

Second Joint Webinar

UK-India-Singapore Joint Biofilm Webinar Series

Theme: Biofilms and Engineered Systems

Biofilm Engineering for Environmental Biotechnology: Biofilm Lifestyle of *Comamonas* in the Environmental Context

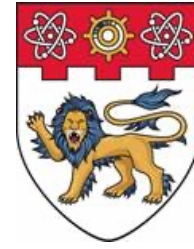
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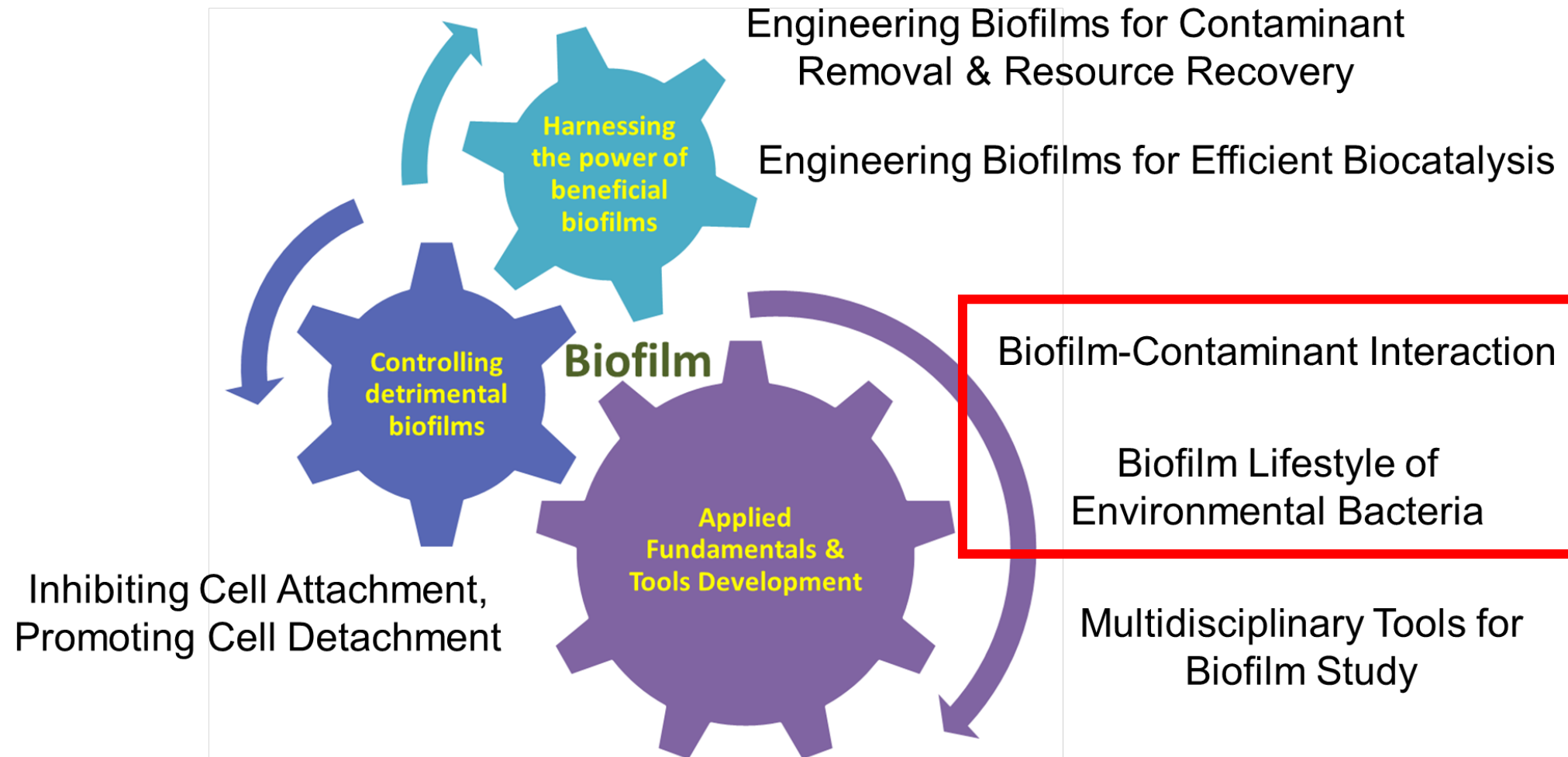
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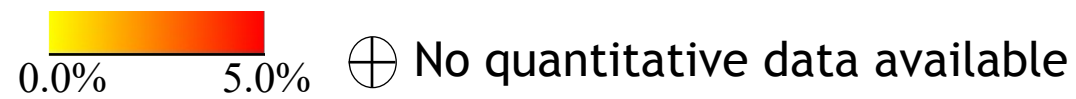
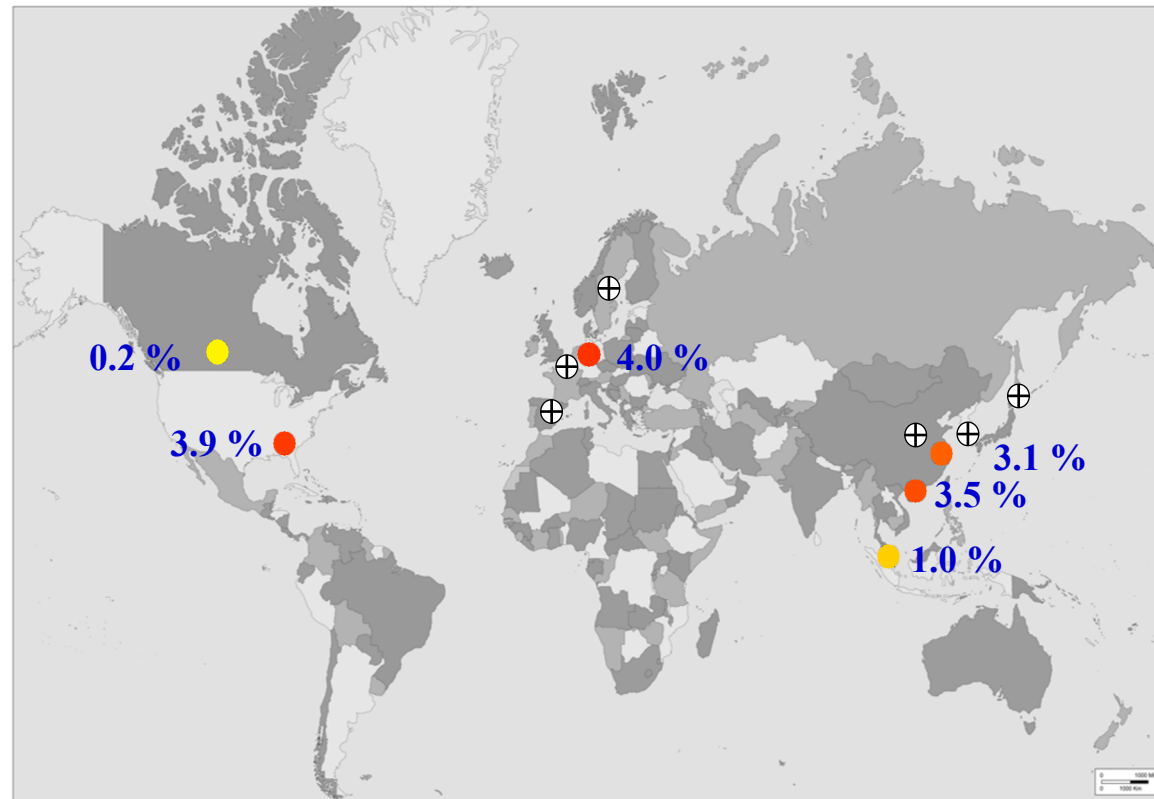
Singapore Centre for Environmental Life Sciences Engineering



