Possibilities for biotechnology in the Arctic

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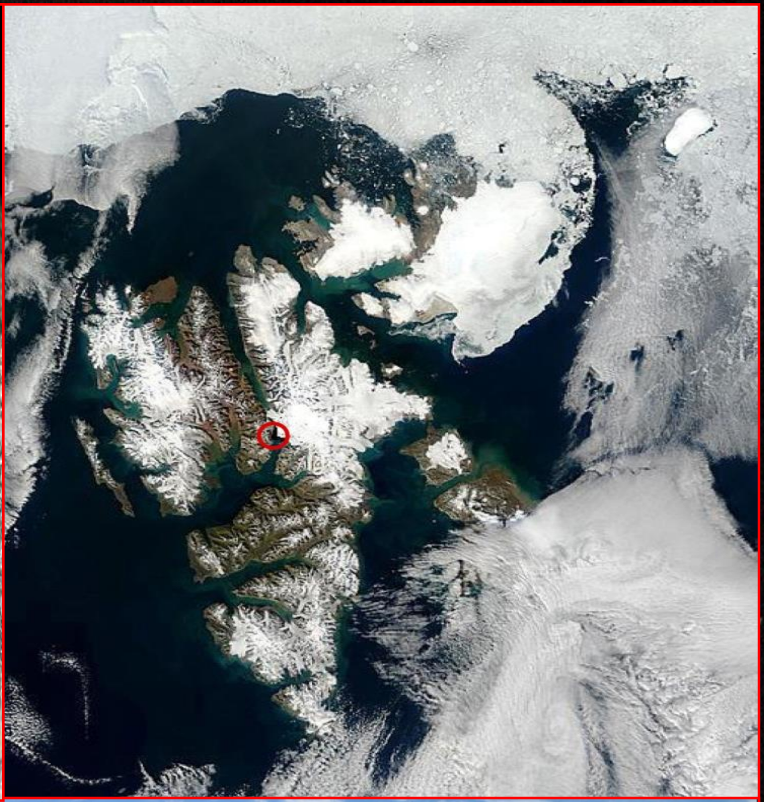
CENTRE FOR POLAR ECOLOGY

Centre for Polar Ecology constructs and manages research infrastructure in Svalbard



Czech Arctic Research Infrastructure

- Manages specialised department Centre for Polar Ecology in university campus
- Manages research station „Julius Payer“ in Longyearbyen
- Manages field research station „Nostoc“ in Petunia Bay
- Manage research motorsailer „Clione“
- Manages logistic support to whole infrastructure

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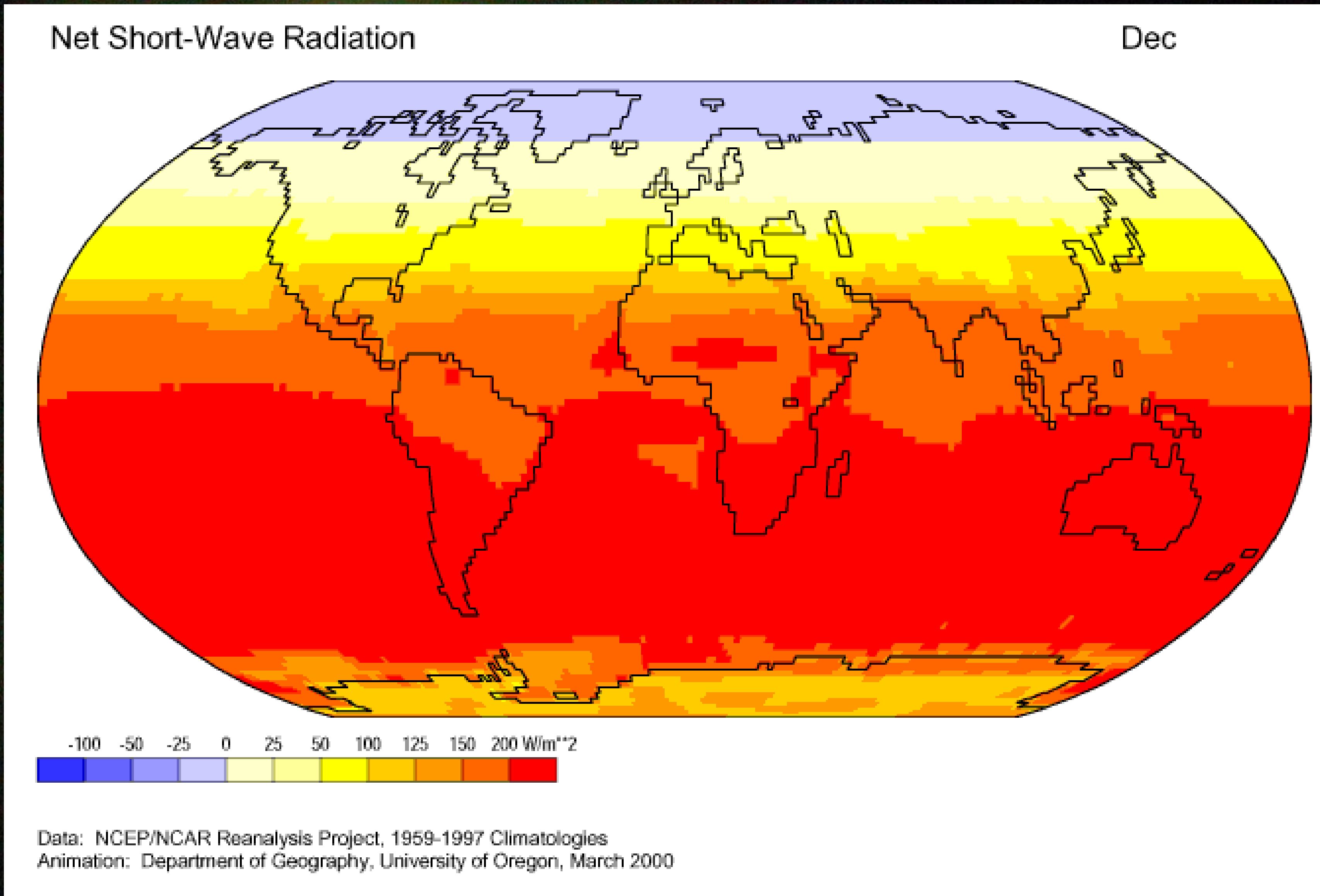
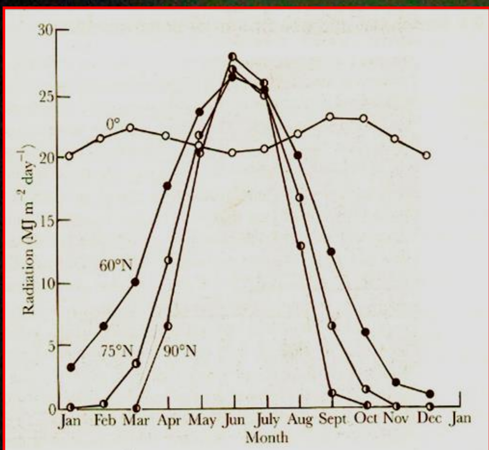
Zonal distribution of solar radiation

