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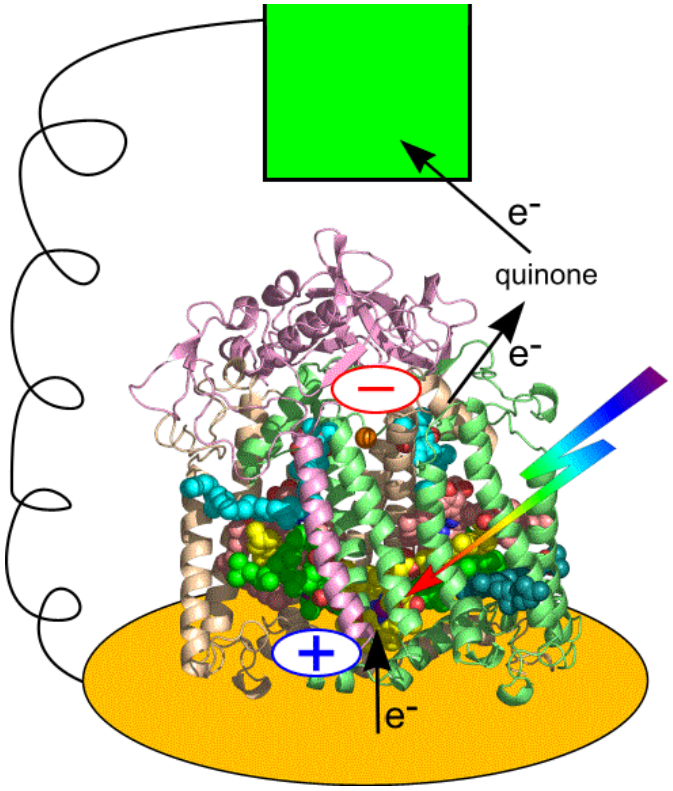
Evaluation of a biohybrid photoelectrochemical cell employing the purple bacterial reaction centre as a biosensor for herbicides



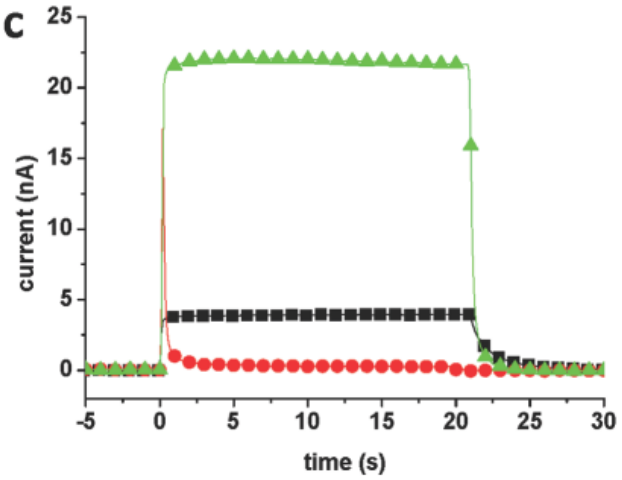
Mike Jones

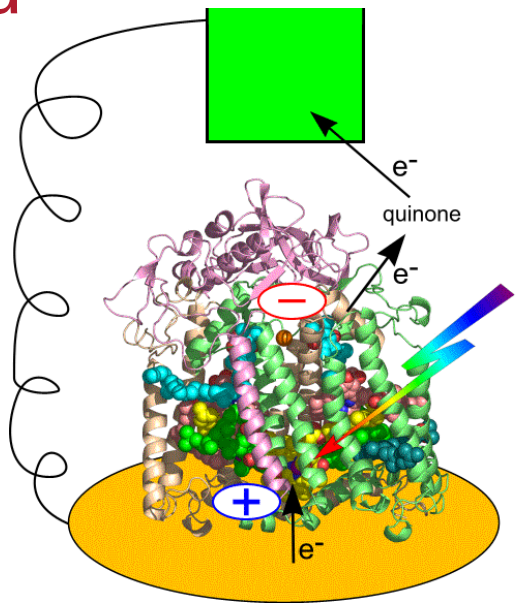
Istanbul 2014

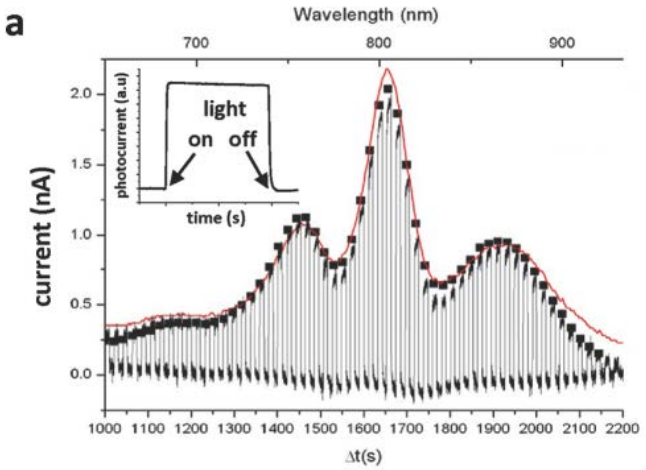
Purple bacterial RCs on bare gold

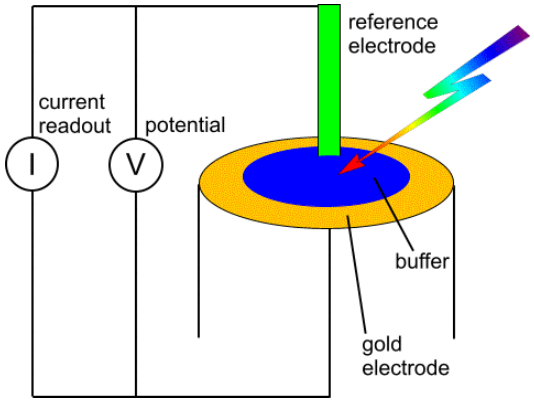
vrije Universiteit amsterdam

den Hollander, M.-J., Magis, J.G., Fuchsenberger, P., Aartsma, T.J., Jones, M.R. and Frese R.N. (2011) Enhanced photocurrent generation by photosynthetic bacterial reaction centers through molecular relays, light-harvesting complexes and direct protein-gold interactions. *Langmuir* **27**, 10282-10294









