

Penn State Astrobiology Research Center (PSARC):

Probing “Unusual” Microorganisms of the Earth

Christopher H. House

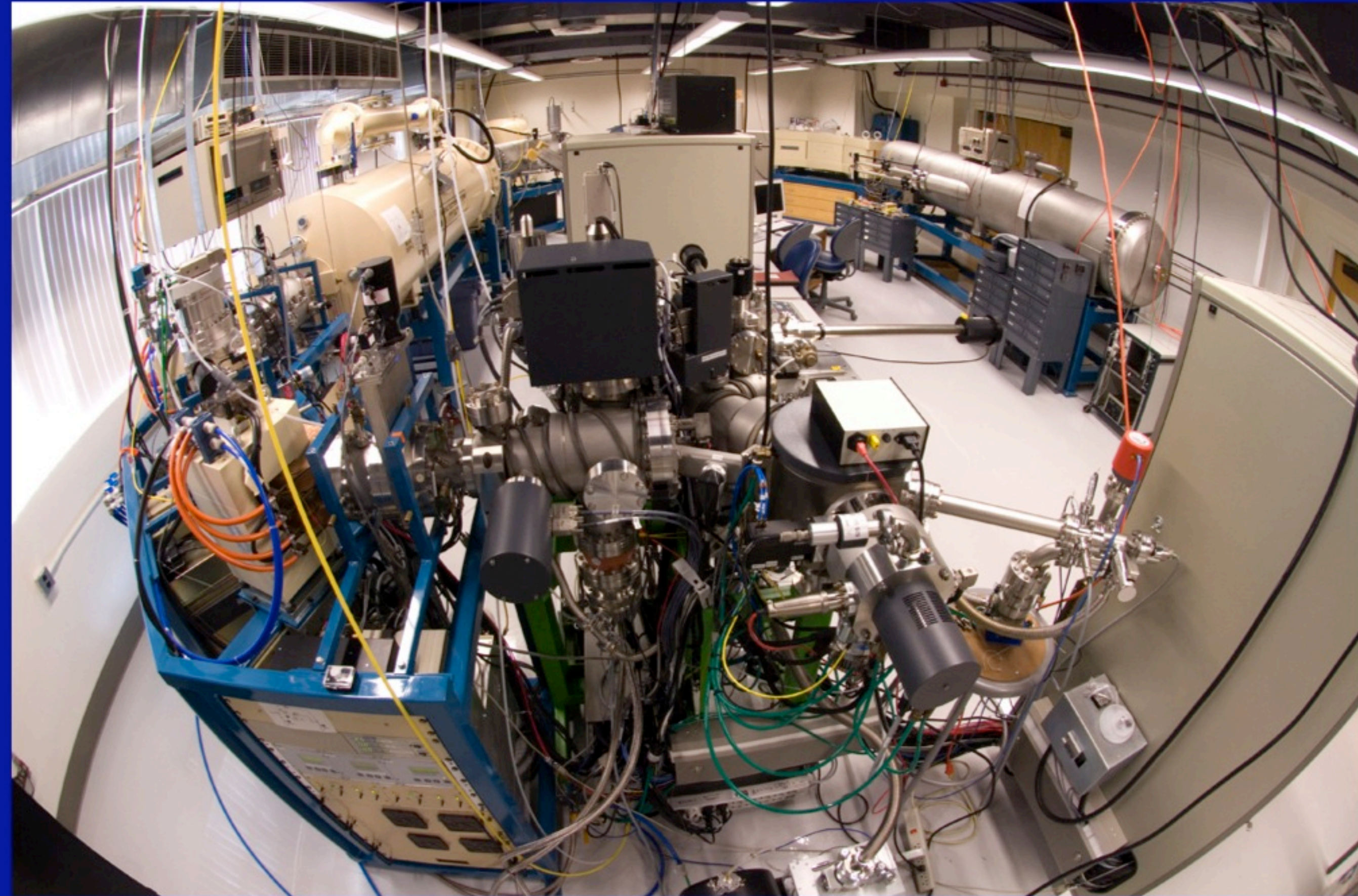
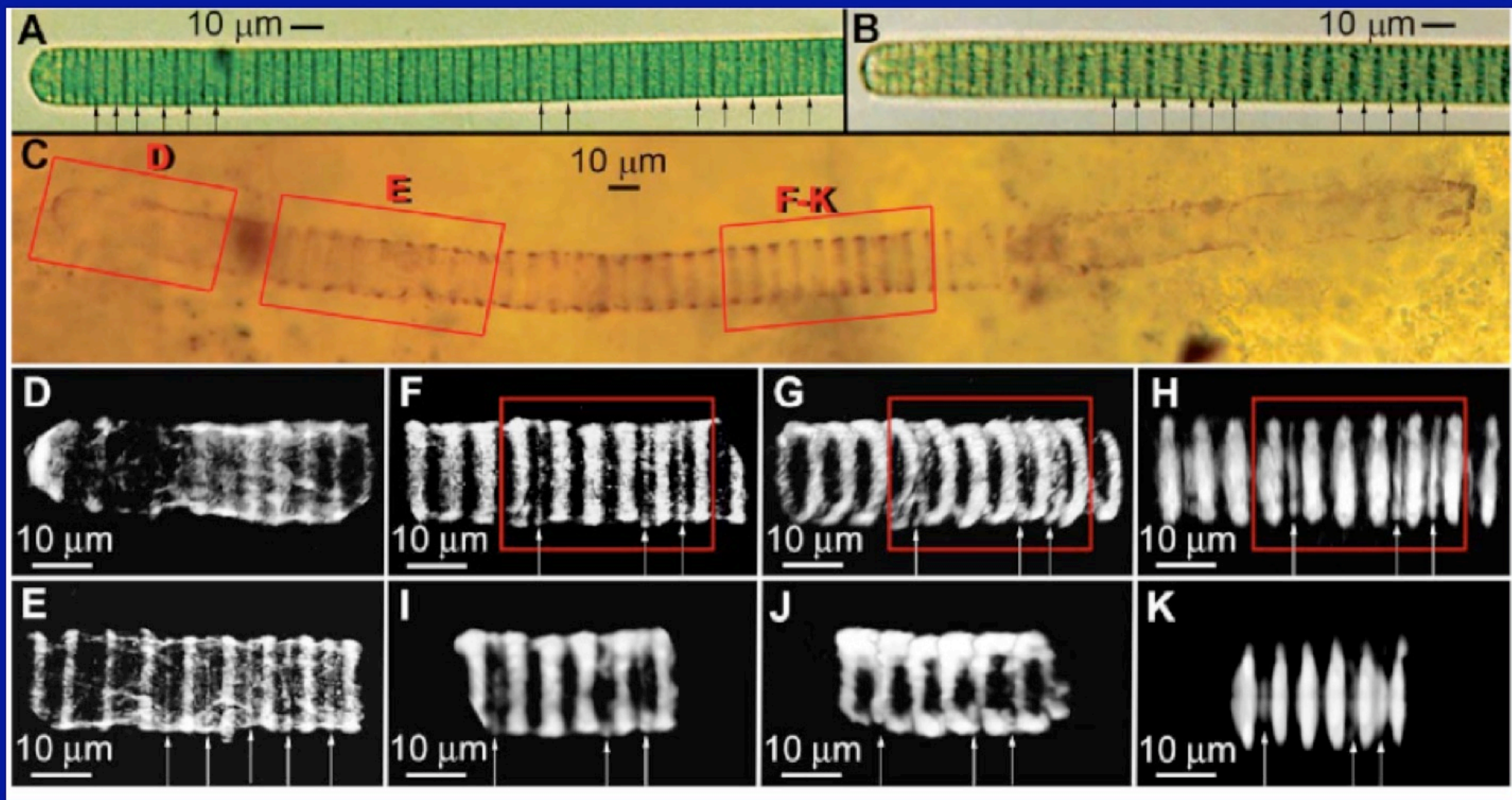


Signatures of Life from Earth and Beyond

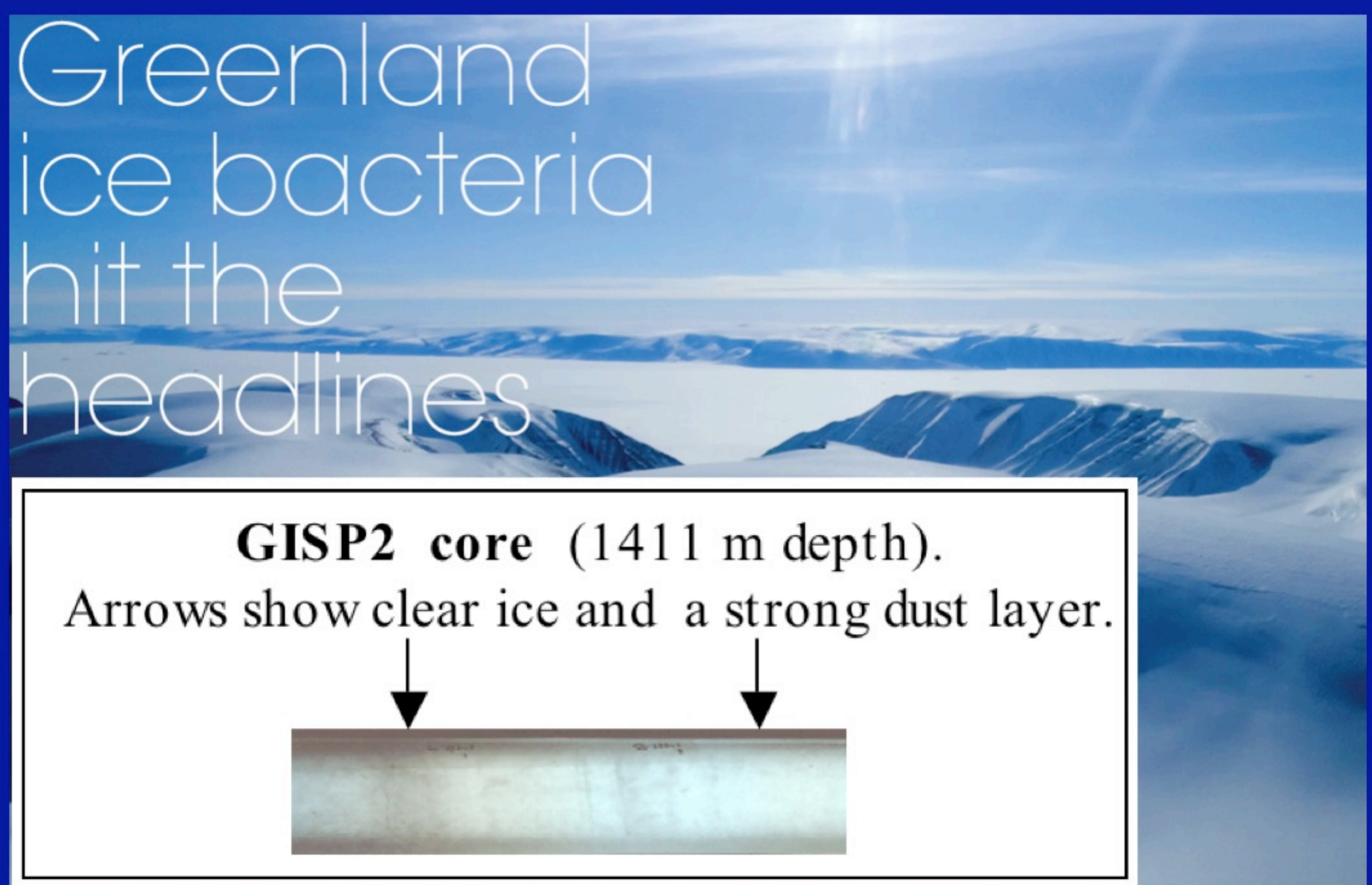
(New five year cycle began January 2009)

- **Astronomy:** Sigurdsson, Wright,
and the PSU Center for Exoplanets & Habitable Worlds
- **Atmospheric Chemistry:** Lyons (UCLA) & Kasting
- **EPO:** Heather Nelson & the PA Space Grant Consortium
- **Evolutionary Genetics:** Hedges & Shapiro
- **Geobiology:** Macalady, Orphan (Caltech), Patzkowsky, House, & Schopf
- **Geochemistry:** Arthur, Brantley, Fantle, Freeman, Kump,
McKeegan (UCLA), & Ohmoto
- **Microbiology and Biochemistry:** Brenchley & Ferry