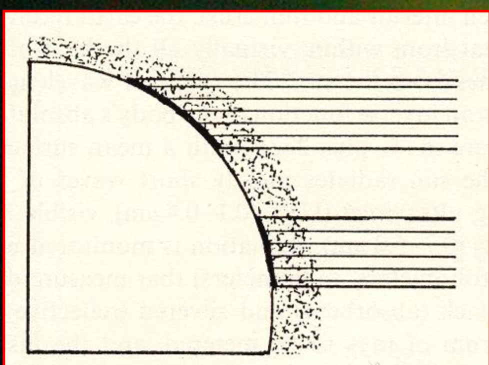


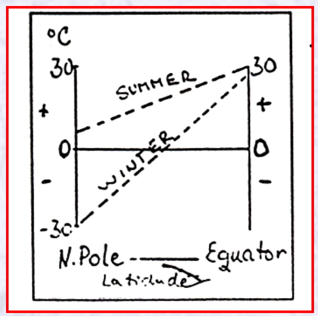
Main climatic factors of Arctic ecosystems

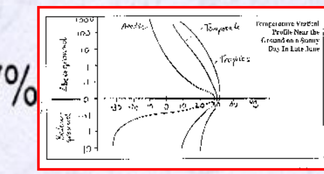
- Temperature
- Wind
- Precipitation
- Sun Radiation

- The sum of solar radiation / Solar Constanta = 1.94 cal/cm^2/min
- In solstice period – more radiation than in tropical areas
- The sum of solar radiation in polar regions is approximately 1/3 radiation in tropical areas
- In polar regions: > 50% of energy used for ablation (Snow/ice melt)
- Albedo – the sum of energy which is reflected back to the atmosphere









- Ice — High albedo: 80 - 97%
- Snow — High albedo: 80 - 97%
- Bare Rock — Albedo 30 - 70%
- Water — Heat sink - very low albedo: 15 - 20%
- Tundra Vegetation — Heat sink - low albedo: 15 - 25%