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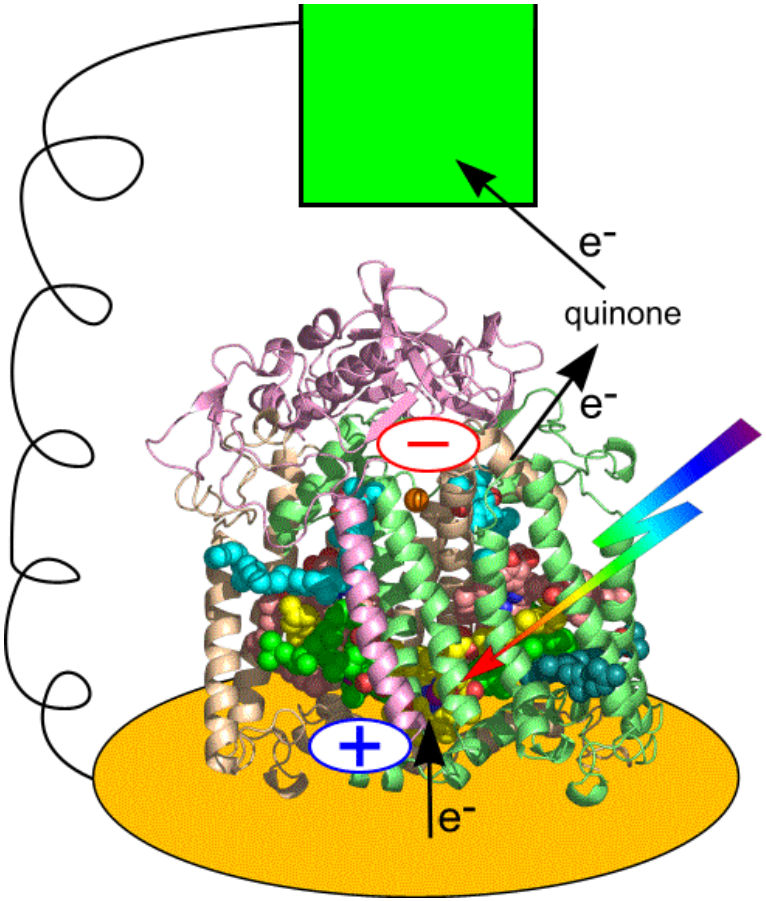
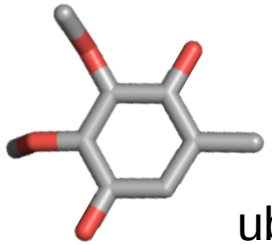
Mechanism of current generation

