Gas Vesicles:

The structural properties, ecophysiological function, and *in vivo* detection of a proteinaceous organelle common in bloom forming cyanobacteria

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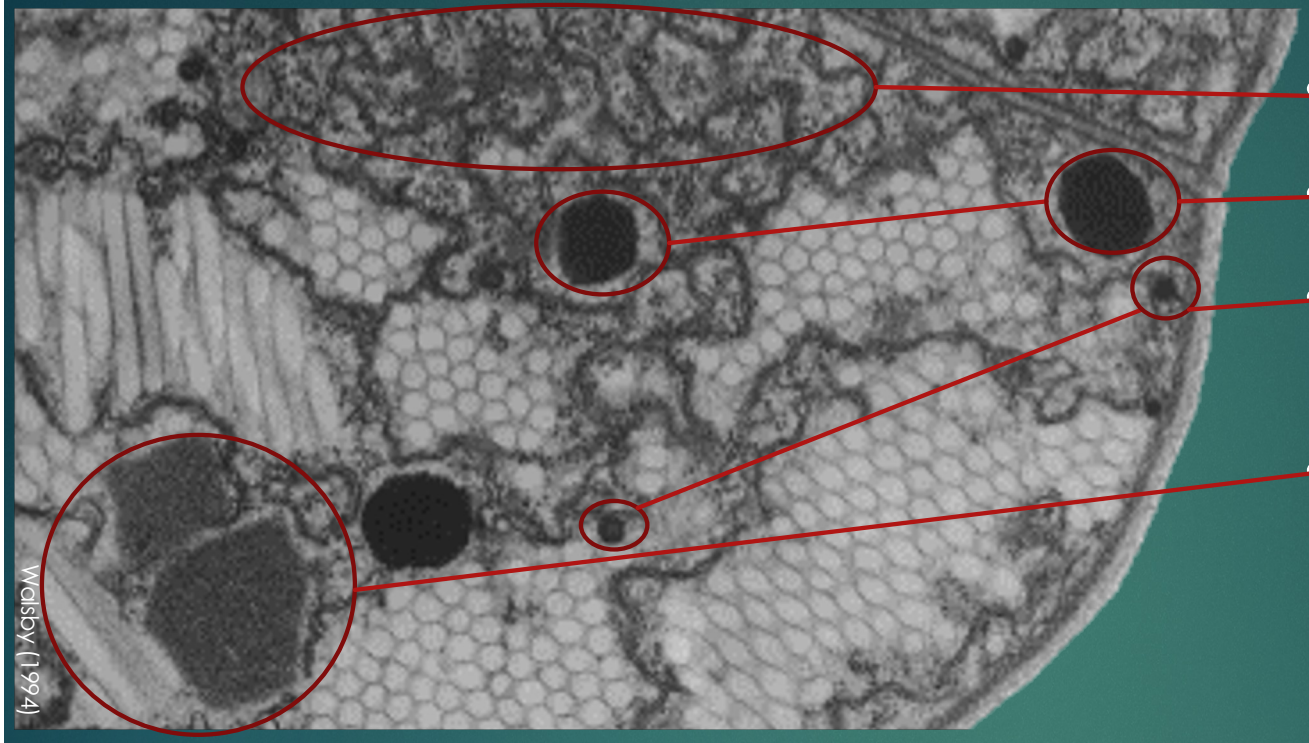
(presentation includes work conducted within the Needoba/Peterson lab at OHSU)

Cyanobacteria-dominated Harmful Algal Blooms (HABs) are an emerging global health threat

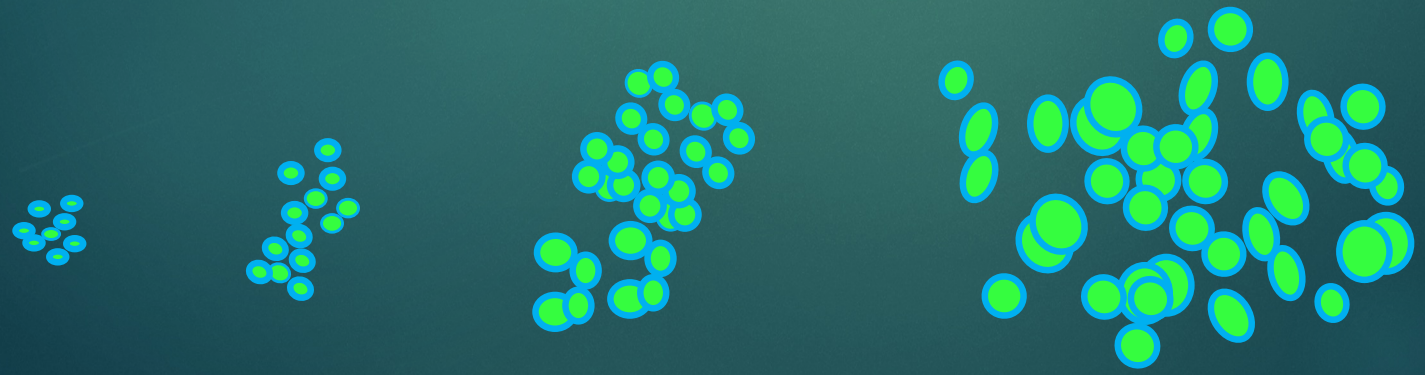
Ross Island Lagoon, Willamette River, Oregon

Opportunistic nutrient uptake



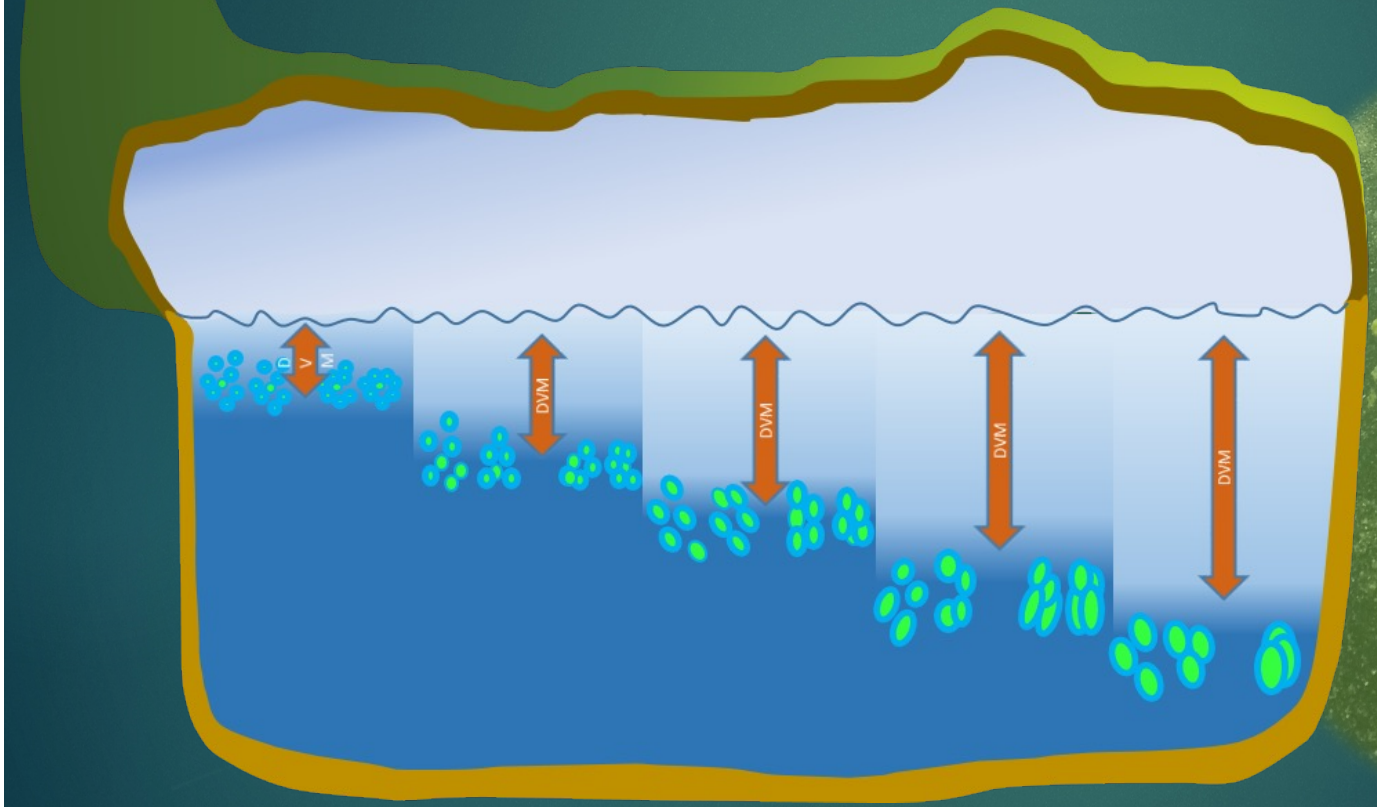
- Glycogen reserves
- Lipid droplets
- Polyphosphate granules
- Carbon concentration mechanisms

Rapid growth due to increased temperature and nutrient availability



- Doubling time < 24 h

warm temperatures increase thermocline depth



Ross Island Lagoon
Willamette River, OR
(2016)

increased separation between nutruent and energy pools

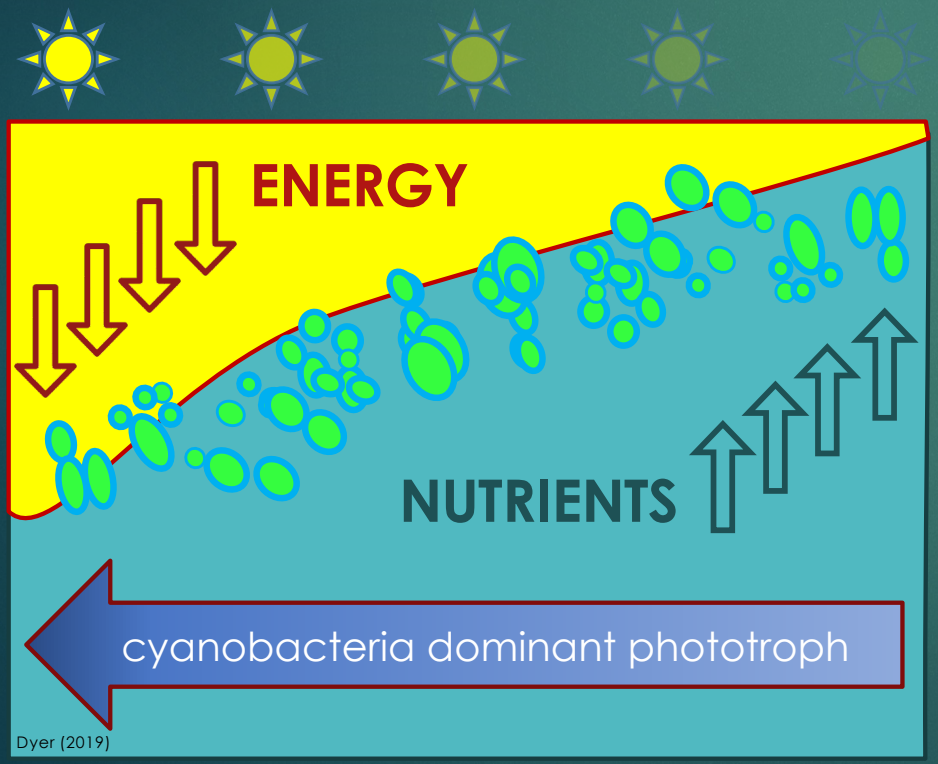
GVs facilitate movement between energy & nutrient pools