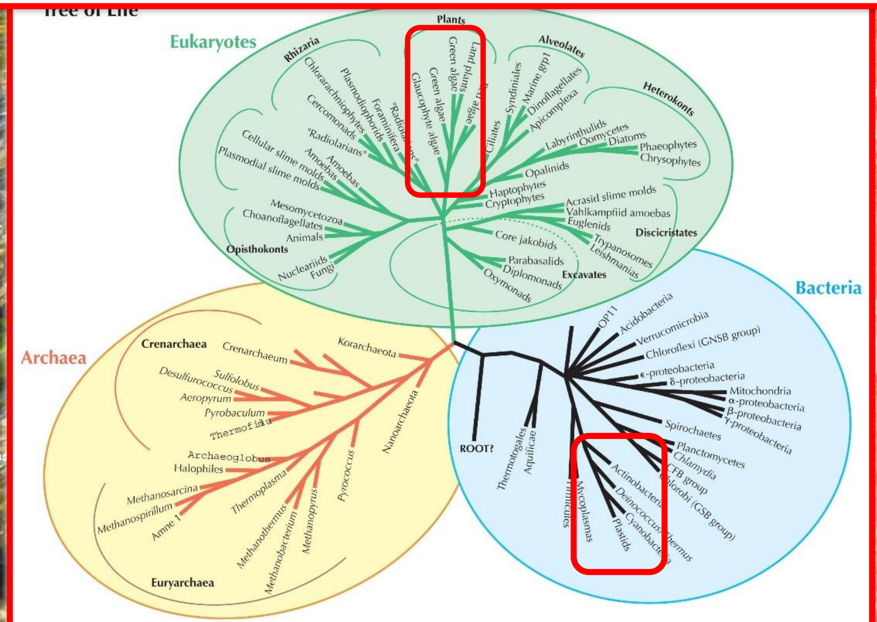
Phylogenetic tree of life

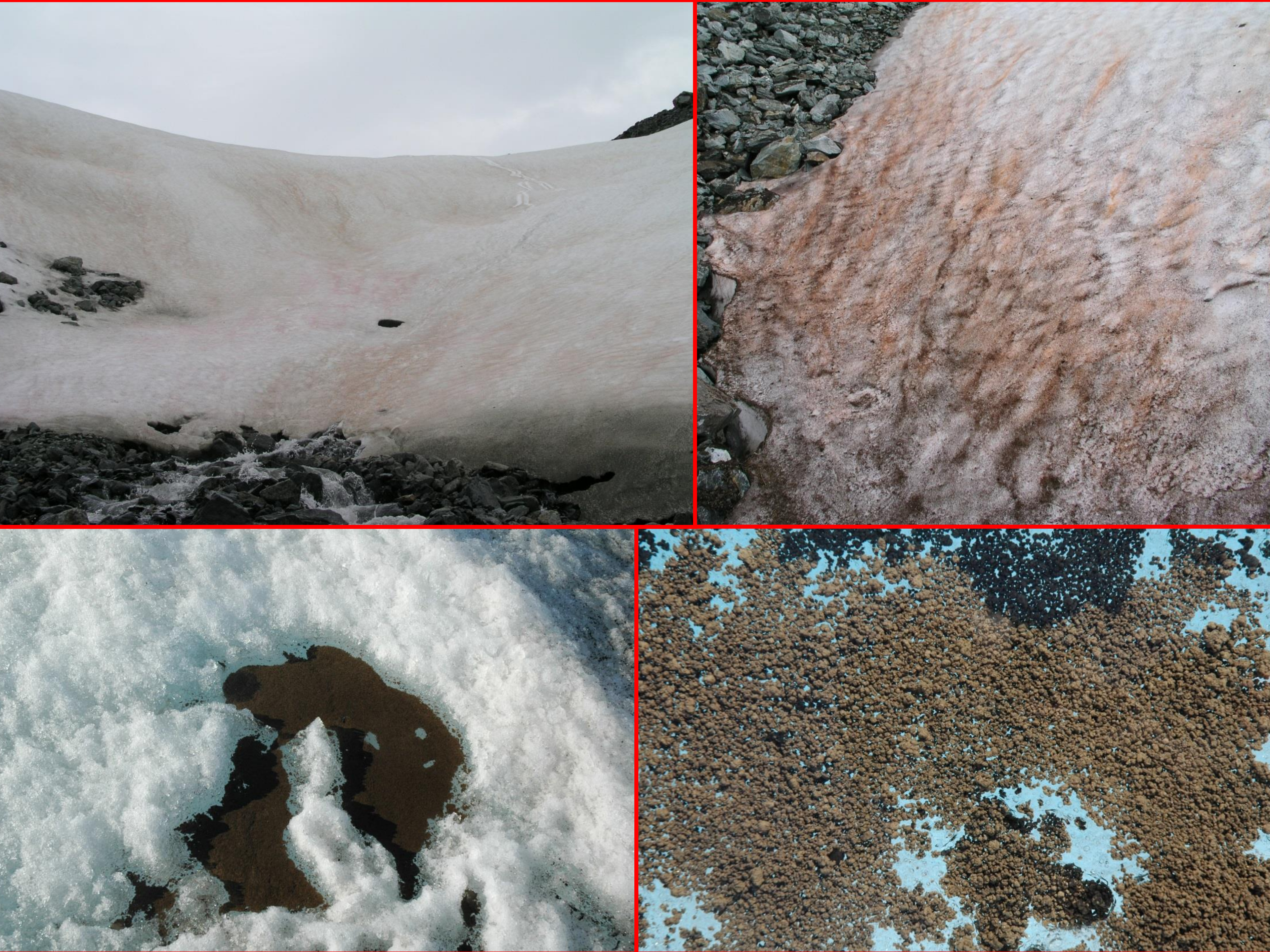
- oxyphotrotrophic photosynthesis
- endosymbiosis

- prokaryotic cyanobacteria – 3.5 billion years old
- eukaryotic microalgae – 0.8 to 1 billion years old

- well adapted to extreme environments of polar habitats

- quick life cycle (short generation time), they multiple their cells from 2 hours up to 2 days