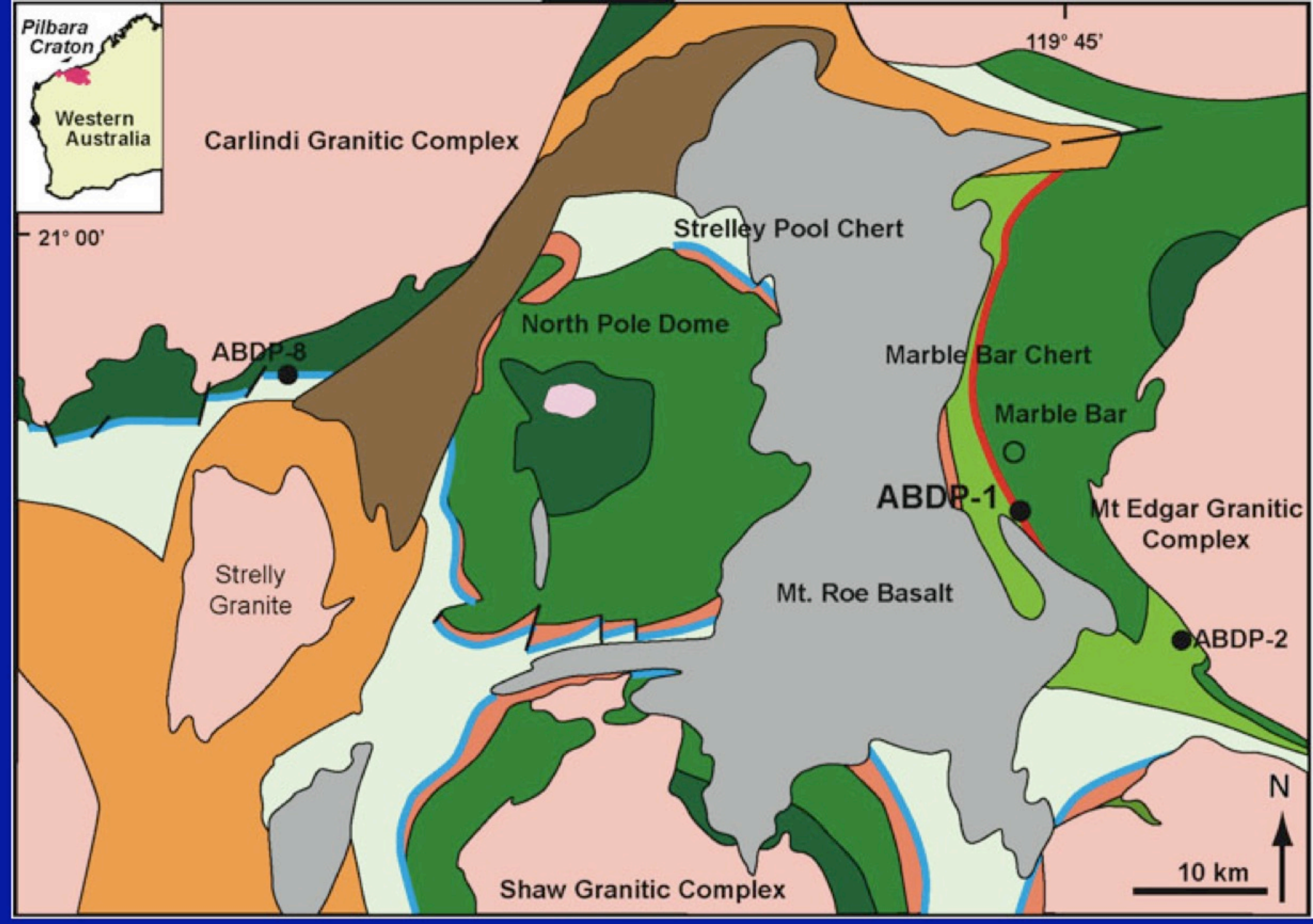
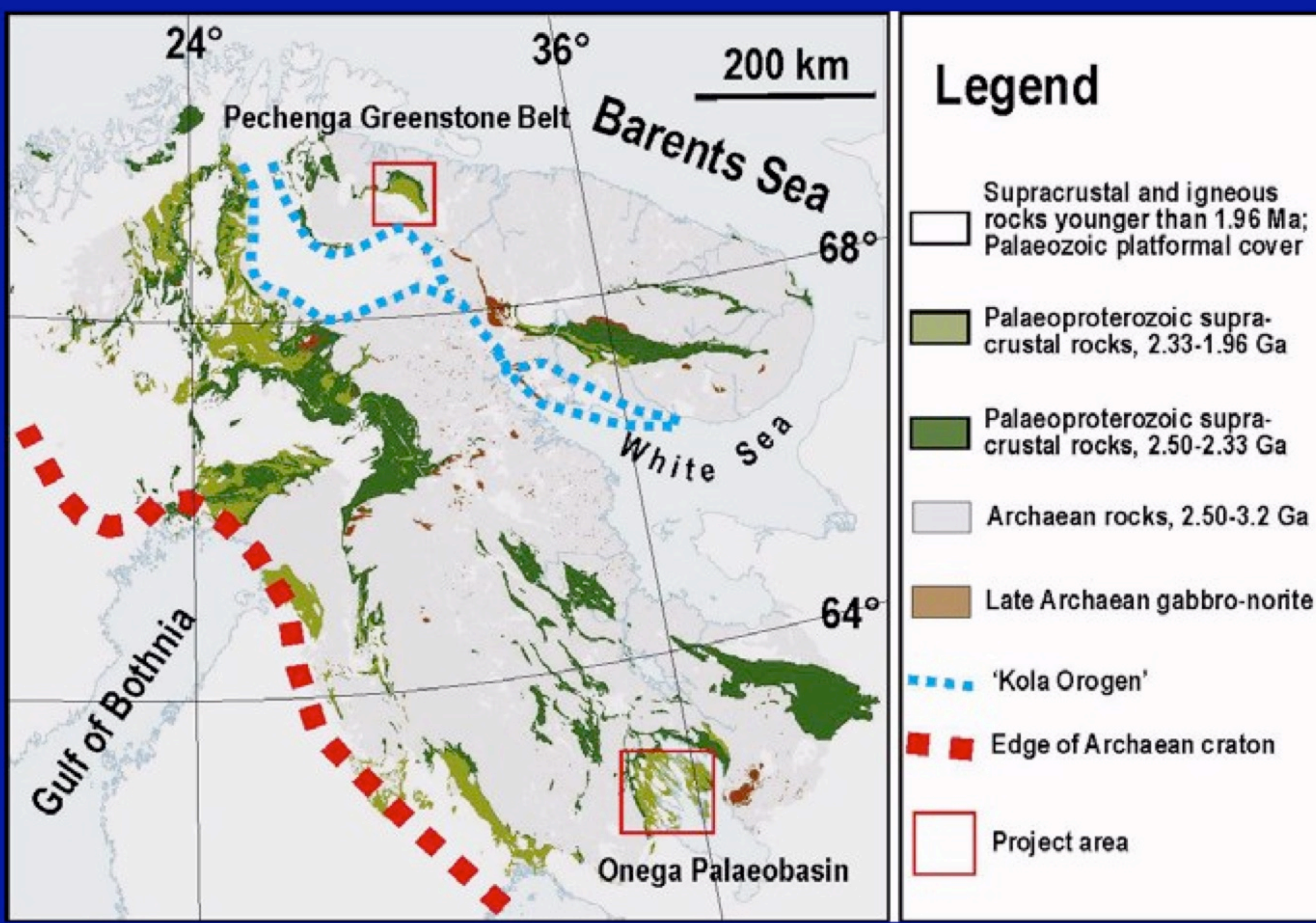
1. Developing new biosignatures



2. Biosignatures in relevant microbial ecosystems



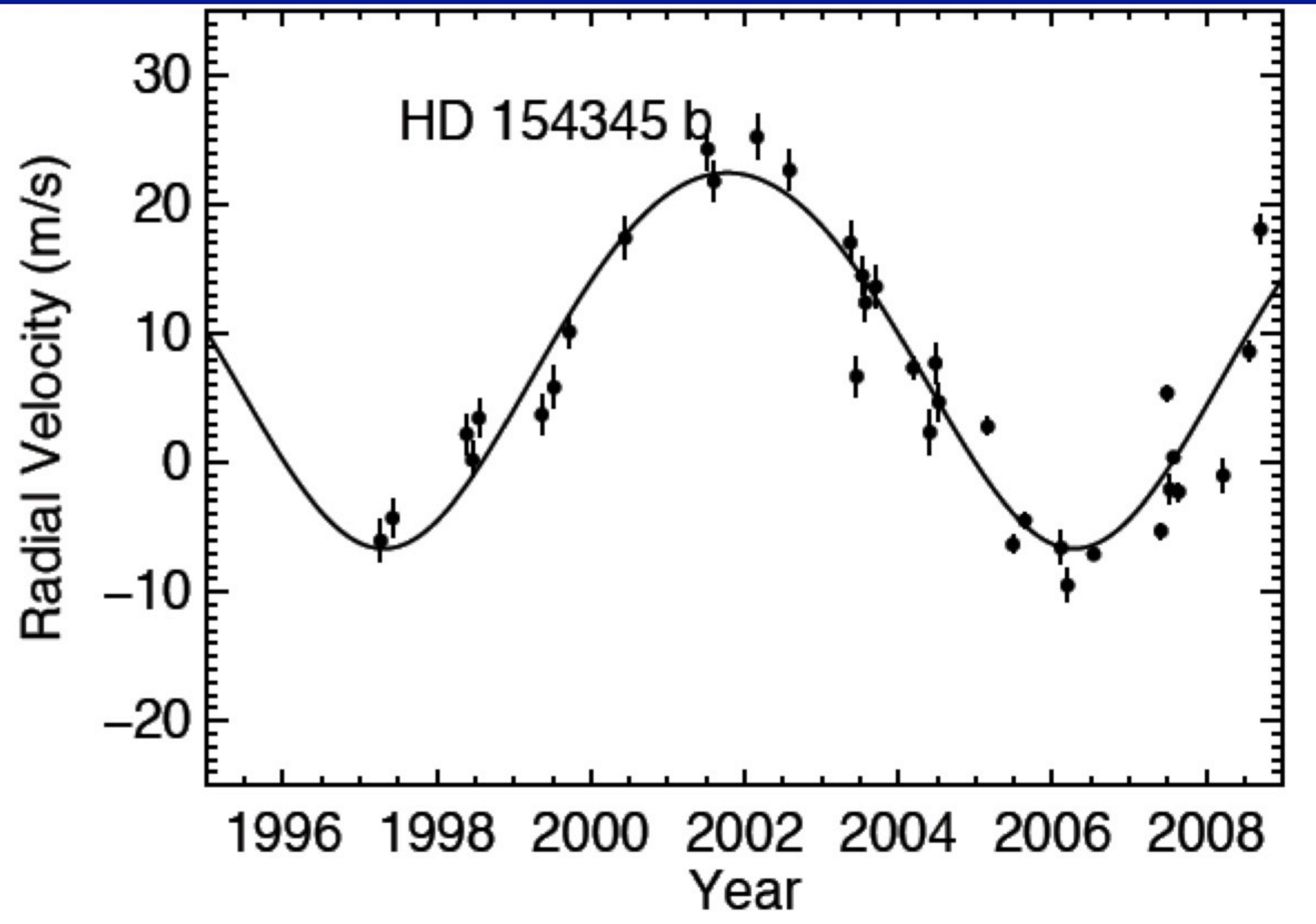
3. Biosignatures in ancient rocks



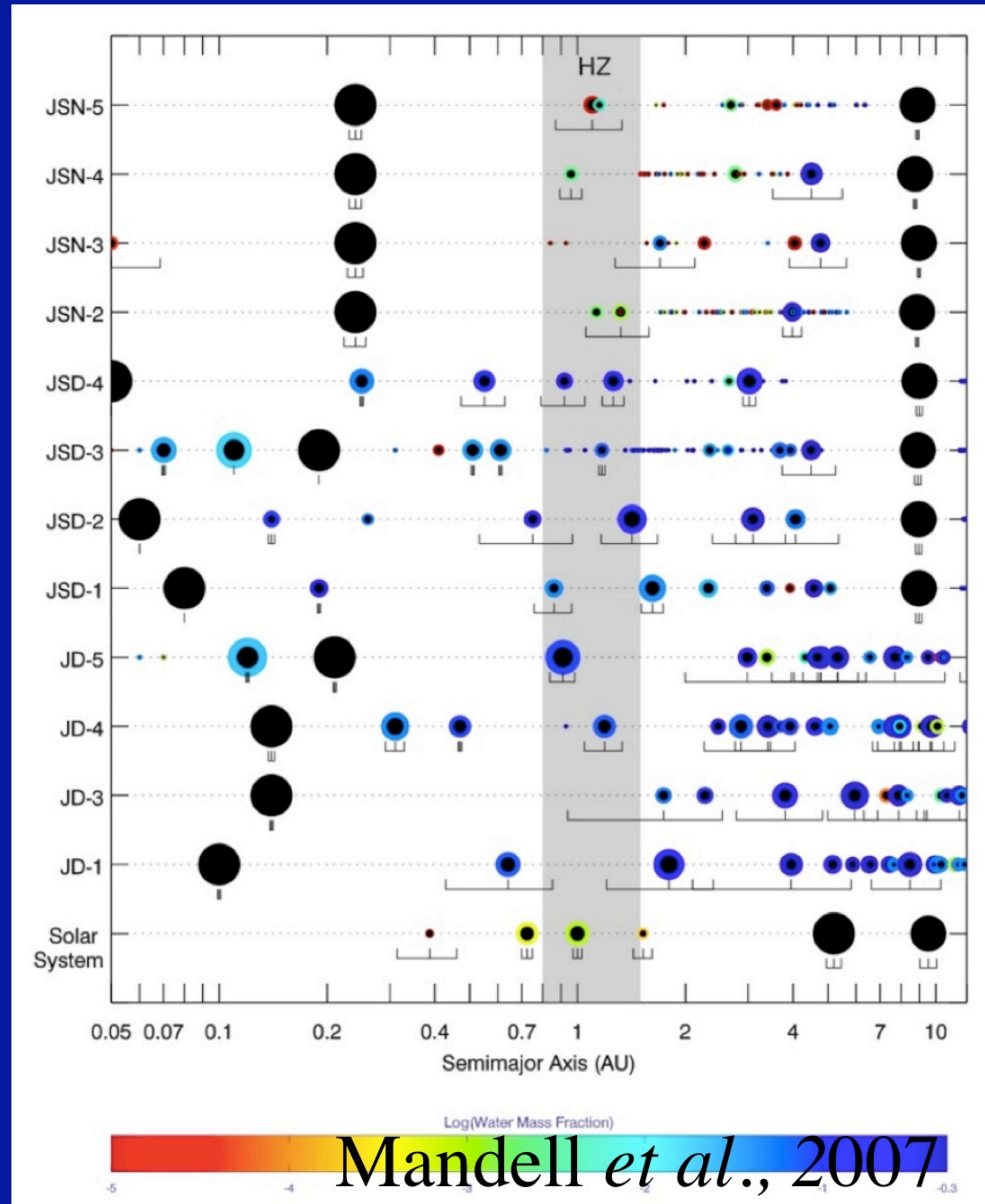
4. Biosignatures in extraterrestrial settings