Photosynthetic **Ballast** generation

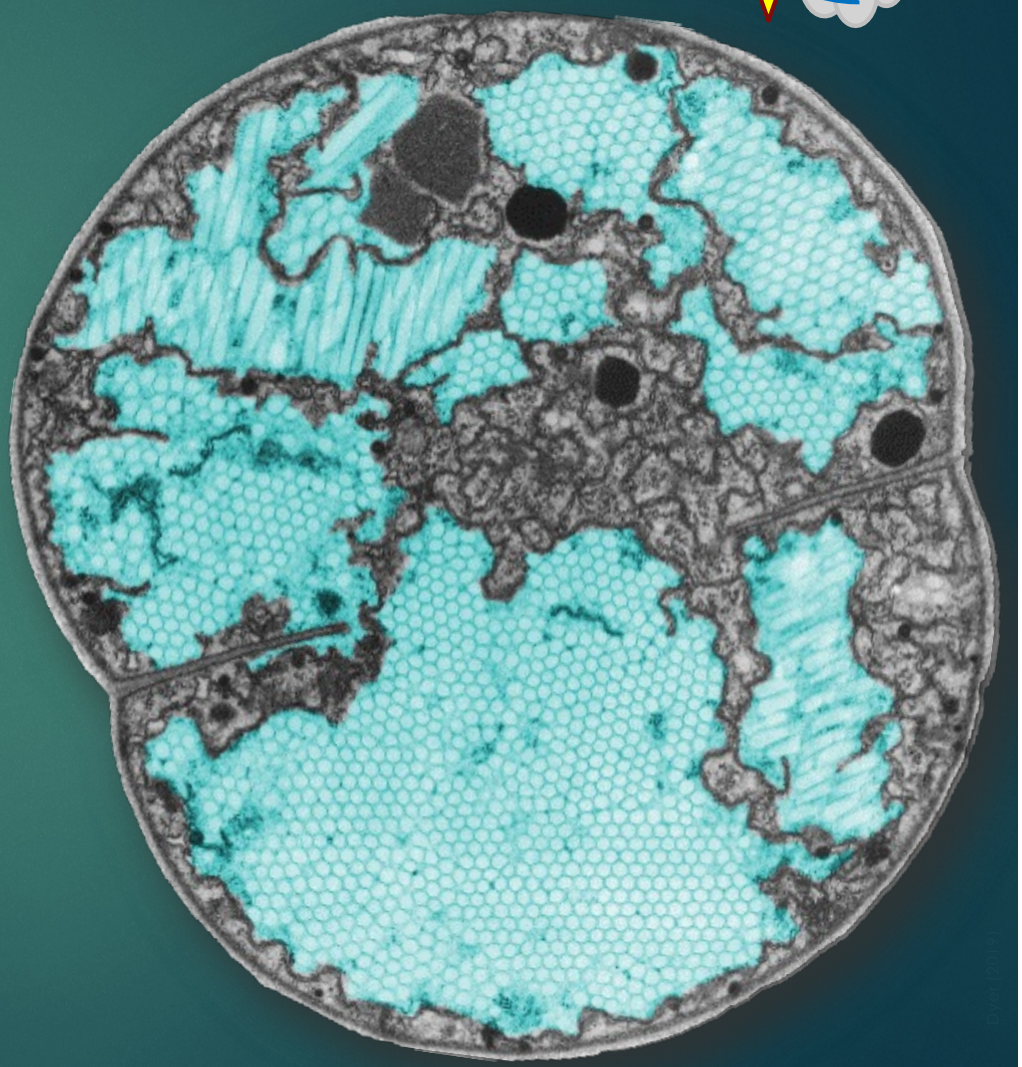
- Generates negative buoyancy

Growth and **GV** biosynthesis

- Generate positive buoyancy

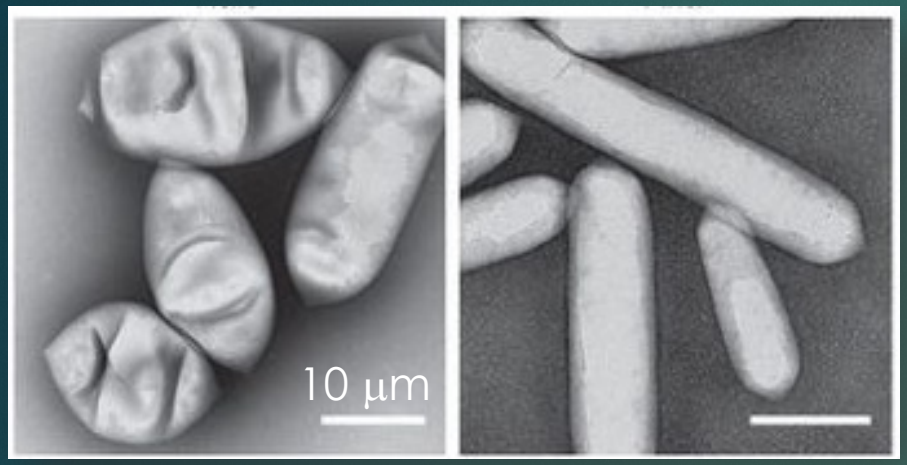


Dyer (2019)

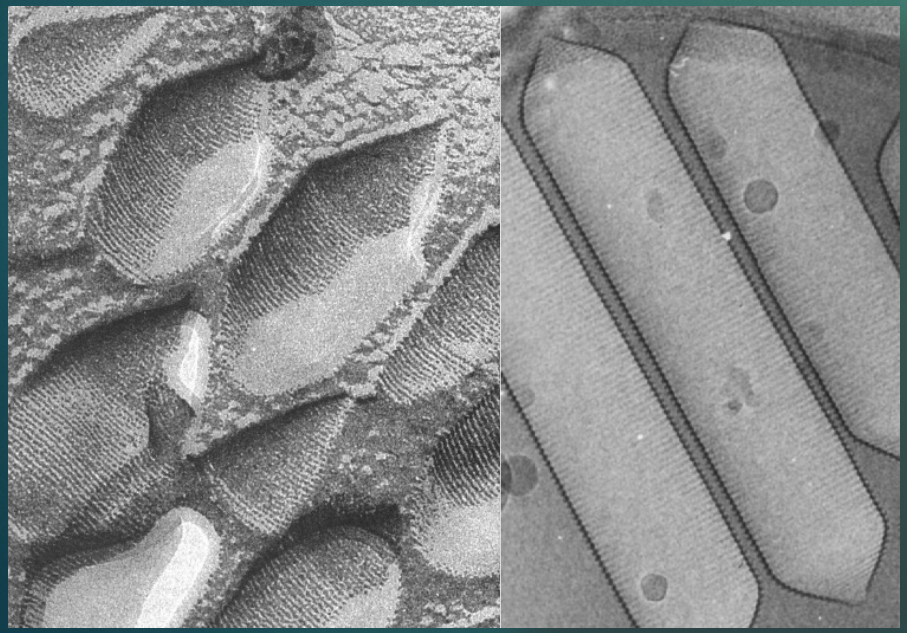


Adapted from Walsby (1994)

GV features in cyanobacteria



Bourdeau et al., 2018

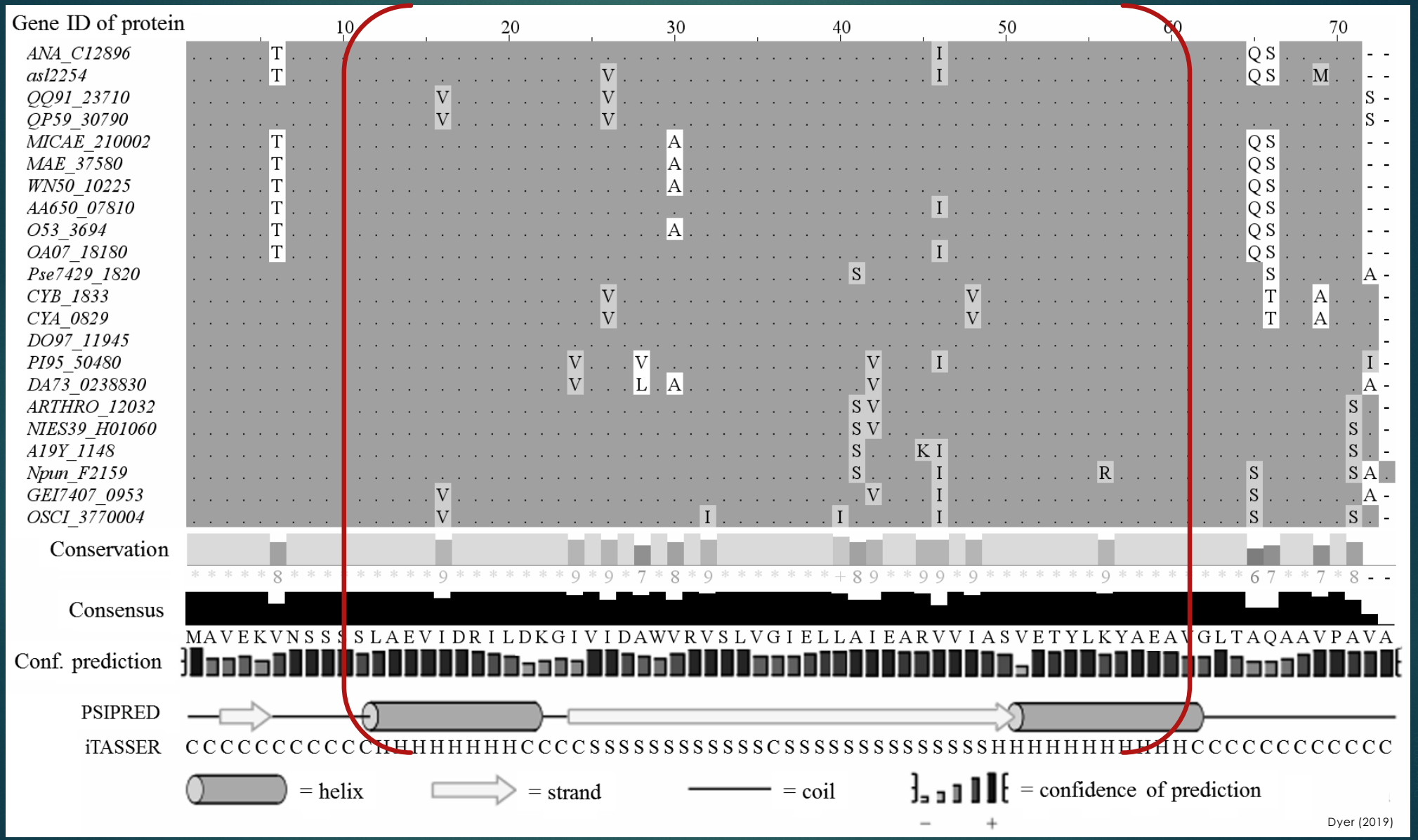


Walsby, 1994

Sivertsen et al., 2009

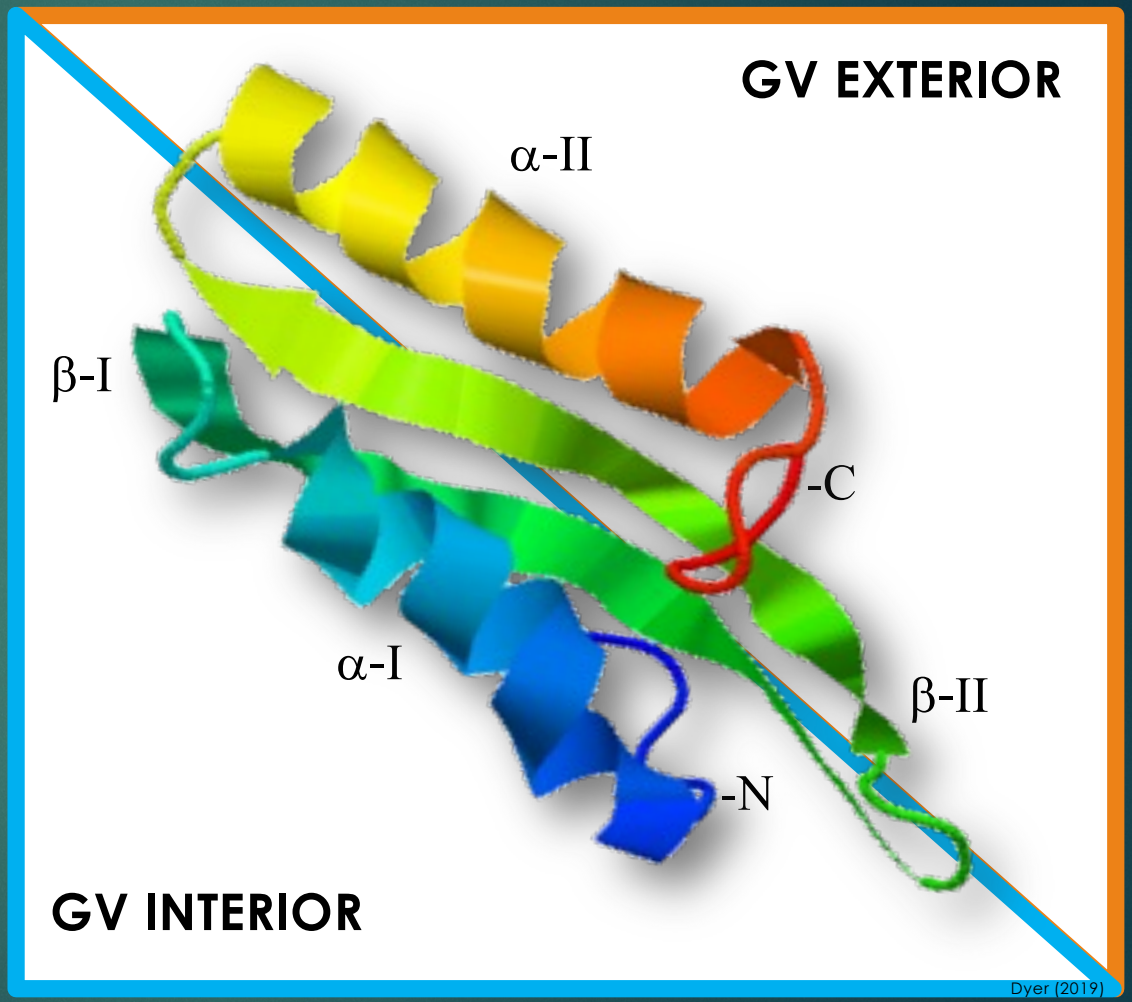
- Gas filled
- Proteinaceous inclusion bodies
- Strength varies between homologs
  - length/width
    - collapse pressure
- Topology does not vary between homologs
  - cylindrical bicone shape
  - "rib" periodicity
  - interactions w/ accessory proteins