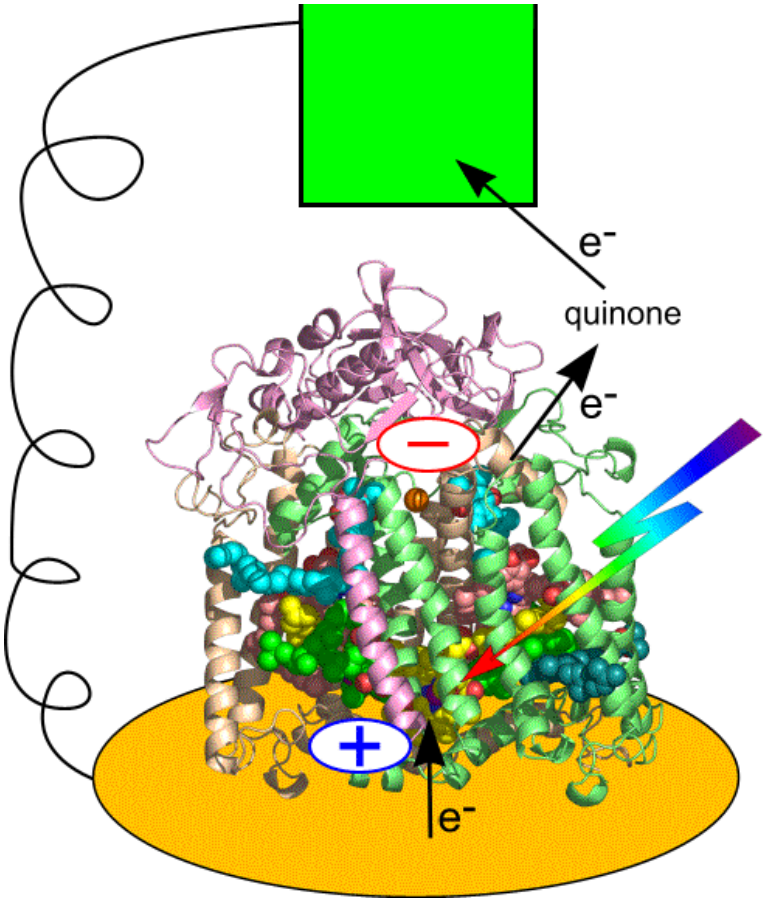




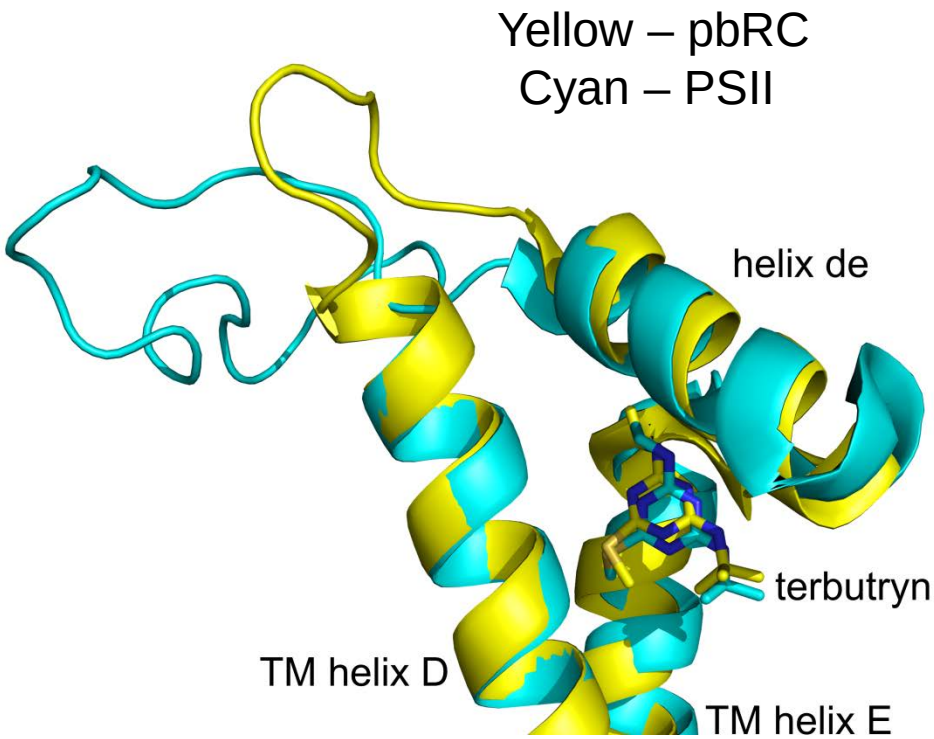
ubiquinone-0

horse heart cytochrome *c*

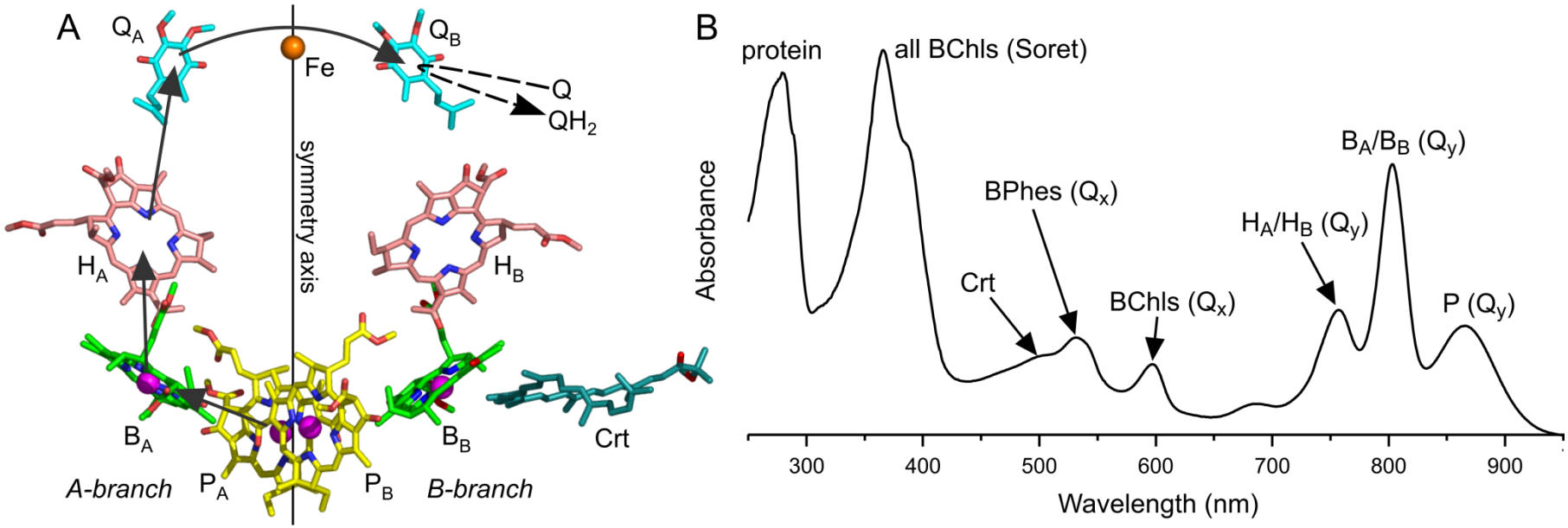
Applications????