$a = 4.2 \pm 0.2 \text{ AU}$
 $P = 9.5 \pm 0.5 \text{ yr}$
 $e = 0.04 \pm 0.04$
 $M \sin i = 0.95 M_{\text{Jup}}$

 G8 V
 $d = 18 \text{ pc}$
 $M_* = 0.9 M_{\odot}$
 $T_{\text{eff}} = 5470$
 $[\text{Fe}/\text{H}] = -0.1$

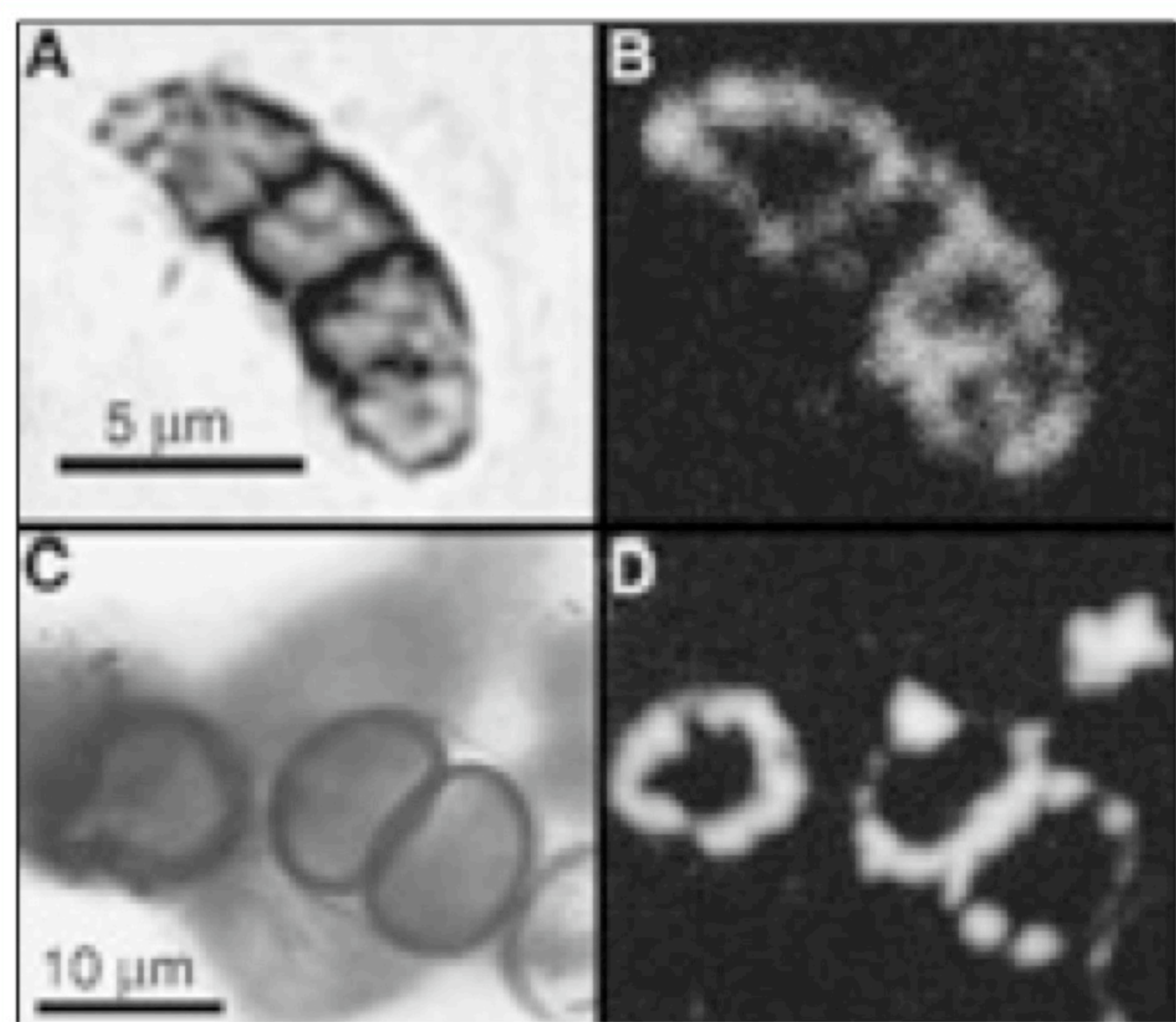
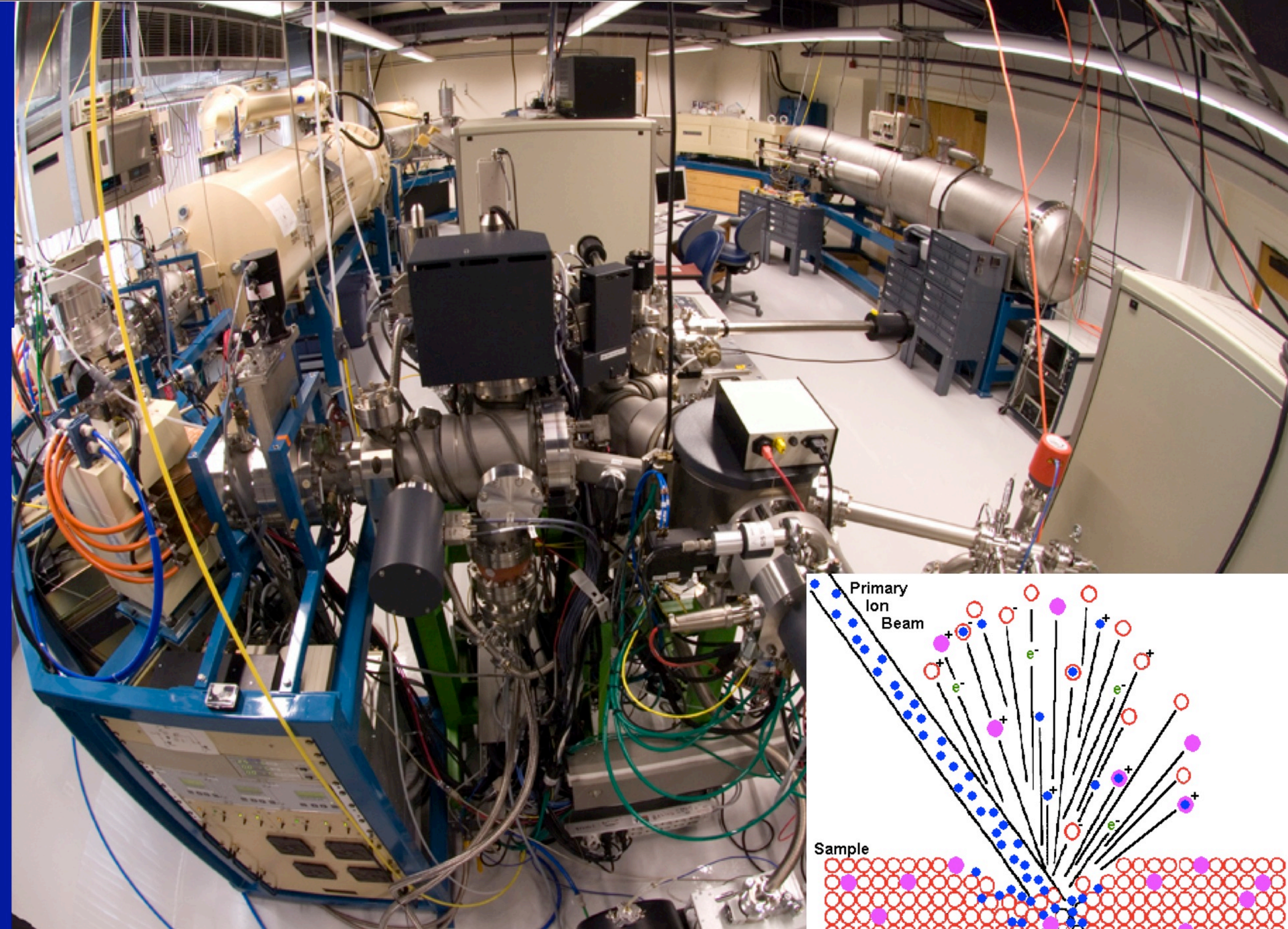
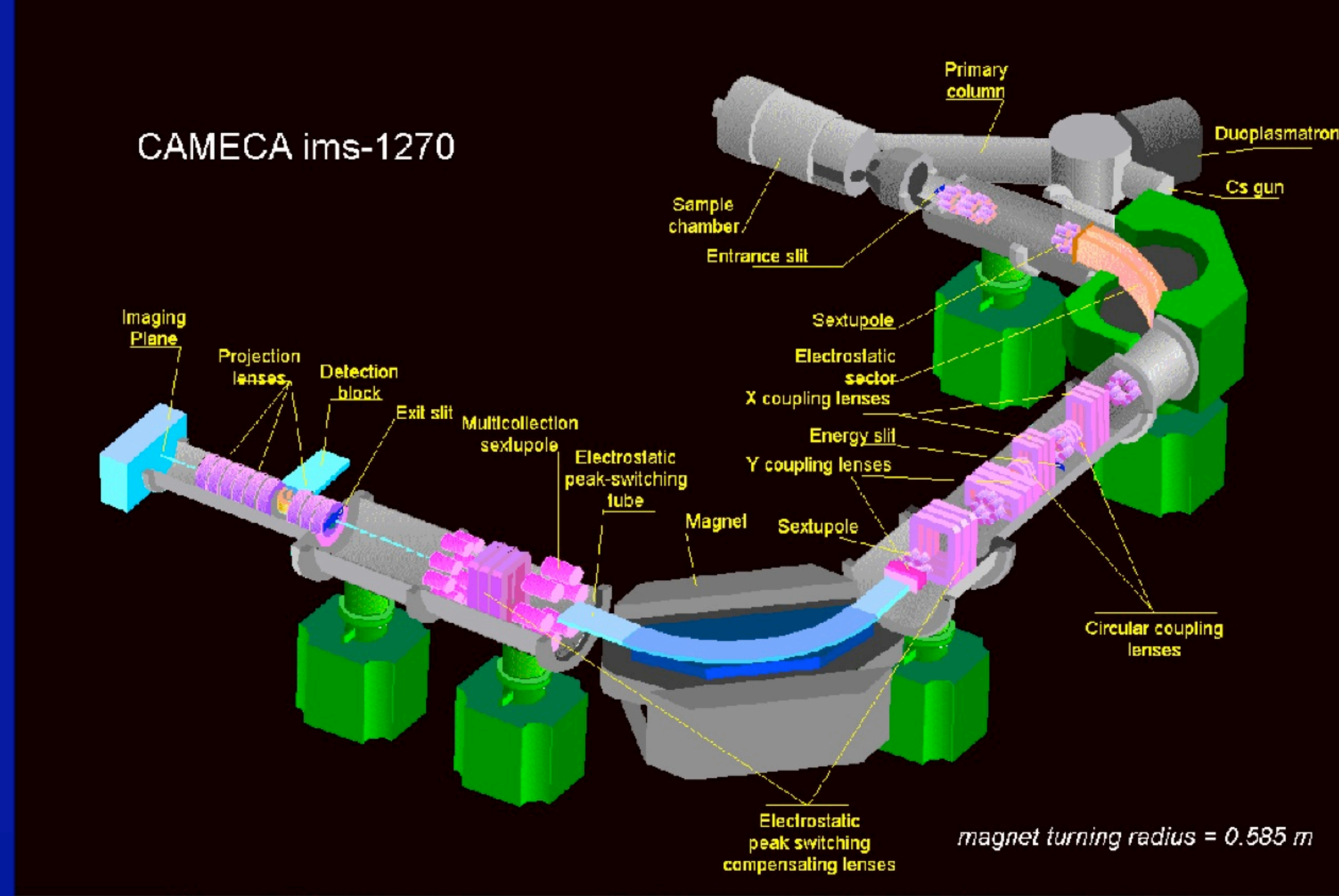


