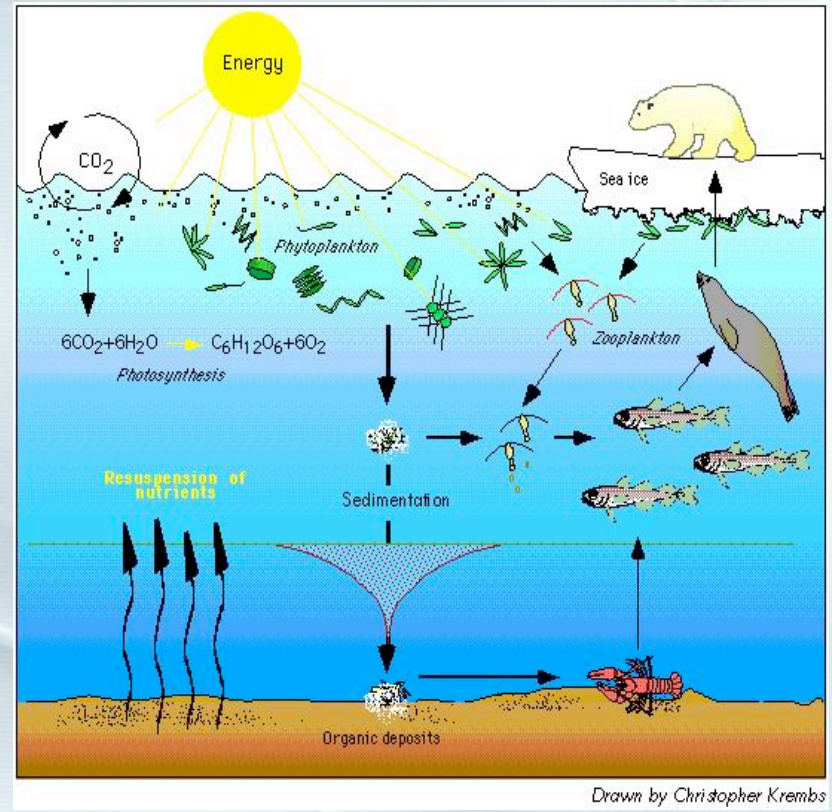
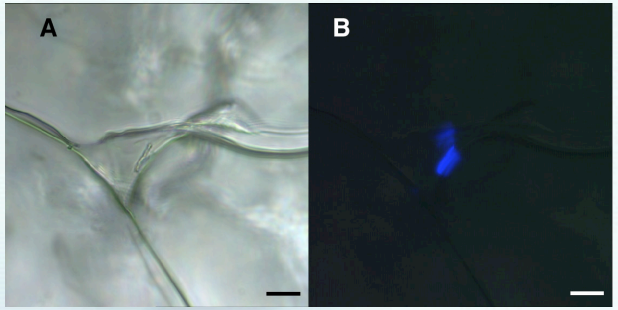
# High-resolution ice nucleation spectra of sea-ice bacteria: Implications for cloud formation and life in frozen environments

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# Introduction

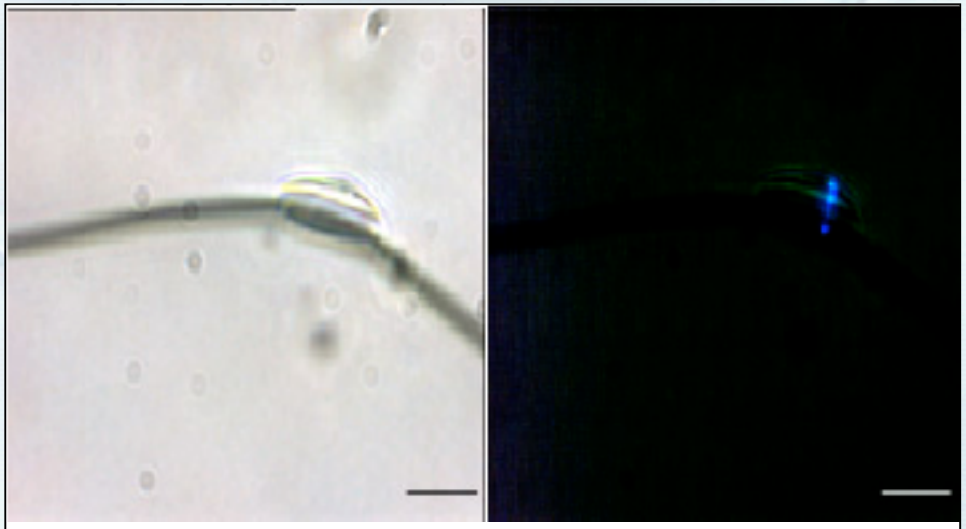
- Objectives
  - » To better understand the interaction of bacteria with ice
  - » To assess the ice initiation potential of polar marine psychrophiles
- Significance
  - » limits of life
    - ➳ active sea-ice bacteria to -20°C (and below Junge et al.,2004 & 2006)
  - » sea-ice ecosystem
    - ➳ initial freezing events (Parker et al.,1985)
  - » cloud formation
    - ➳ source of ice forming particles in Arctic clouds (Bigg and Leck, 2001)