To understand biofilm lifestyle of environmental bacteria and to develop biofilm biology-informed environmental biofilm biotechnologies



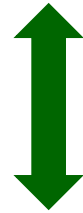
Comamonas: Ubiquitous, relatively abundant, primary surface-colonizers



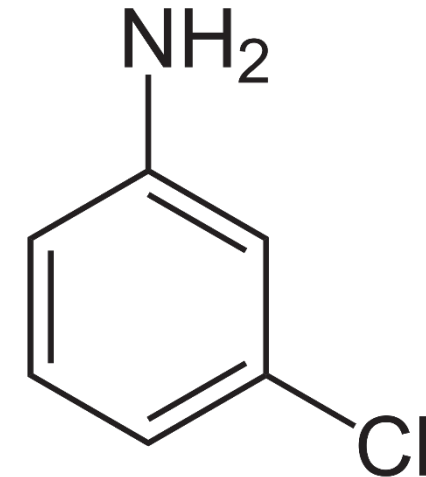
Model bacteria-contaminant interaction

Comamonas testosteroni

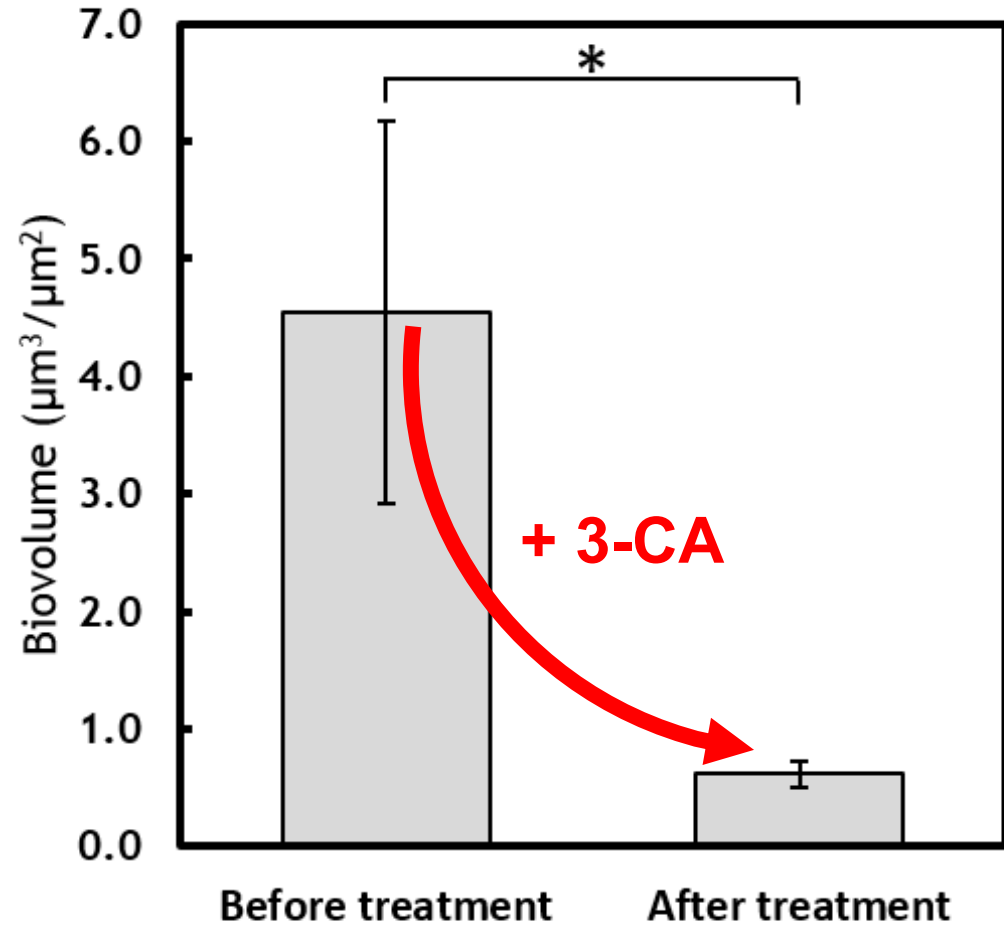
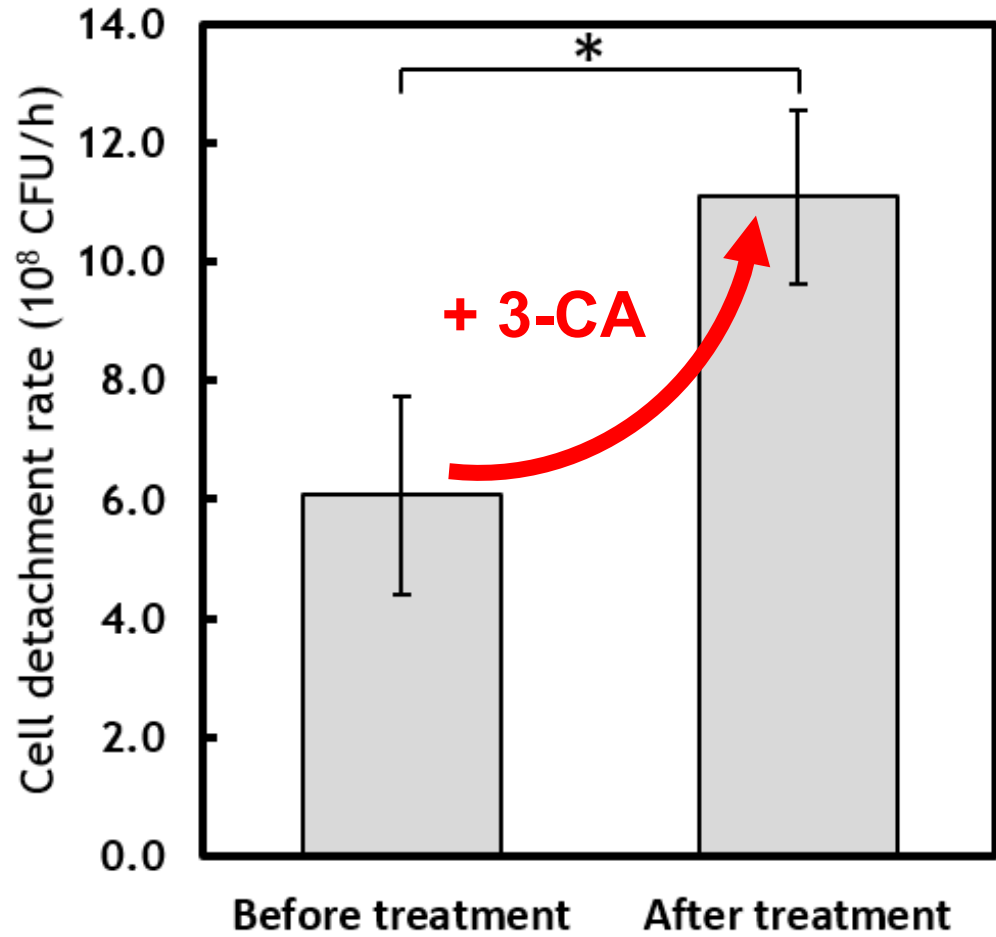
Oxygen