Wright et al. 2008

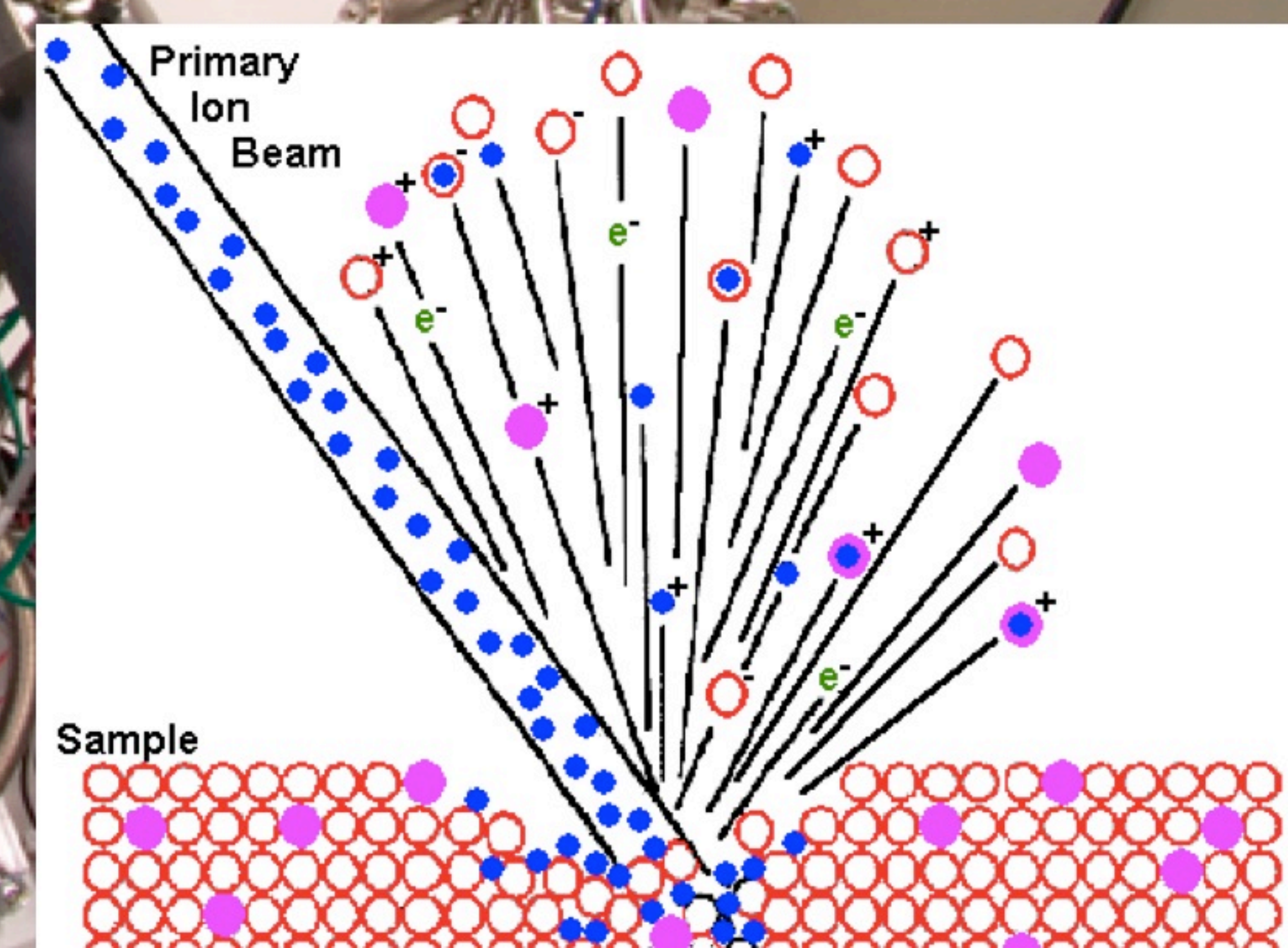


Probing “Unusual” Microorganisms of the Earth

- Methane Seeps
- Cave Symbionts
- Subsurface Sediment



House *et al.*, *Geology*, 2000

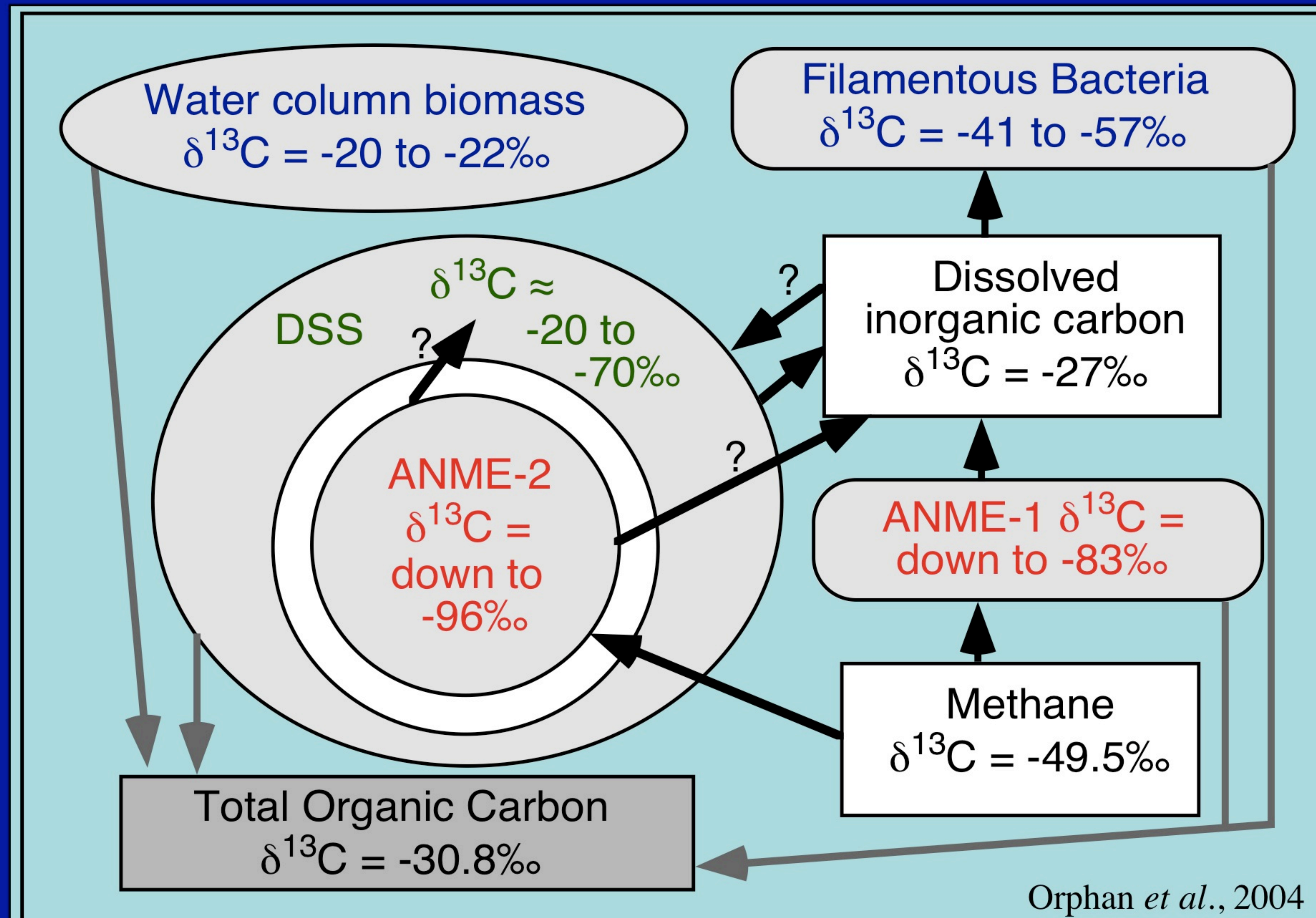
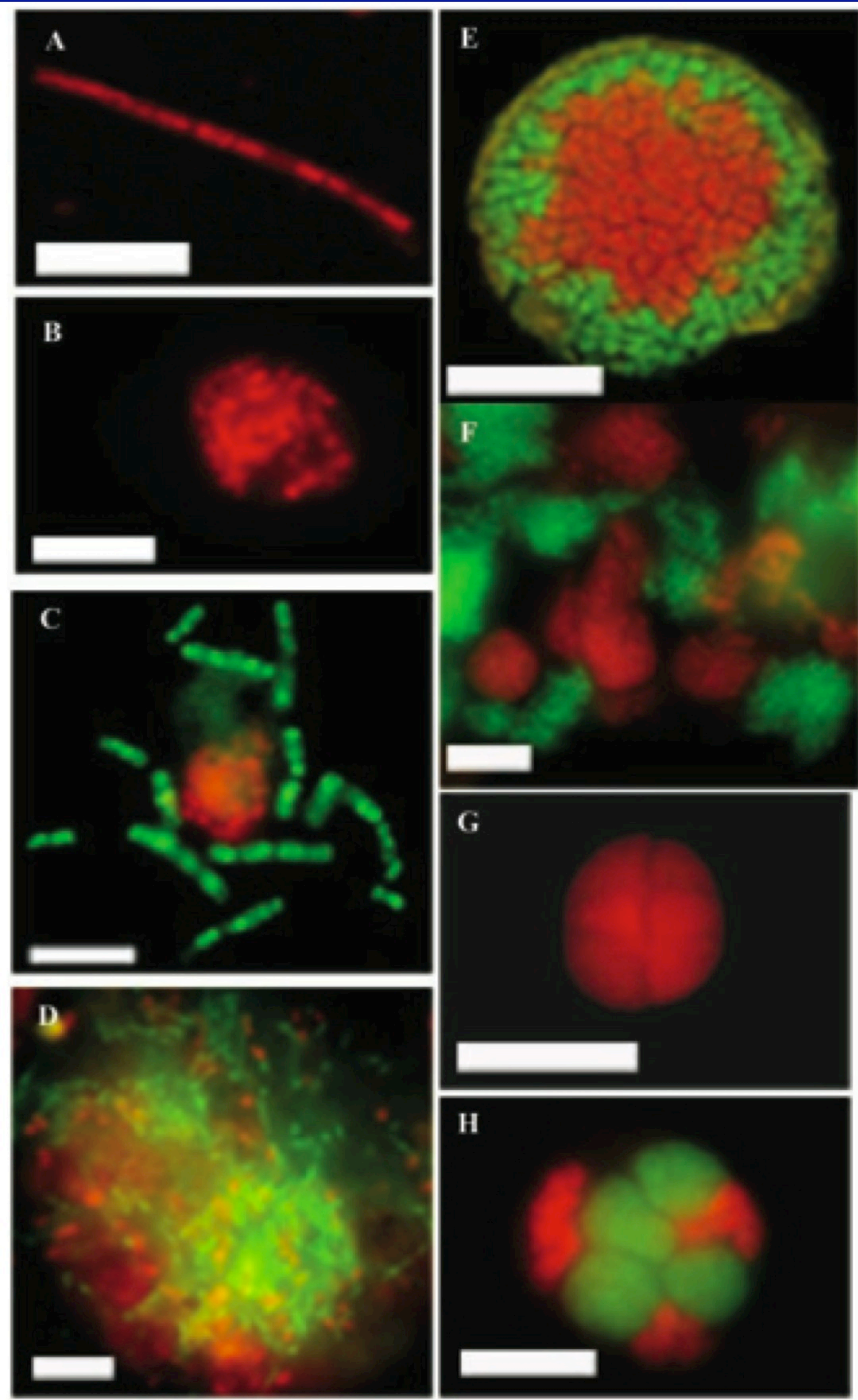
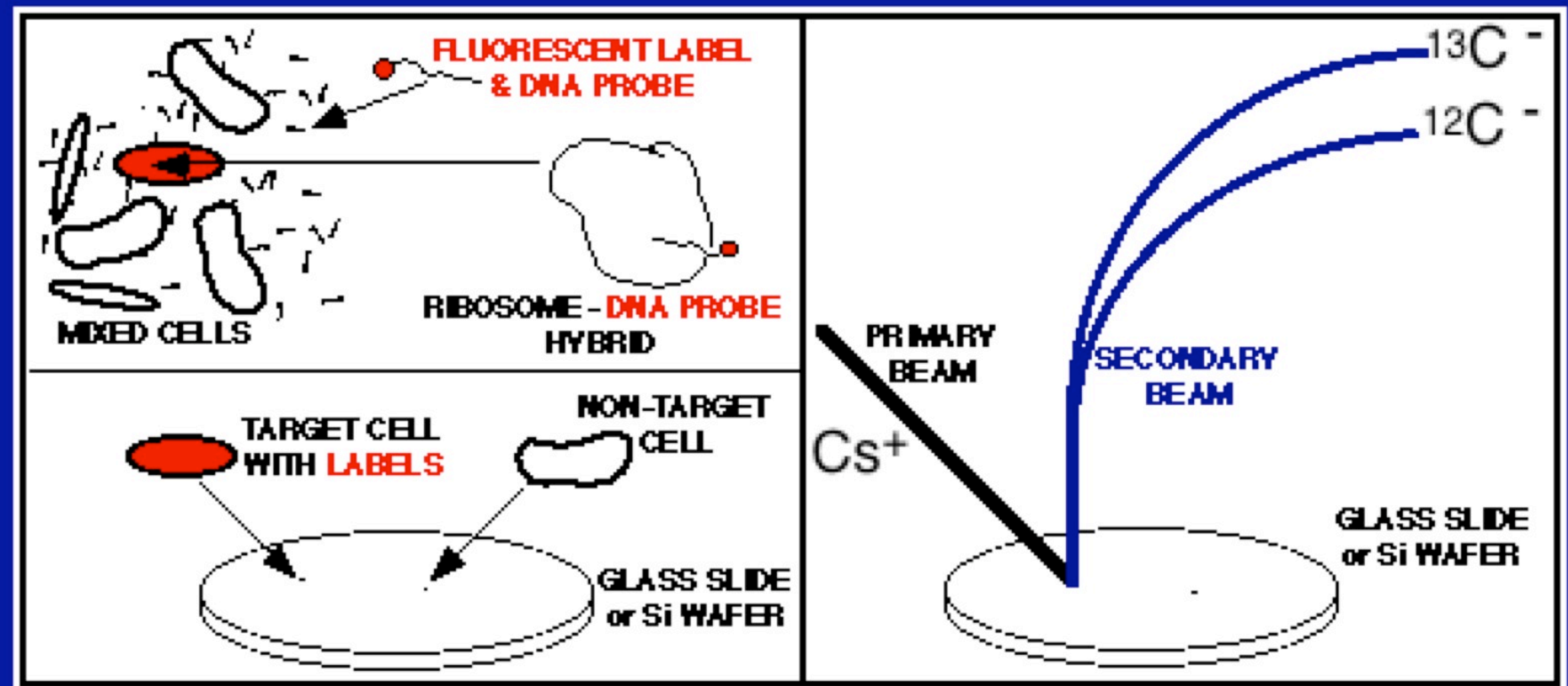