Herbicides – Q_B site inhibitors



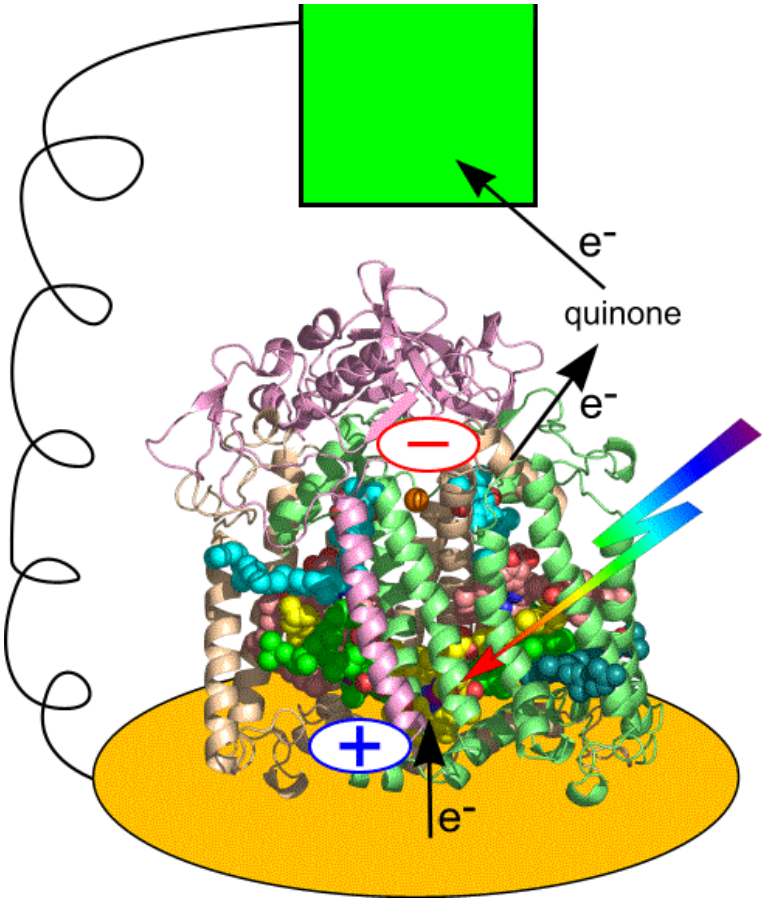
Biosensing through RC kinetics

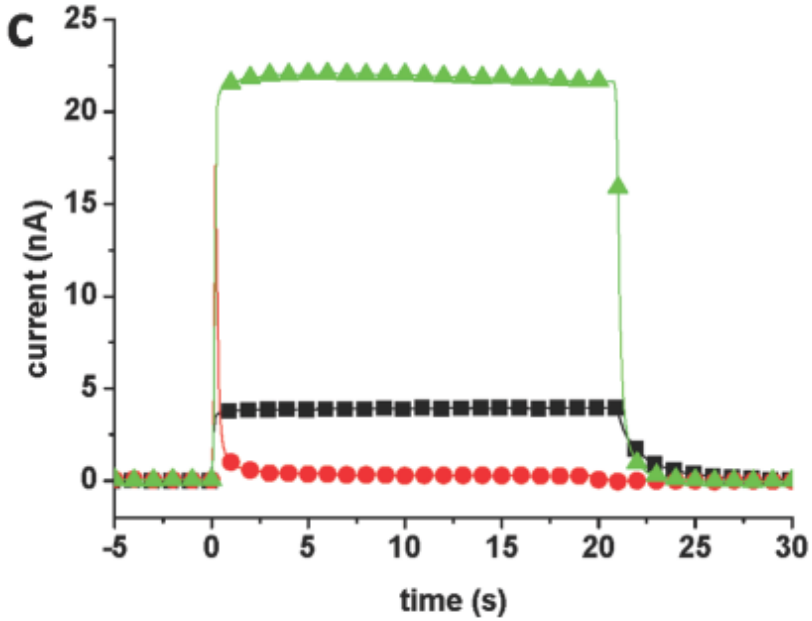


$P^+Q_A^-$ charge recombination – lifetime ~100 ms

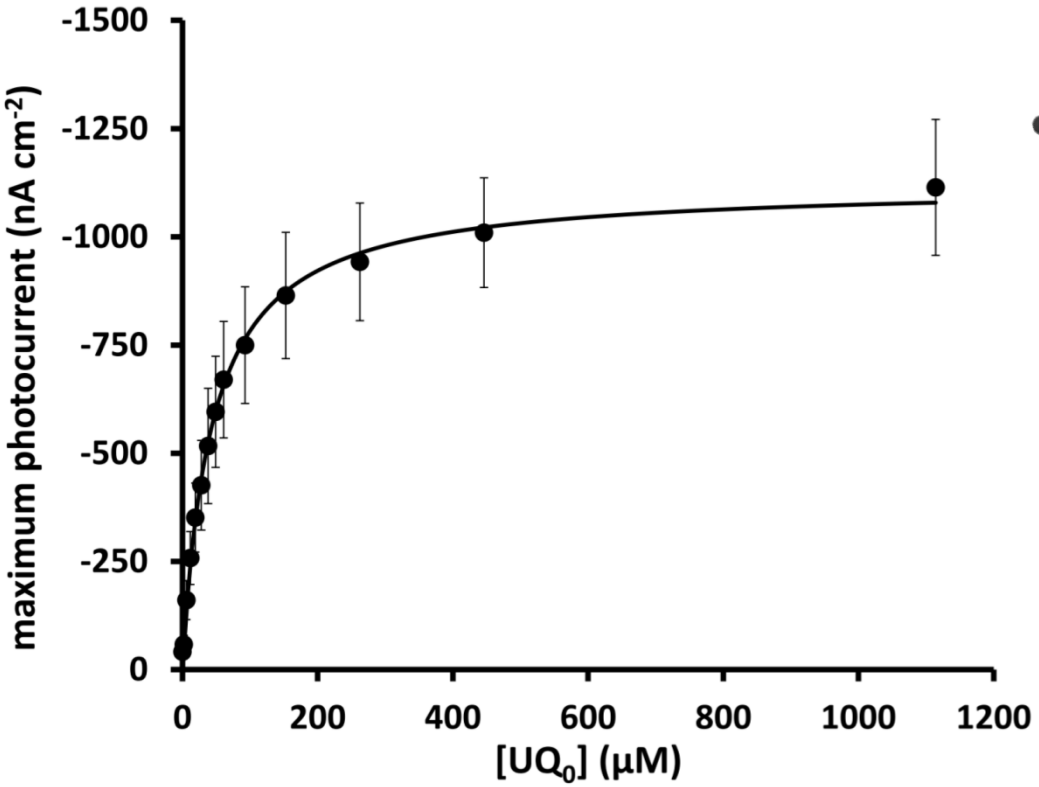
$P^+Q_B^-$ charge recombination – lifetime ~1 s

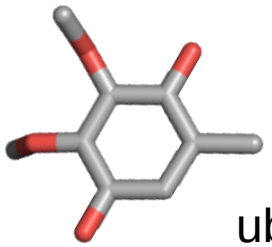
Photocurrents as a signal for biosensing?



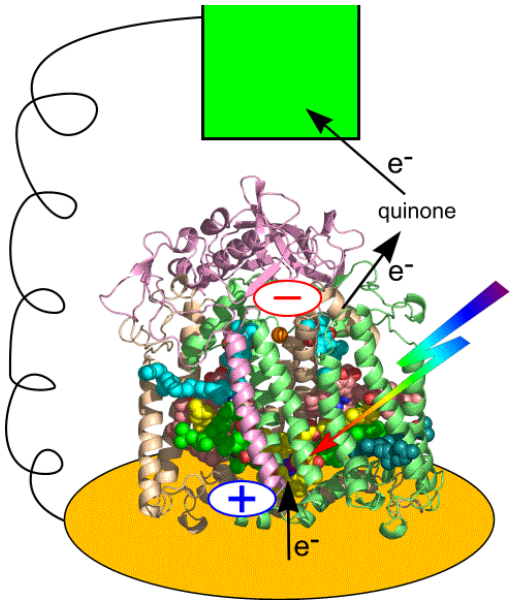


Optimum quinone concentration



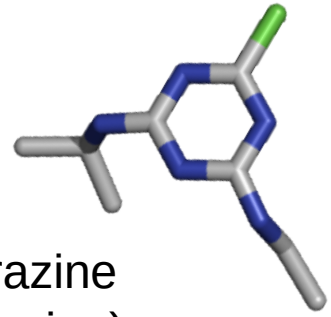


ubiquinone-0

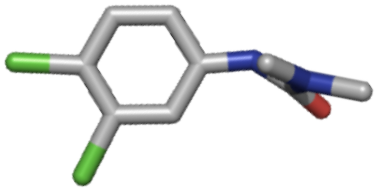


30 µM UQ_0 selected

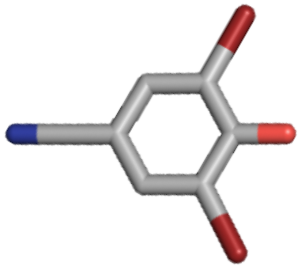
Herbicides from different classes



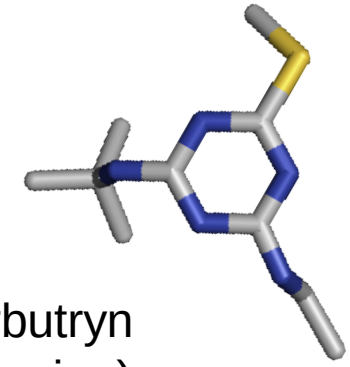
atrazine
(triazine)



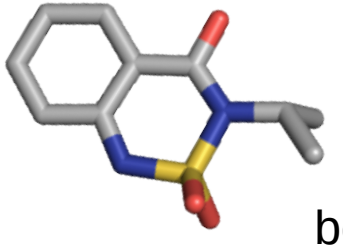
DCMU (urea)



bromoxynil
(nitrile)



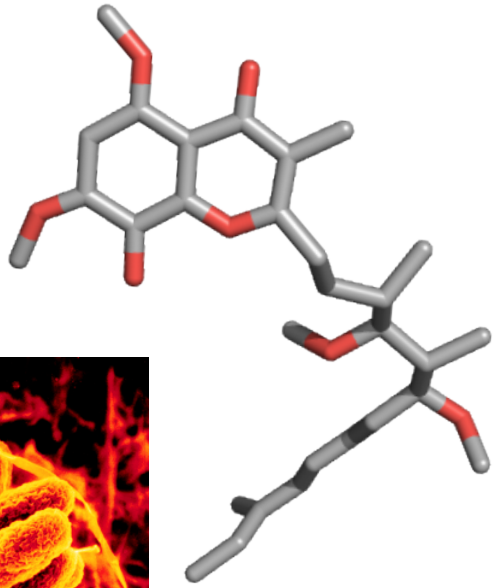
terbutryn
(triazine)

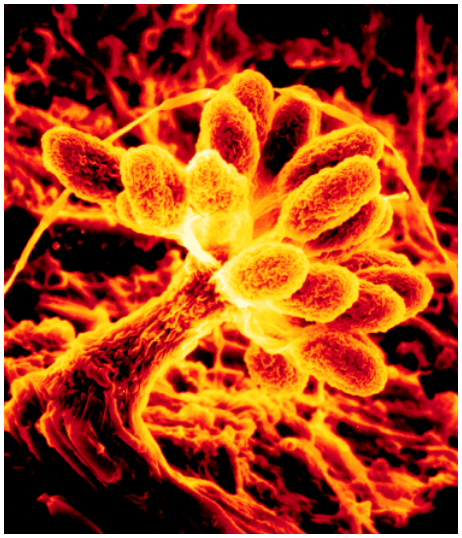


bentazon
(thiadiazine)