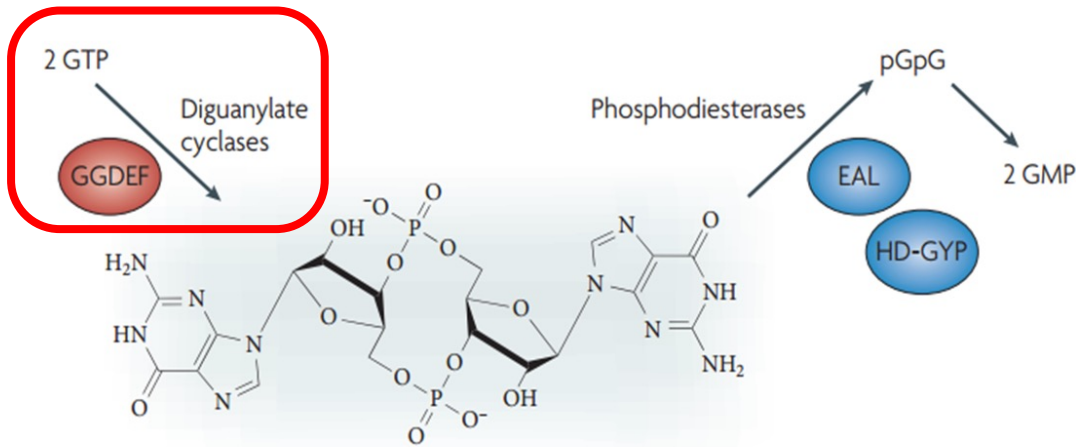
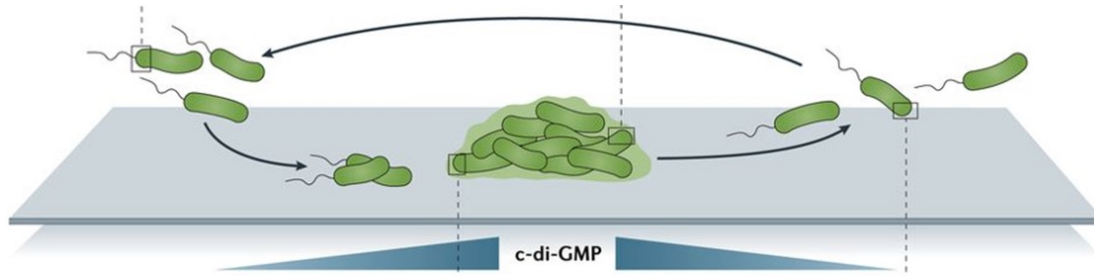
3-Choloroaniline (**3-CA**)



3-CA induces biofilm dispersal



3-CA reduces expression of c-di-GMP synthase genes



Hengge R (2009) *Nat. Rev. Microbiol.* 7: 263-273.

