Snow field campaign in Slovakia
Chopok
15.-17.2.2016

Microorganisms of snow cover in high mountains of Slovakia

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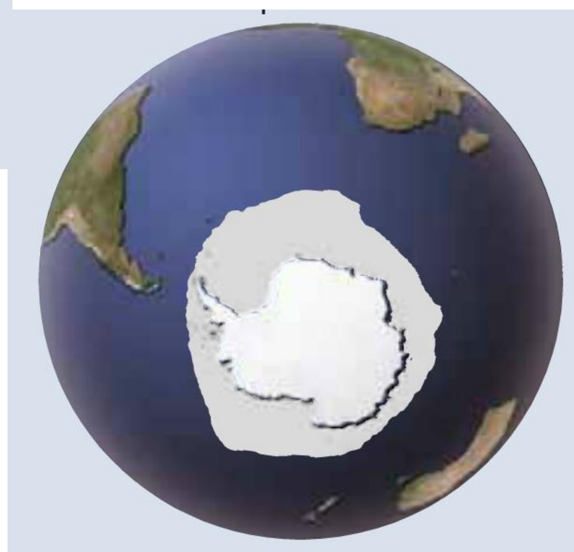
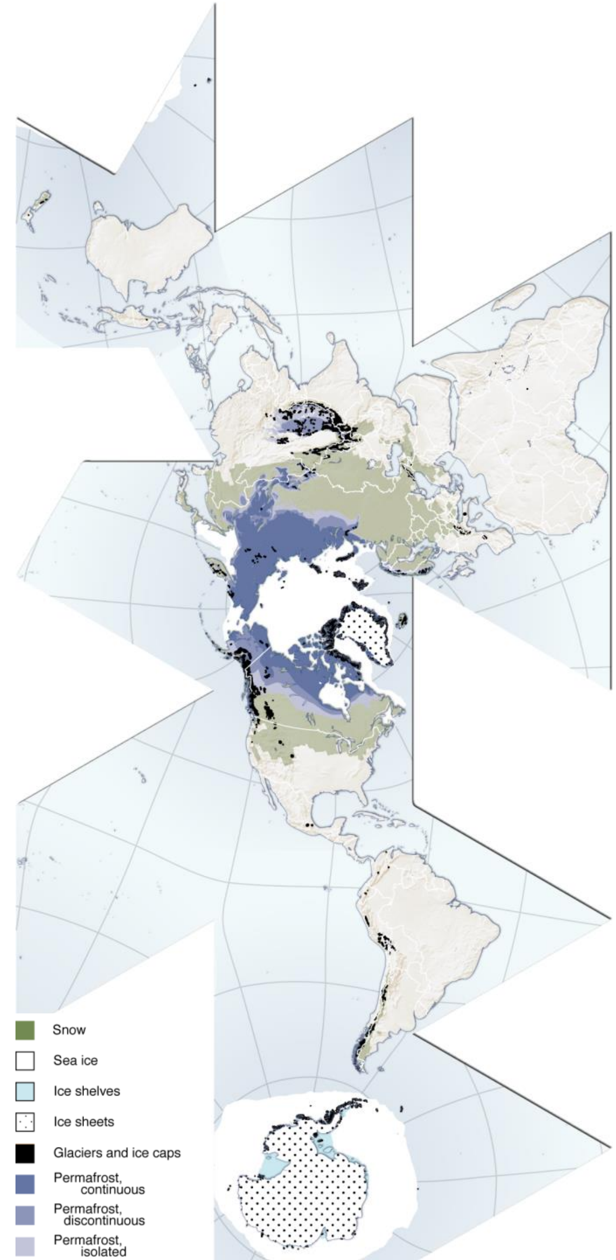
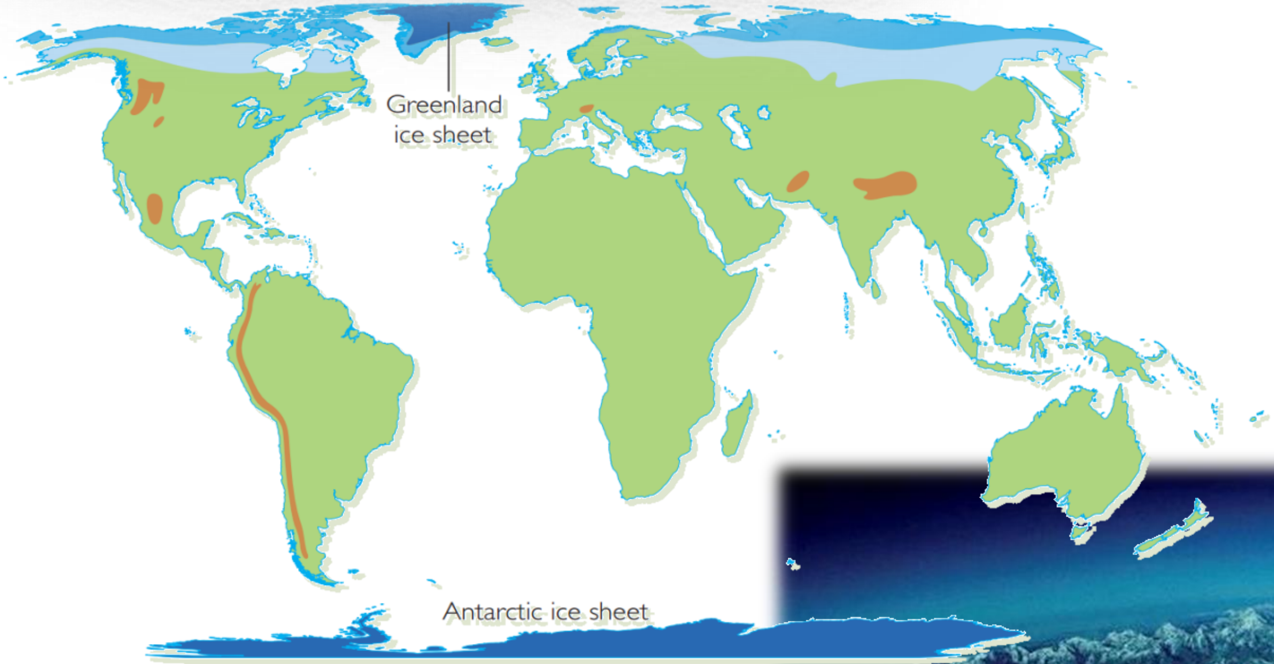
The Earth – cold biosphere



Ice and snow cover at the peak periods in the annual cycles, Northern and Southern Hemispheres (*http://www.grida.no/publications/geo-ice-snow/ebook.aspx*)