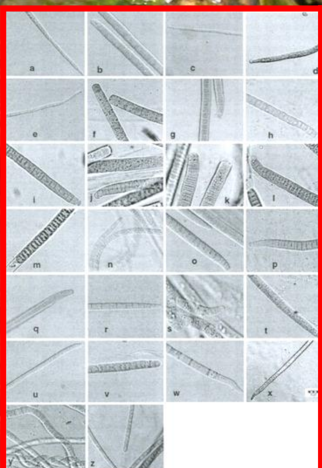


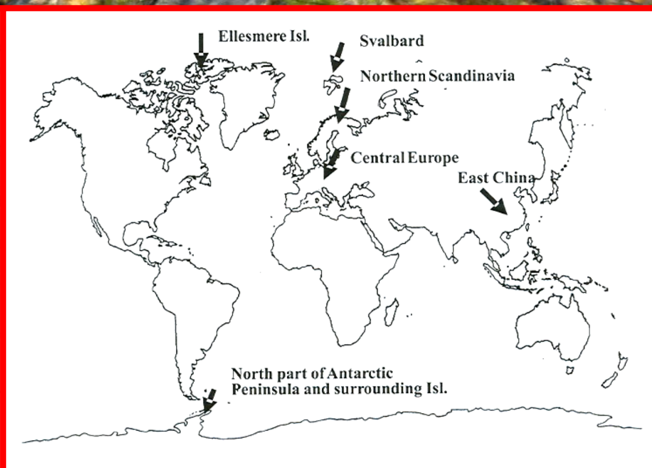


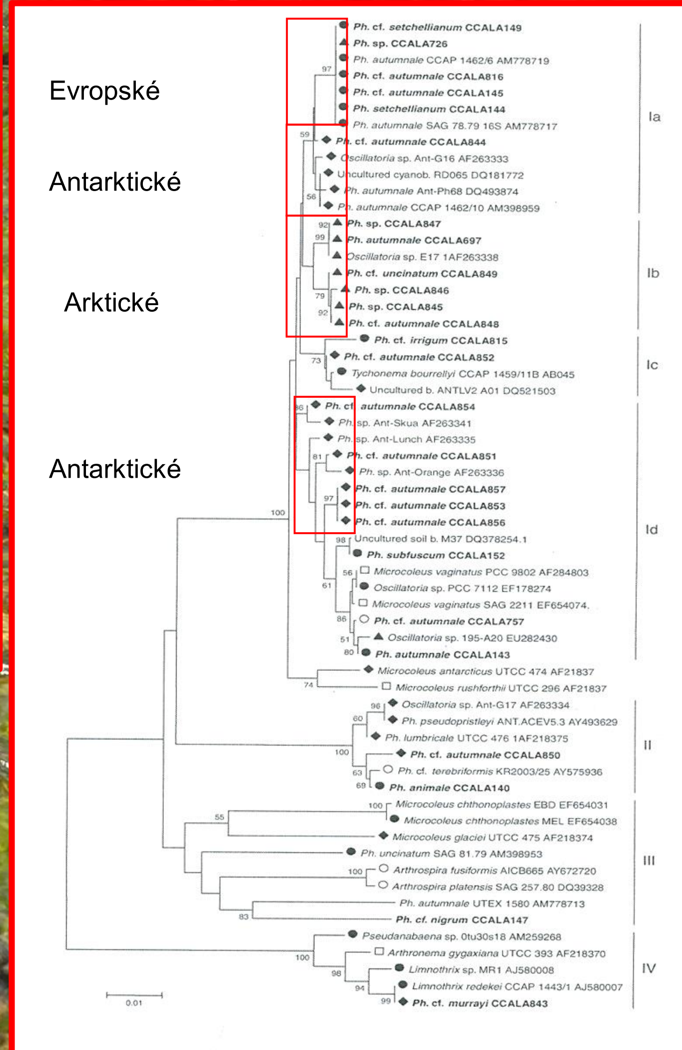
Experimental Background

Endemic or cosmopolitan? For how long live species of cyanobacteria and microalgae in polar regions?

- Simple filamentous cyanobacteria (Oscillatoriales) of genus Phormidium are very common organisms in polar hydroterrestrial environment
- Polyphasic study (16S rDNA and morphology) of 26 strains isolated from different parts of the Arctic – Antarctic and temperate regions.
- No genotype common for Arctic – Antarctic and temperate regions was found. Some Arctic species can be found also in temperate regions.

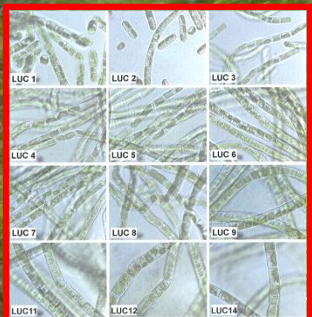


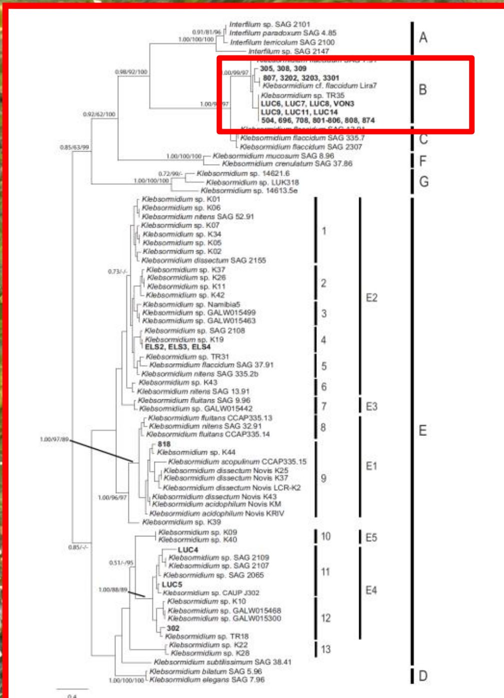




Diversity and dispersal capacities of a polar terrestrial algal genus Klebsormidium (Streptophyta)

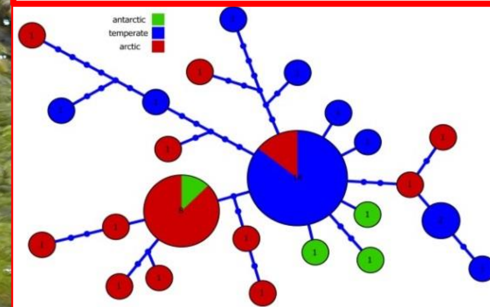
Phylogenetic position of investigated arctic and antarctic Klebsormidium genotypes.