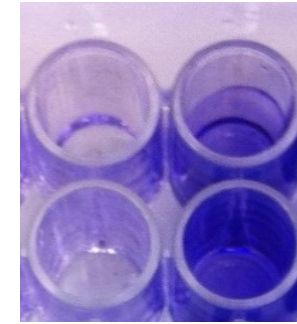
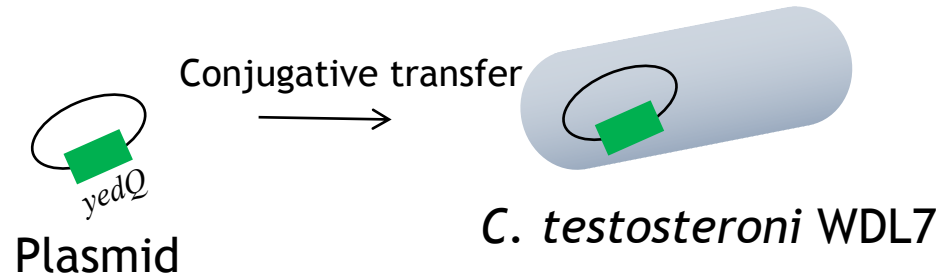
Jenal et al. (2017) *Nat. Rev. Microbiol.* 15: 271-284.

| Gene product | Feature ID | log2 Ratio |
|--|------------------|------------|
| diguanylate cyclase/phosphodiesterase with PAS sensor(s) | WDL7contig_00679 | -2.81 |
| PAS domain S-box/diguanylate cyclase (GGDEF) domain | WDL7contig_02402 | -2.24 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_01842 | -2.11 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_03518 | -1.81 |
| diguanylate cyclase/phosphodiesterase with PAS/PAC sensor(s) | WDL7contig_04686 | -1.42 |
| PAS domain S-box/diguanylate cyclase (GGDEF) domain | WDL7contig_00113 | -1.40 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_03907 | -1.36 |
| diguanylate cyclase/phosphodiesterase with PAS Chase sensor(s) | WDL7contig_04012 | -1.36 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_02218 | -1.31 |
| diguanylate cyclase/phosphodiesterase | WDL7contig_00447 | -1.21 |
| PAS domain S-box/diguanylate cyclase (GGDEF) domain | WDL7contig_00230 | -0.99 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_01803 | -0.98 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_00747 | -0.98 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_02055 | -0.97 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_02791 | -0.87 |
| diguanylate cyclase (GGDEF) domain | WDL7contig_00546 | -0.83 |
| PAS domain S-box/diguanylate cyclase (GGDEF) domain | WDL7contig_01961 | -0.78 |
| PAS domain S-box/diguanylate cyclase (GGDEF) domain | WDL7contig_02793 | -0.72 |

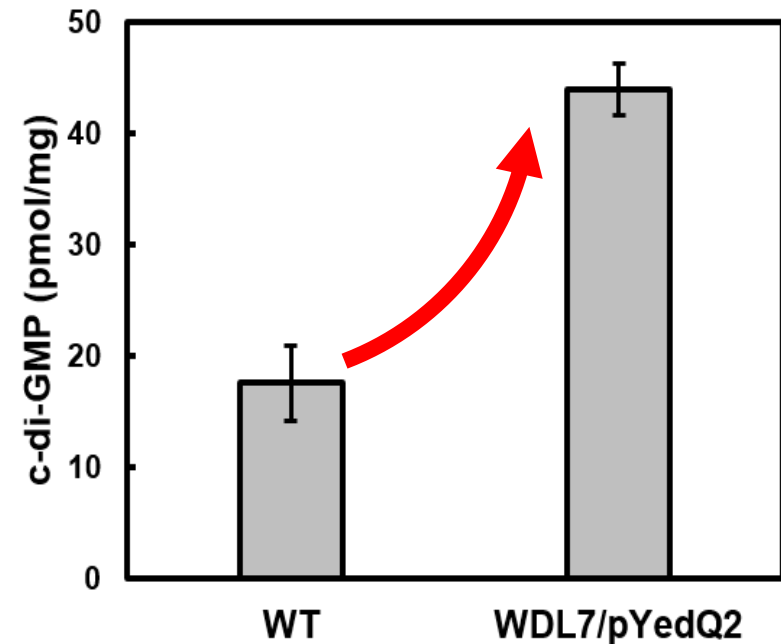
Wu Y, Mohanty A, Chia WS, Cao B* (2016) *AEM* 82: 4401-4409.