Strong and weak Q_B inhibitors

stigmatellin

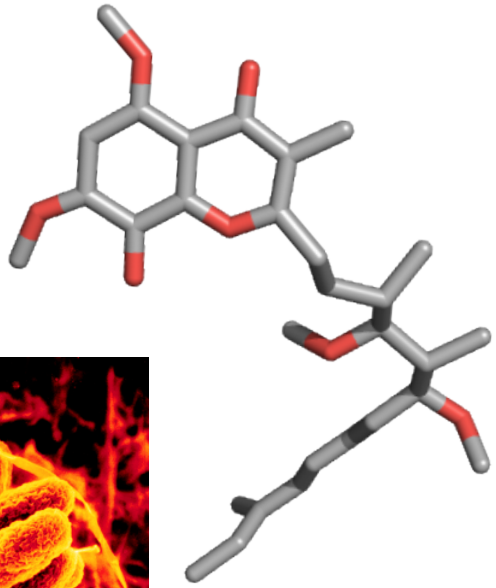




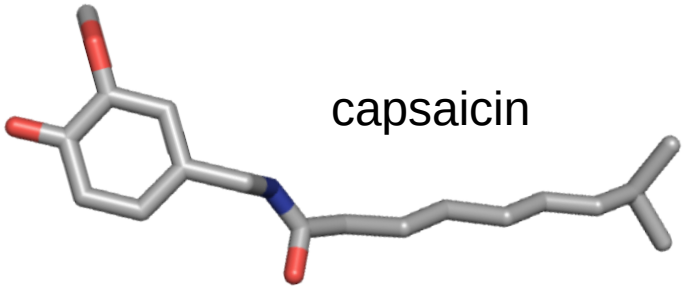
Fruiting bodies of
the myxobacterium
Stigmatella aurantiaca

