* model



Dr. Yoshihito Ohmura

Dr. Yoshiaki Kon

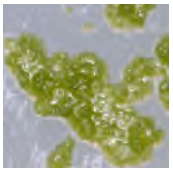
Dr. Yoko Satta

Dr. Yohey Terai

Whole genome sequencing

Fungus

Alga



	U. hakonensis	*Trebouxia sp.*
Genome size	41 Mb	69 Mb
Gene number	21,105	21,207

3 Gb = 3000 Mb

human

138 Mb

fruit fly

12 Mb

baker's yeast

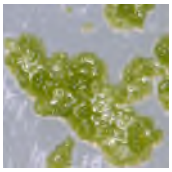
1 base pairs (bp)

1 kb = 1000 bp

1 Mb = 1000000 bp

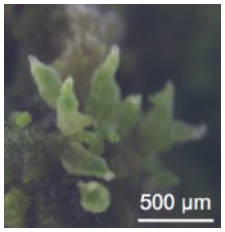
Symbiosis-specific genes

Alga



Fungus

Reproduced



Higher gene expression	
Fungus	675
Alga	395

Natural

Higher gene expression	
Fungus	2,261
Alga	1,778

In both symbiotic states	
Fungus	305
Alga	204

305 fungal and 204 algal genes were identified as “symbiosis-specific” genes

Functions of symbiosis-specific genes

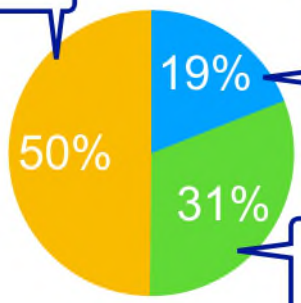
Symbiosis-specific genes	
Fungus	305
Alga	204

Are there similar genes with known function?

Search the database for genes with similar amino acid sequences

Protein Amino acid

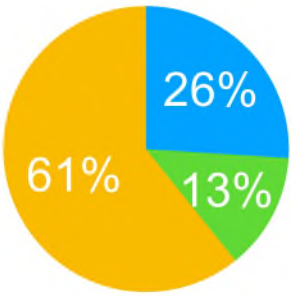
Lichen-specific?



Similar to proteins with known function

Similar to proteins with unknown function

Fungus



Alga

Perspectives

- Identify the role of the bacterium in the symbiosis.
- Identify other symbiotic partners required to reproduce a lichen thallus in the lab.

How did lichens evolve?

Is there an universal set of symbiosis-specific genes?

Lichens or Saprotrophs or Both?

Stictidaceae

Closely related species with various lifestyles

What is the genetic background of each lifestyle?

Compare the genetic features among the three fungal species in Stictidaceae

Optional lichenization

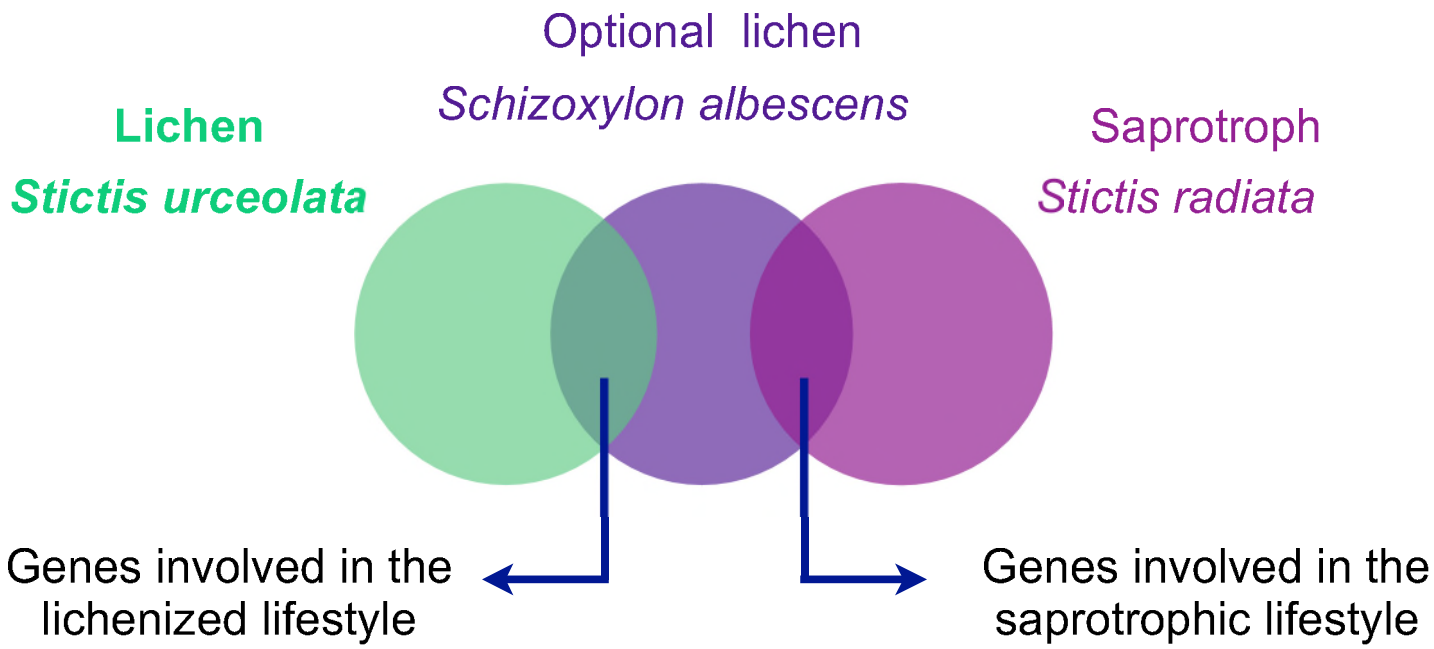
Schizoxylon albescens

Choose the lifestyle depending on the environment (substrate)