      After all, many bacteria are CCN active (Bauer et al. 2003)
  - » astrobiology
- Fundamental question:

  Do psychrophiles express ice nucleation activity as a means to enhance survival in subzero environments -- whether in sea ice or in the upper atmosphere?

# Sea-ice bacterial isolates:

- Arctic: Chukchi Sea
- Antarctica: McMurdo Sound



Bacteria attached to ice wall (Junge et al.2001)

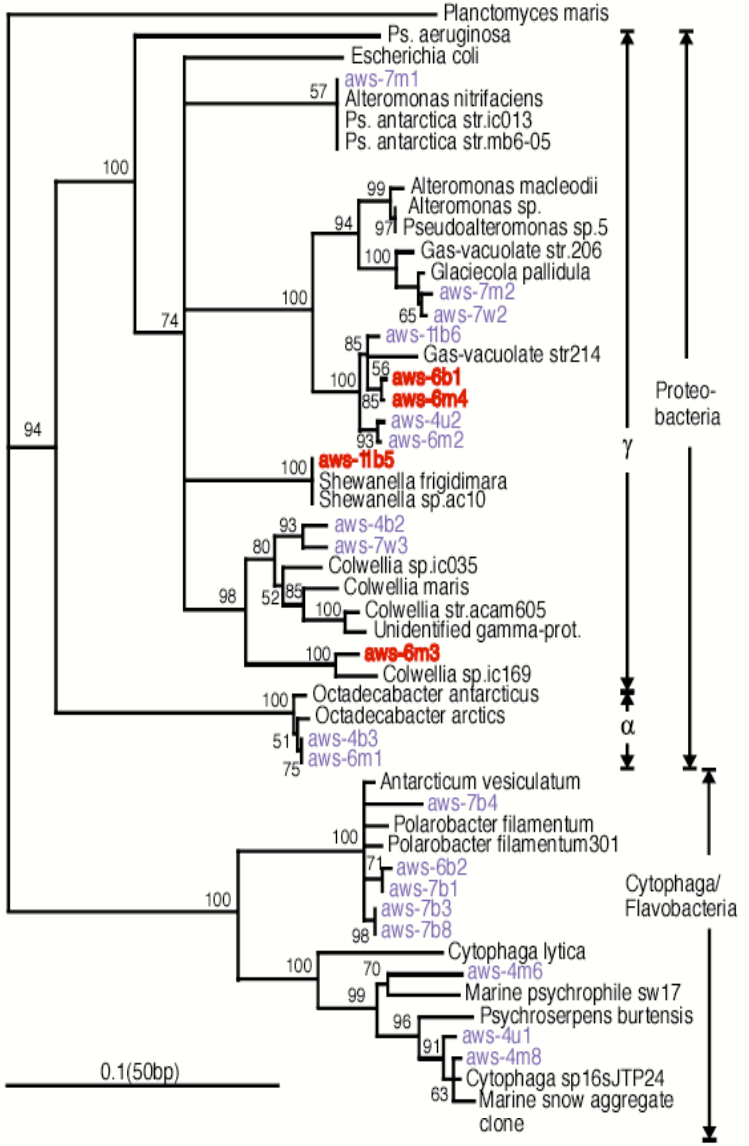
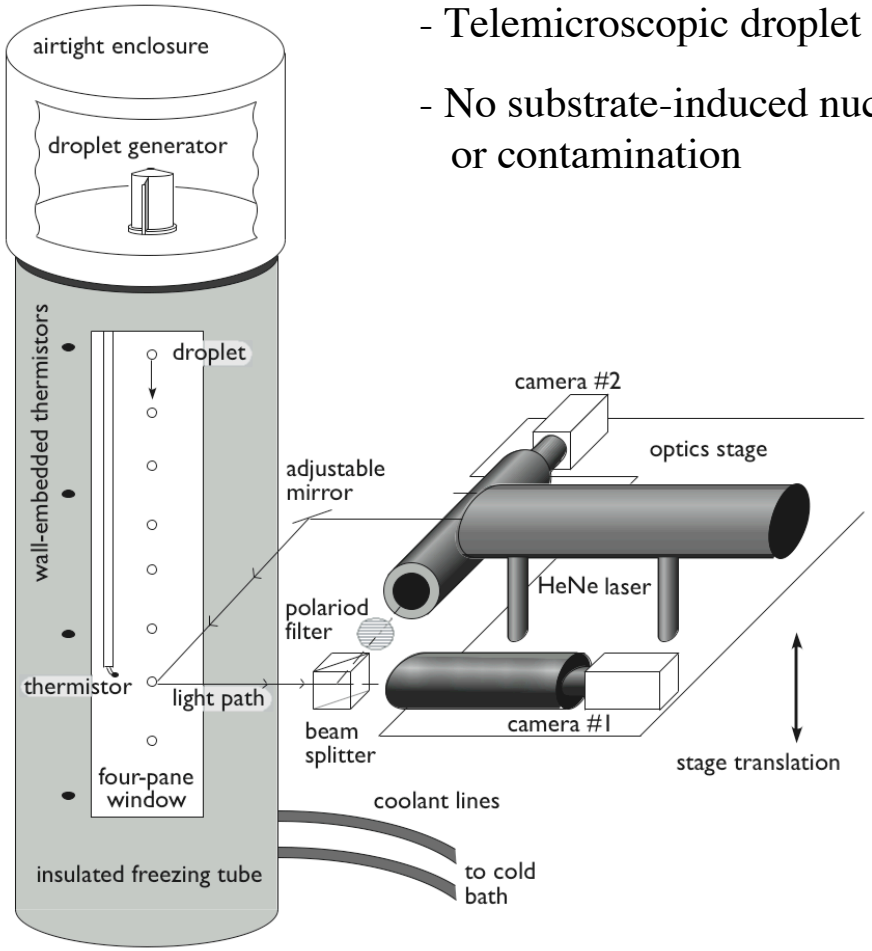