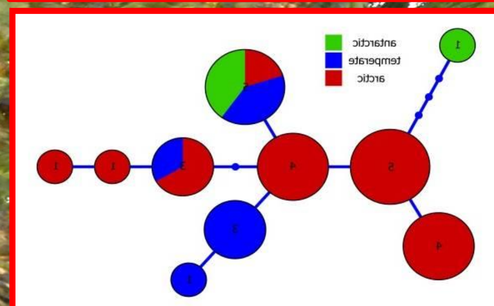
Population marker: spacer atpE - trnM

➢ alignment of 644 bp



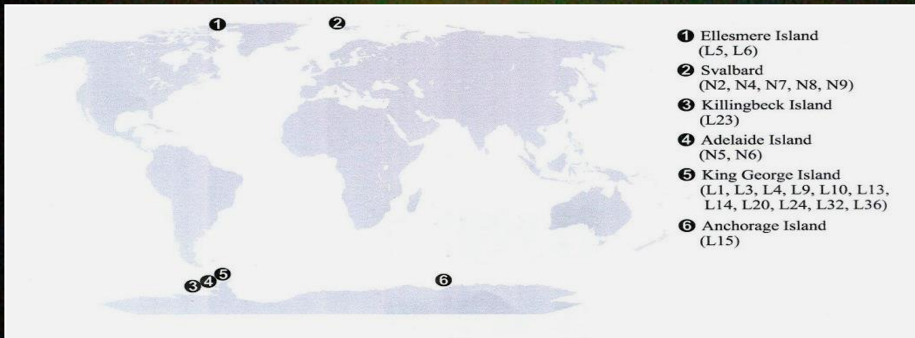
Population marker: spacer ndhK – ndhC

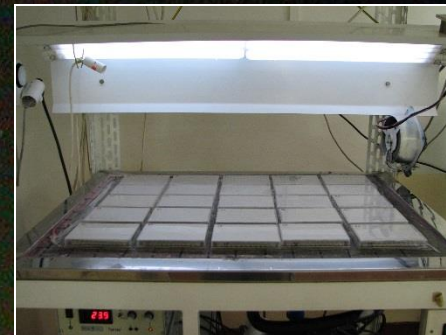
➢ alignment of 460 bp

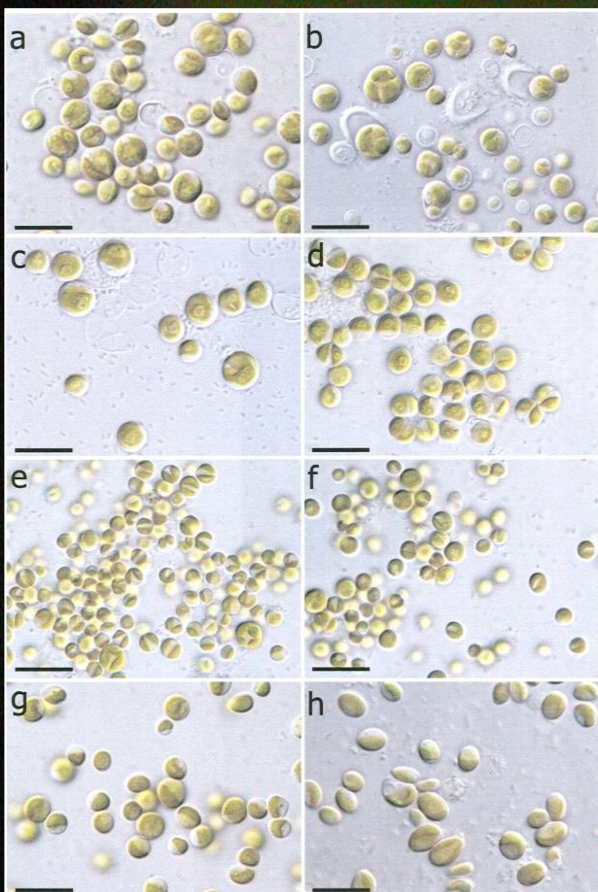


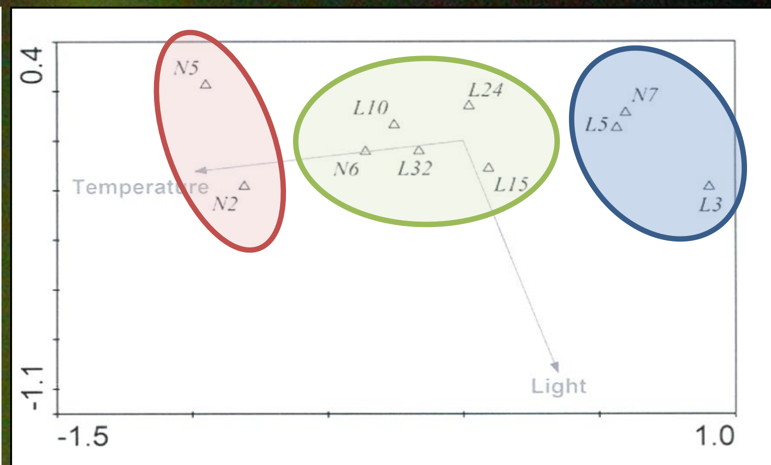
In comparison to temperate regions, the observed diversity of genus Klebsormidium in polar regions is low. The majority of polar strains were inferred within the cosmopolitan clade B. Population structure of the clade B indicates recent dispersal of algal across the climatic zones.

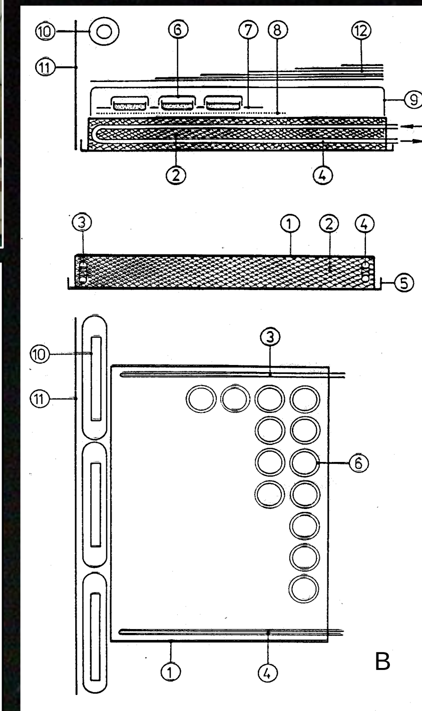
Ecophysiological properties of Arctic cyanobacteria and microalgae