Expressing YedQ increases c-di-GMP level

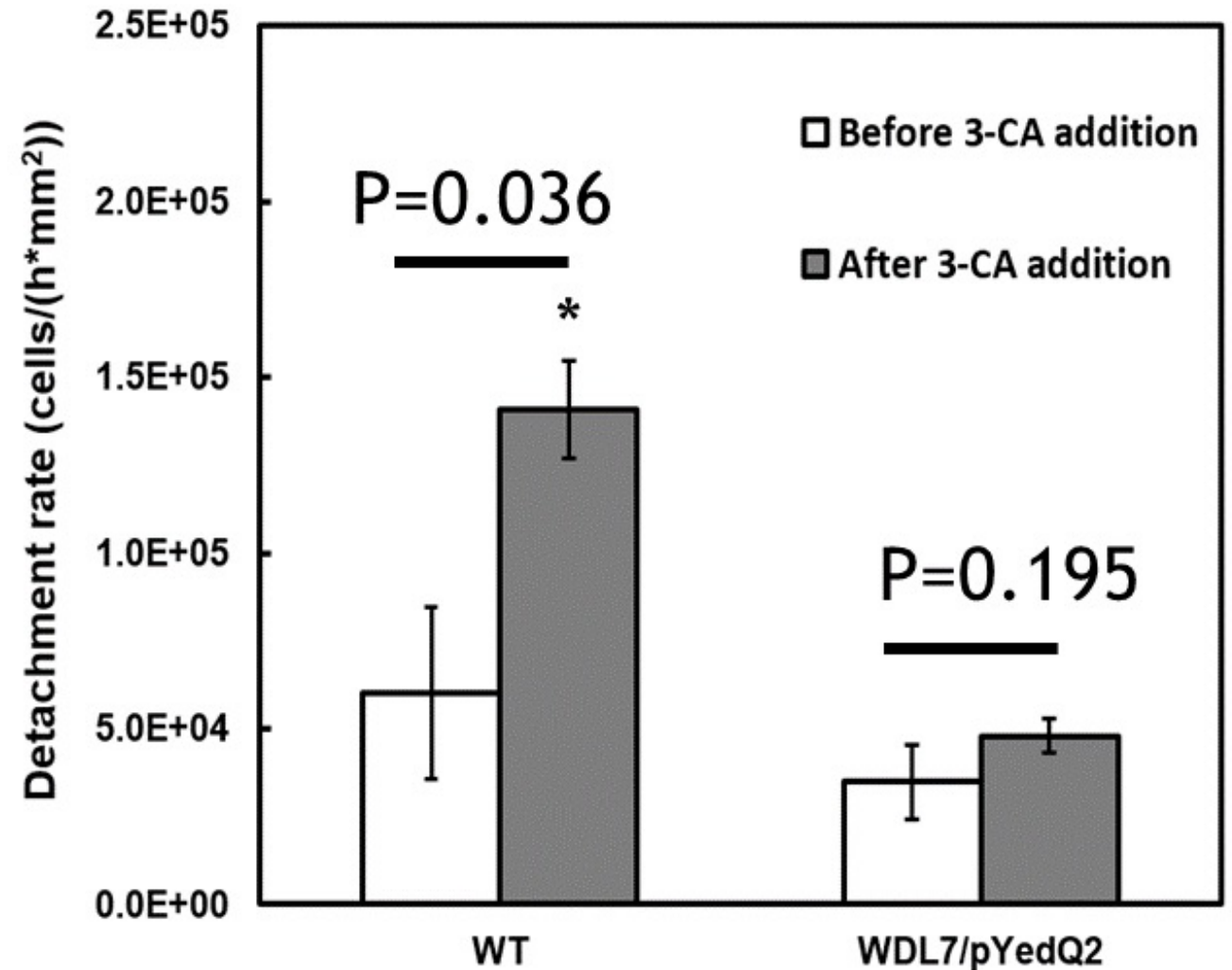
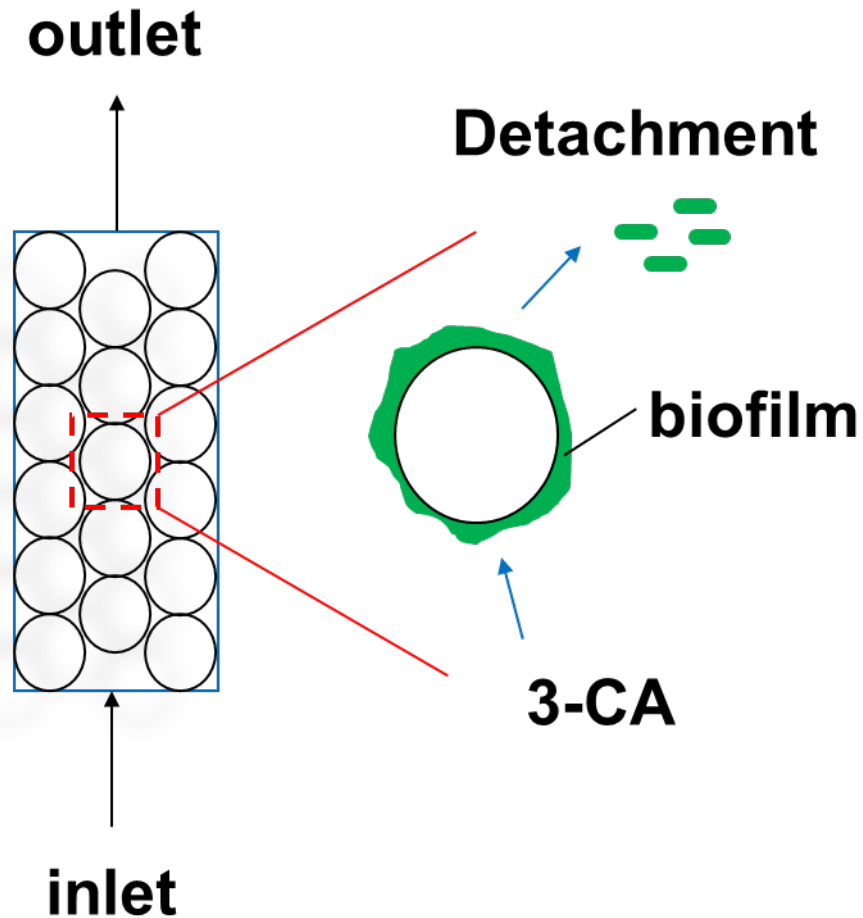
YedQ: a c-di-GMP synthase from *E. coli*