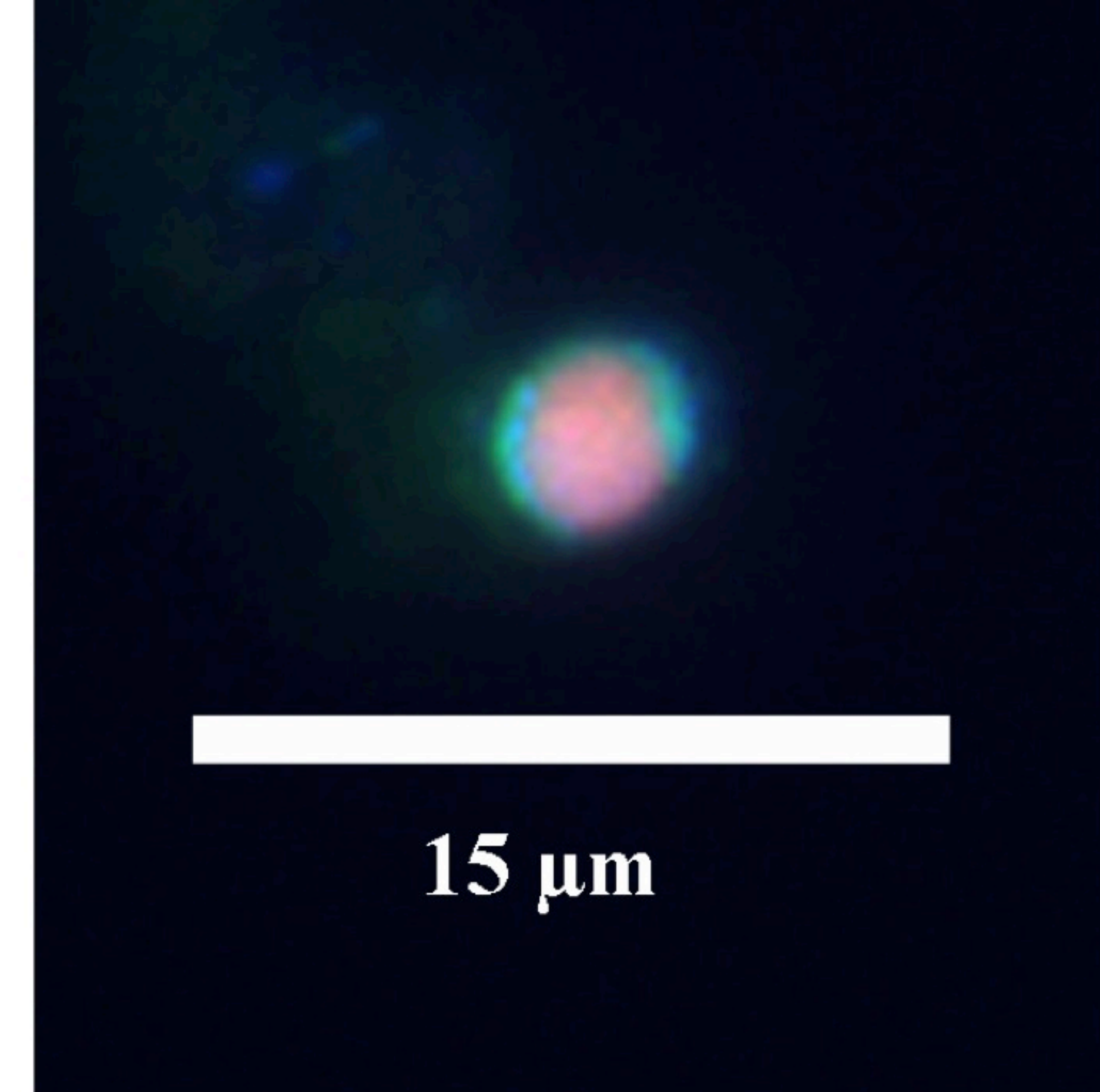
Emily Beal



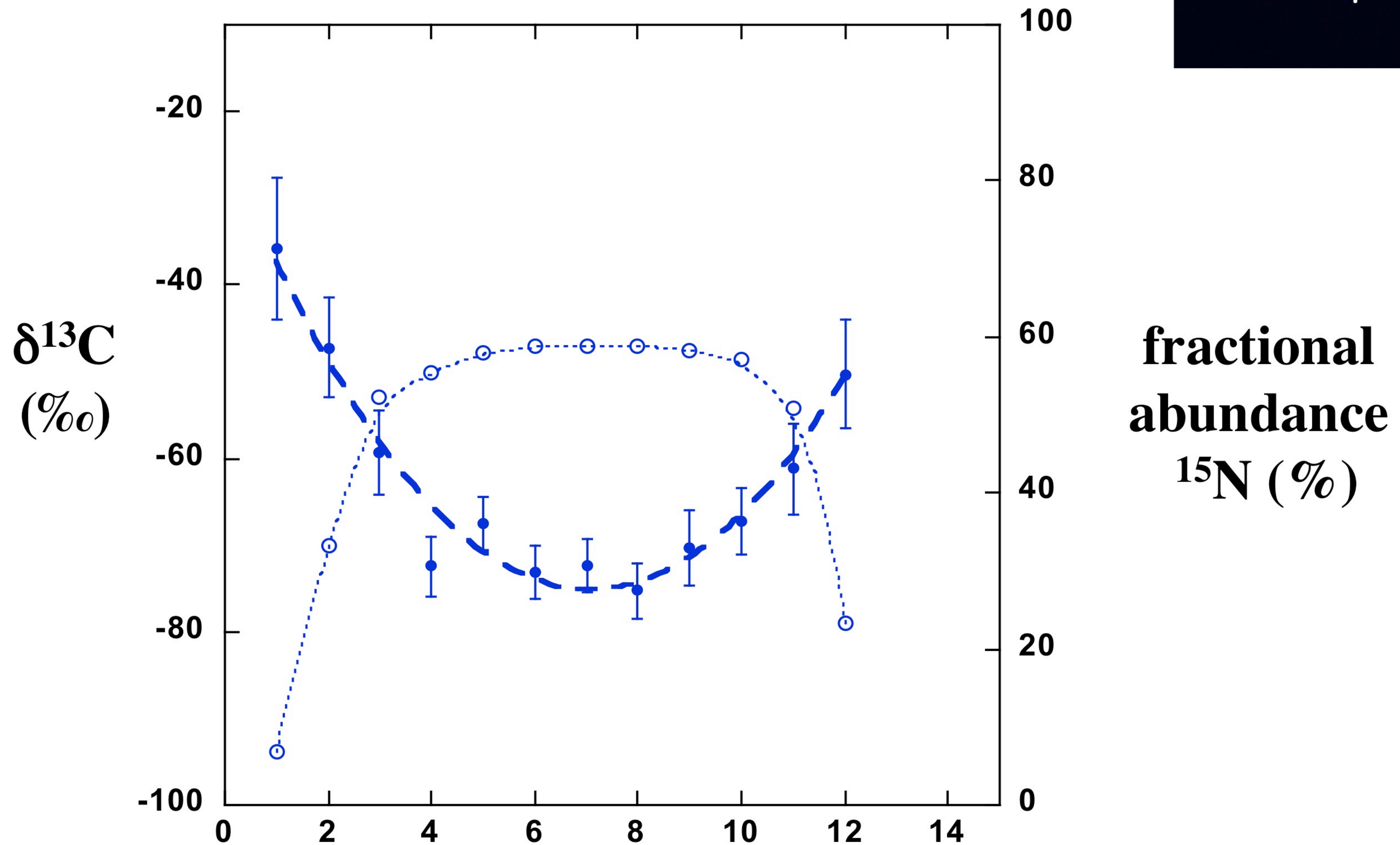
SIMS applied to modern methane seeps



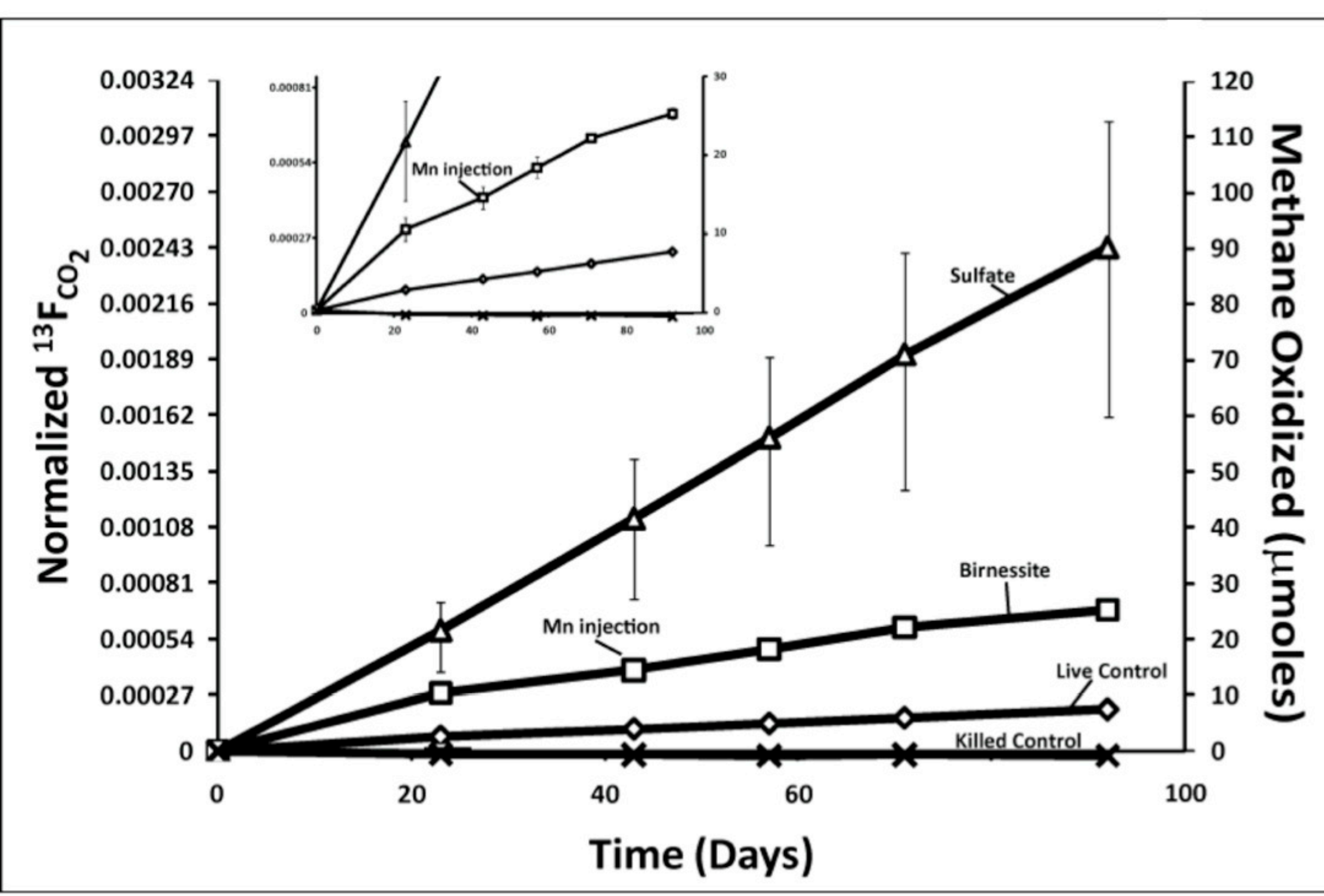
Nitrogen Isotope Labeled Experiments on “shell aggregates”



S4N sp14 natural abundance ^{13}C vs. ^{15}N



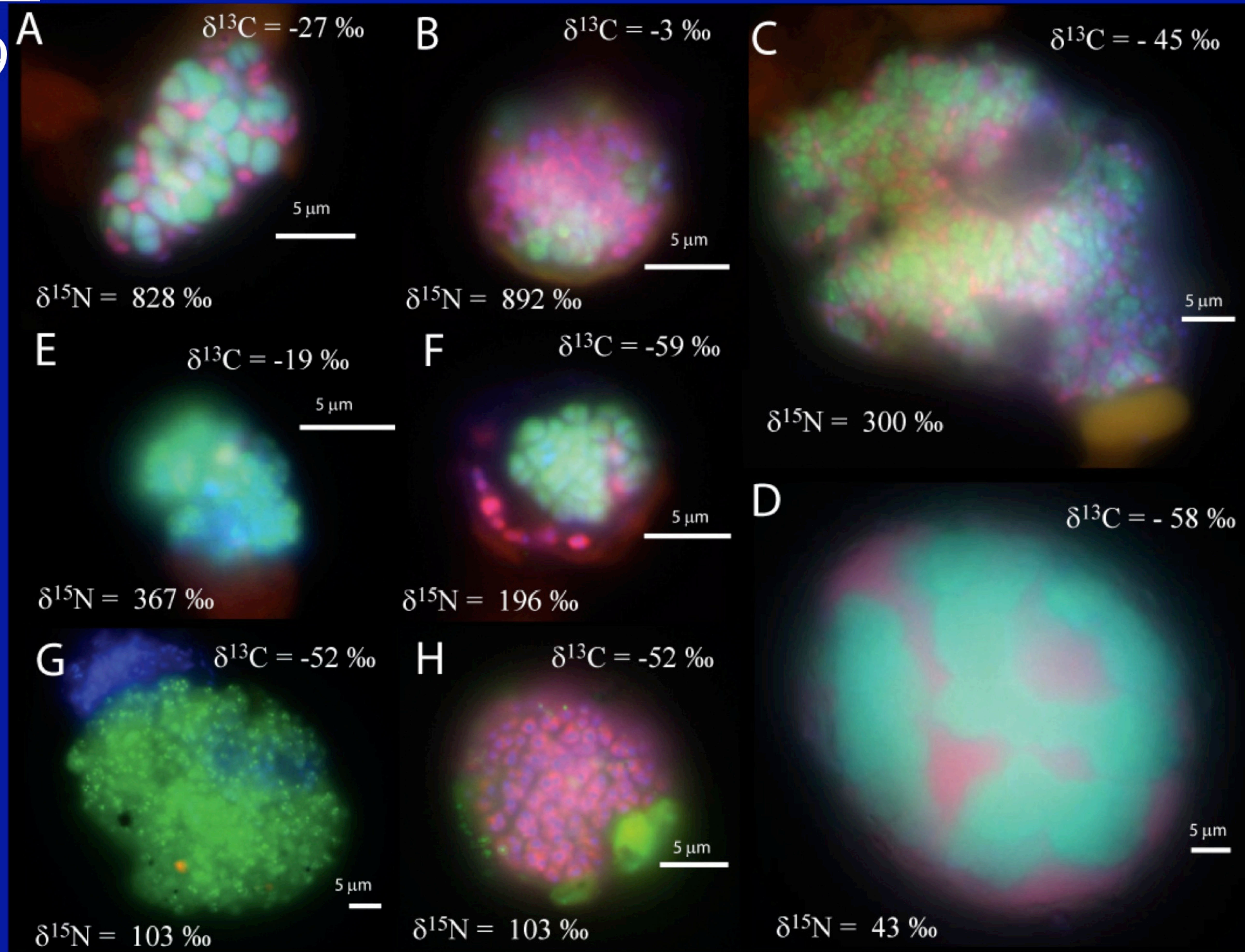
Methane oxidation coupled to Mn-reduction



Beal *et al.*, *Science*, 2009

After incubation with ^{15}N

Beal *et al.*, in prep.