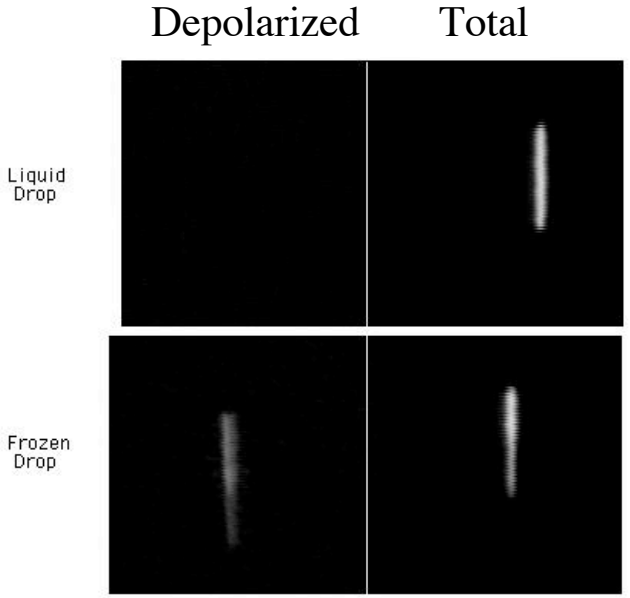

**Fig. 2.** Phylogenetic analysis of Arctic sea-ice bacteria and closest relatives as determined by Blast Genbank search (Junge et al., 2000).

**Bacteria strains used for INA tests marked red.**

# Freezing Tube Apparatus

- High repetition rates (~5 hz)
- Well controlled solution concentration
- Telemicroscopic droplet images
- No substrate-induced nucleation or contamination