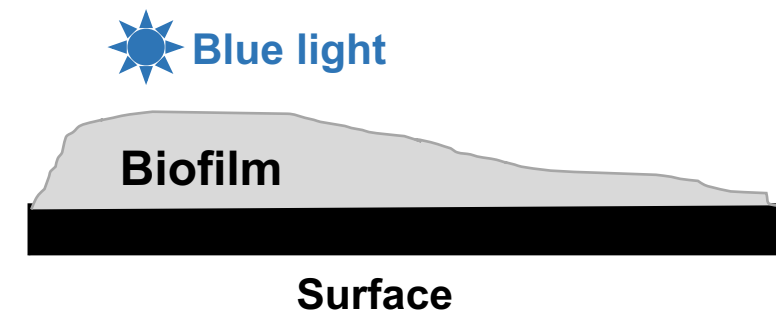
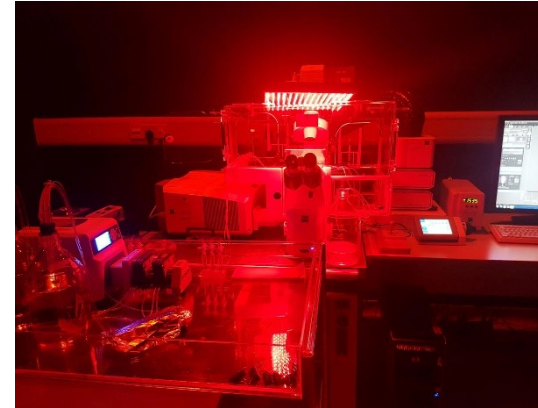
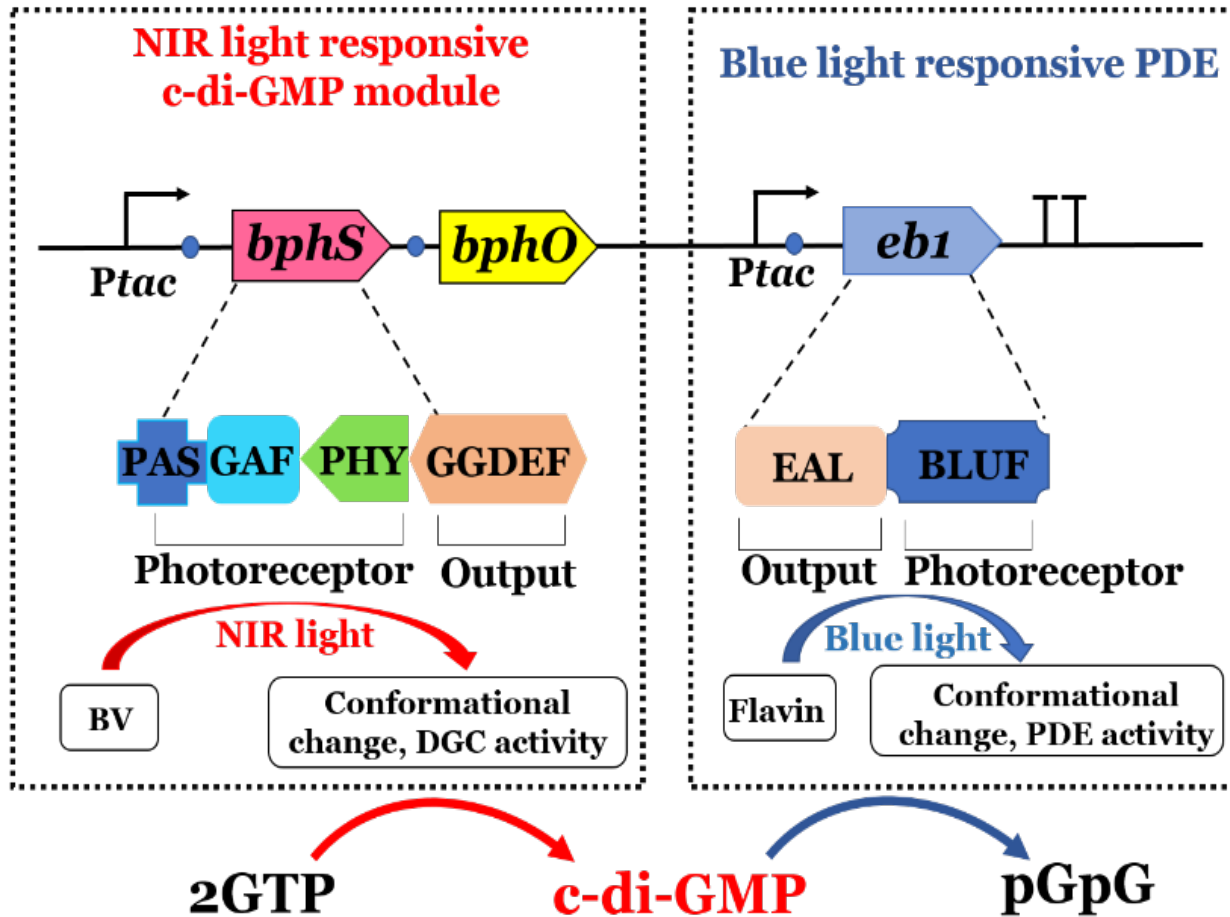
WT WDL7/pYedQ2