The Earth – cold biosphere

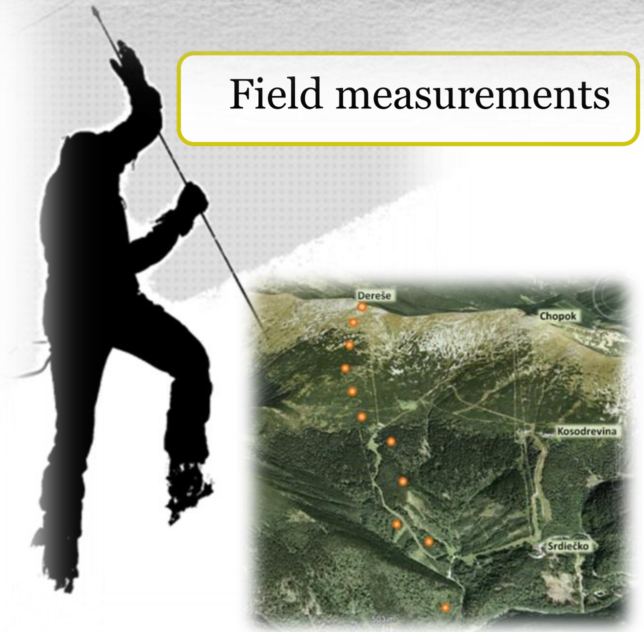


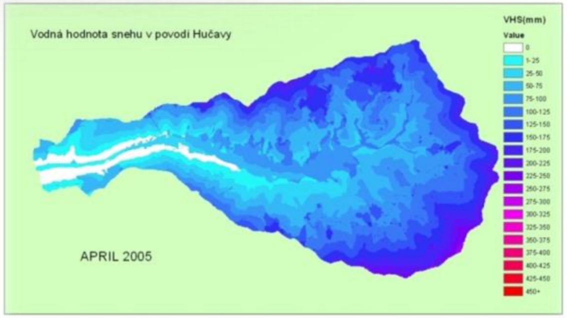
http://fds.oup.com/www.oup.com/pdf/oxed/Pages%20from%20aqa_as_ch02.pdf