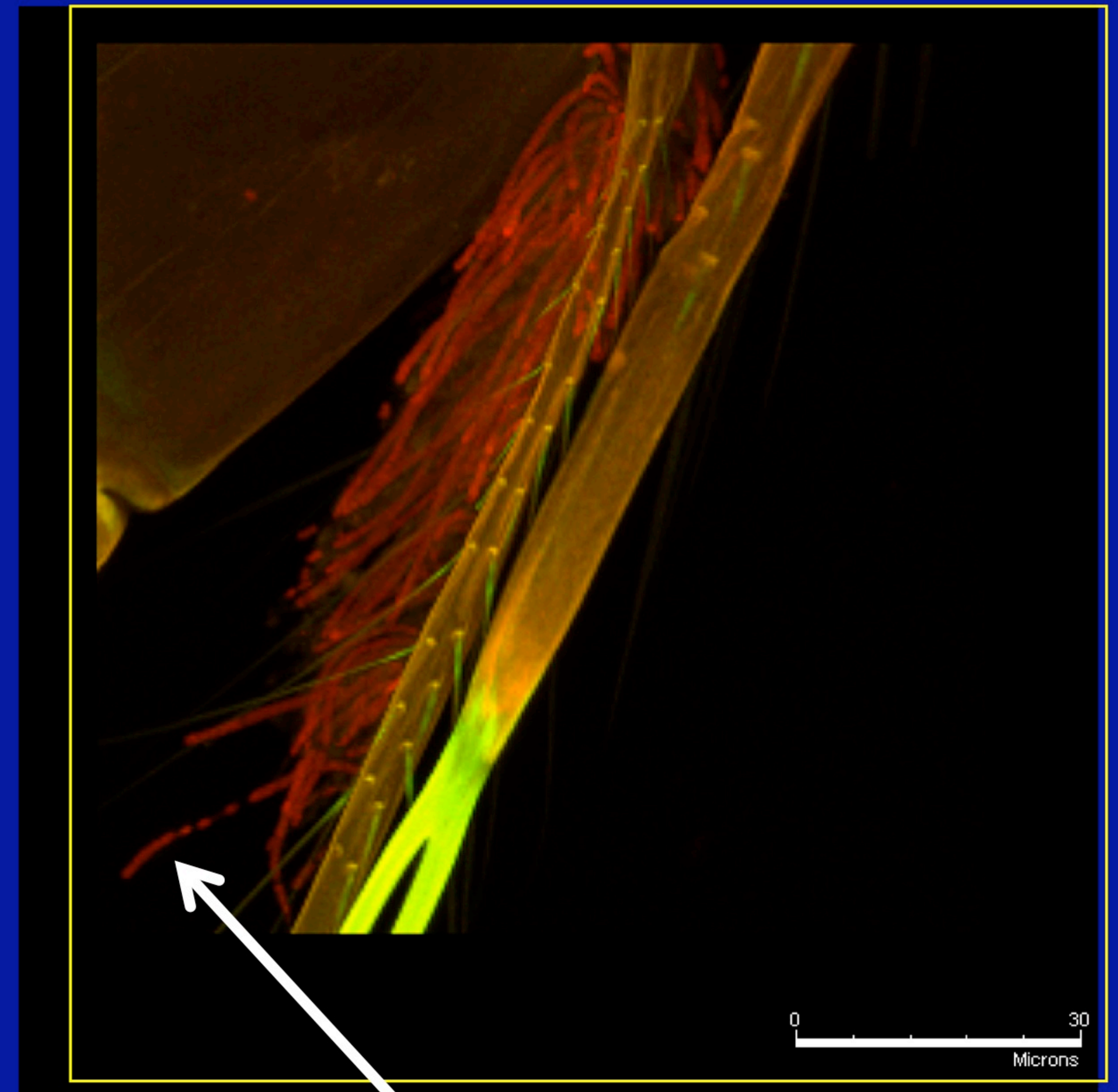
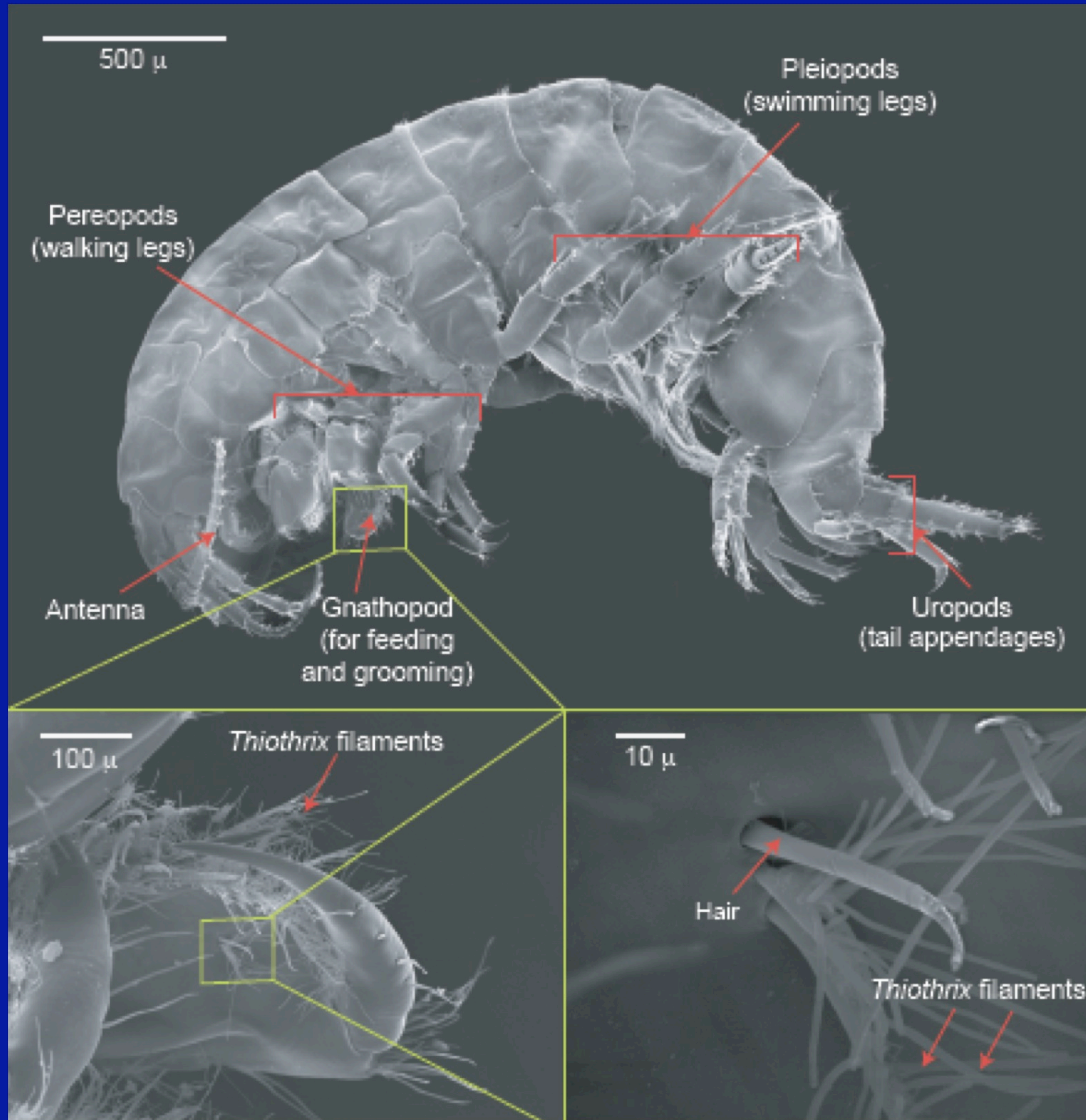


Subsurface Extremophiles

Macaldy Lab (Penn State)

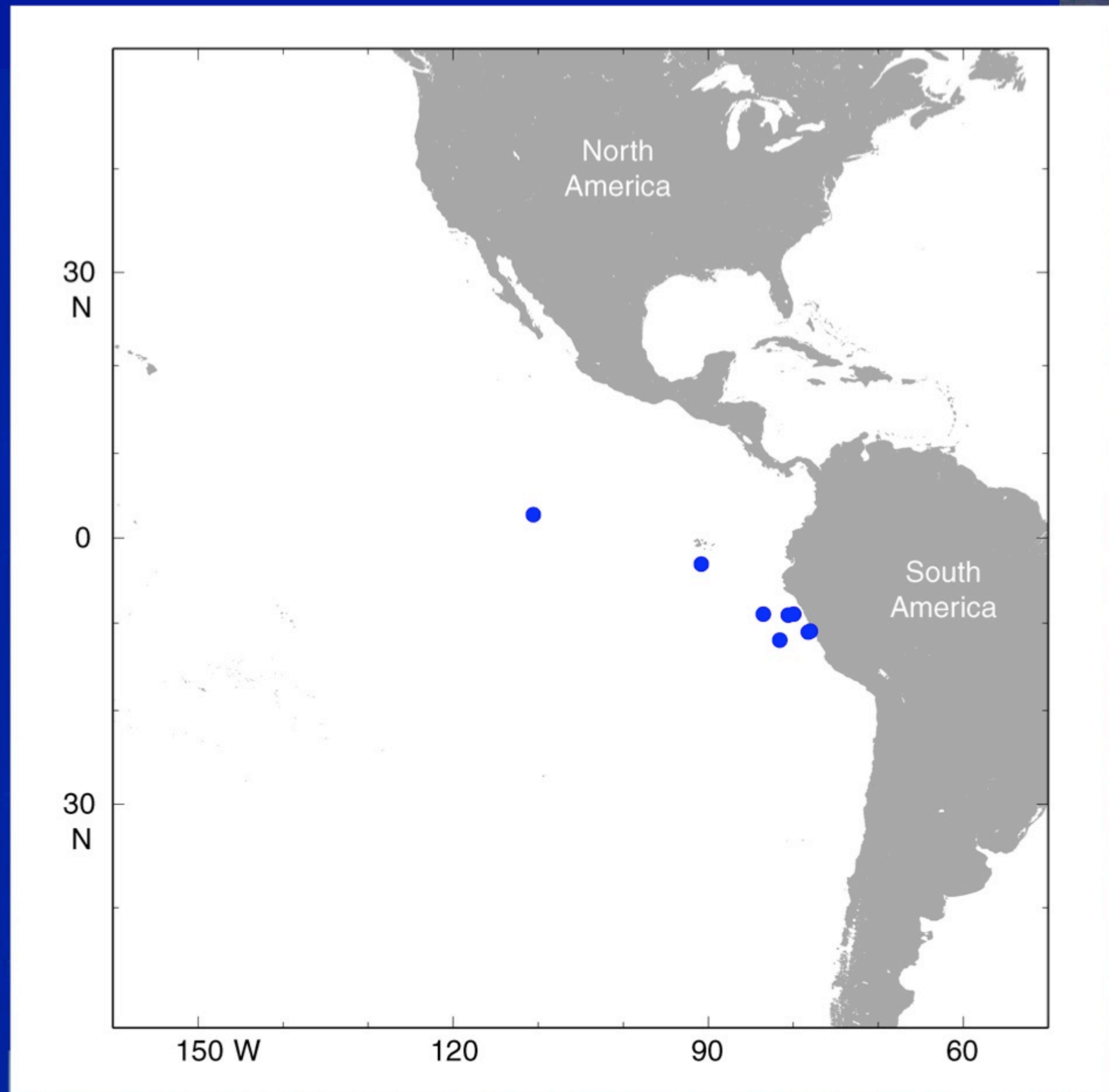
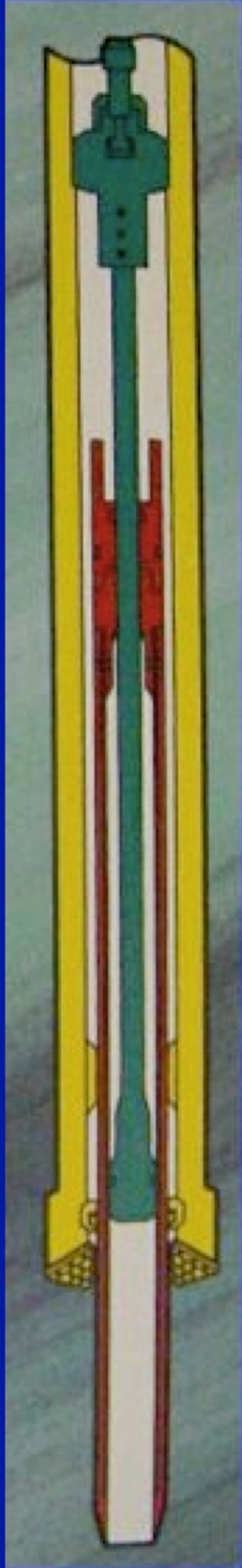


Novel Symbiosis Between Chemoautotrophic Bacteria and a Cave-dwelling Amphipod



Incubated with ^{13}C bicarbonate,
 $^{13}\text{C}/^{12}\text{C} = 0.07$

Microbiology of the Peru Margin (Ocean Drilling Program)