GvpA homology/variability and the 51-residue core

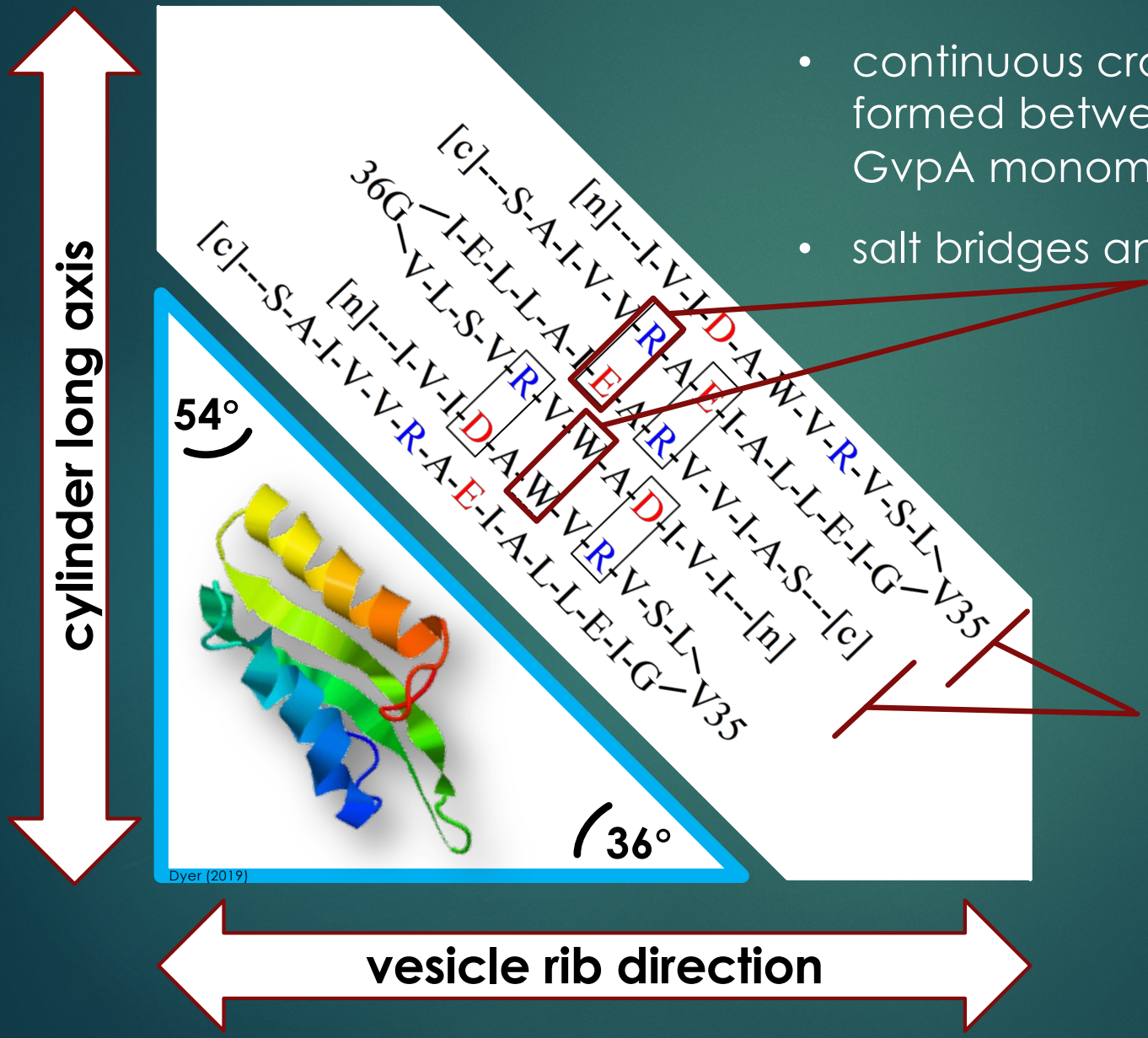


Features of GvpA & the 51-residue core

- α-β-β-α structural motif
- α-I strongly hydrophobic
- α-II strongly hydrophilic
- conserved across all gas vacuolate organisms*

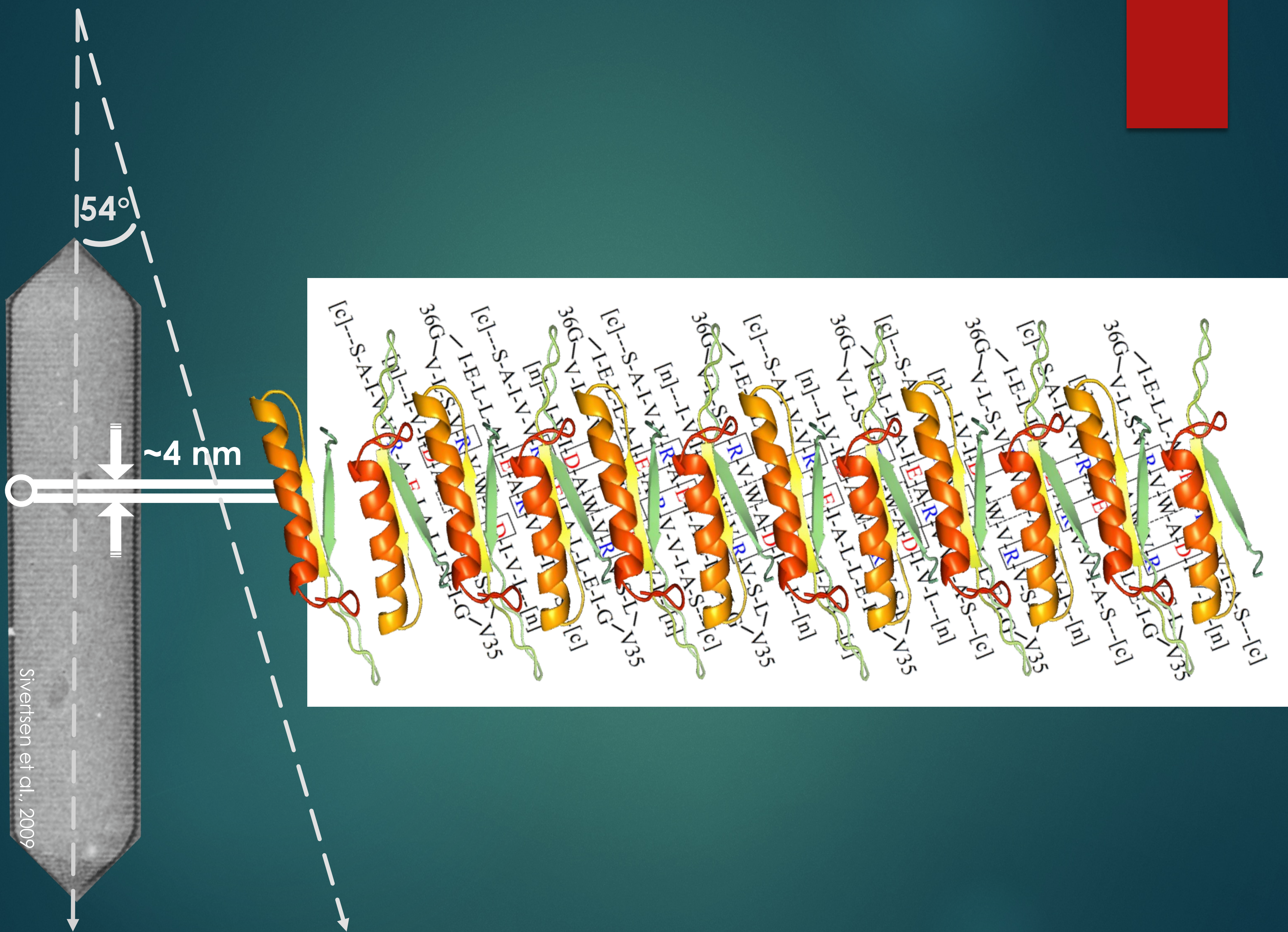


Association of GvpA monomers

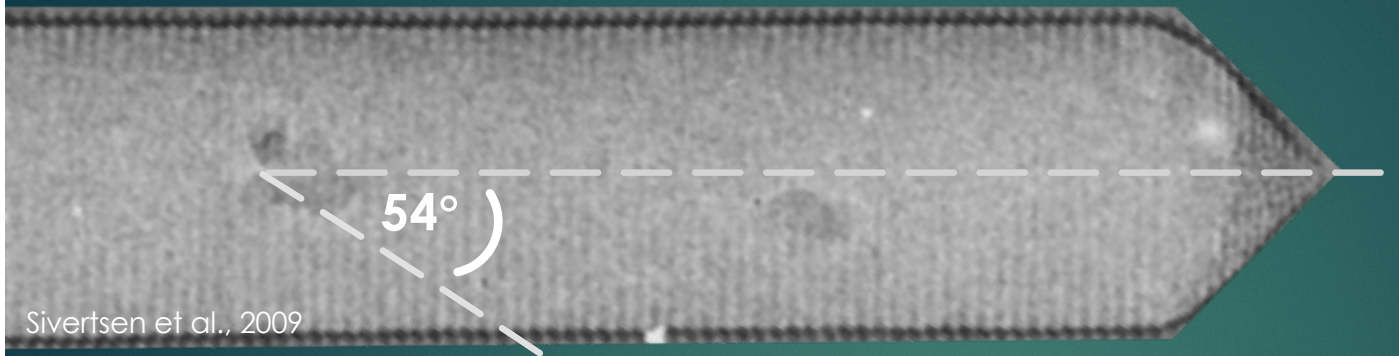


- continuous cross-β-sheet formed between adjacent GvpA monomer → "ribs"
- salt bridges and π-stacking

- alternating "inequivalent" GvpA monomers
- 4-residue translation per 2-monomer segments → "slant"