- High latitude and **altitude**

Fields of our research

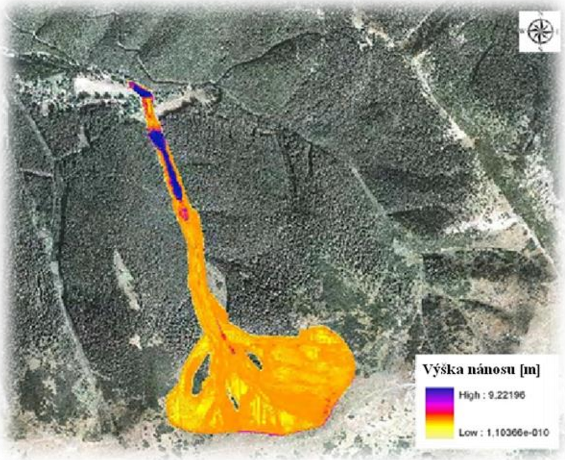
Field measurements



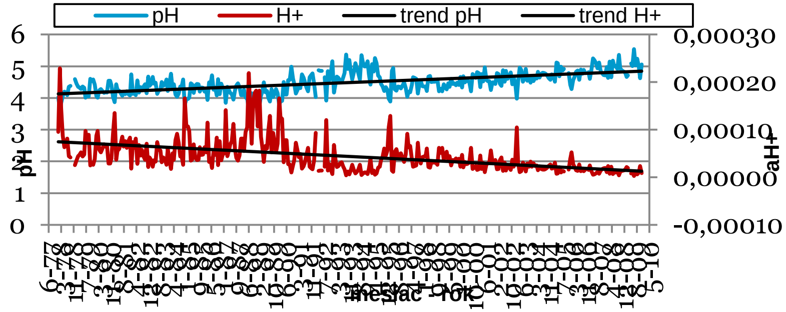


Data visualization and modeling in ArcGIS 10

Avalanche simulations



Long-term temporal changes of precipitation quality in the mountainous region

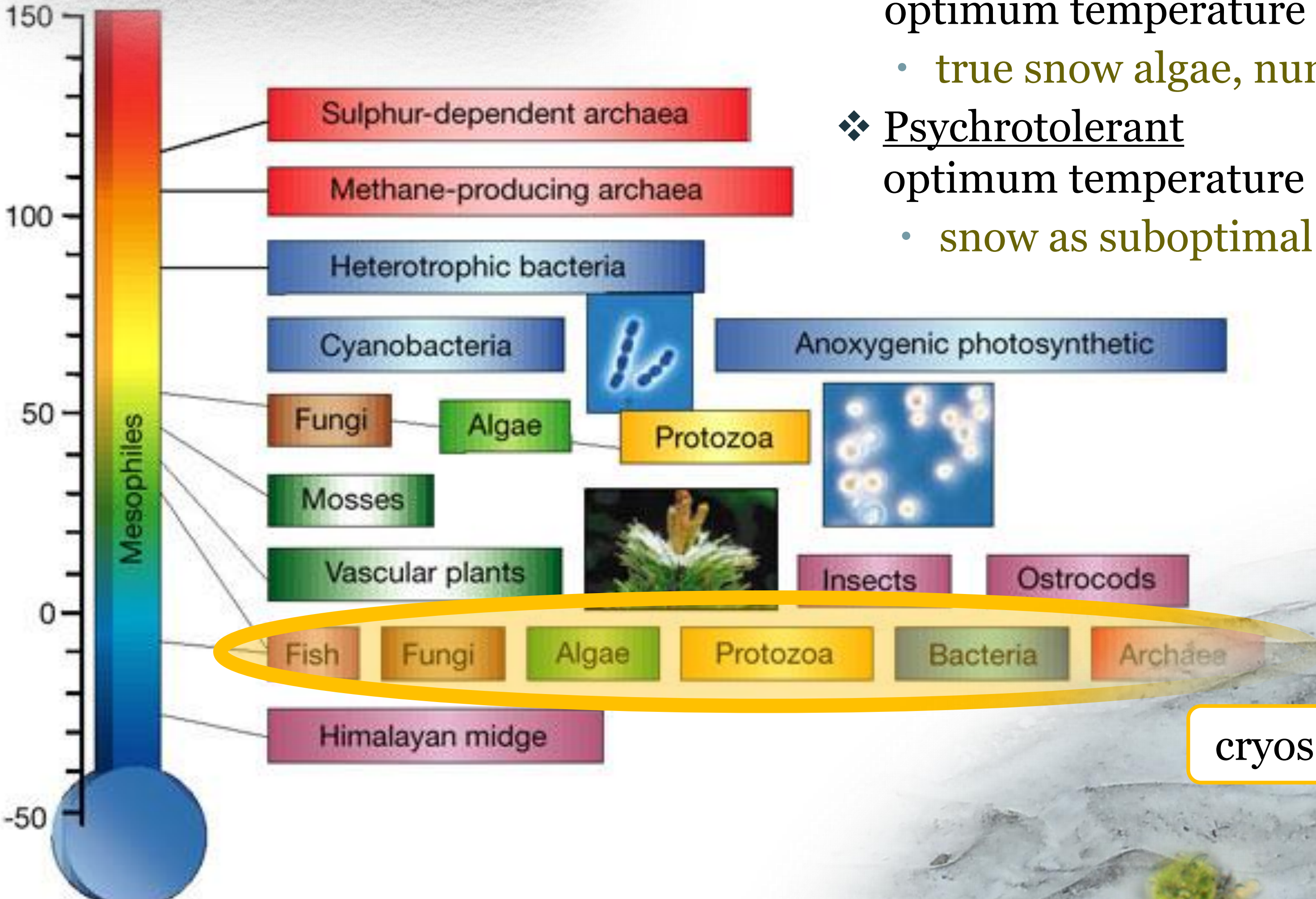


Snow microbiology

Cryobiotop in Slovak republic

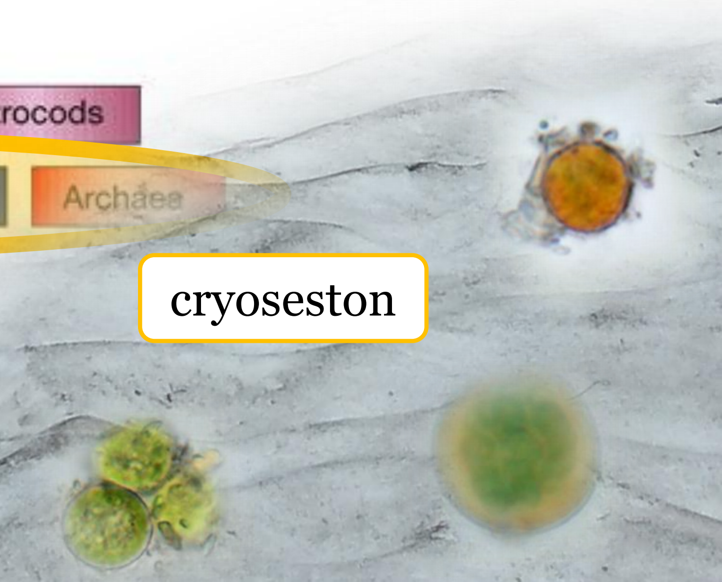
7 – 8
8 – 9
9 – 10
> 10

Organisms

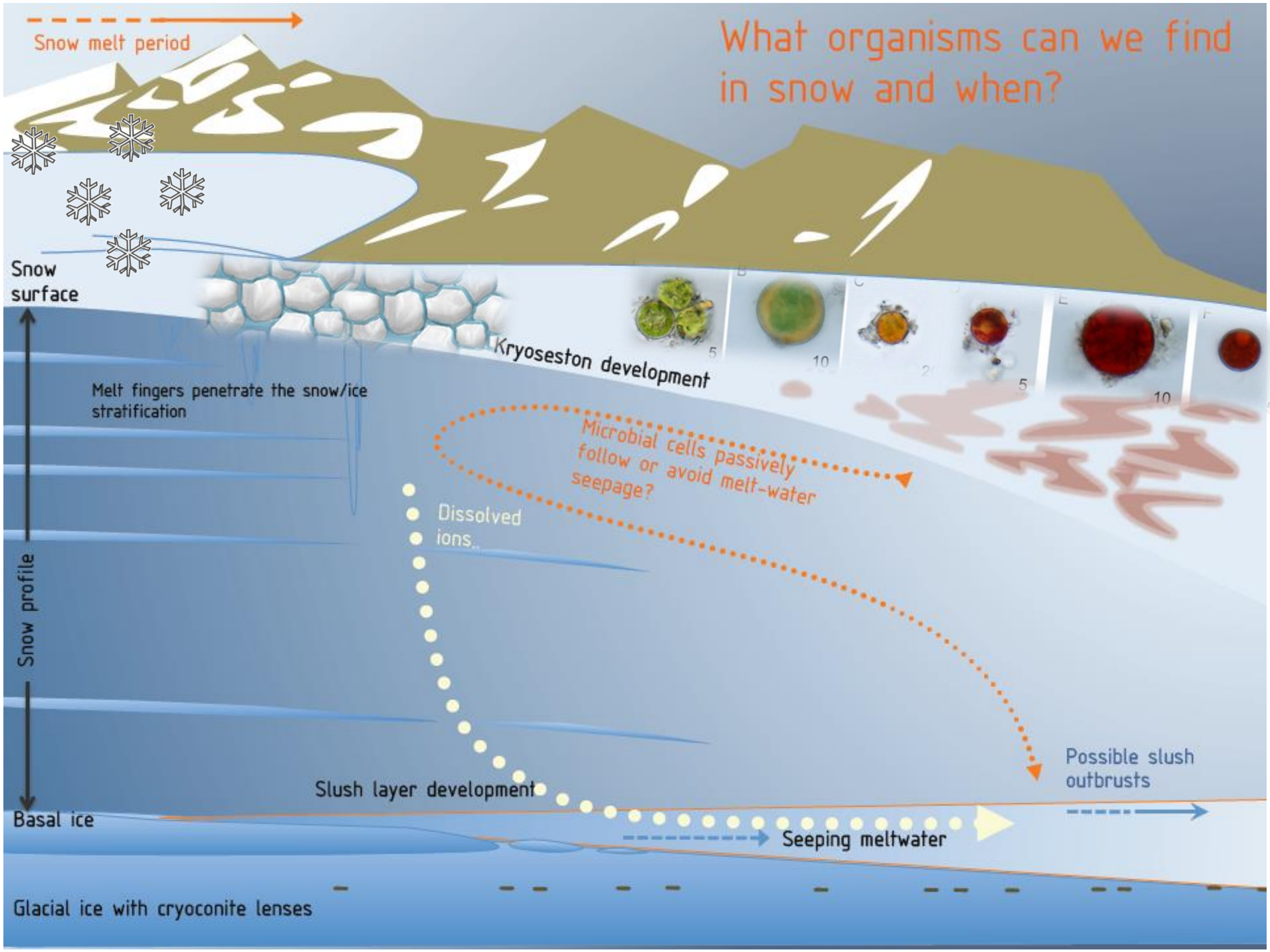


❖ <u>Psychrophile</u>
optimum temperature < 10°C
- true snow algae, numerous adaptations

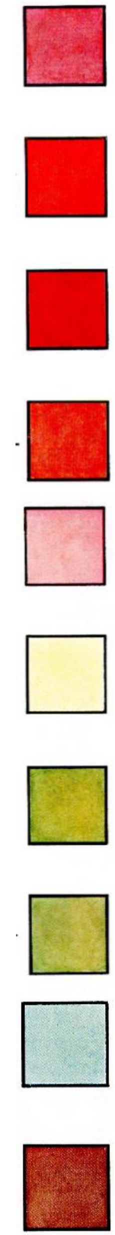
❖ <u>Psychrotolerant</u>
optimum temperature > 10°C
- snow as suboptimal environment



cryoseston



Upravené z originálu Jakub Žársky – Kurz glaciologie (České Budějovice 2013)



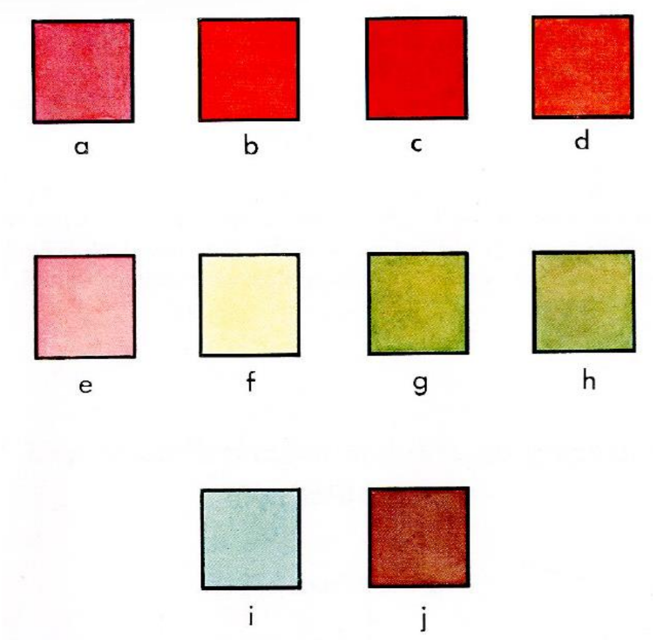
Kol 1968

Colouration of snow

Algal cell concentration $4x10^4$ cells.ml^{-1} in coloured snow

0,1-5 % of this value in white snow

(Kol 1968)