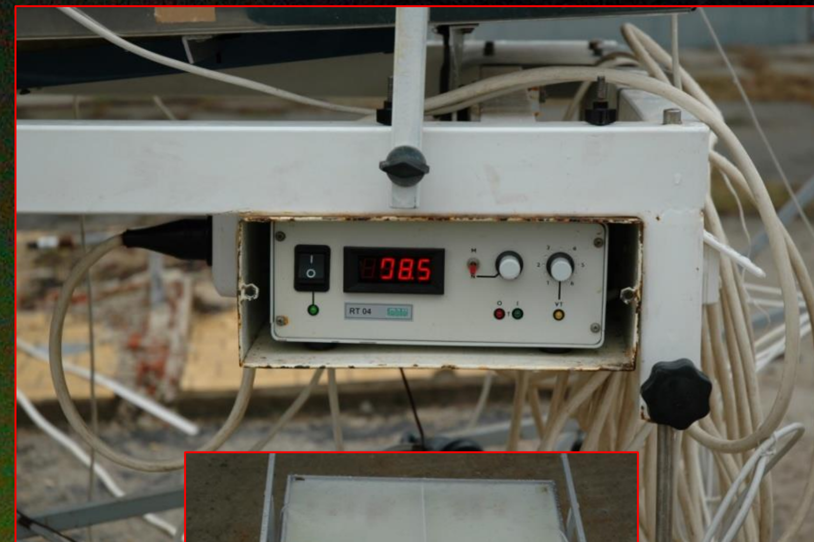


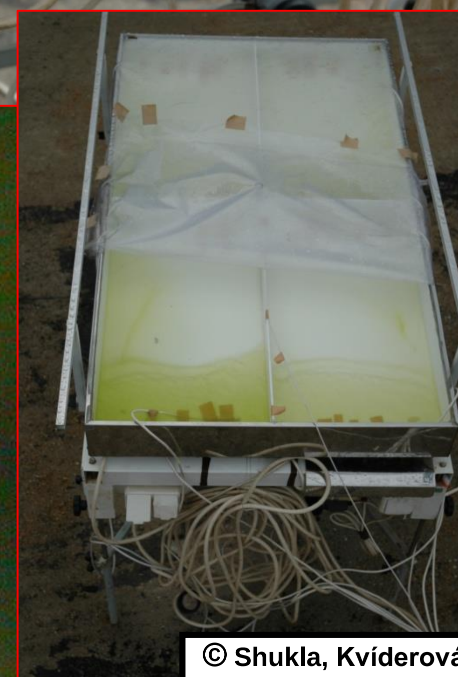


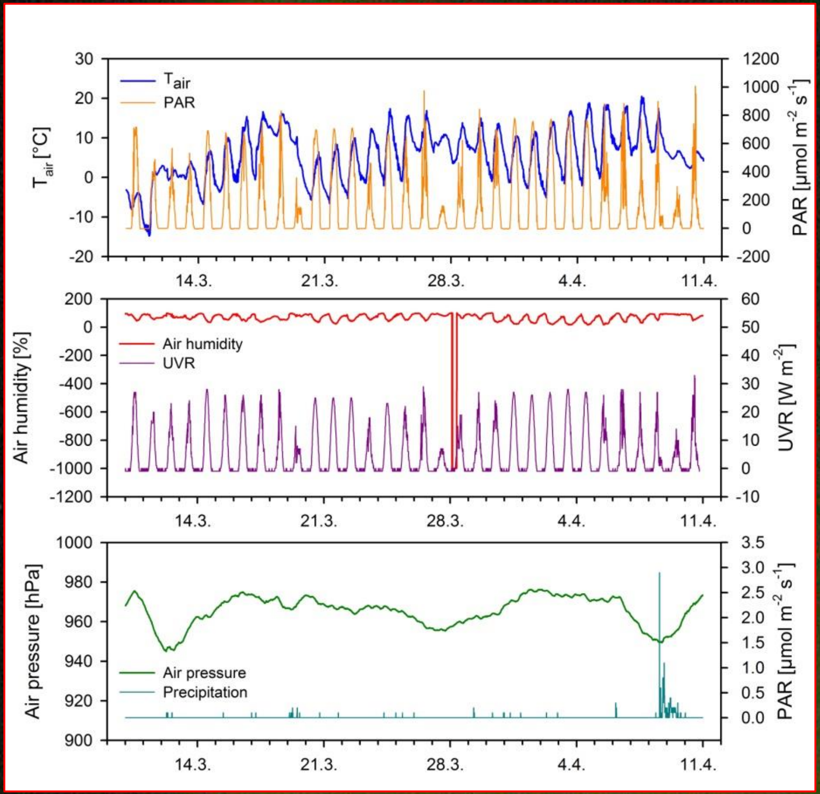


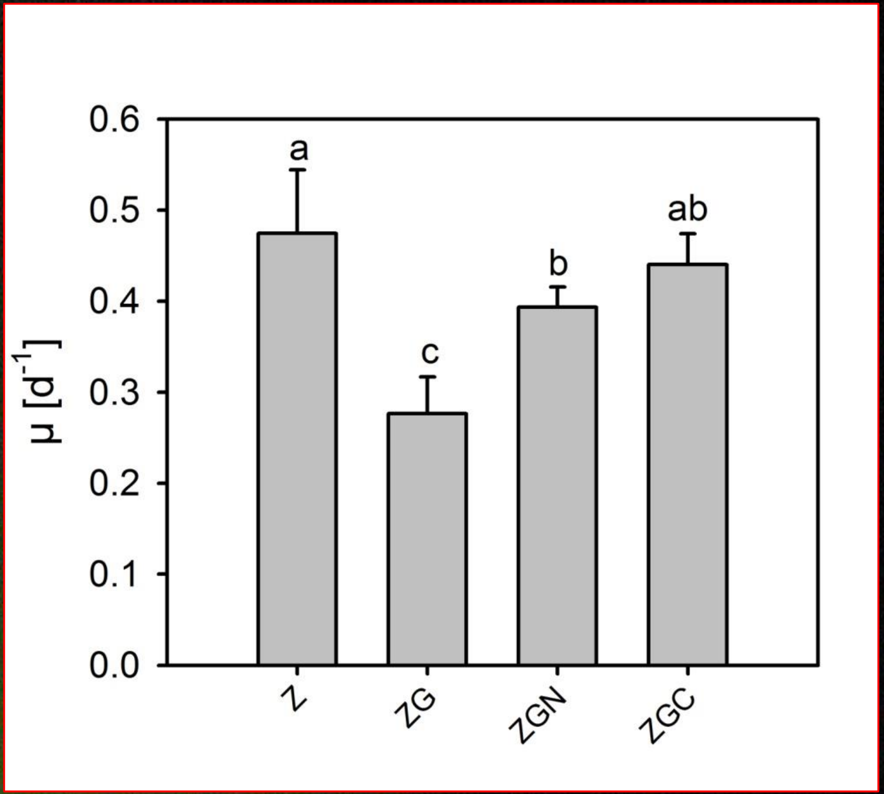
Strain	Temperature [°C]			Irradiance [µmol m^{-2} s^{-1}]		
	Lower limit	Optimum	Upper limit	Lower limit	Optimum	Upper limit
L5 (*Chlorella vulgaris*)	1-4,5	10.1-18.4	>20.5	<12.3	<12.3->50.5	>50.5
L3 (*´Micractinium´* sp.)	1-4,5	10.1-14.3	20,5	15.9-21.5	21.5->50.5	>50.5
N6 (*Muriella* sp.)	1-4,5	14.3-18.4	>20.5	<12.3	<12.3->50.5	>50.5
N5 (*Muriella* sp.)	4,5	>20.5	>20.5	<12.3	12.3-15.9	>50.5
L15 (*Nannochloris* sp.)	1-10,1	10.1 – 18.4	>20.5	<12.3	<12.3->50.5	>50.5
L32 (*Nannochloris* sp.)	4.5-10.1	10.1-18.4	>20.5	<12.3	15,9	>50.5
L24 (unidentified Chlorellales)	1-4,5	10.1->20.5	>20.5	<12.3	<12.3->21.5	>50.5
L10 (*Chlorella mirabilis*)	4.5-10.1	10.1-20.5	>20.5	12.3-15.9	15.9-21.5	27,8
N2 (*Bracteacoccus* sp.)	4.5-10.1	14.3-20.5	>20.5	<12.3	<12.3->50.5	>50.5
N7 (*Dictyococcus schumacherensis*)	1-4,5	10.1-14.3	>20.5	<12.3	15.9-21.5	>50.5