Option 1: Lichenized style	Option 2: Saprotrophic style
In and around cracks in the bark	On dead, decorticated branches
Associated with algae that provide nutrients	No algae! Exploit the substrates for nutrients

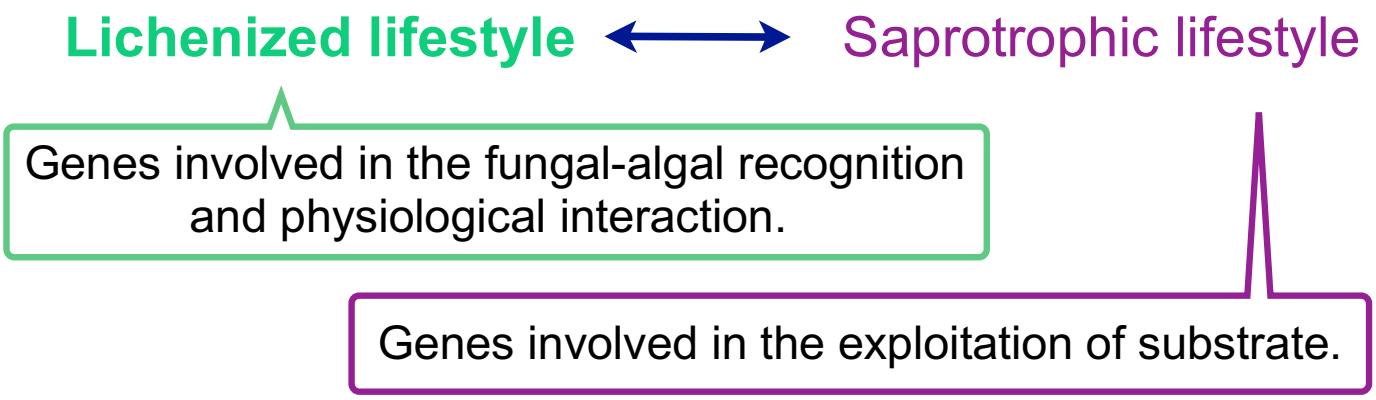
Identify genes related to each lifestyle

Step 1 Compare the genomic structures



Identify genes related to each lifestyle

Step 2 Investigate the gene expression of *Schizoxylon albescens* in different lifestyles



Our goal

Identify the genes that involve in the choices of lifestyles in fungi

Understand lichenizaiton in the context of fungal evolution

How far have we gotten?

Culturing the fungi in the laboratory

Cut out one fruiting body

↓

Culture 1 month on an agar plate

↓

Transfer a fungal colony to a new plate

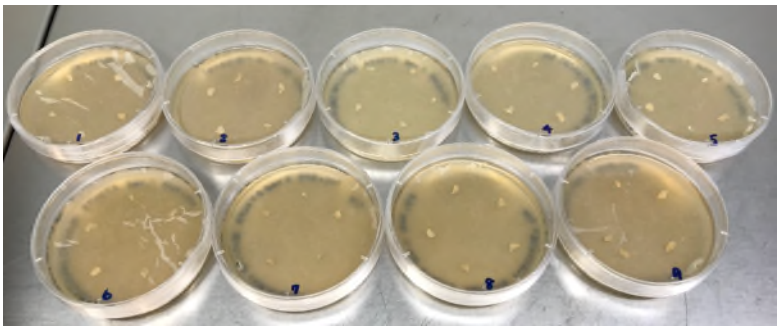
↓ 1~2 months

READY!

Stictis radiata

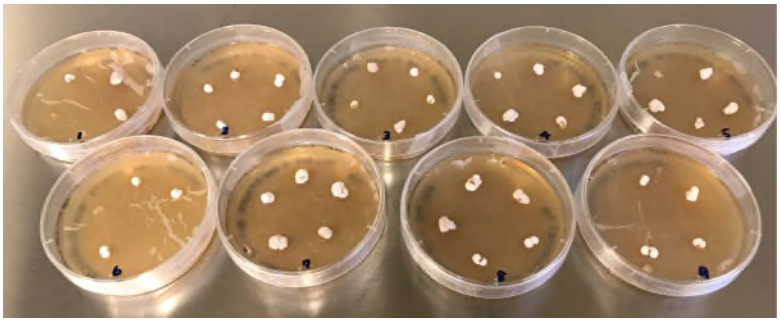
Schizoxylon albescens

Preparing DNA for the whole genome sequencing



Stictis radiata

1 month later



DNA extraction

10 ~ 15 µg required

ca. 100 ng /colony

at least 100 colonies

Growing fastest ever!

Acknowledgements

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Dr. Yoko Satta

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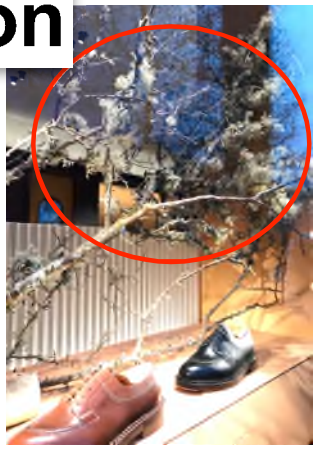
Sasag

Thank you for your attention



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