Reduce the snow albedo – increase the rate of snow melting

a) *Chlamydomonas nivalis* raspberry red

b) *Smithsonimonas abbotii* red pepper

c) *Chlamydomonas sanguinea* blood red

d) *Scotiella nivalis* brick red

e) Pink colouration

f) *Cystococcus nivicolus* yellow

g) Genus *Koliella* green

h) Genus *Carteria* green

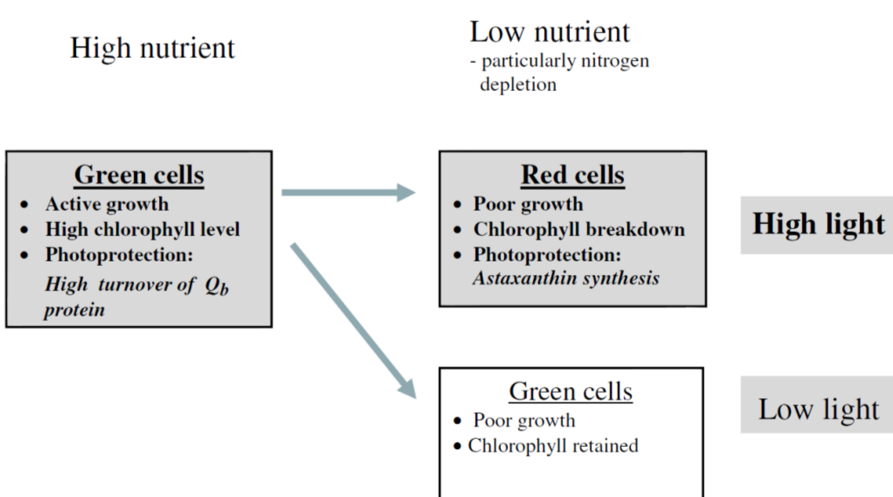
i) *Dactylococcopsis hungarica* blue

j) *Ancylonema nordenskiöldii* violet-brown

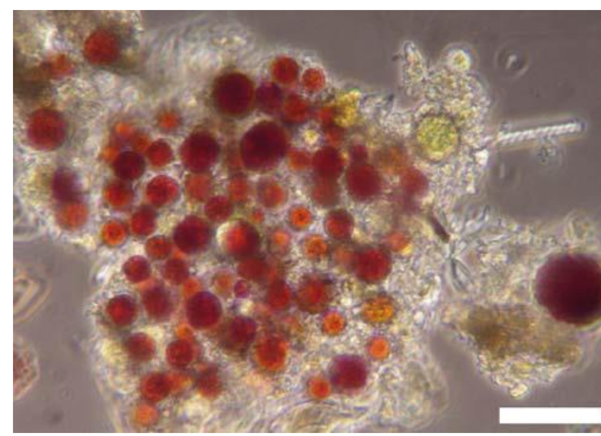
Colouration of snow

- Green colouration
  - Large areas
  - Lower altitude, below the tree line
  - Less solar radiation – under the trees
- Red colouration
  - Above tree line
  - Avalanche paths
  - Intensive solar radiation on exposed surface

- Dominant taxa :
  - *Chloromonas,*
  - *Chlamydomonas*
- Supporting taxa:
  - *Stichococcus,*
  - *Raphidonema,*
  - *Koliella,*
  - *Selenotila nivalis,*
  - *Chionaster nivalis*



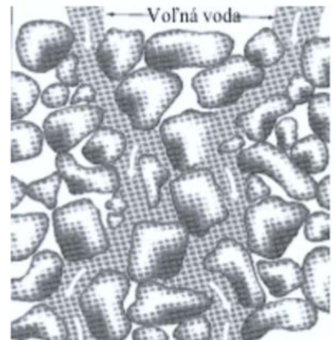
SIGEE 2005



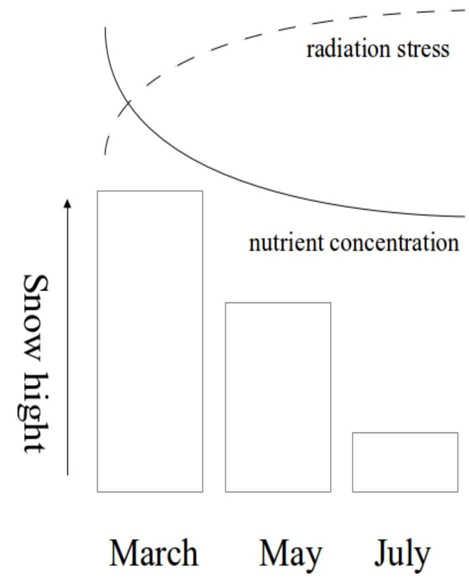
Microphotograph of the fresh red snow sample from Antarctida. Bar indicates 50 μm (FUJII *et al* 2010)

Occurrence

- Spring, summer – firn snow
- Edge of snow fields
- Accumulated pollution
- Environmental heterogenity
- Seasonal dynamics
- Altitude
- Forest



McClung – Schearer 2006



Beer et al 2011

Open area

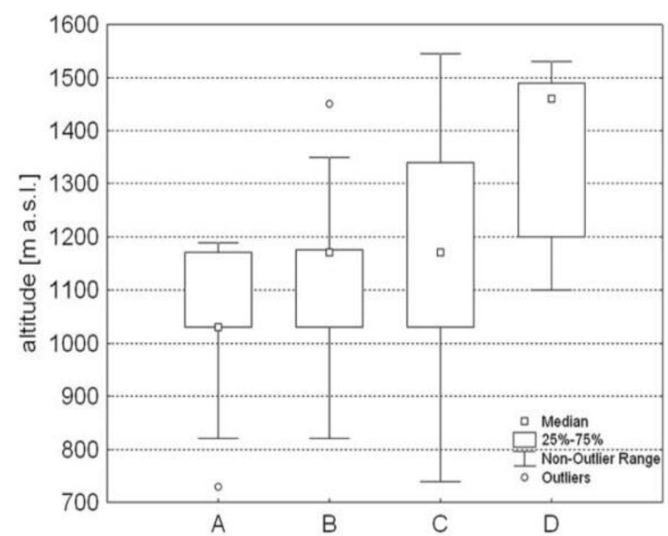
Chlamydomonas nivalis (Bauer) Wille

Chloromonas nivalis (Chod.) Hoh. *et* Mull.

Chloromonas rosae v. *psychrophila* Hoh.