54°
~4 nm
Sivertsen et al., 2009

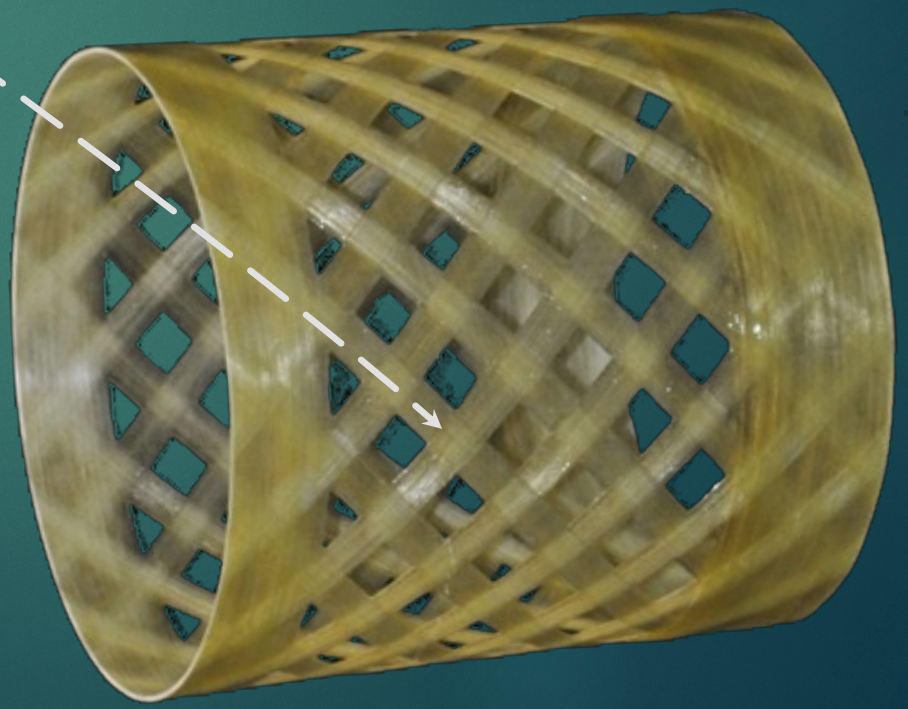
GVs: biological engineering at its best



- slant of GvpA strands oriented 54° to cylinder long axis

- balances axial- and circumferential stresses

  used in filament-wound tubes and vessels →



Nephel-o-metr-ic

→ relating to the measurement of light scattering

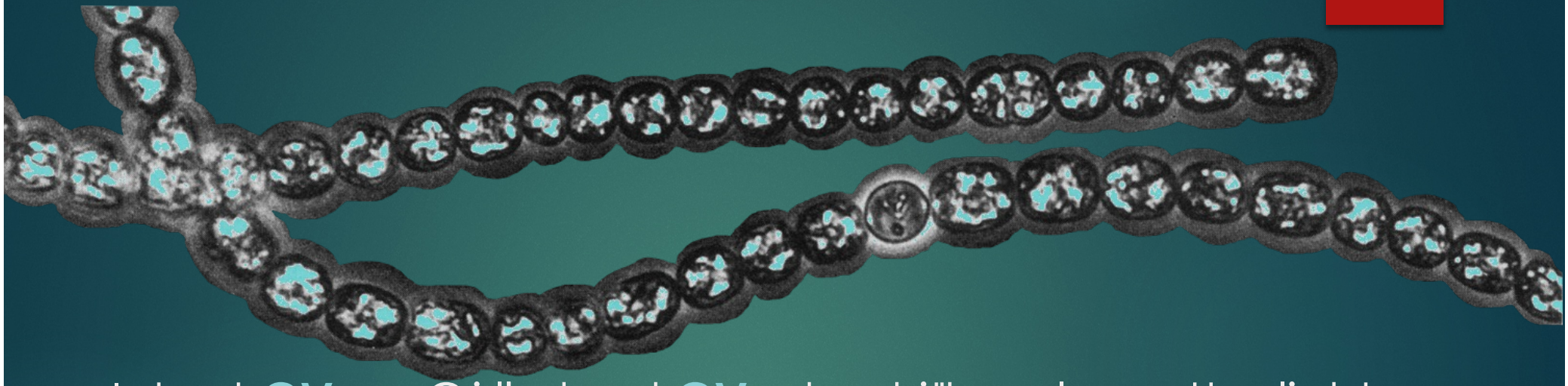
Turbid-i-meter

→ an instrument for measuring the concentration of suspended solids in a liquid medium

➔ An instrument that measures the scattering of light as a proxy for the concentration of suspended solids in a liquid medium

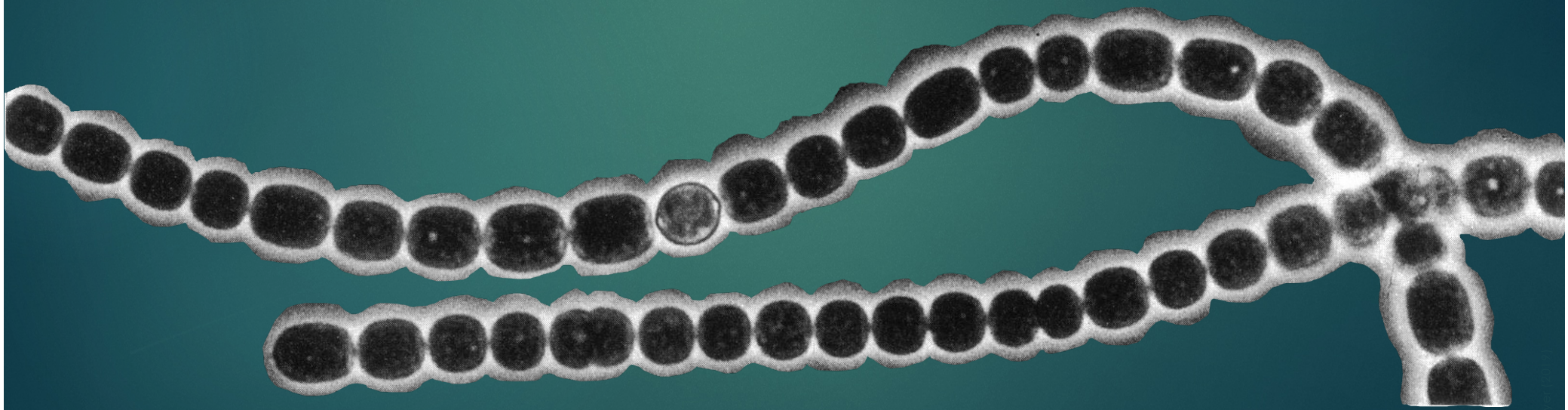
Pressure Nephelometer

➔ An instrument that is able to modulate pressure within a nephelometric cell, measure the resulting scattering of light, and determine pressure/turbidity relationships

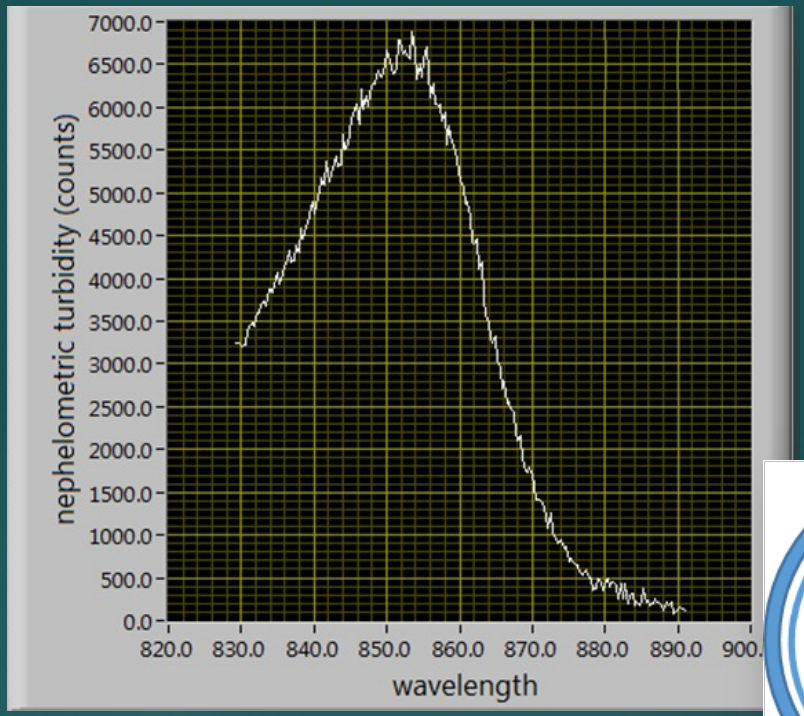


Intact **GVs** provide buoyancy

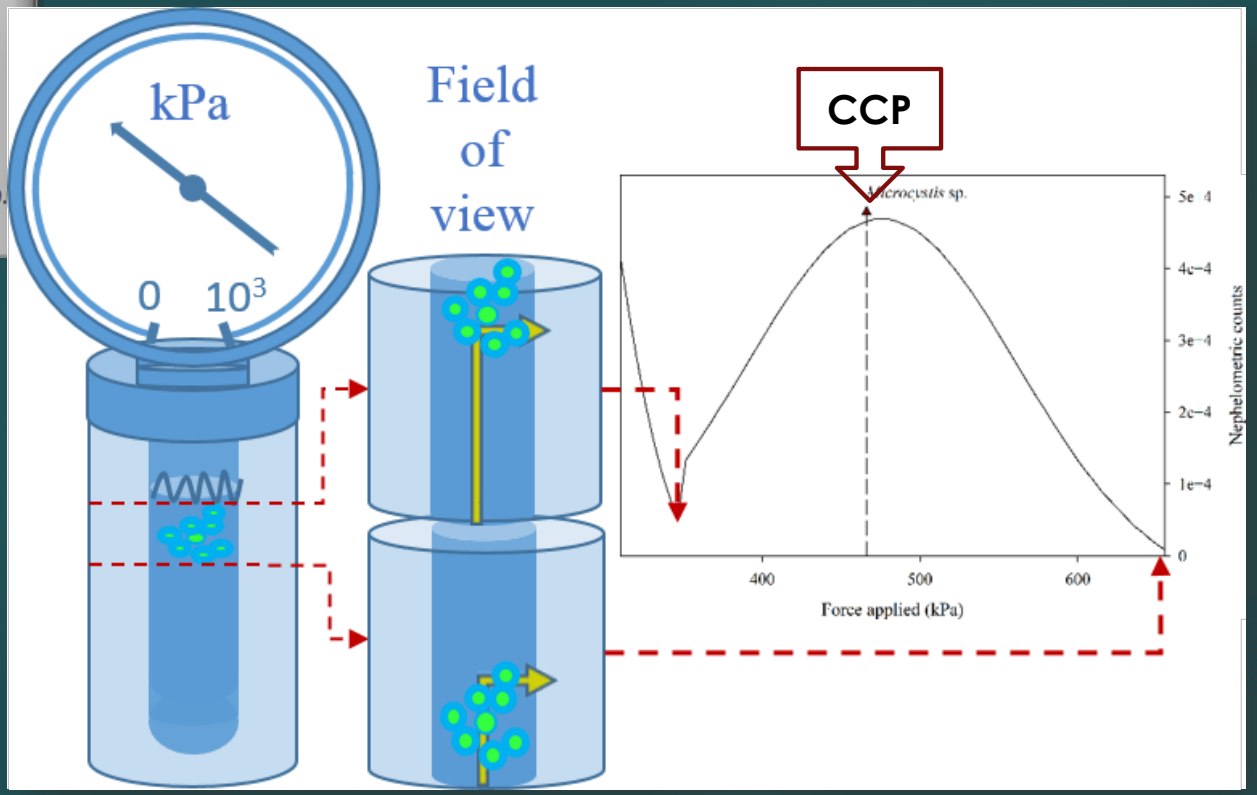
Collapsed **GVs** do not strongly scatter light