Elevated c-di-GMP level \rightarrow more robust biofilm



NIR and blue light-controllable biofilm dynamics

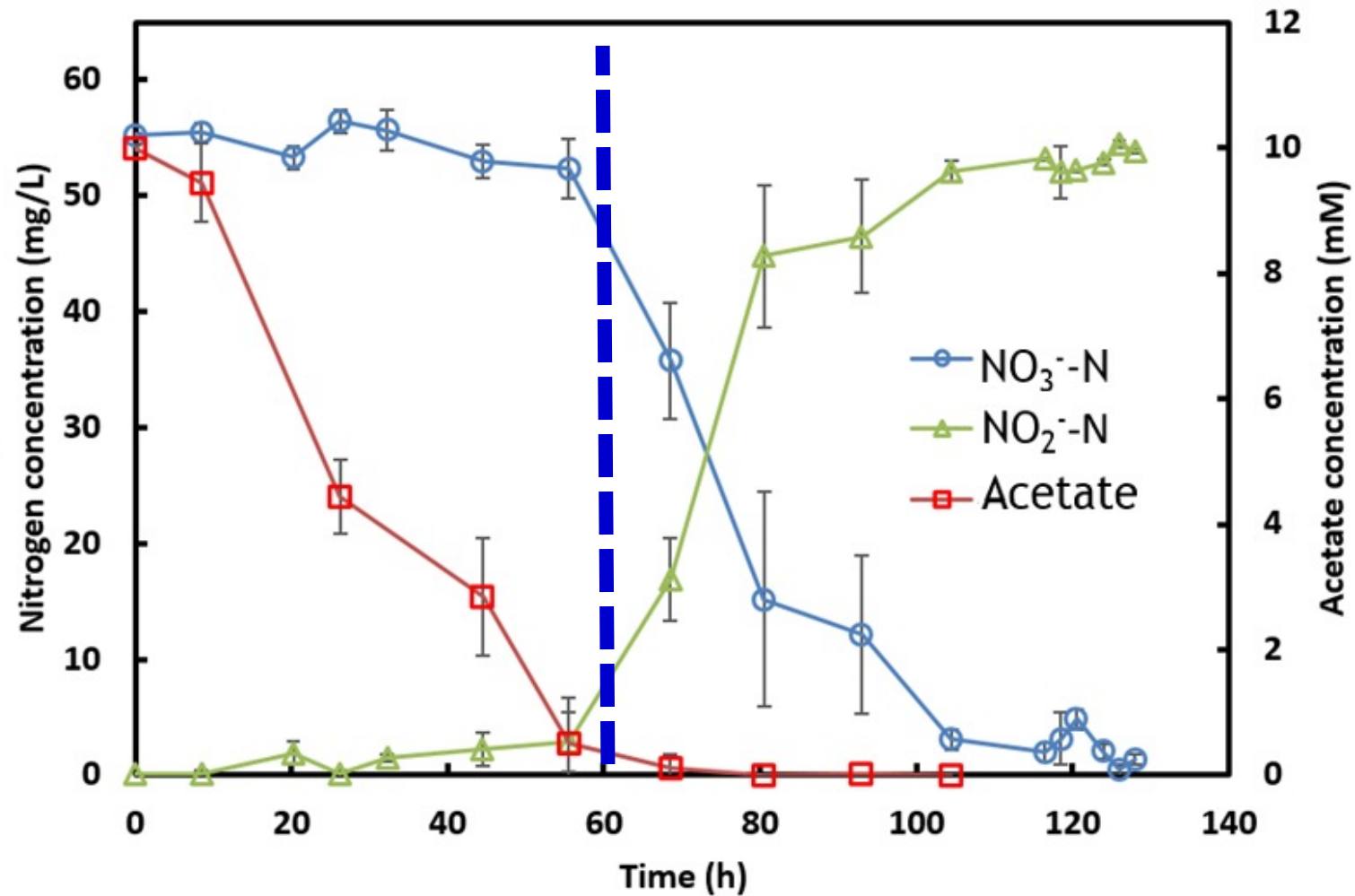


Biocatalysis: Hu Y, Liu X, Teng AMR, Gu JD, Cao B* (2019), *ChemSusChem* 12: 5142-5148.

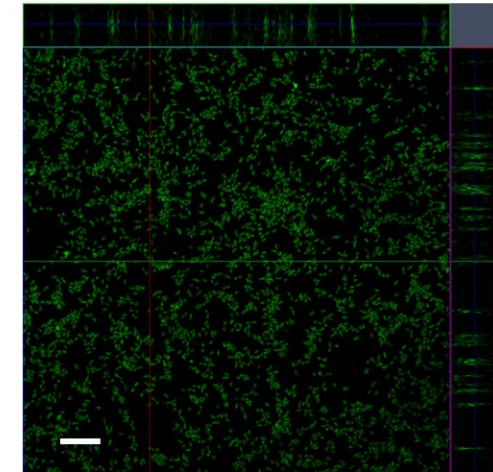
Biofouling control: Mukherjee M, Hu Y, Tan CH, Rice S, Cao B* (2018), *Science Advances* 4(12): eaau1459.

Electrochemically active biofilm: Hu Y, Wu Y, Mukherjee M, Cao B* (2017) *Chem. Comm.* 53: 1646-1648.

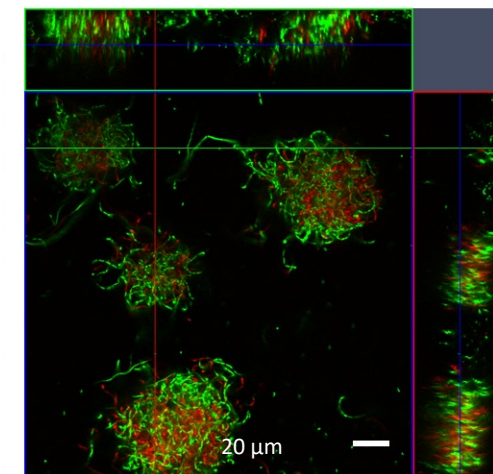
Nitrate reduction occurs in biofilm under bulk aerobic condition