Chloromonas brevispina (Fritsch) Hoh., Roem. *et* Mull

Forest

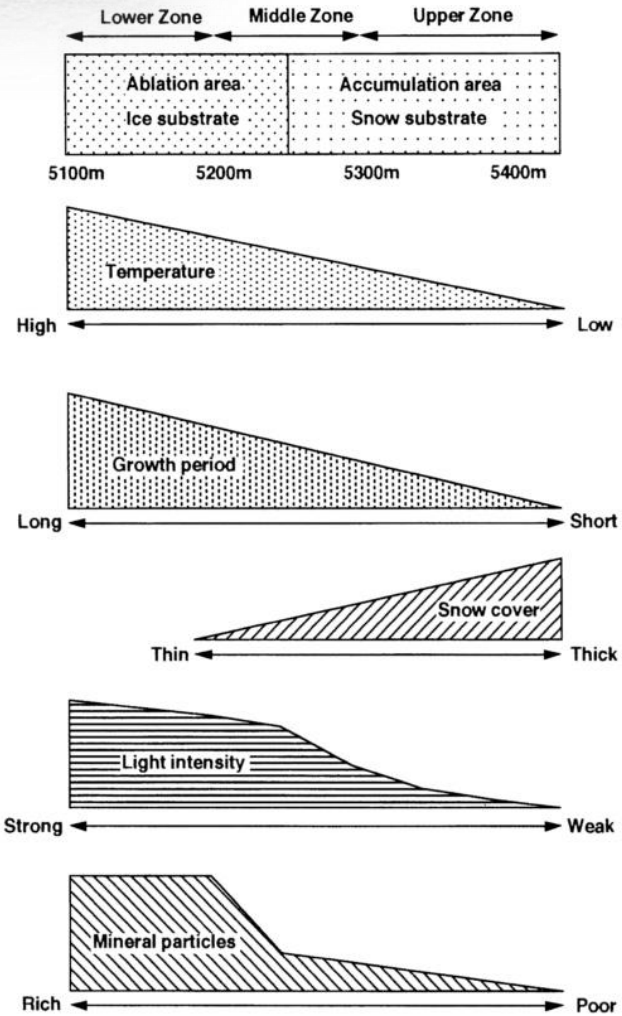


Distribution of snow algae along the altitudinal gradient of the Giant Mts. A – *Chloromonas brevispina* (n = 25), B – *Chloromonas rosae* var. *psychrophila* (n = 17), C – *Chloromonas nivalis* (n = 33), D – *Chlamydomonas* cf. *nivalis* (n = 11). Based on original data collected in 2002–2006 and observations published in Fott et al. (1978) and Kociánová et al. (1989).

Nedbalová et al 2008

Extreme environment

- Low temperature
- Absence of free water
- High solar radiation and UV
- Cycles of melt and freeze
- Nutrient depletion
- Unstability of biotop – mechanical disturbance
- pH

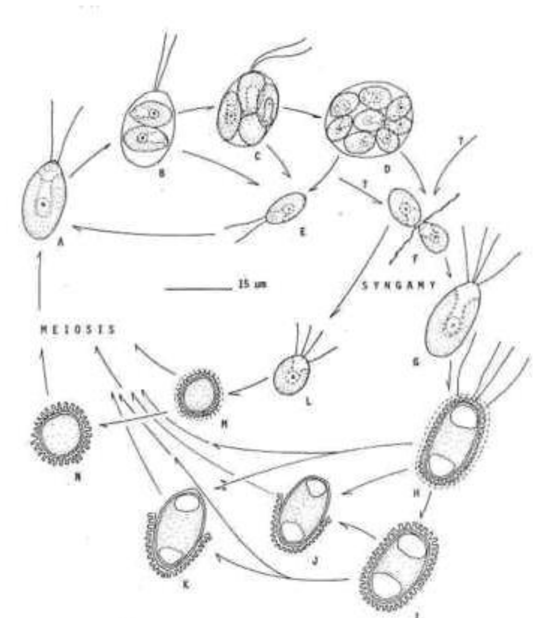


Yoshimura et al. 1997

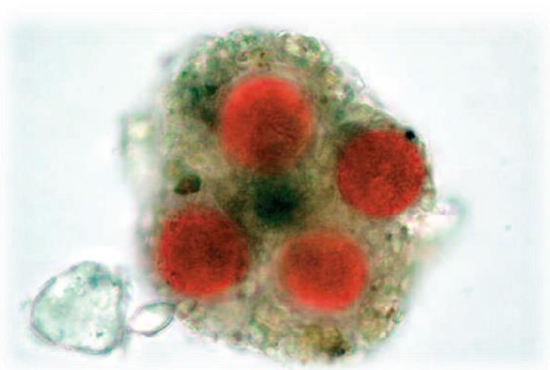
Adaptations

- **Brief growth period**
  - Rapid colonization and motility
  - Rapid population growth: *r-selected species*
  - Reproduction strategy – resting spores – asexual reproduction

- **Protection from harmful irradiation**
  - Intracellular production
    - photoprotectants – secondary carotenoid pigments (astaxanthin)
    - antioxidants
    - Repair system– repair UV damage to chlorophyll and other photosynthetic pigments



Life cycle of *Chloromonas brevispina*
HOHAM, ROEMER & MULLET, 1979



Resting spores of *Chlamydomonas nivalis*
NEDBALOVÁ & LUKAVSKÝ 2007

Adaptations

- **Lack of nutrients**
  - Resting spores
  - Flagella
  - Quick colonization environment with plenty of nutrients
  - Ratio of surface area / volume cell – optimize the absorption of nutrients
- **Low temperature**
  - Ability to photosynthesize
  - Cells with low water content
  - Ratio of fatty acid in the cell – increase the fluidity of the membrane and maintain this state
- **Desiccation**
  - Resting spores with more stratified cell wall
  - Mucilage layer

- The species composition of communities of snow algae in selected mountains of Slovakia
- Monitoring of physico-chemical parameters of snow

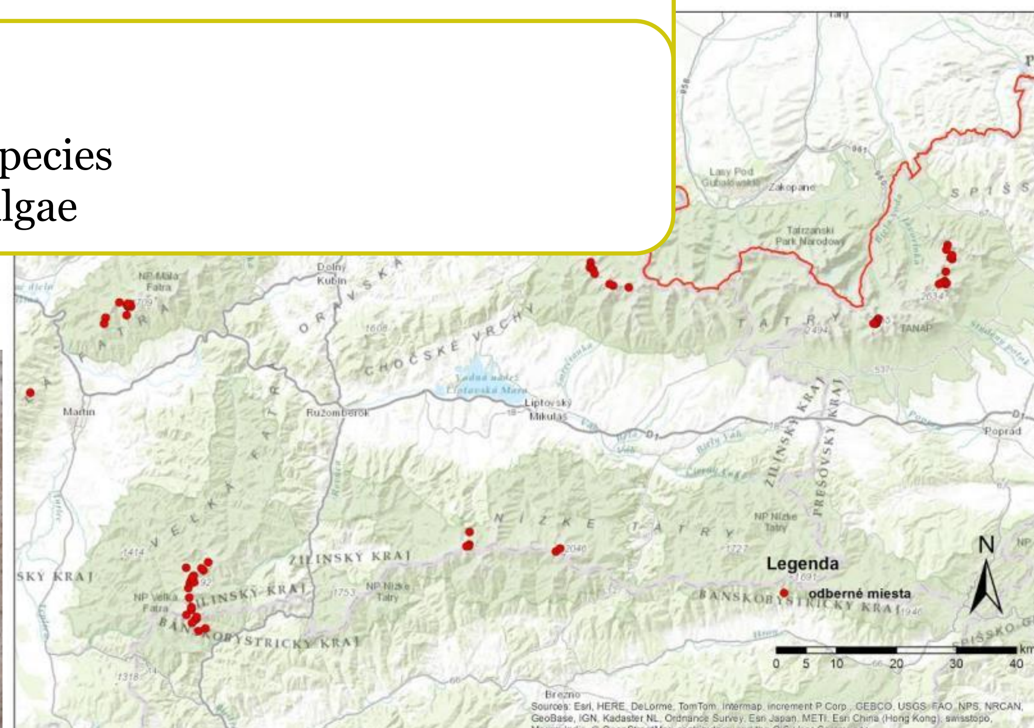
Locations

Sampling

Physico-chemical parameters of environment

Treatment of samples

- The microscopic identification of species
- Cultivation and isolation of snow algae