GV Critical Collapse Pressure (CCP) can be quantified via pressure nephelometry



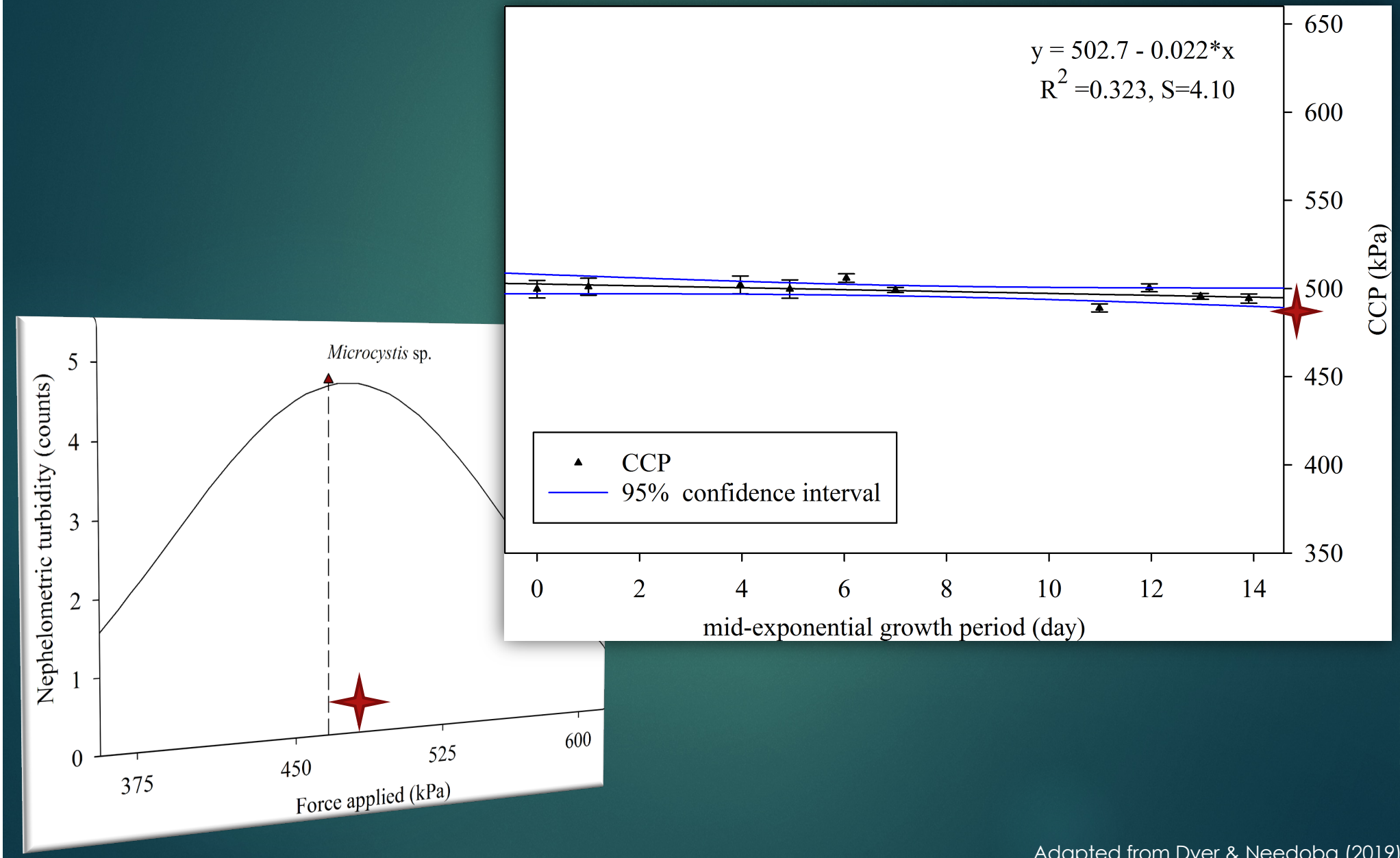
- nephelometric spectra recorded & integrated at successive pressure steps



- Change in turbidity due to pressure-induced GV collapse and sedimentation of cells

Adapted from Dyer & Needoba (2019)

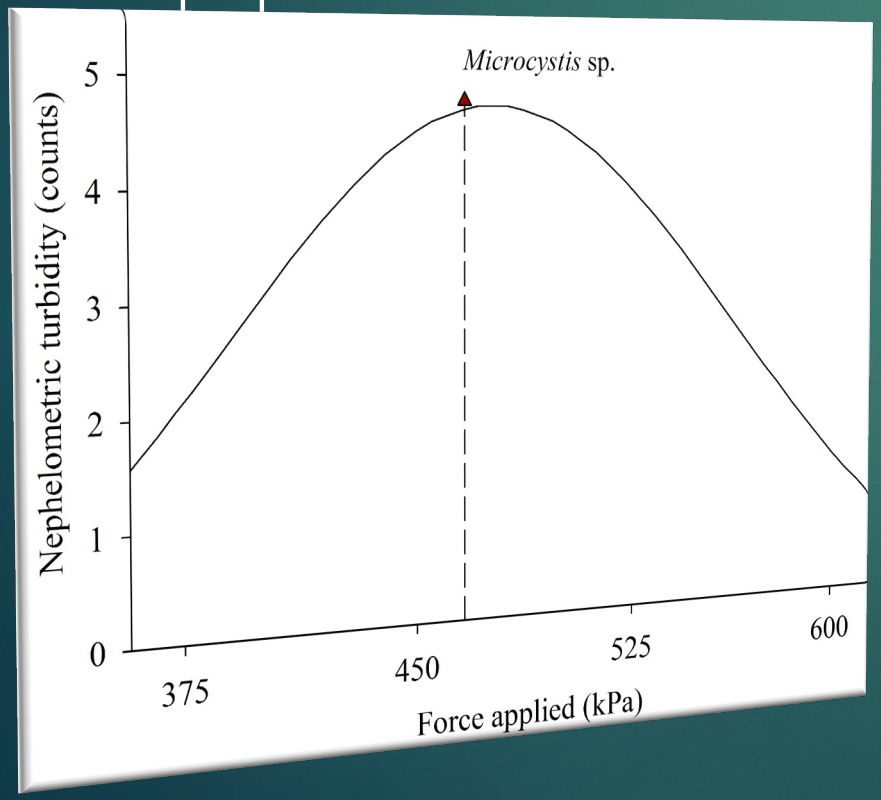
GV critical collapse pressure is stable during balanced growth: *Microcystis aeruginosa* NIES-843

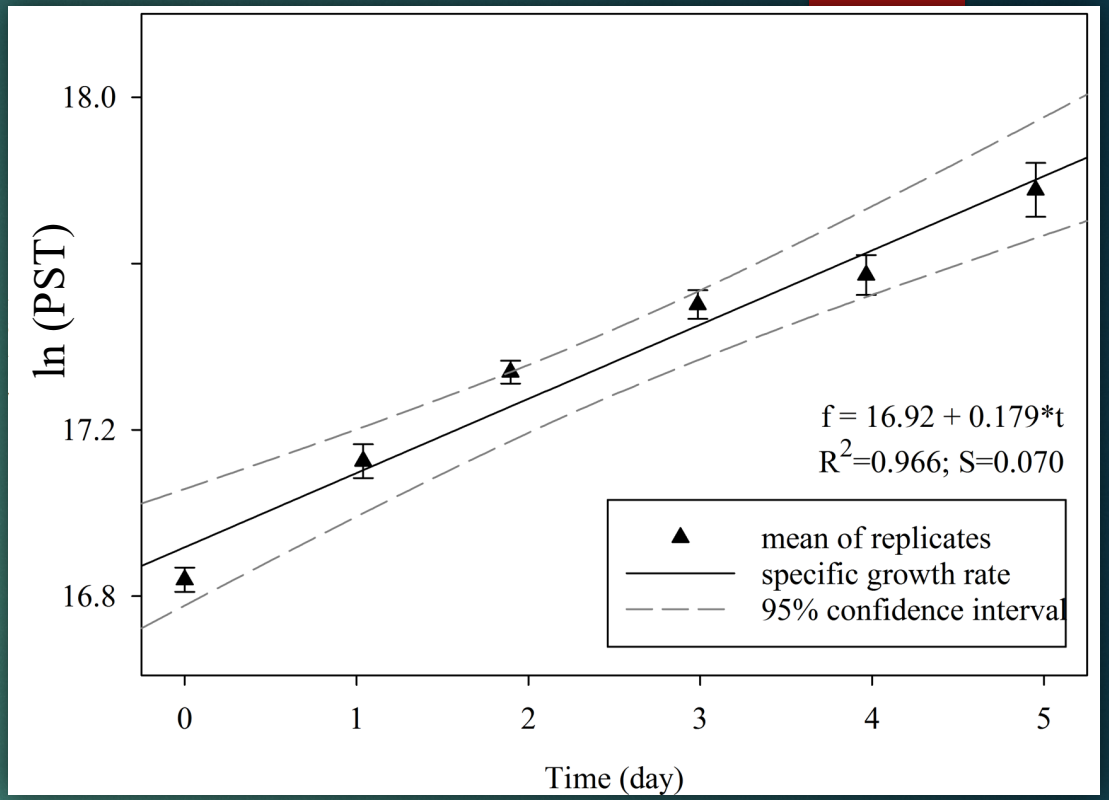


Adapted from Dyer & Needoba (2019)

Pressure Sensitive Turbidity (PST) is a proxy for cyanobacterial abundance

$$\text{PST} = \int \text{turbidity}(P)\, dP$$

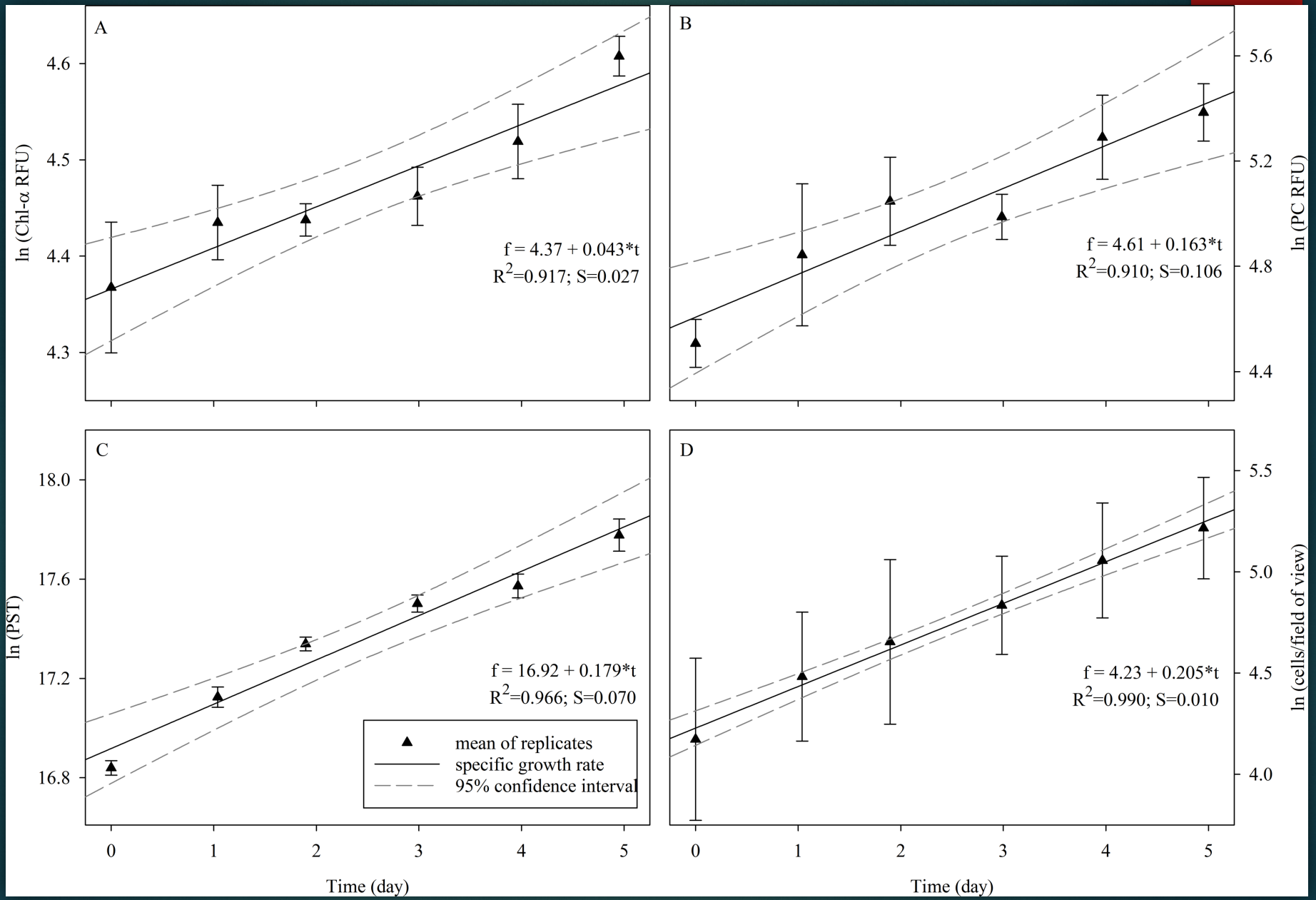




- PST is the integrated change in turbidity due to pressure
- PST is a proxy for GV abundance (i.e. cell abundance)