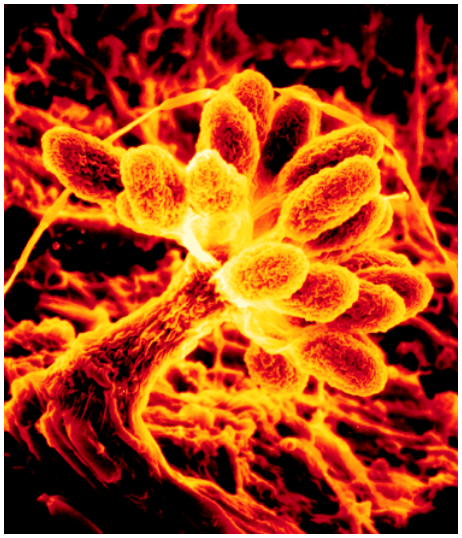
Strong and weak Q_B inhibitors

stigmatellin



capsaicin





Fruiting bodies of
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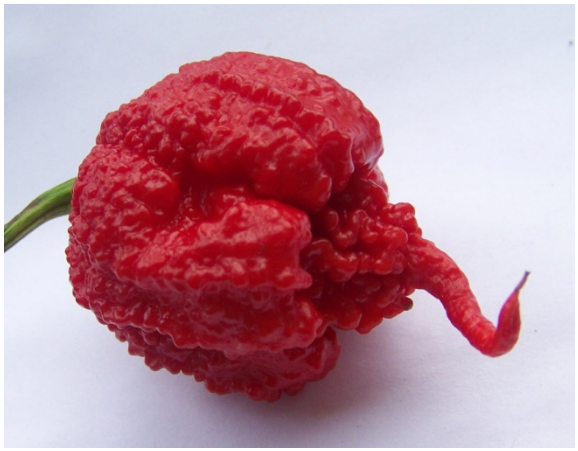
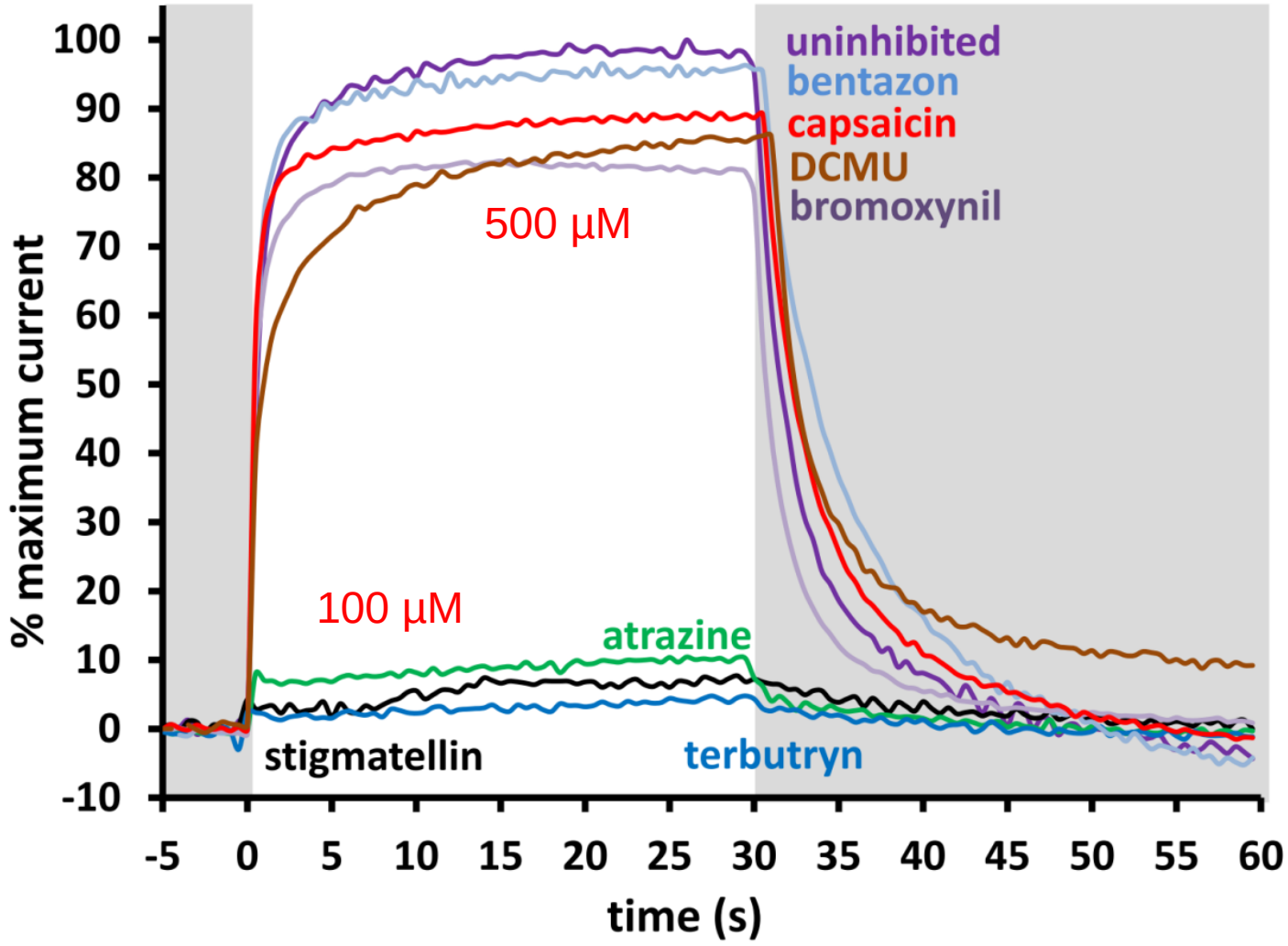
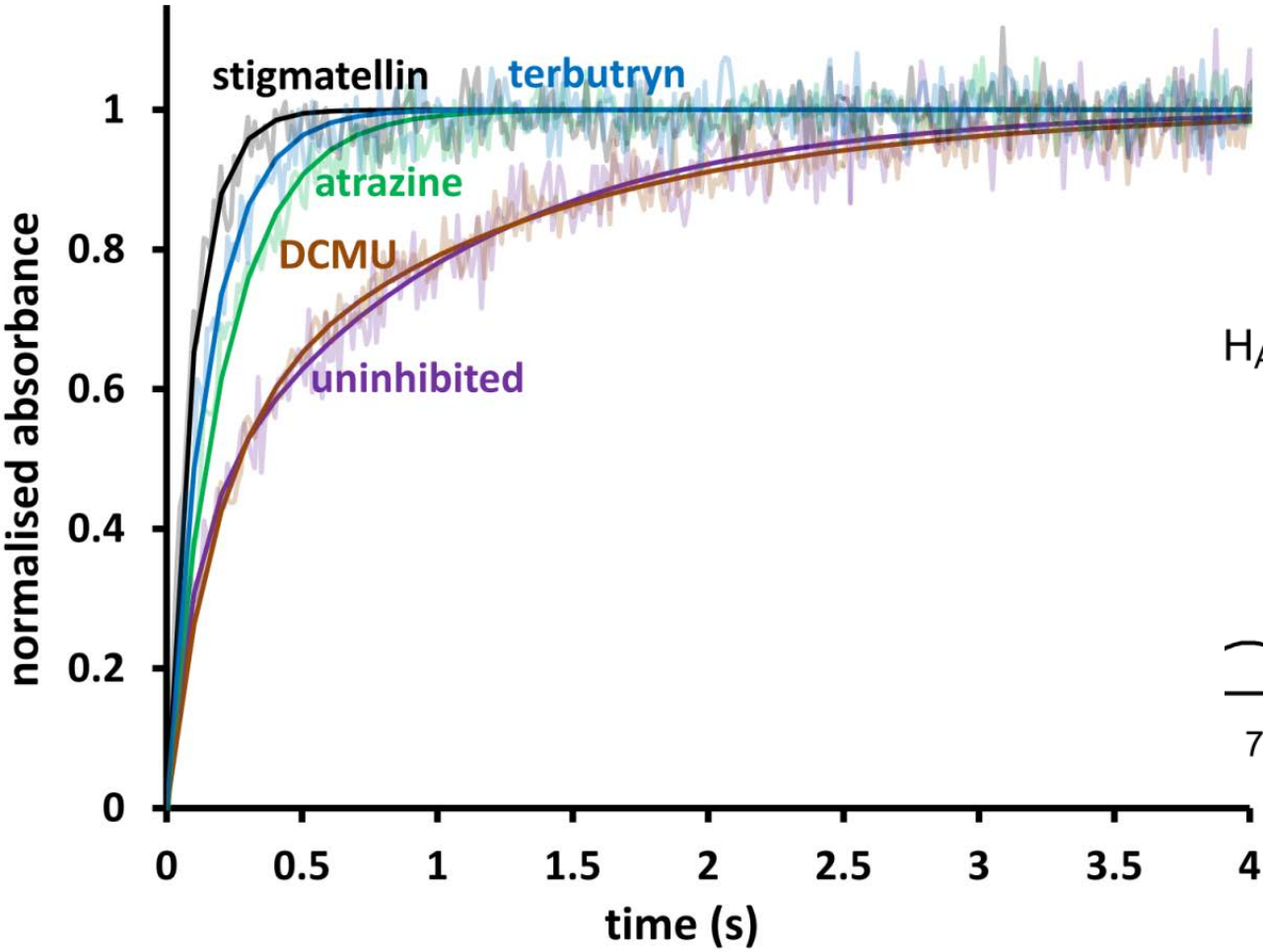


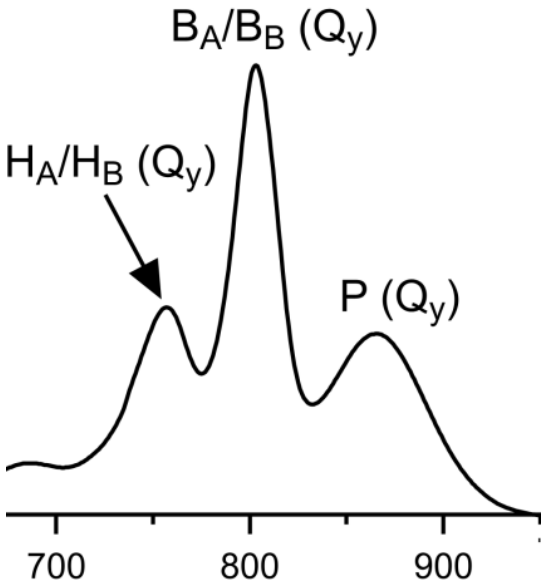
Carolina Reaper chilli pepper
Average 1,569,300 units on
the Scoville heat scale