Medená a Veľká Zmrzlá valley

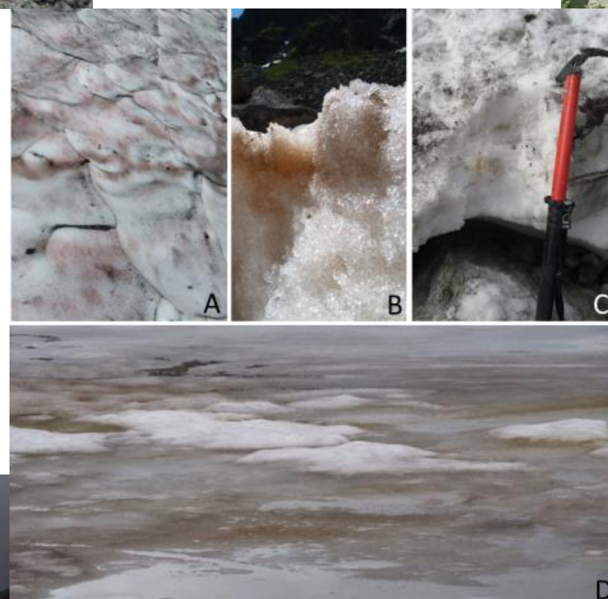
High Tatras Mts.

August – N exp. – 1950-2150 a.s.l.

Ďumbier

Low Tatras Mts.

Jun – N exp. – 1695 a.s.l.



Zelené pleso (mountain lake)

High Tatras Mts.

May – 1550 a.s.l.

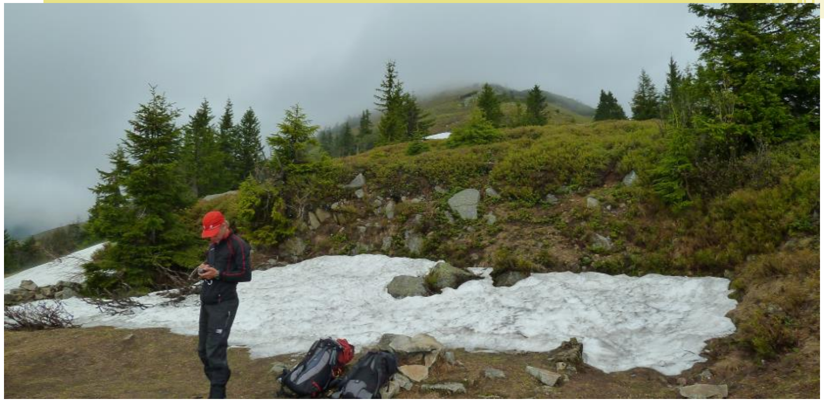
Zlomisková valley

High Tatras Mts.

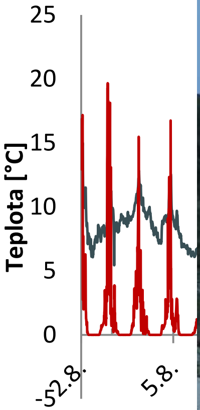
September – W exp. – 2100 a.s.l.

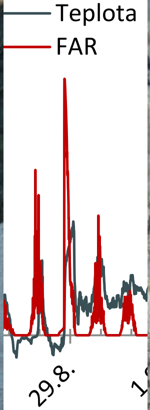
Other sampling points ...

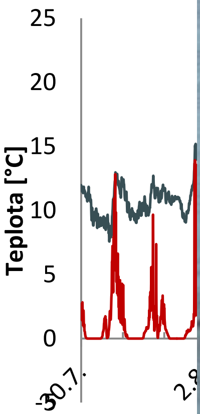


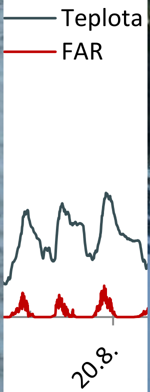






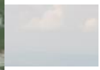




Tatras Mts

s-1

μmol.m^{-2}.s^{-1}

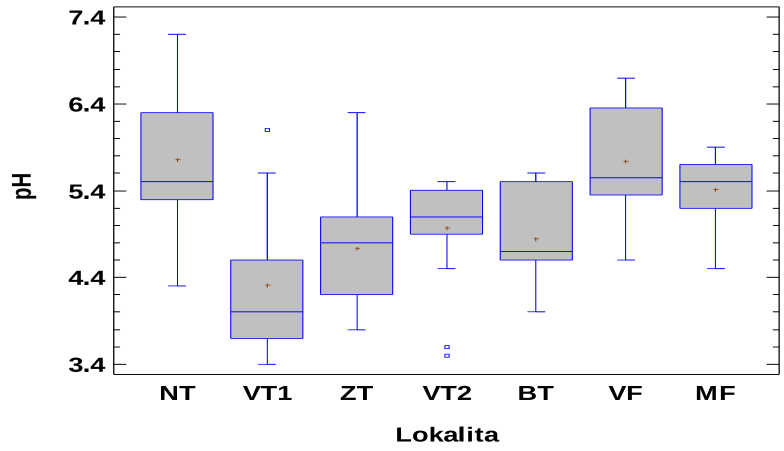


est Tatras

s

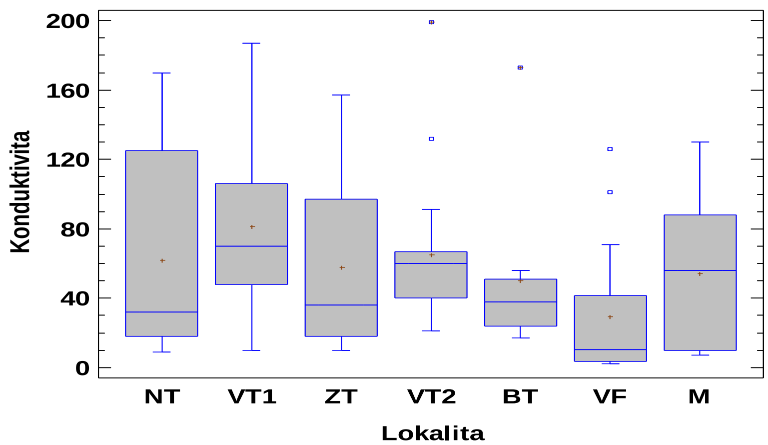
s-1

Results – chemical analysis



pH

- 3,4-7,2
- Slightly acidified environment
- Comparison of samples : 3 groups
- Coloured snow



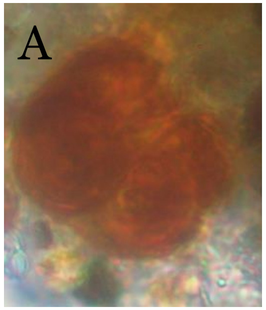
Conductivity

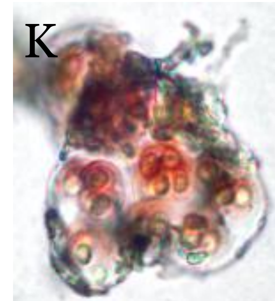
- 3,9-147 µS.cm^{-1}
- Large coefficient of variation within localities
- Relationship conduct. vs. snow algae