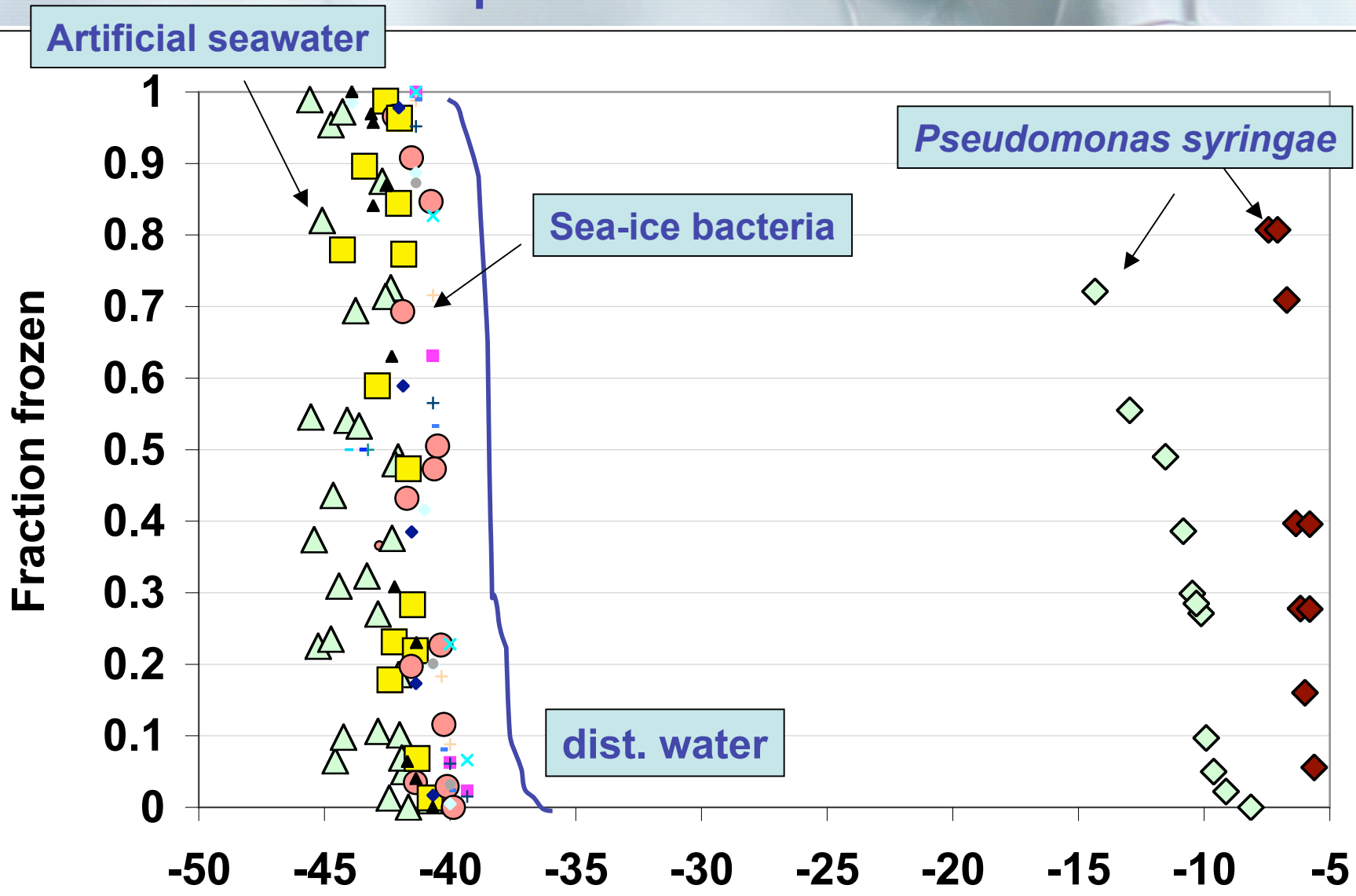



D/T = Depolarized scattering intensity/Total scattering intensity

From D/T at various heights we extract the fraction of frozen droplets F(T)

# Ice nucleation spectra for sea-ice bacteria isolates




Each data point represents F(T) for 200-300 droplets

Calibrations were done to insure at least 1 bacteria per droplet

(Junge et al. in prep.)

# Summary

- **We have used a novel freeze tube method to study biogenic ice nucleation.**
- **We find substrate-free methods are useful. Anomalously high ice nucleation temperatures can be obtained if a substrate is not sufficiently passivated for low-temperature nucleation studies.**
- **Results from 17 different sea-ice bacteria and virus isolates show limited Ice nucleation activity**
    - Ice inititation mediated by bacteria and virus isolates was at or **near** homogeneous nucleation temperature (**<-37°C to -44°C**)
- **Results indicate that avoidance of ice formation in close proximity of their cells may be one of the cold-adaption and survival stragegies for sea-ice bacteria and could be imporatnt for their ability to remain active at temperatures far below the freezing point of seawater.**