Photocurrents sensitive to triazine herbicides

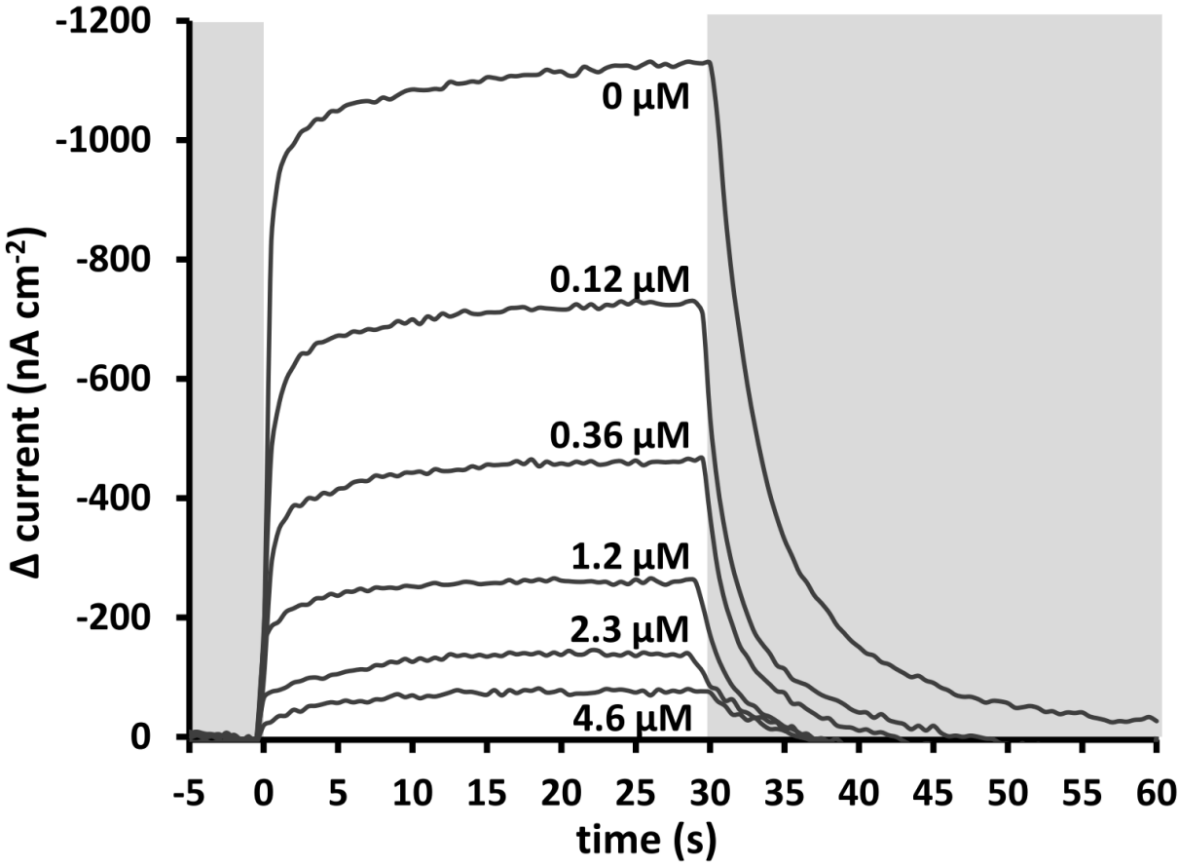


Recombination accelerated by triazines

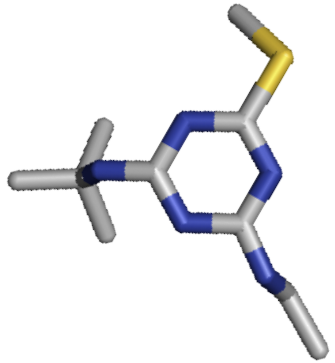




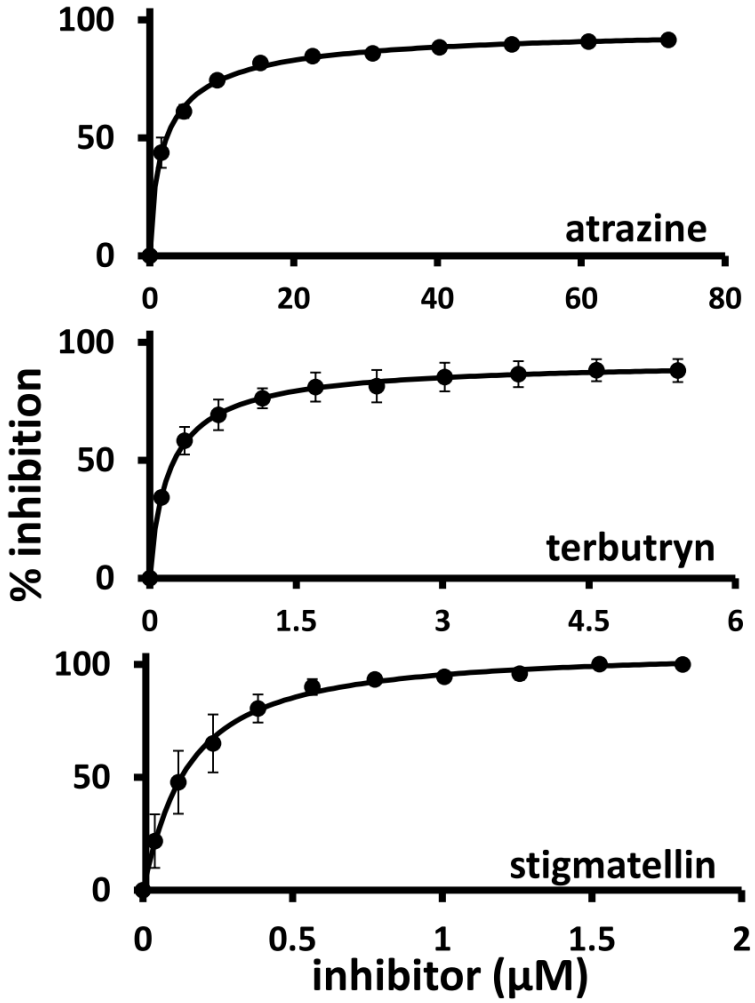
Current attenuation is concentration dependent



terbutryn



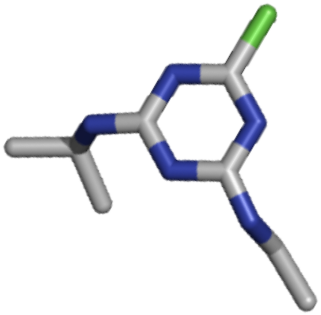
Current attenuation is concentration dependent

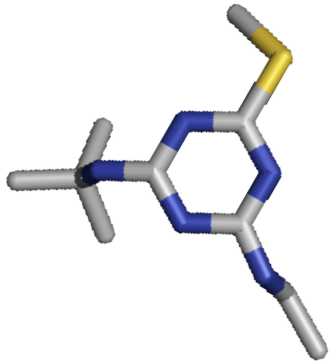


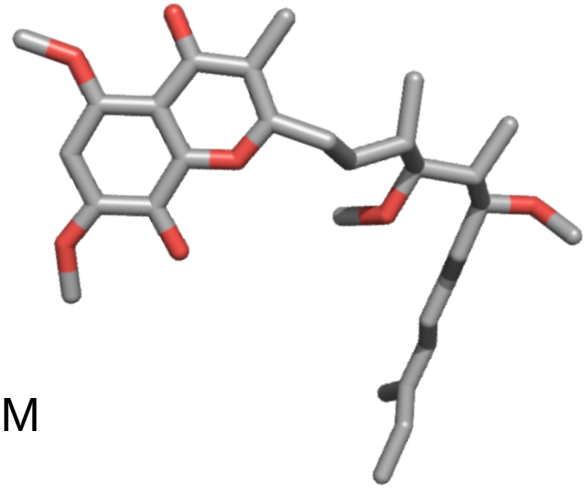
Sensitivity to triazine herbicides

Table 1
Sensitivity of photocurrent generation to effective Q_B inhibitors.