Nutrient content

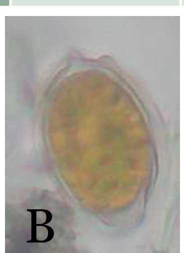
- N-NH_4 0,06-5,39 mg.l^{-1}
- N-NO_3 < 0,03-12,54 mg.l^{-1}
- P-PO_4 < 0,06-1,44 mg.l^{-1}
- Dominant N-NO_3 (except for NT, VT2)

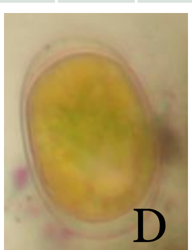
- Snow in general : oligotrophic
- Heterogenous distribution of nutrients within the fields
- Unnoticed impact of algae on nutrient content
- Impact of trees

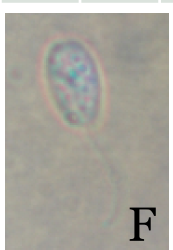


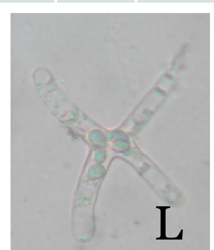


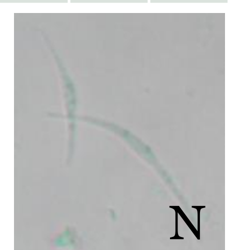
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Mountains	Altitude of sampling (a. s. l.)	*Chlamydomonas cf.nivalis*	*Cf. Chloromonas nivalis*	*Chloromonas rostafinski*	*Chloromonas sp.*	chlorococal green algae	*Notosolenus sp.*	*Bacilariophyceae*	*Hantzchia amphioxys*	*Alternaria sp.*	*Cyanobacteria*	*Gloeocapsa sp.*	*Chionaster nivalis*	*Chionaster bicornis*	*Selenotila nivalis*	*Rotifera - Philodina sp.*	*Tardigrada – Hypsibius sp.*	*Nematoda - Tylenchida*	*Ciliophora*
NT	1324-1895	x	x			x		x	x	x			x	x	x	x		x	x
VT1	1850-2220	x	x	x			x			x			x			x	x		
VT2	1900-2100	x	x		x	x	x	x	x	x	x		x			x	x	x	x
ZT	1848-2021	x	x		x			x	x	x	x	x	x	x		x		x	x
BT	1725-1770	x	x					x					x			x			x
VF	975- 1562		x		x	x		x	x	x			x	x	x				x
MF	1150-1642		x		x	x	x	x	x			x	x		x				

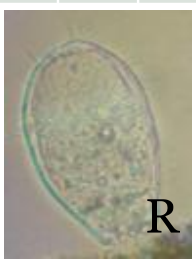


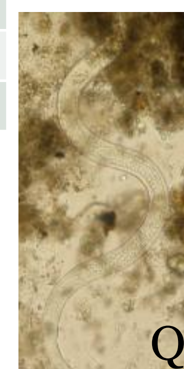






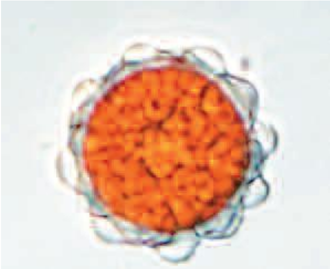




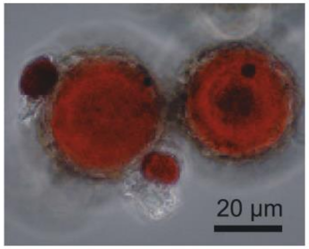


Chlamydomonas cf. *nivalis*

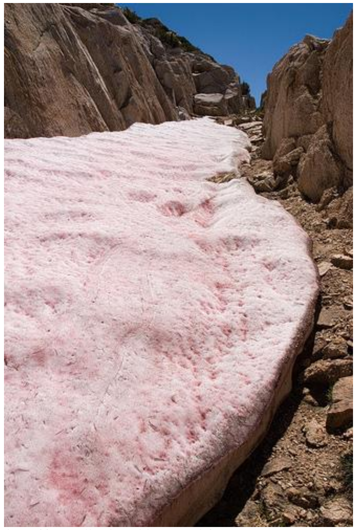
- No shaded locations
- In mountains (even above and below tree line) and in polar regions
- Traces of avalanches, slopes made by glaciers
- Obvious red coloured snow (accumulation of secondary carotenoid astaxanthin)
  - High levels of UV radiation and PAR



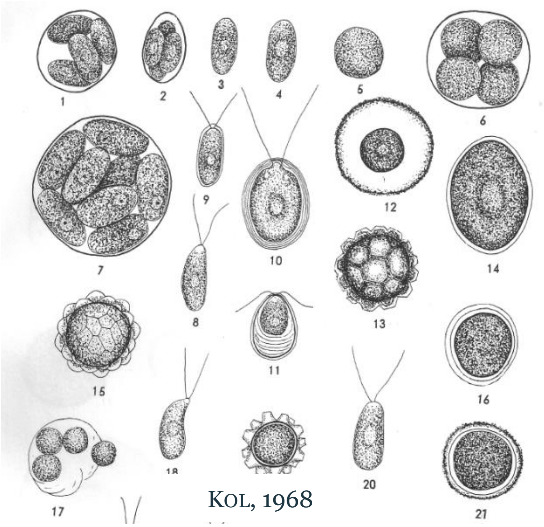
(Nedbalová – Lukavský 2007)



Takeuchi et al 2006



http://annagiiordano.blogspot.sk/2010_01_01_archive.html

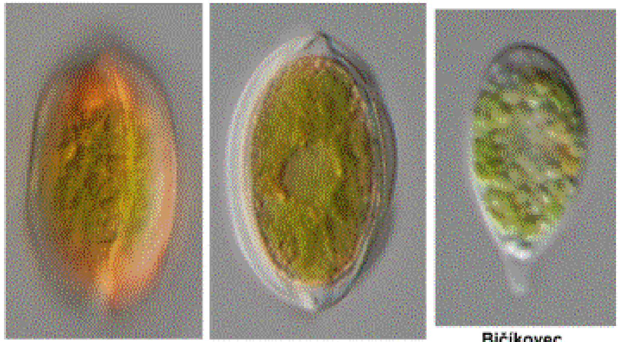


Kol, 1968

http://www.coolantarctica.com/gallery/arctic/svalbard/svalbard0153.php

Chloromonas nivalis

- Cosmopolitan species (prímorské časti Antarktídy, Špicbergy, Kaukaz, Balkán, Alijaška,...)
- Wide tolerance of living conditions
  - Polar and alpine areas
  - Shaded (conifers also decidious trees) and no shaded areas
  - Above and below the tree line
  - Tolerance of high levels of UV radiations and PAR (similar like
  - *Chlamydomonas nivalis*, but able to grow at a lower radiation)
- Coloration of snow – green, orange, pink
  - Depending on teh stage of life cycle