Biofilm at 24 h

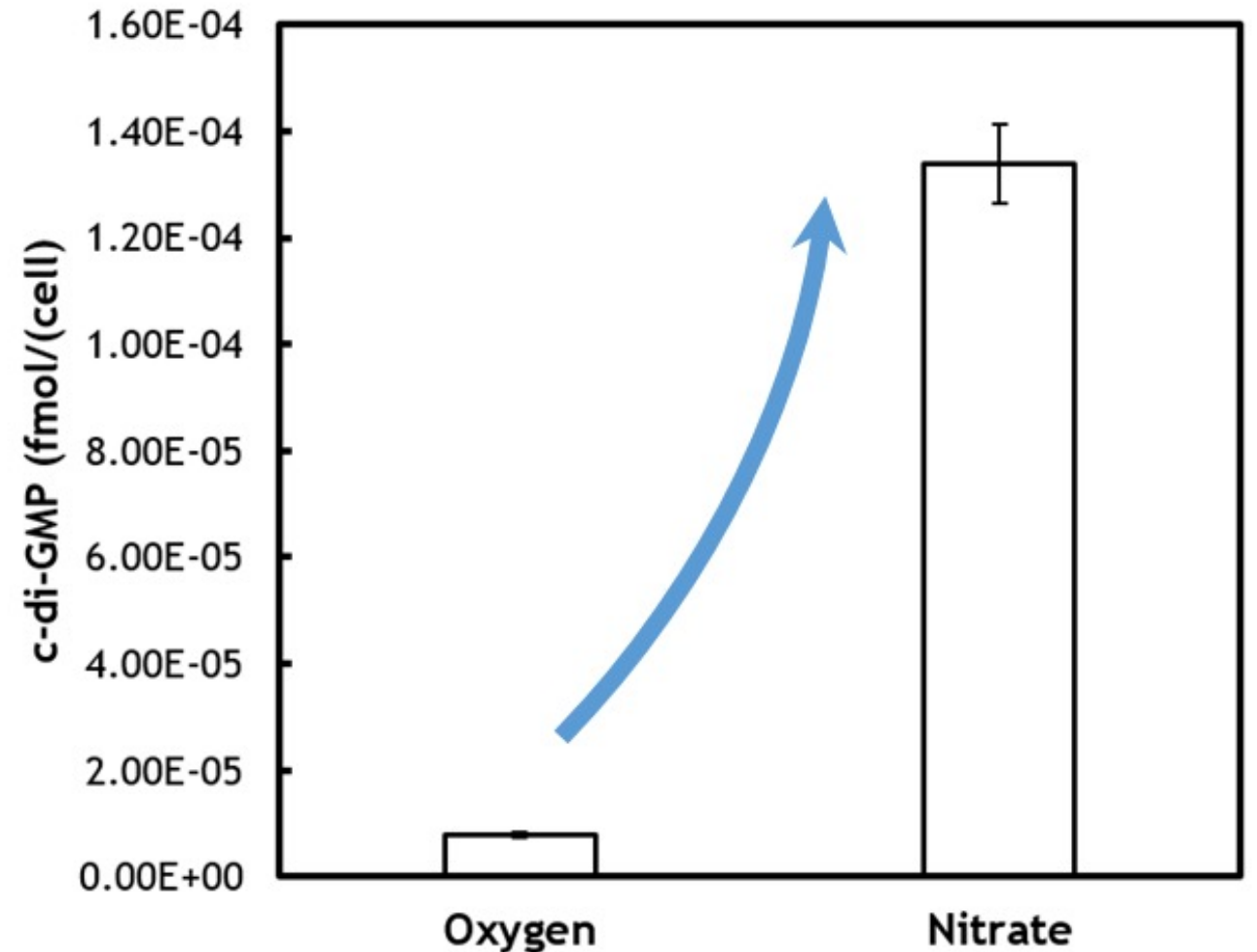


Biofilm at 60 h

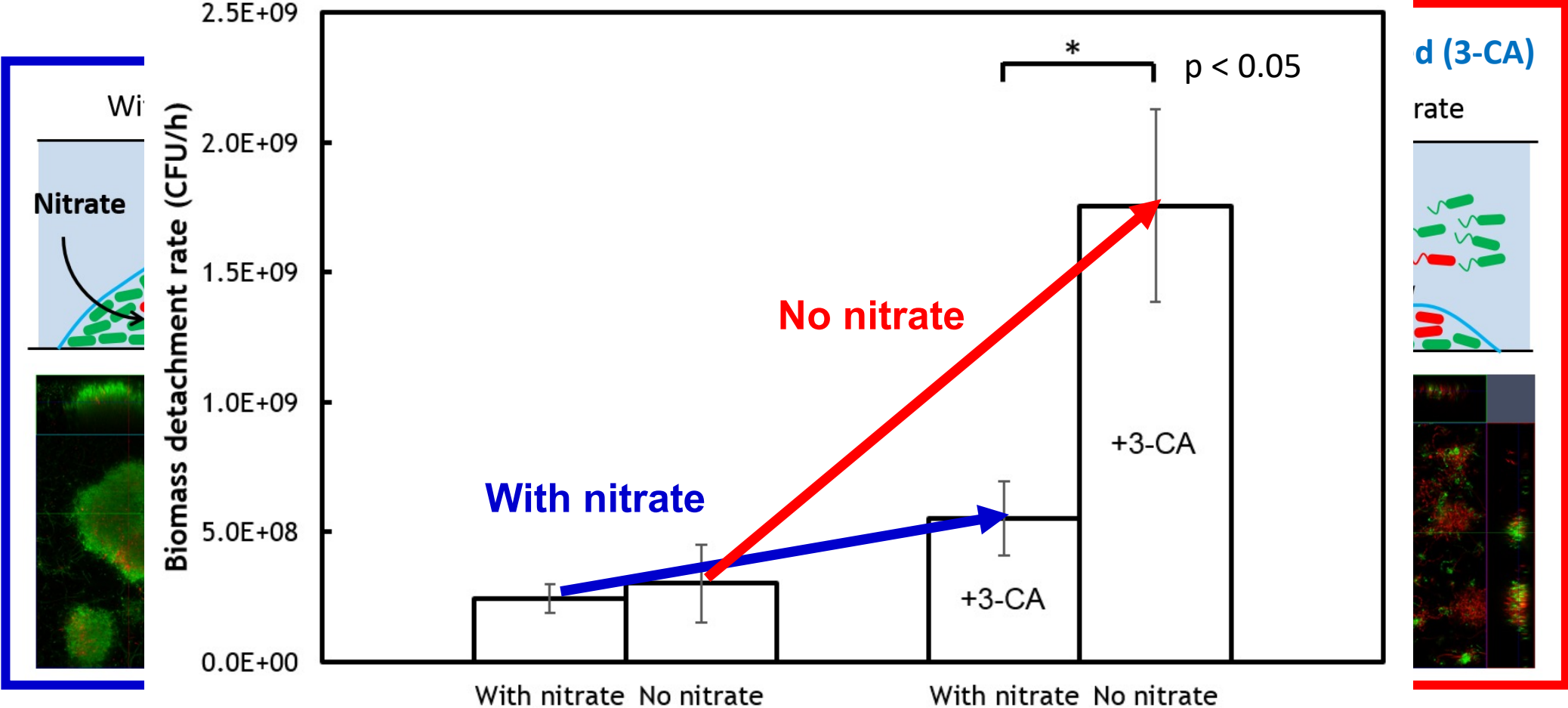


Nitrate respiration increases c-di-GMP level

| Feature ID | Description | Log ₂ Ratio |
|----------------|--|------------------------|
| I2contig_00961 | PAS domain S-box/diguanylate cyclase domain (DGC-2) | 2.46 |
| I2contig_05141 | Diguanylate cyclase domain (DGC-3) | 2.41 |
| I2contig_04562 | Diguanylate cyclase domain (DGC-1) | 2.01 |
| I2contig_00763 | Diguanylate cyclase domain | 1.59 |
| I2contig_02275 | Diguanylate cyclase/phosphodiesterase | 1.50 |
| I2contig_04913 | Diguanylate cyclase | 1.25 |
| I2contig_01952 | Response regulator containing a CheY-like receiver domain and a GGDEF domain | 1.04 |
| I2contig_04723 | Diguanylate cyclase domain | 1.02 |
| I2contig_01917 | Diguanylate cyclase domain | 1.00 |
| I2contig_02501 | Diguanylate cyclase domain | 0.88 |
| I2contig_03397 | Diguanylate cyclase domain | 0.60 |



Nitrate reduction enhances biofilm stability under environmental stress



Insights from biofilm-contaminant interaction → environmental biofilm biotechnology

- Environmental contaminants may influence biofilm dynamics via c-di-GMP signaling
- Environmental cues altering [c-di-GMP] can be harnessed to modulate biofilm-contaminant interaction
- C-di-GMP dynamics - environmental biofilm biotechnology



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