Inhibitor	IC_{50}[a] (nM)	Calculated K_i[b] (nM)	LOD[c] (nM)
Atrazine	2100 ± 100	1200	49
Terbutryn	208 ± 10	123	8.3
Stigmatellin	280 ± 60	165	10







pbRC – IC_{50} of 750-3000 nM and LOD of 40-170 nM

PSII – IC_{50} of 50-900 nM and LOD of 1-2 nM

Maximum permitted concentration in EU drinking water 2 nM

Advantages and disadvantages over PSII

Advantages

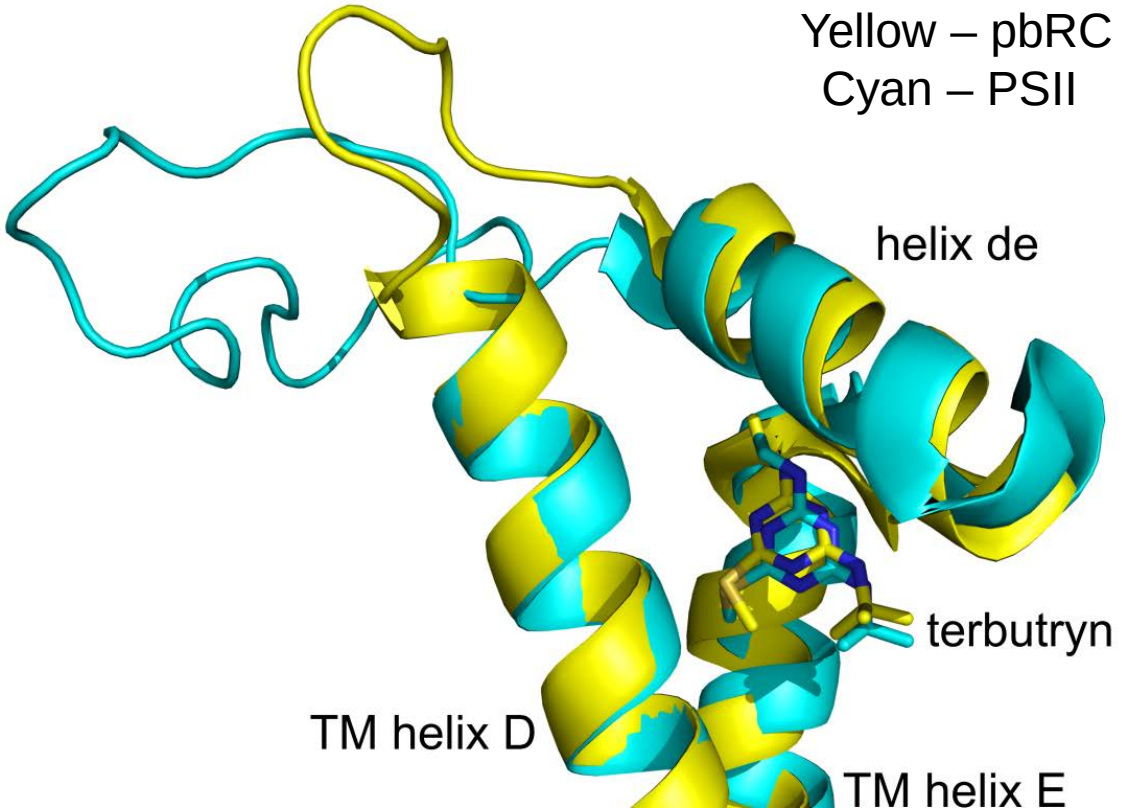
Selectivity for triazines

Reasonable stability

Amenable to mutation

Disadvantages

Lower sensitivity



Seeking sensitivity but saving selectivity

Advantages

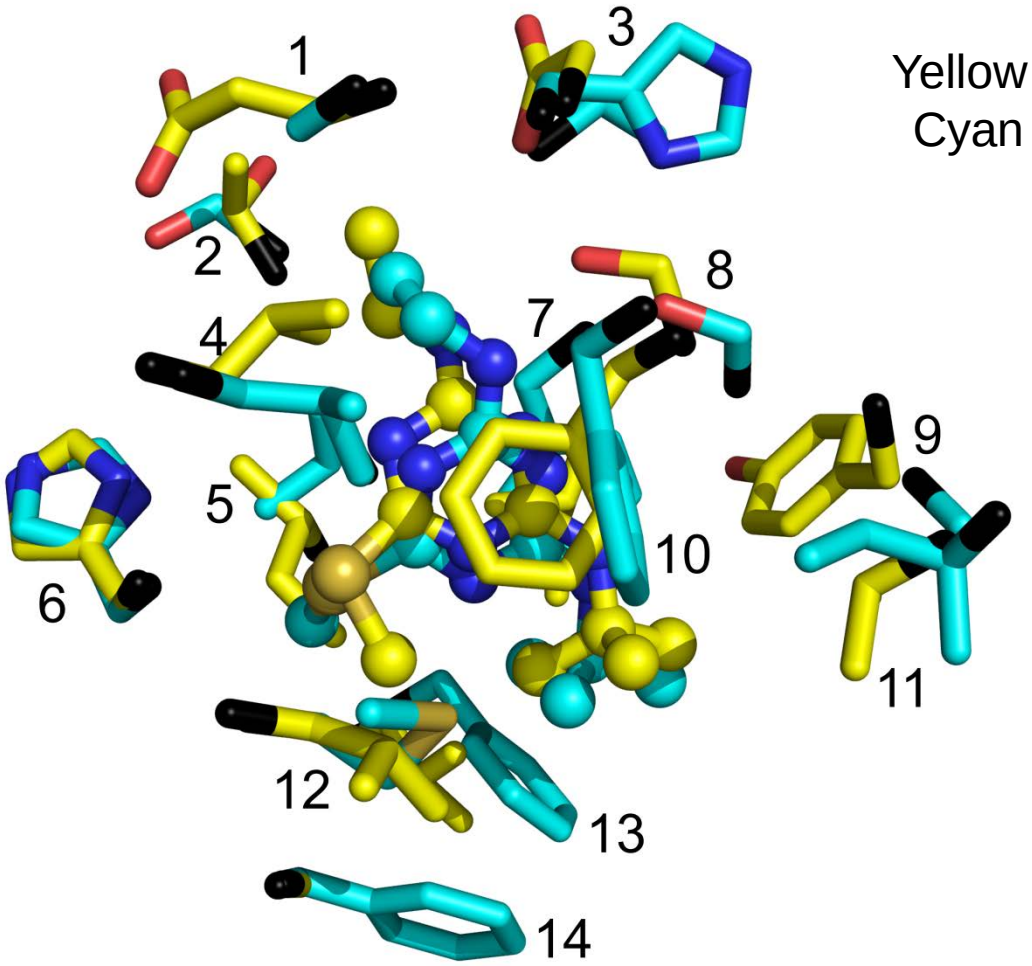
Selectivity for triazines

Reasonable stability

Amenable to mutation

Disadvantages

Lower sensitivity



Yellow – pbRC
Cyan – PSII

Purple bacterial RCs as a herbicide biosensor

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Evaluation of a biohybrid photoelectrochemical cell employing the purple bacterial reaction centre as a biosensor for herbicides

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David Swainsbury
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Raoul Frese

BBSRC
bioscience for the future

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