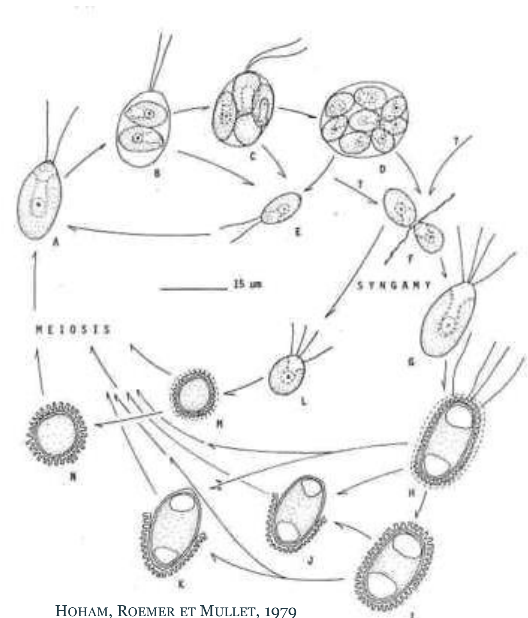
Zygospory *Chloromonas nivalis*

Bičíkovec *Chloromonas nivalis*

… ·NEDBALOVÁ

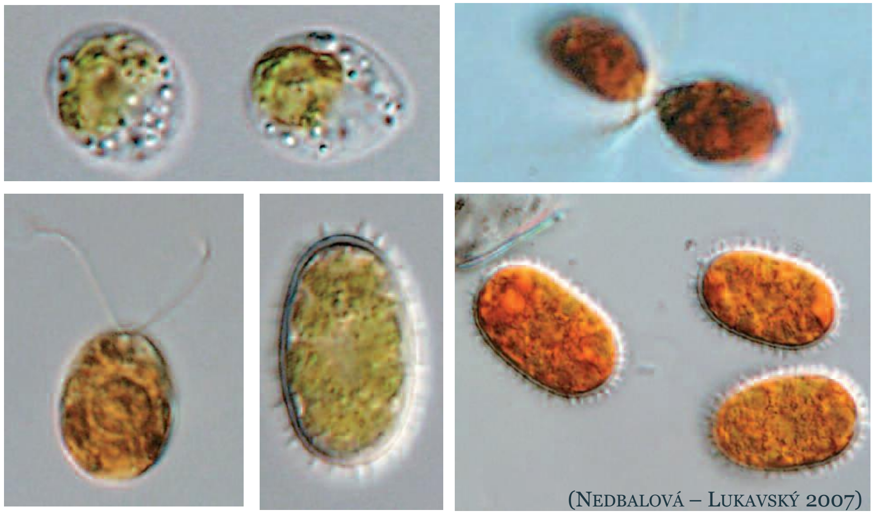
Chloromonas brevispina

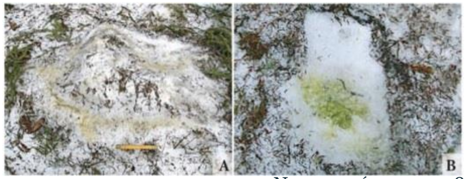
- Lower altitudes (730-1180 m)
- Near or under spruce crowns
- Shaded areas
- Frequent occurrence with *Chloromonas nivalis*
- Volume of accumulated carotenoids reflect the varying exposure to light
- Green coloration (flagellates, young zygospores), orange/red coloration (adult zygospores)



Hoham, Roemer et Mullet, 1979

Cryocystis brevispina (Fritsch) Kol
Cryocystis japonica
Cryodactylon glaciale
Oocystis laeustris f. nivalis
Trochiscia nivalis
Trochiscia rubra Kol - ***T. cryophila***


(Nedbalová – Lukavský 2007)



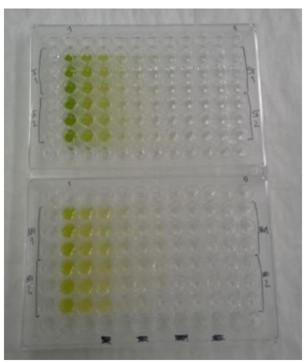
Nedbalová et al 2008

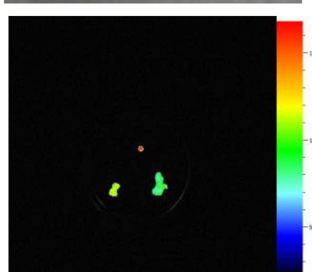
- Flagellates and copulation of gametes
- Result of copulation - planozygot – then zygospores characterized by a progressive accumulation of carotenoids

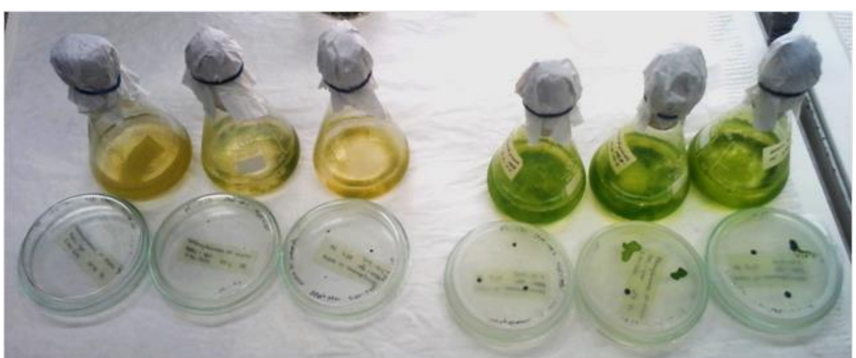

L5<=15 µm
L22=9 µm
L53=12 µm
L23=7 µm
L24=10 µm
=16 µm
L25=12 µm
L55=16 µm
20 µm


20 µm


20 µm

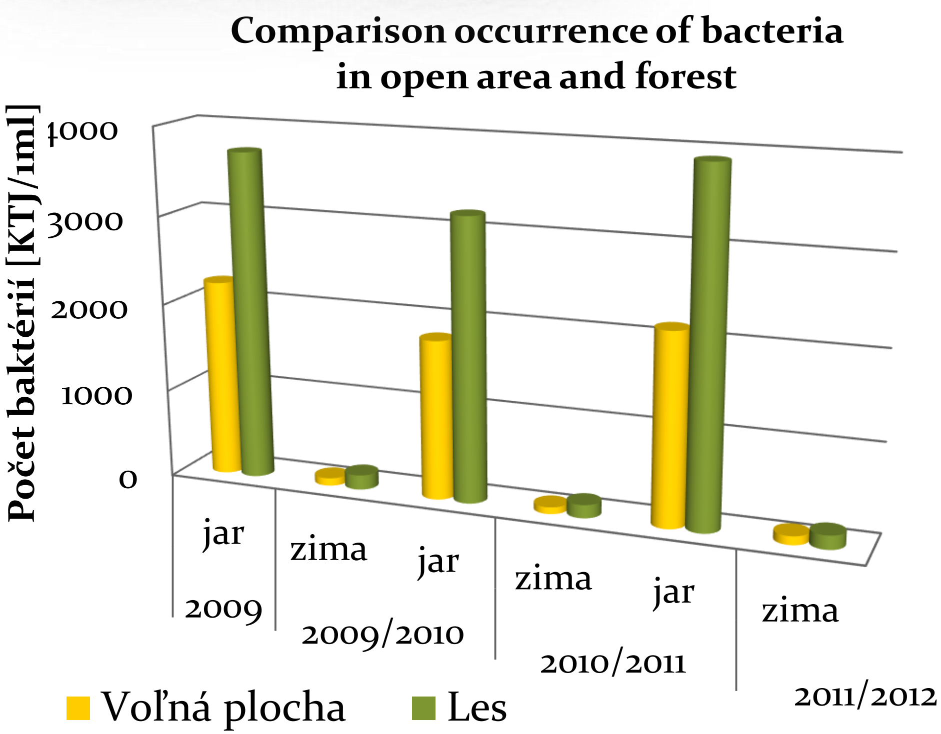







UV-1650PC
SHIMADZU

Some results …



Winter < Spring

Open area < Forest

Thank you for attention ...