Cultivation of *Chlorela mirabilis* (from the Antarctic) and its rate of growth and production of fatty acids in winter conditions in central Europe





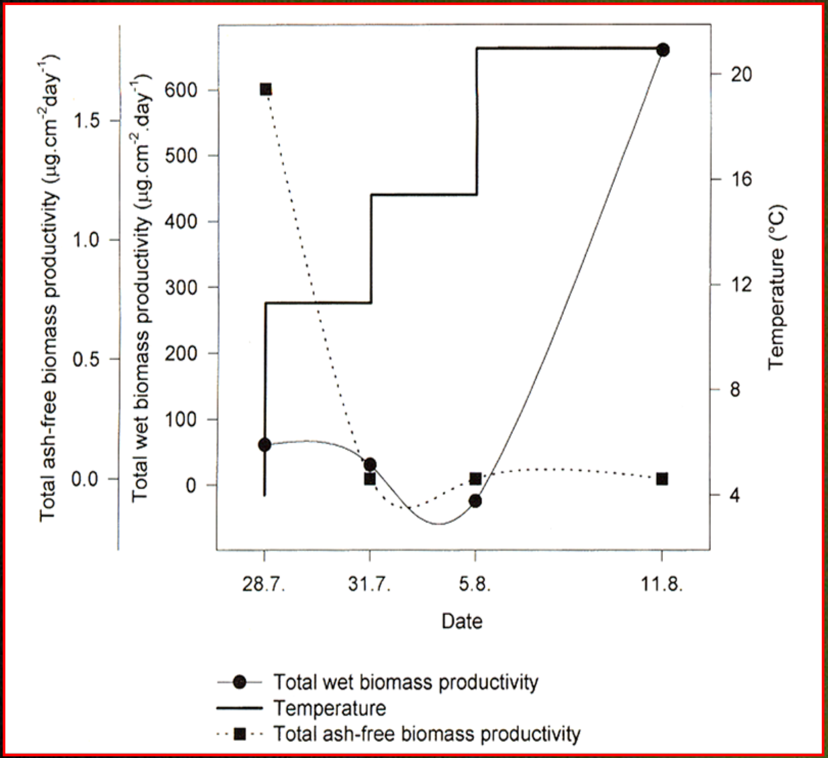


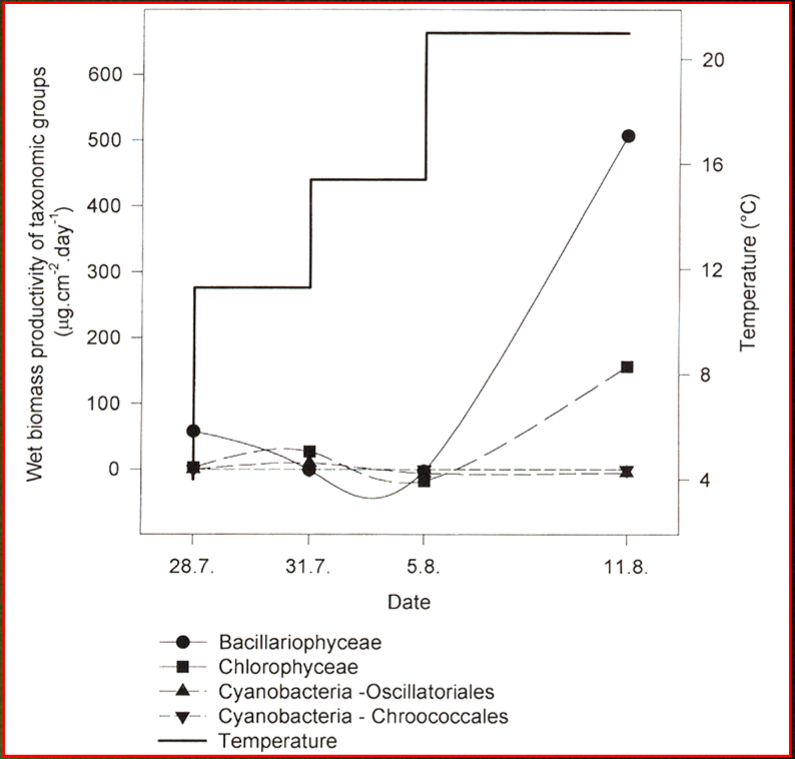


Sample	Fatty acids composition [%]					
	Myristic acid	Palmitic acid	Linoleic acid	Oleic acid	Elaidic acid	**Unidentified**
Indoor experiments						
Z	1.70	7.83	7.70	70.44	1.97	**10.36**
ZG	0.37	16.00	22.60	40.31	1.62	**19.10**
ZGN	1.49	23.46	15.13	49.97	2.83	**7.12**
Outdoor experiments						
Z	0.87	10.72	16.86	49.87	0.83	**20.85**
ZG	1.55	27.03	9.98	49.62	3.65	**8.17**
ZGN	**1.44**	**23.84**	**10.20**	**43.28**	**10.37**	**10.87**

Cyanobacteria and algae ecology - *in situ* temperature manipulation, Svalbard, 79°N, Norwegian Arctic