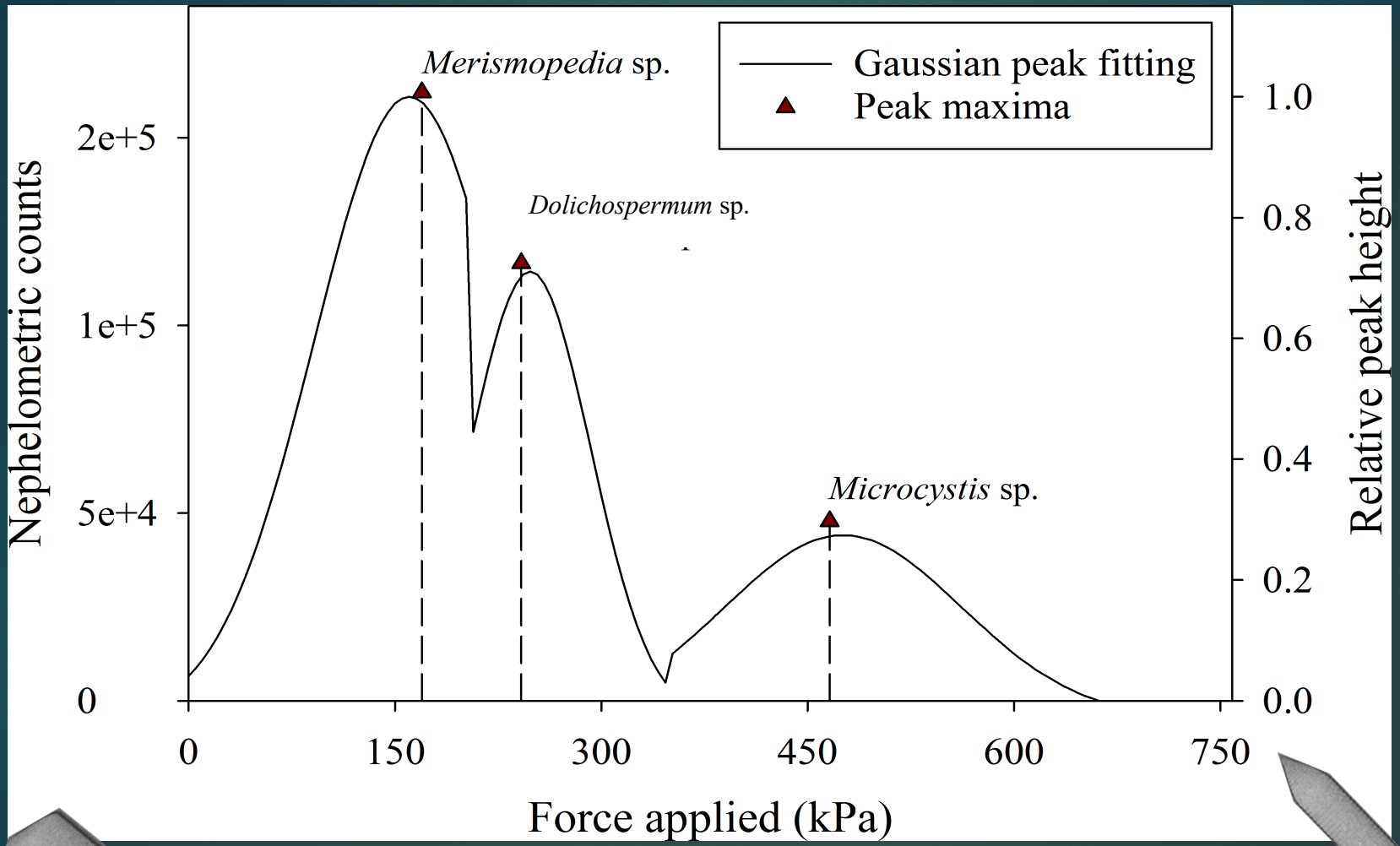
Adapted from Dyer & Needoba (2019)

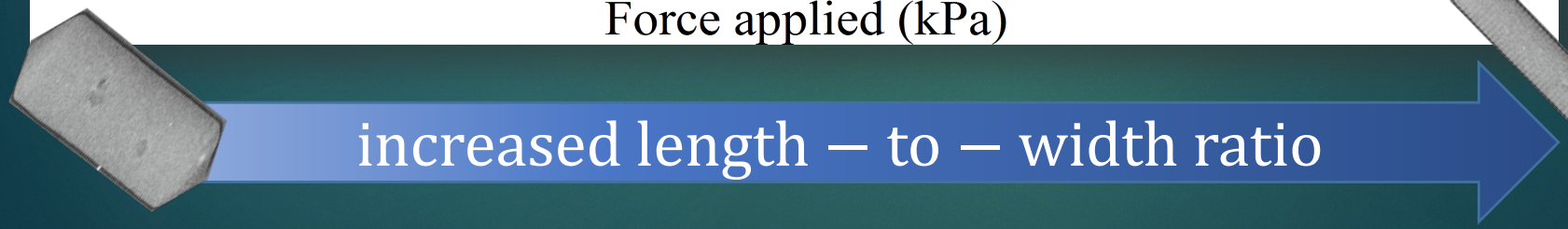
Specific growth rate (μ) in *Microcystis* sp. cultures



Dyer & Needoba (2019)

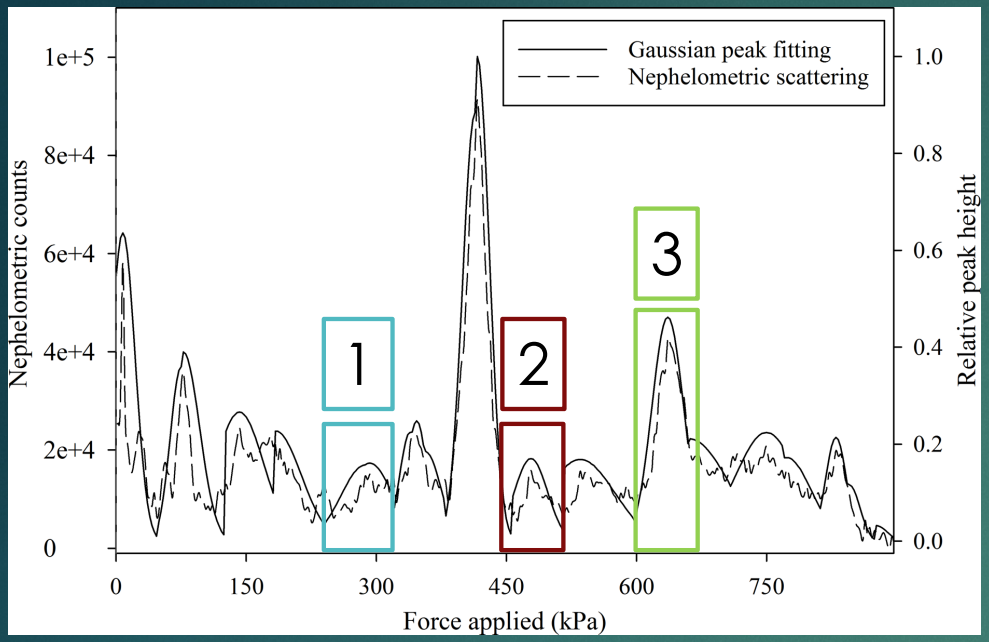
Species delineation via pressure nephelometry in mixed cultures

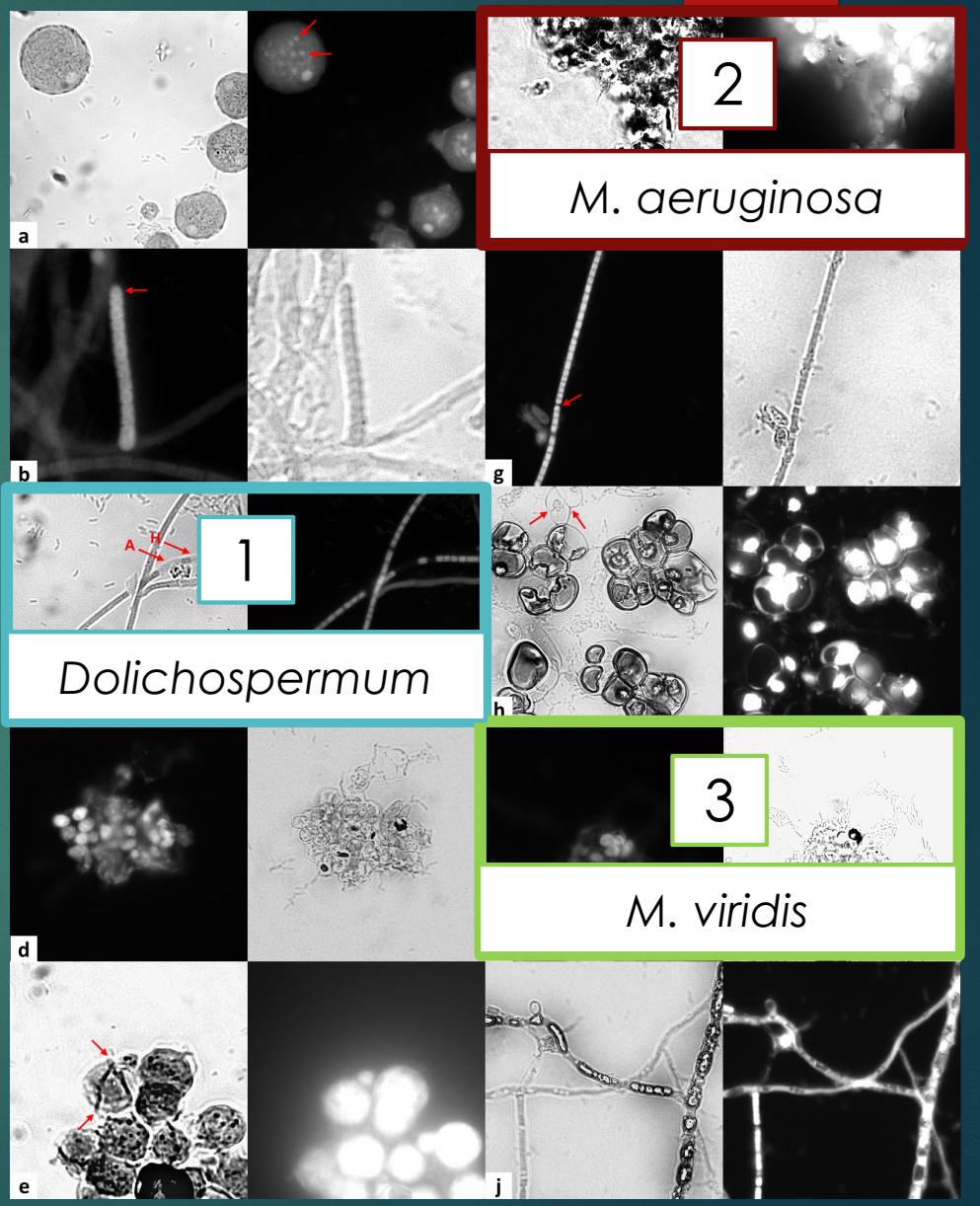




Dyer, Cook, Peterson, & Needoba; in revision (2019)

Species delineation via pressure nephelometry in whole-water environmental samples



