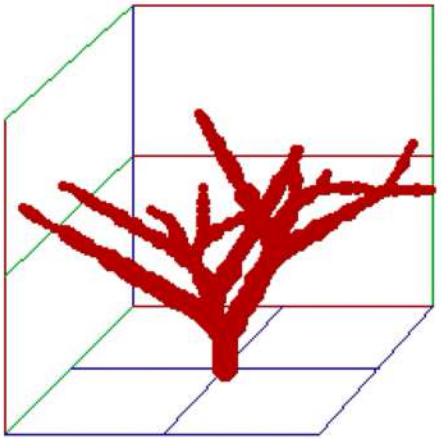


Modellazione della *vita*

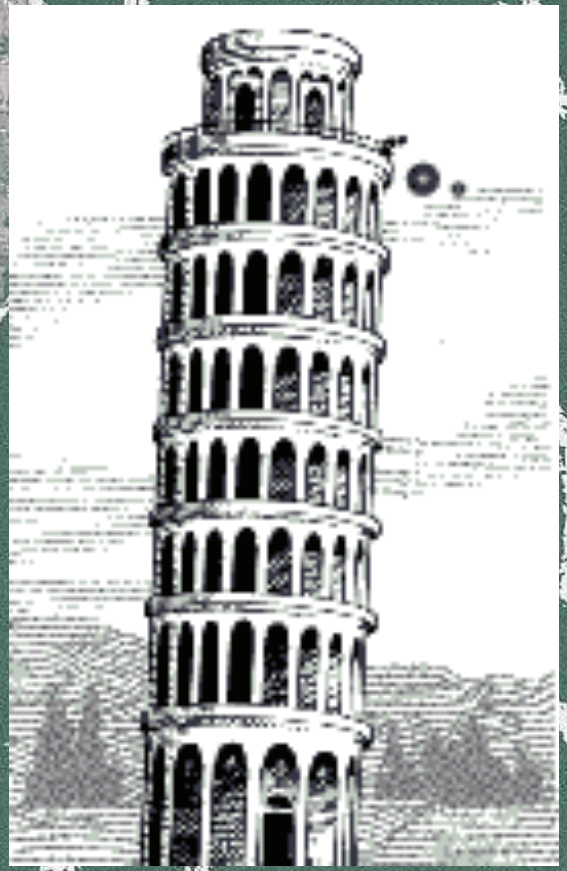
dai virus

ai coralli

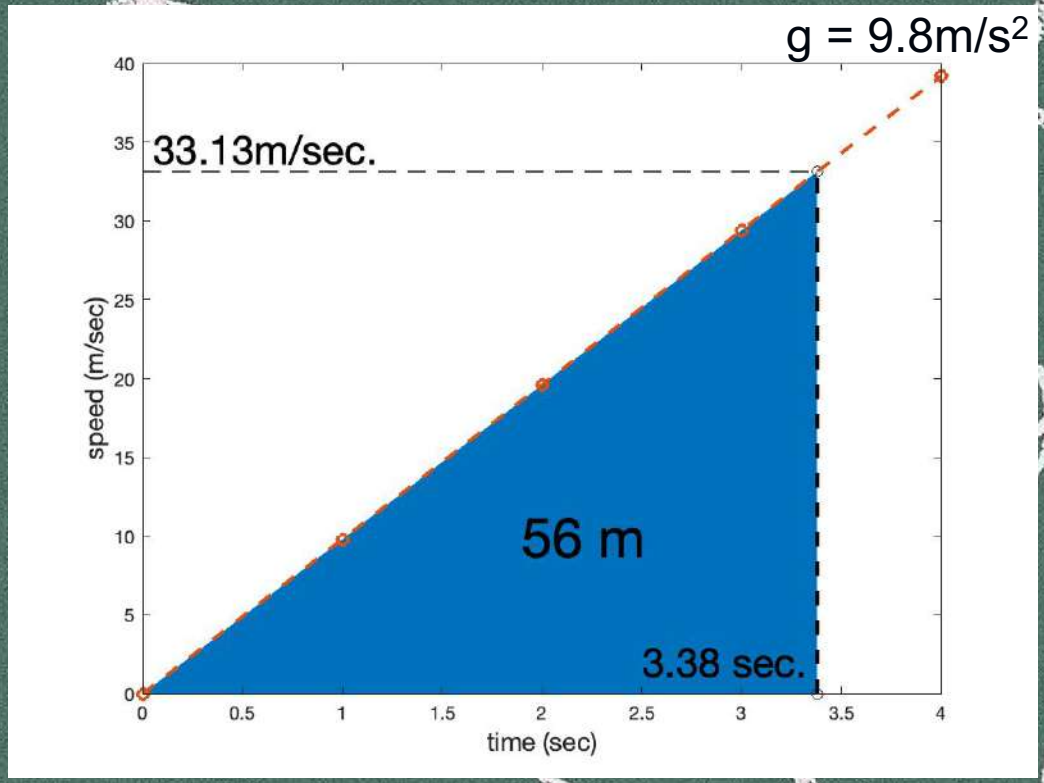
Ozan

Kahramanoğulları

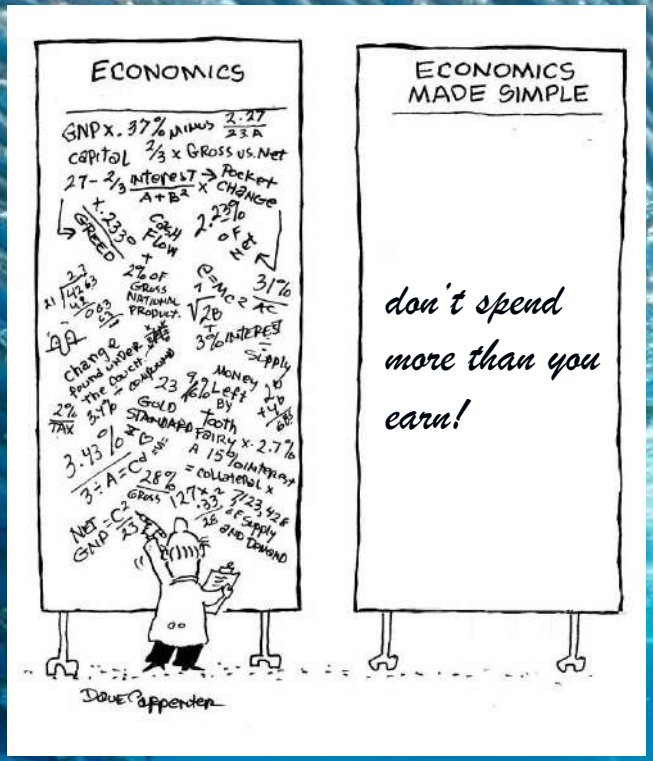
Photo credits: Lorenzo Bramanti