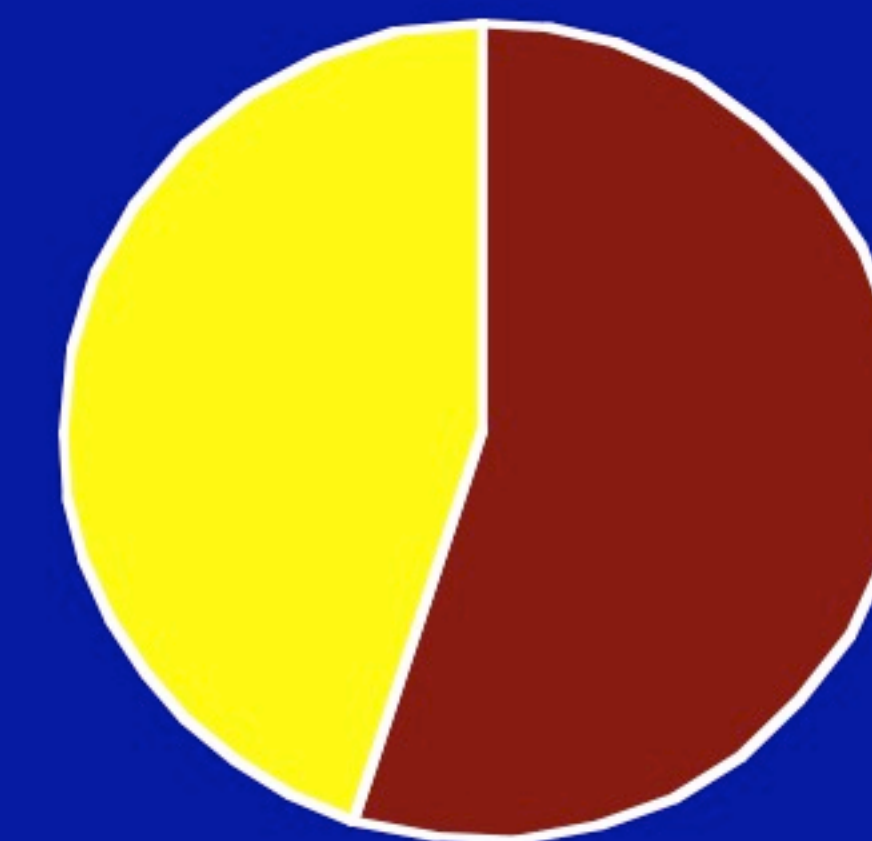
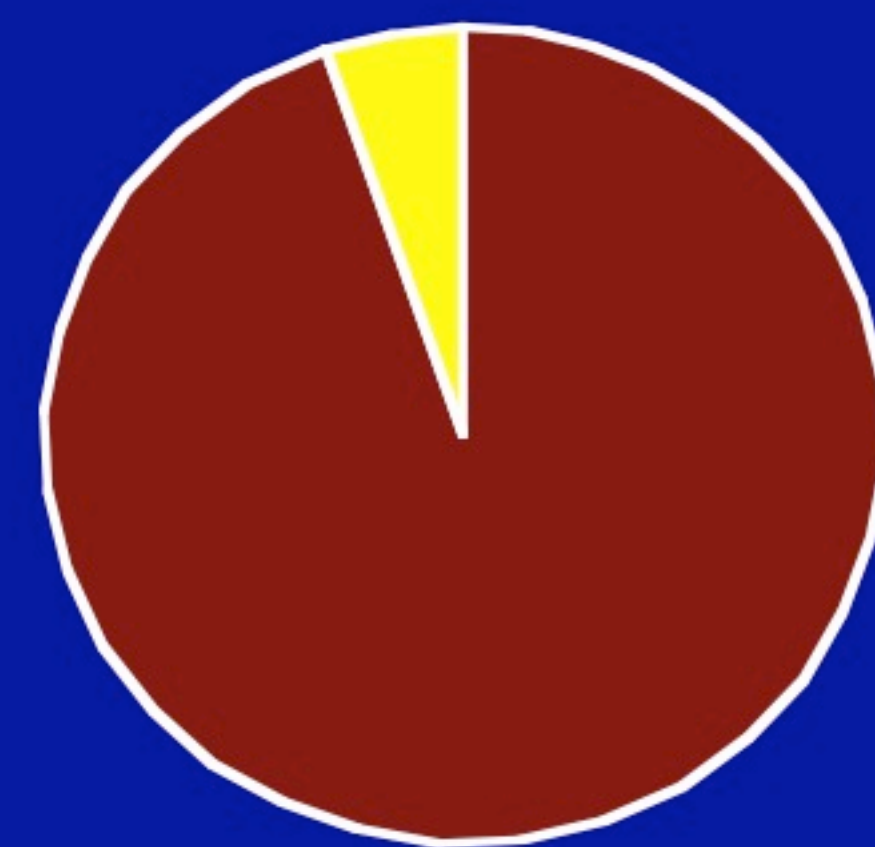
Microbial populations at Peru Margin ODP Site 1229

Sample depth
(mbsf)

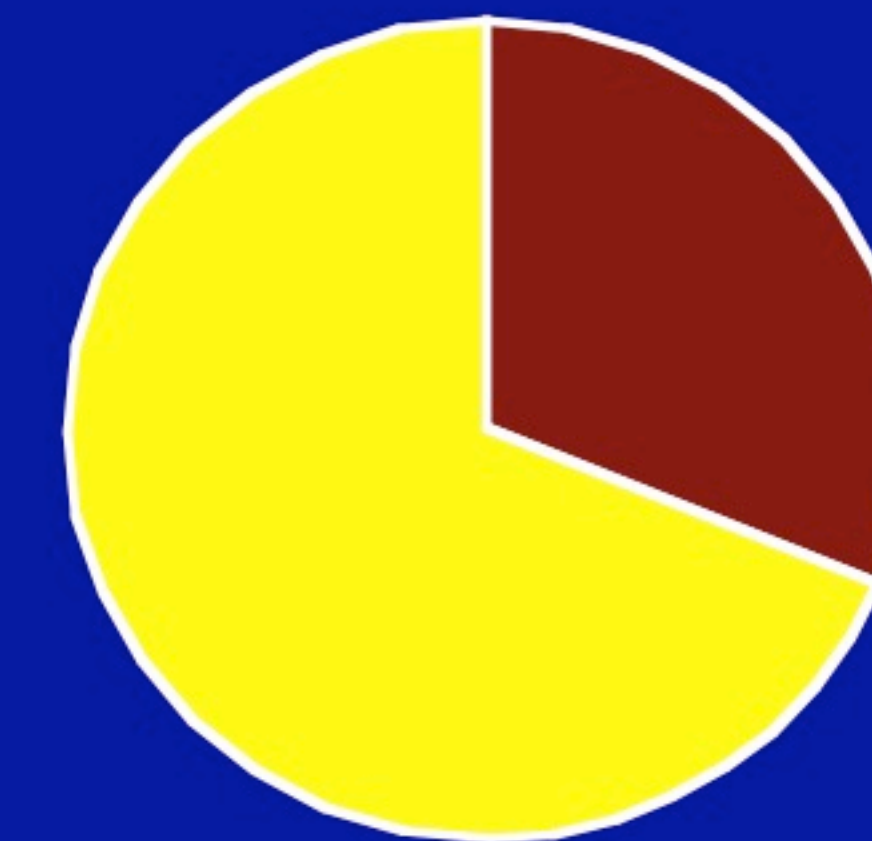
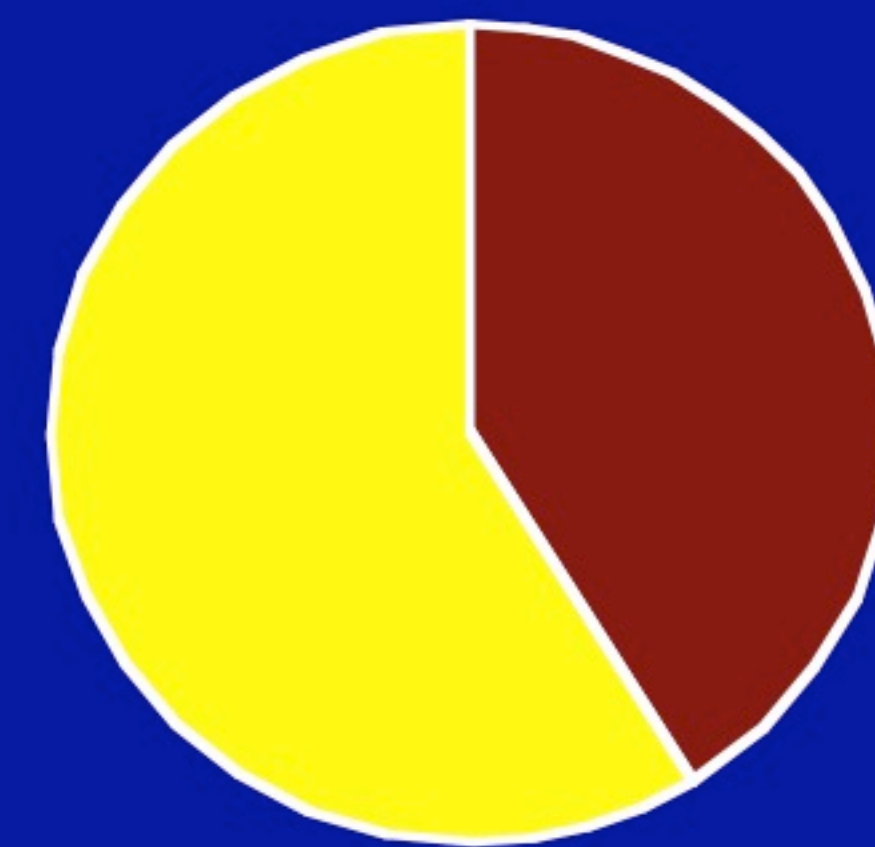
Results by sequence
analysis (metagenome)

Results by FISH
counts

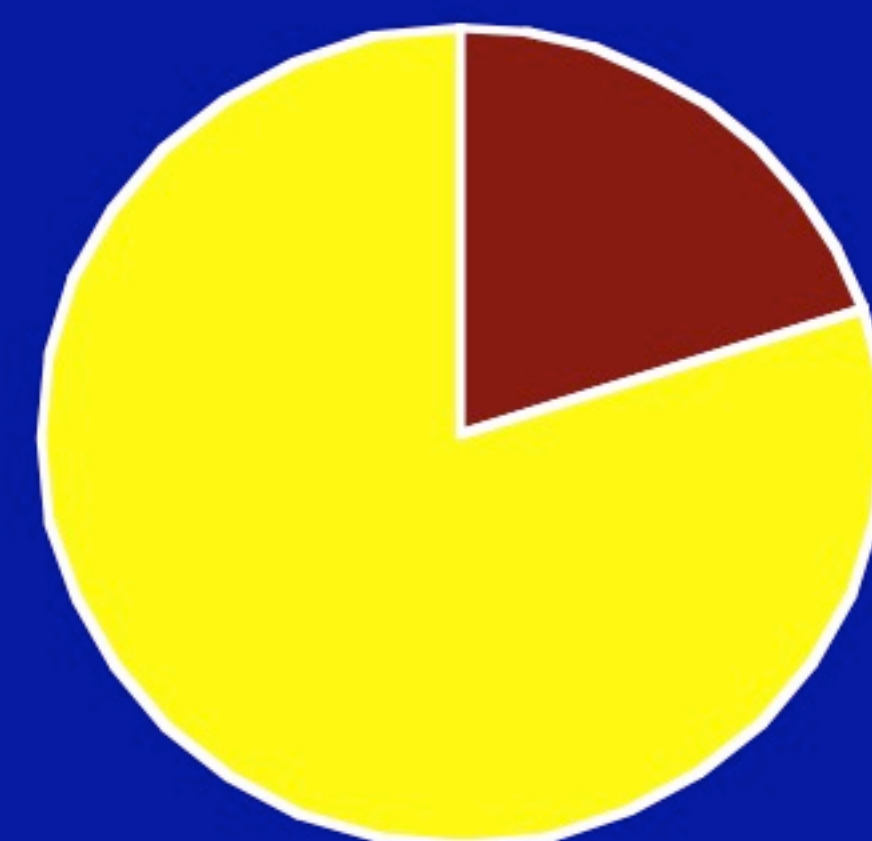
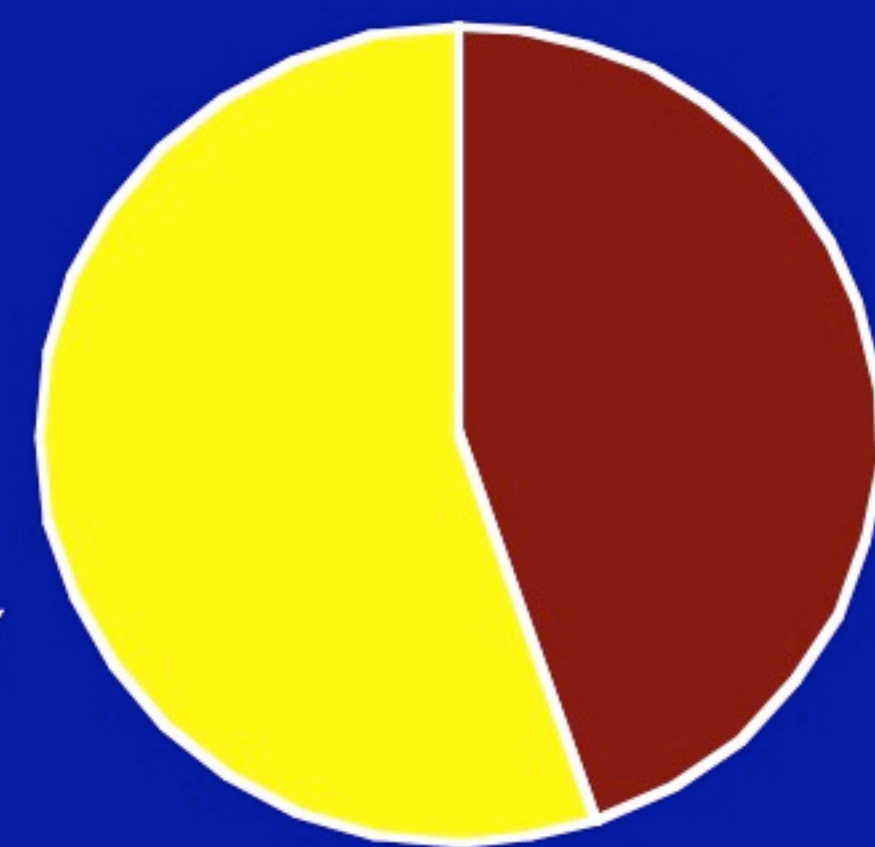
1