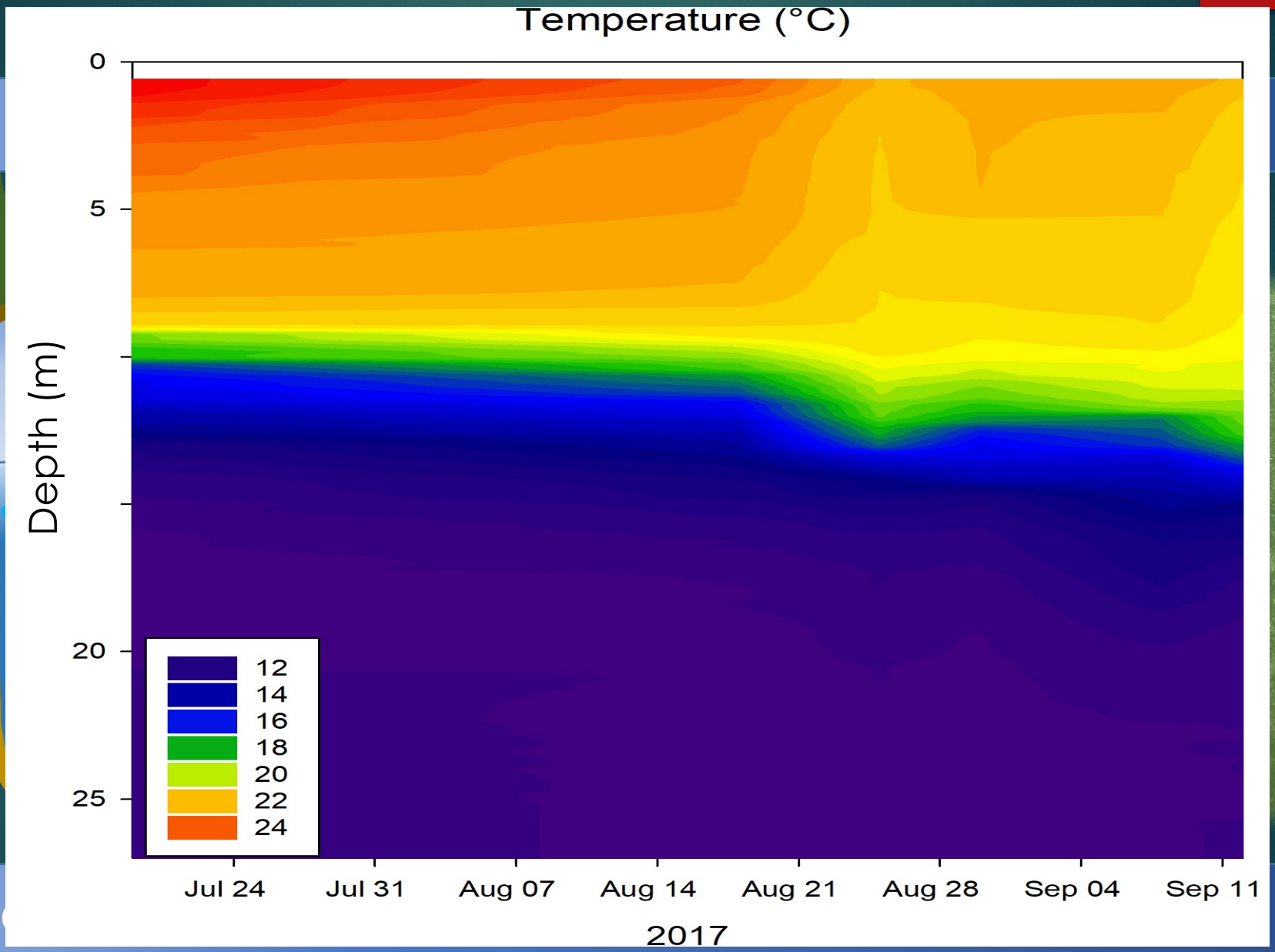


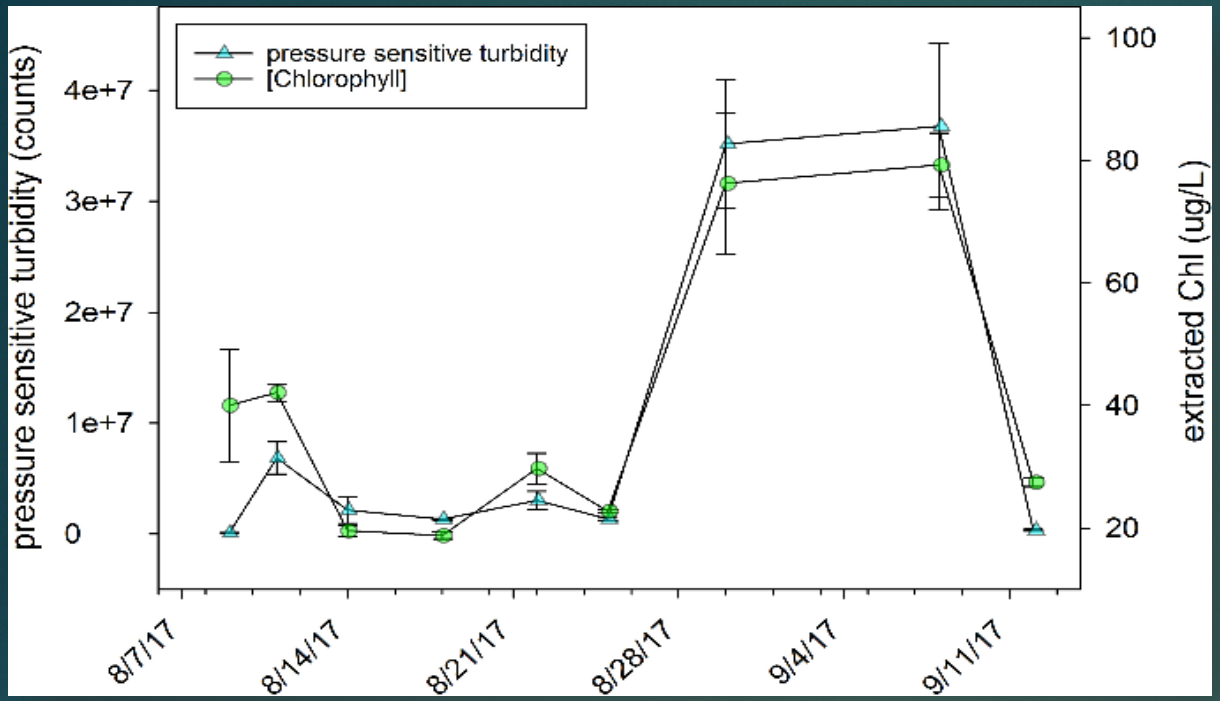
- CCP identifies discrete populations present in mixed environmental assemblages

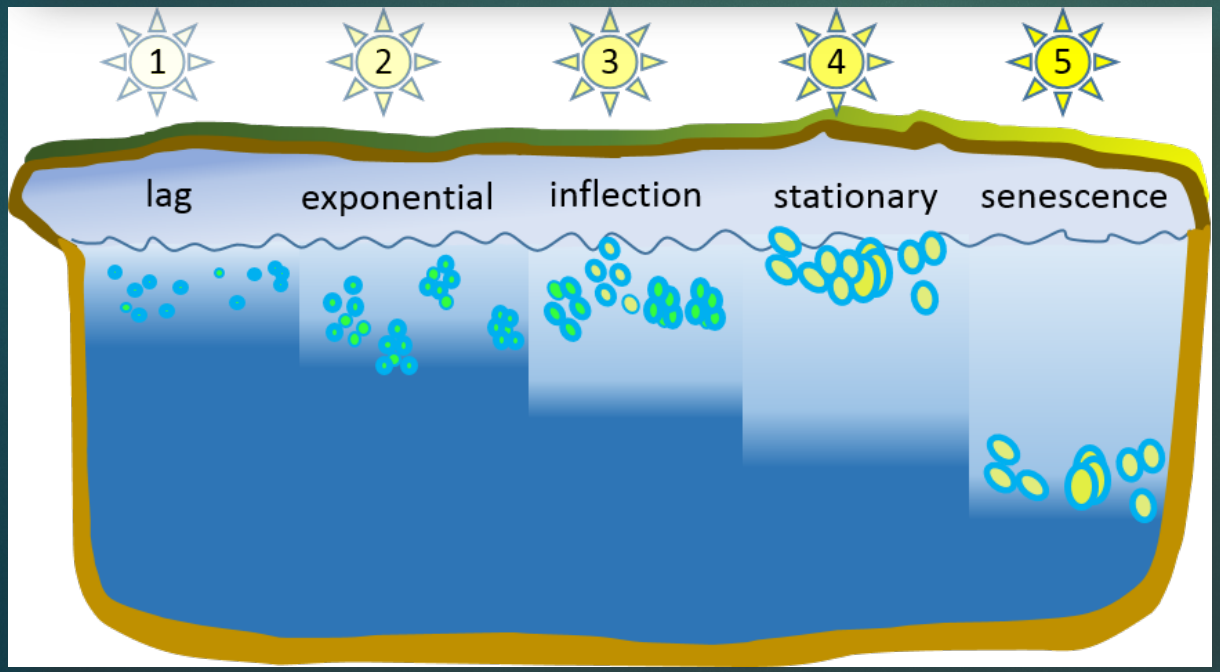
Dyer, Cook, Peterson, & Needoba; in revision

Harmful Algal Bloms in Ross Island Lagoon (RIL), Willamette River, Oregon

Ross Island Lagoon—2017





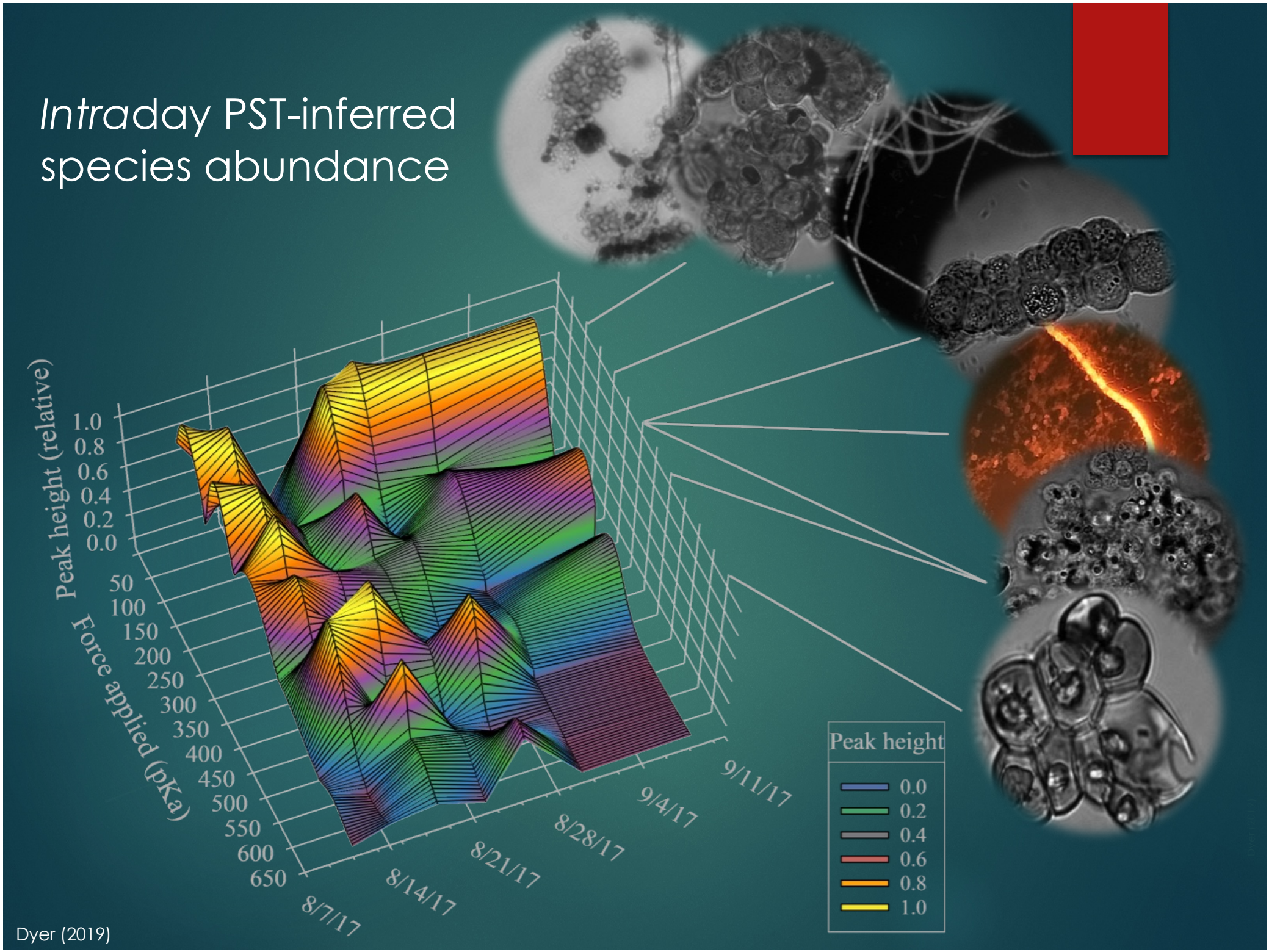


- PST & Chl-a track well together
- *Microcystis* sp. dominated HAB

- five phases of bloom progression

Dyer (2019)