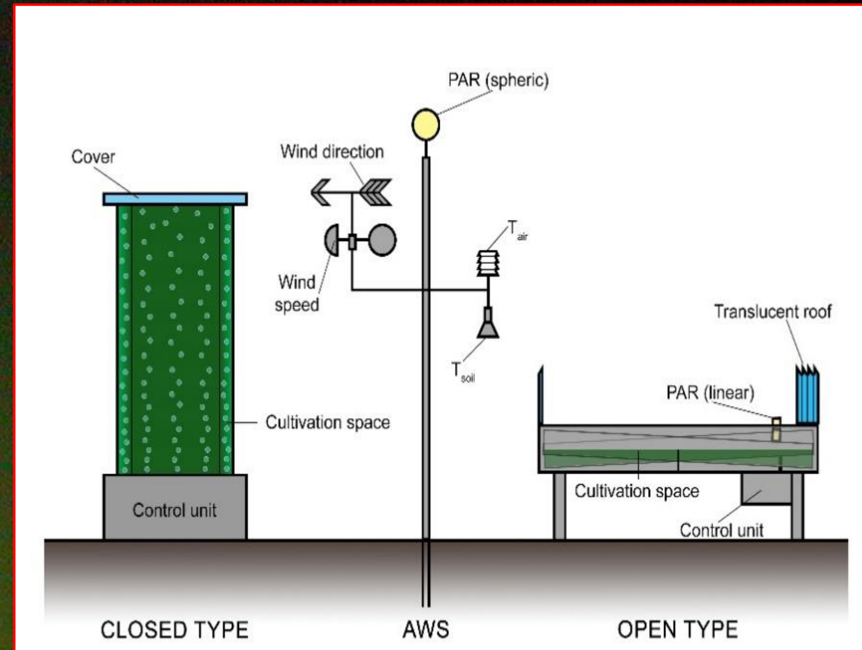
- Temperature was gradually increased (11,3, 15,4 and 21,0 °C) in five days steps.
- Larvae of mosquito grazed the biomass. Diatoms disappeared the most rapidly. Diatoms were dominant algae in natural snow-melt stream.
- Some species of green algae (*Chlorococcales*), filamentous cyanobacteria and selected species of diatoms increased their occurrence and growth in warmer environment (temperature 21,0 °C).



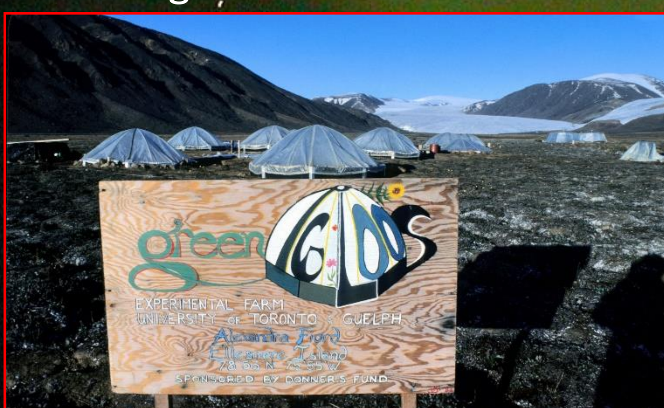


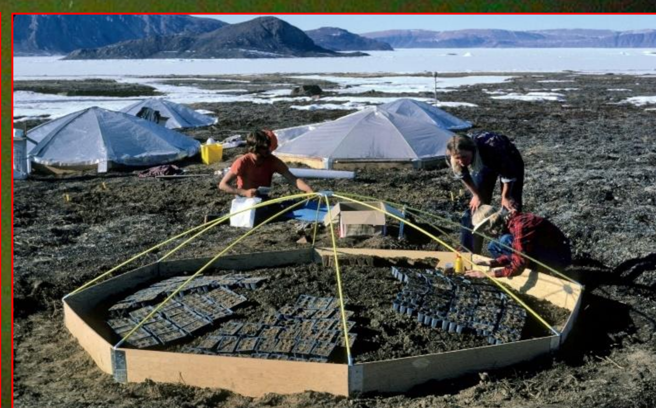
Adaptations of cyanobacteria and microalgae to Arctic environment and proposed cultivation techniques

Stress factor	Adaptations	Applications
Low temperature and freezing	Antifreeze proteins	Cryobiology
	Higher superoxide dismutase activity	Medicine, Space Biology
	High lipid content	Nutrition, Biofuel
	Desiccation tolerance	Improved strains of crop plants
	Nutrient uptake at low temperature	Bioremediation at low temperature
	Nitrogen fixation at low temperature	Superior biofertilizers for temperate and alpine regions
Localized hypersaline conditions*	Salt tolerance genes/compounds	Salt tolerant crop /microalgae
	Salt sequestration/exclusion mechanisms	Salt tolerant crop /microalgae
High UV-radiation	Mycosporine-like amino acids and other UV-protective compounds	Development of transgenic crops with higher UV-resistance, nutrition
Prolonged light and dark periods	Higher photosynthetic efficiency	Improved varieties of crop plants with higher yield



Green Igloos Farm





From Prague's Arctic Science Summit Week 2017 (https://ASSW2017.EU) a few globally important suggestions came out:

a) **Arctic is changing under presure of climate movement**. We still understand only a little what ecosystem consequences climate changes are bringing.

a) **The Arctic is home for many indigenous people**. Climate movement threate indigenous people life. Research should be focussed to help to solve local environmental problems at particular areas with indigenous people setlements.

c) **Resources and economic activities in the Arctic - <u>Arctic urbanisation</u>.**

Arctic under present climatic changes brings new opportunities for **<u>industrial developments</u>** (oil and gas resources, fish and fisheries management, shipping in the Arctic ocean, etc.). Urbanisation and development all technological support for humen life is one of the most glabolly urgent tast for future.

<u>Development of low temperature biotechnology</u> is the challenge for Czech Science.

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Thanks for your attention

We are looking forward to work in Arctic science together