16

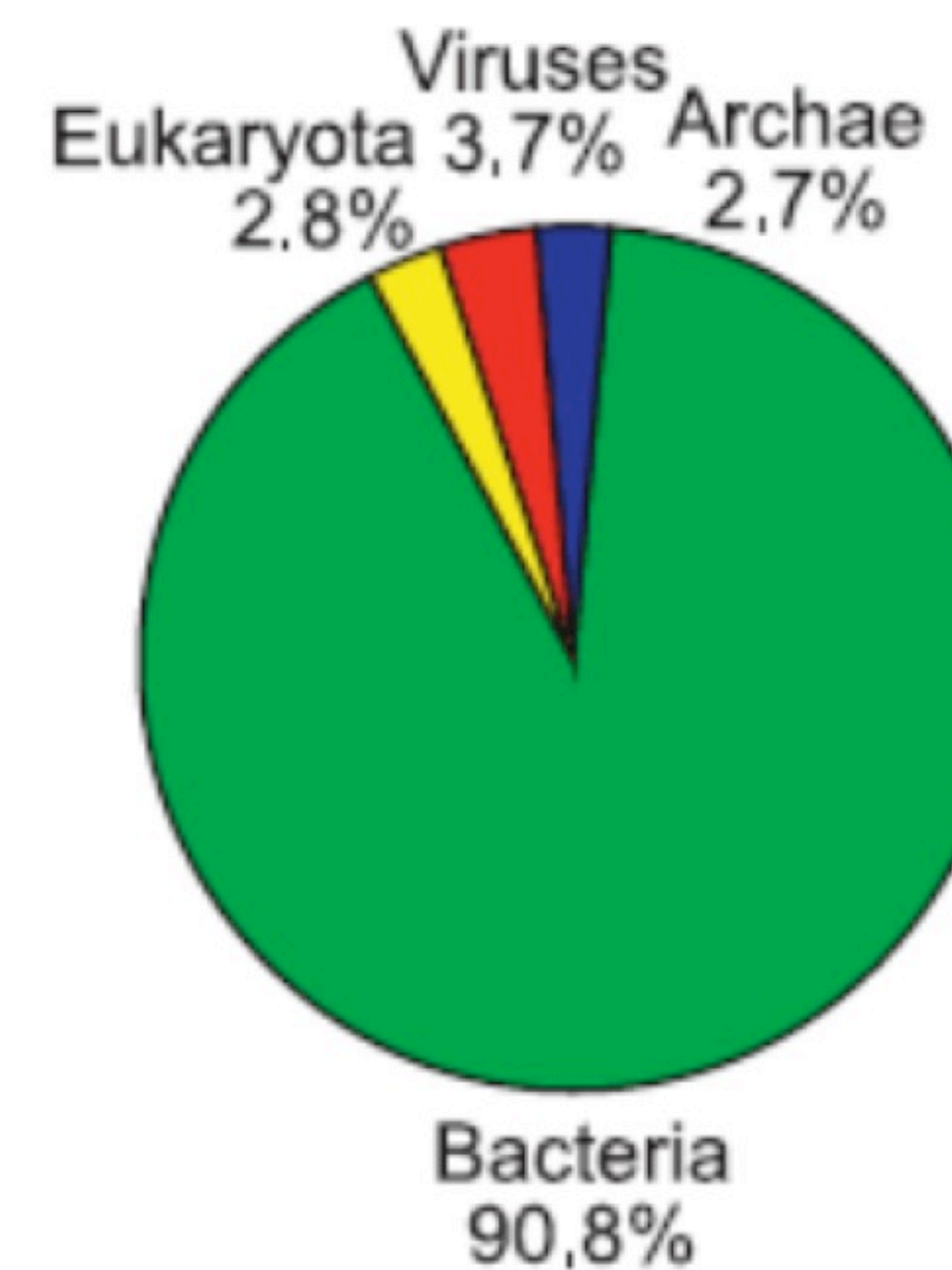


32



Archaea

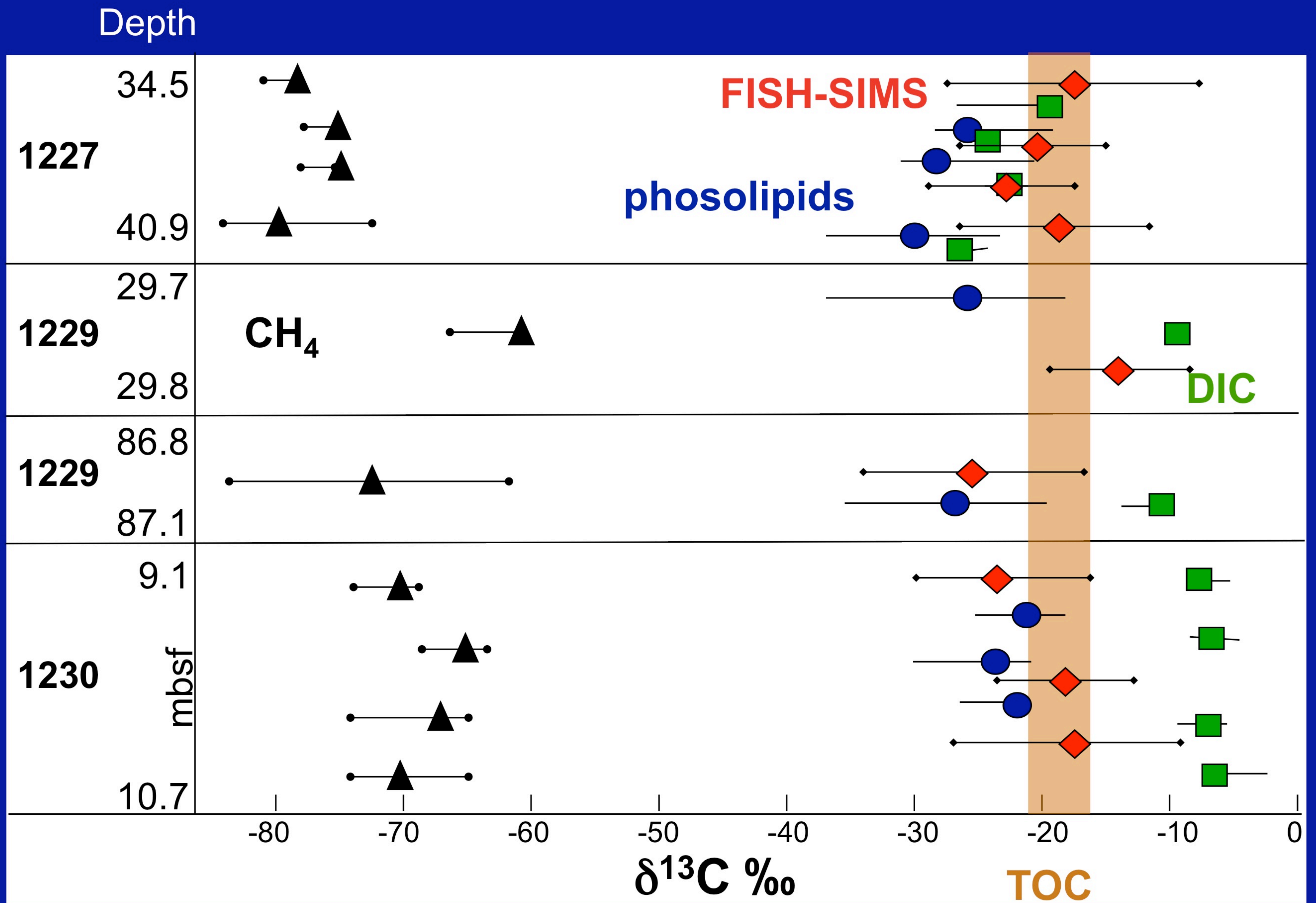
Bacteria



**“Global Ocean
Sampling”**

Yooseph *et al.*, 2007

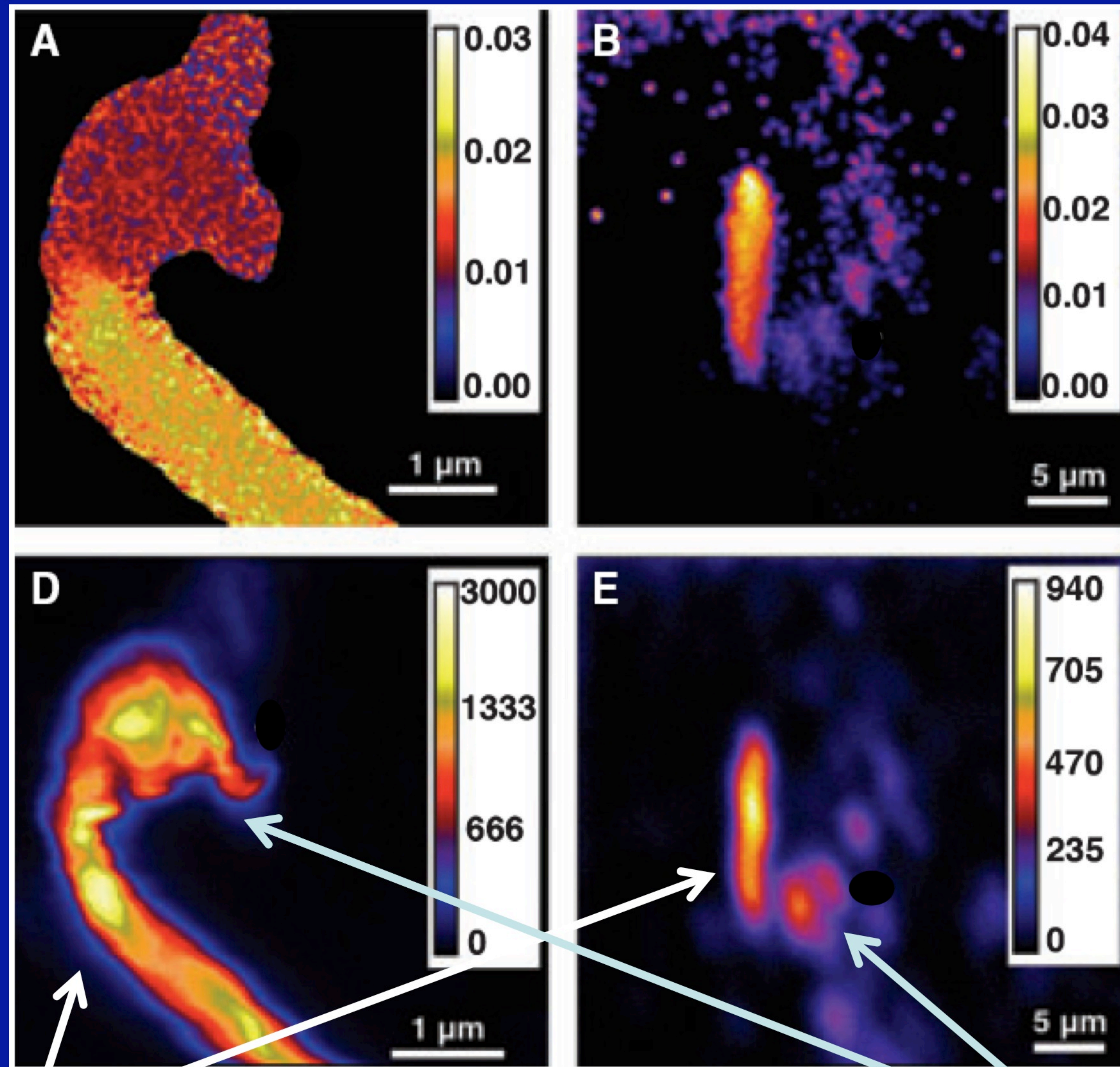
Site



$\delta^{13}\text{C}$ values: **cells**, **lipids**, methane, **Inorganic** & **Organic** carbon

Biddle *et al.*, PNAS, 2006

Nano-SIMS 1270 w/ Gallium source



$^{13}\text{C} / ^{12}\text{C}$

^{12}C image

Orphan and House, 2009

Methanopyrus grown in ^{13}C bicarbonate with *Pyrococcus*

50 PSARC Completed Ph.D. Students

N. Suits, '98; L. Brown '99; A. Pavlov, '01; B. Borup, '01; S. Ono, '01; P. Iver, '01; R. Hotinski, '02, M. Van Tuinen, '02; K. Yamaguchi, '02; Y. Watanabe, '02; H. Pointkiviska, '03; M. Borda, '03; M. Hurtgen, '03; S. Lawrence, '04, A. Herrmann, '04; F. Cruz, '04; S. Shipkowski, '05; P. Kharecha, '05; J. Blair, '05; J. Eigenbrode, '04; J. Debes, '05; H. Buss, '06; J. Biddle, '06; A. Zerkle, '06; Z. Krug, '06; A. Smirnov, '06; C. Cohn, '06; C. Turich, '06; S. Stafford, '06; J. Moran, '07; E. Herman, '07; D. Hydutsky, '07; S. Zimmerman, '07; S. Goldman, '07; M. Bachmann, '07; K. Panchuk, '07; A. Mandell, '07; A. Riccardi, '07; F. Battistuzzi, '07; V. Cameron, '08; L. Hausrath, '08; B. Thomas; '08, K. Meyer '08; A. Edson '08; L. Horodyskyj '09; E. Patridge '09; E. Beal '09; M. Heinicke '09; K. Moody '09; B. Kimball '09

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