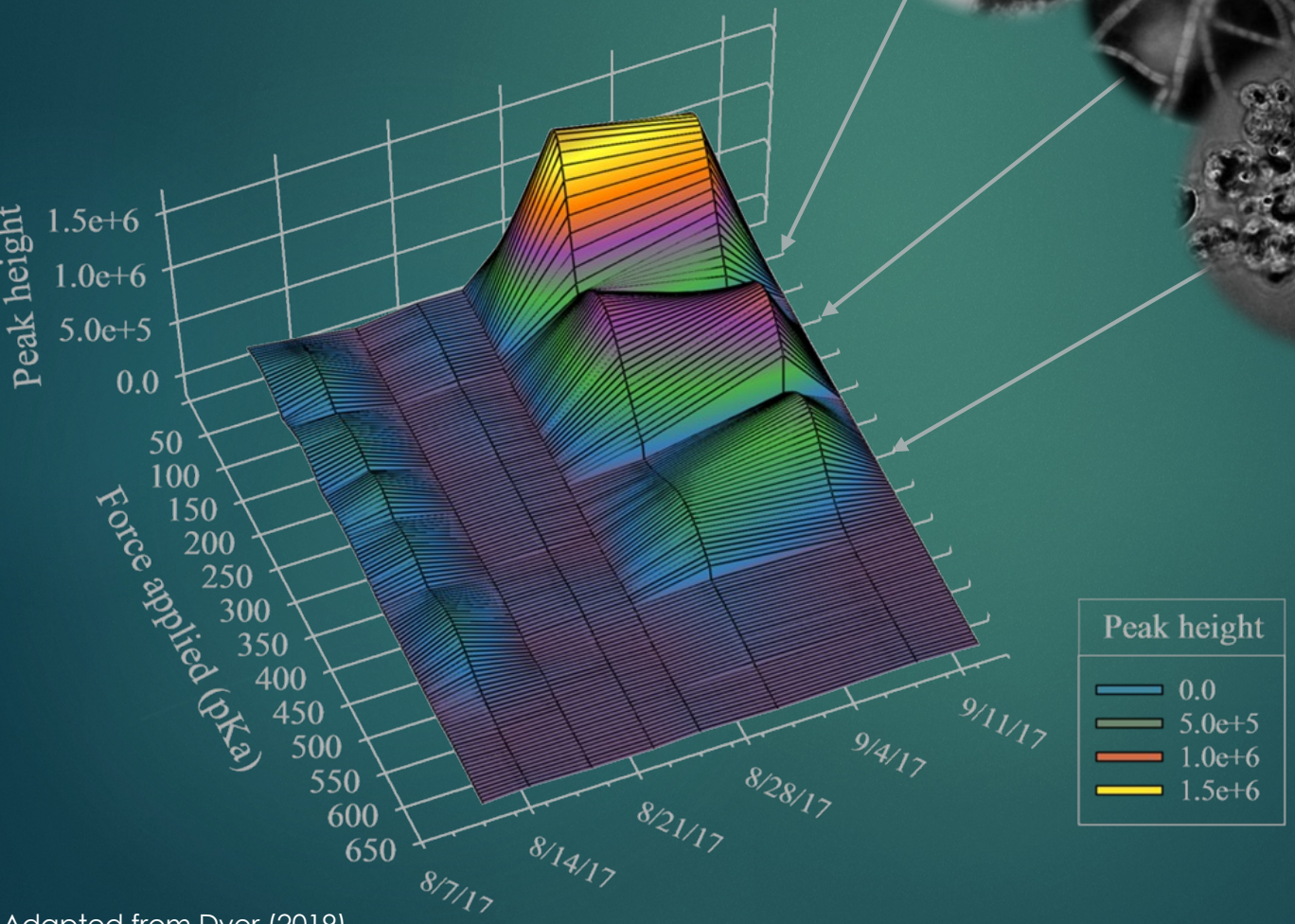
*Intra*day PST-inferred species abundance



Dyer (2019)

*Inter*day PST-inferred species abundance in Ross Island Lagoon

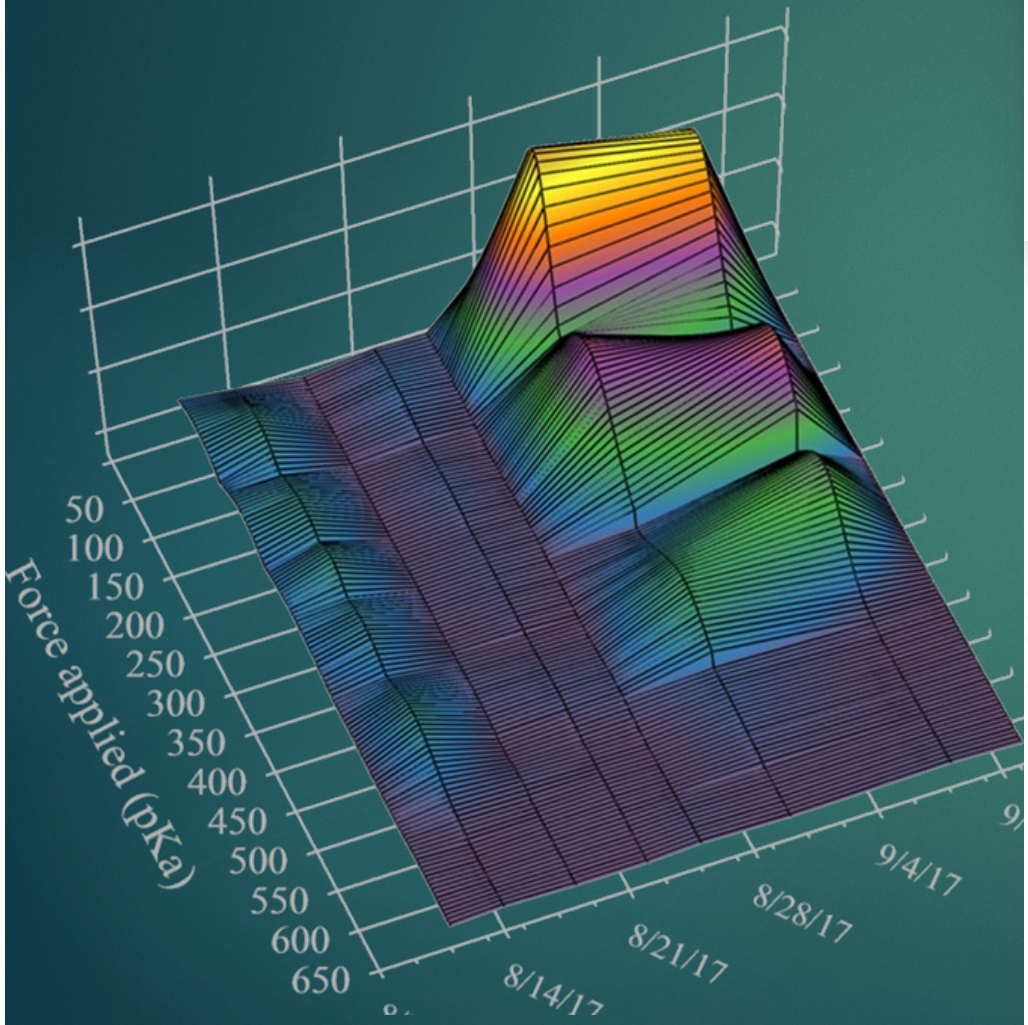
- Heterogeneous colonies w/ inorganic particulates
- Heterogeneous filaments dominated by *Dolichospermum* sp.
- Homogenous colonies of *Microcystis* sp.

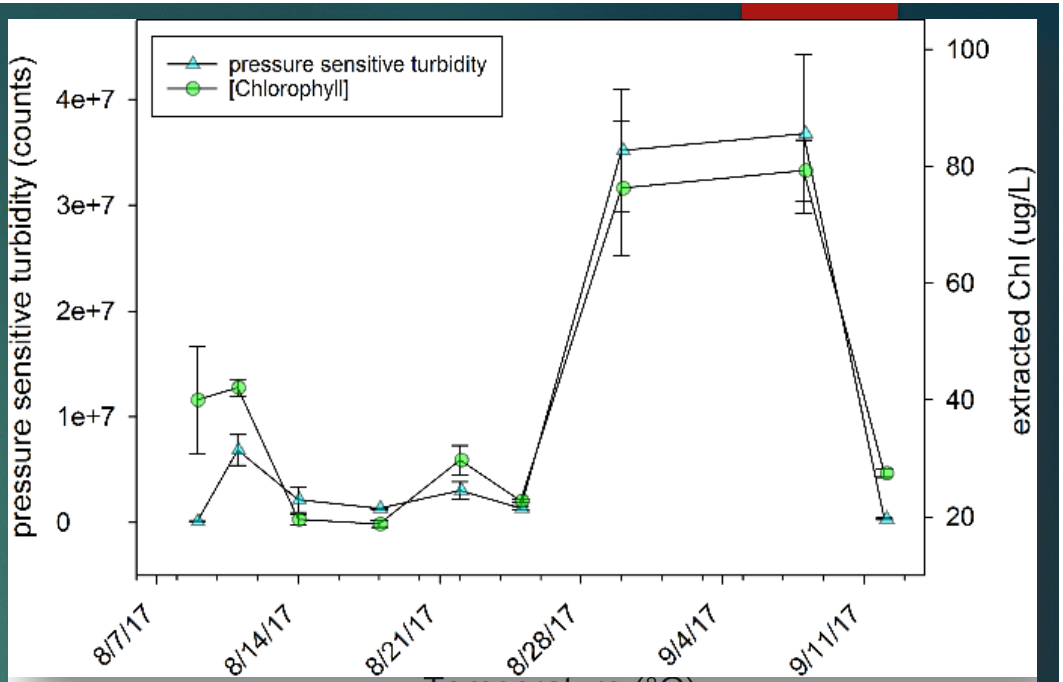


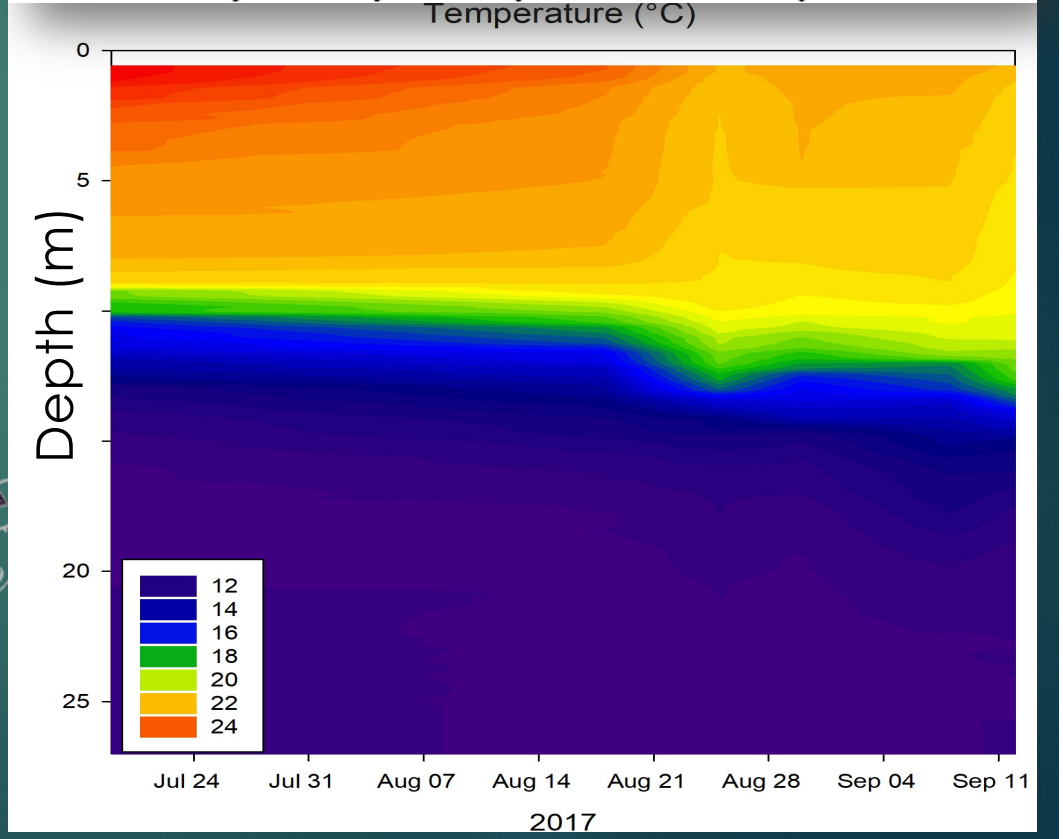
Adapted from Dyer (2019)

Dyer, Peterson, & Needoba – unpublished results

Nutrient limitation with increased hydrostatic pressure at the thermocline causes senescence of the dominant, low-CCP population







Questions?

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