$g = 9.8 m/s^2$


33.13m/sec.
56 m
3.38 sec.
speed (m/sec)
time (sec)
0
5
10
15
20
25
30
35
40
0
0.5
1
1.5
2
2.5
3
3.5
4

Abstraction



Lotka – Volterra

 → 

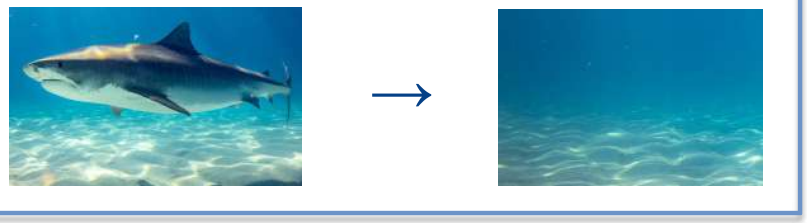
 → 2 x 

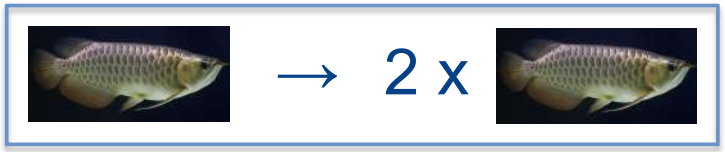
 +  → 2 x 

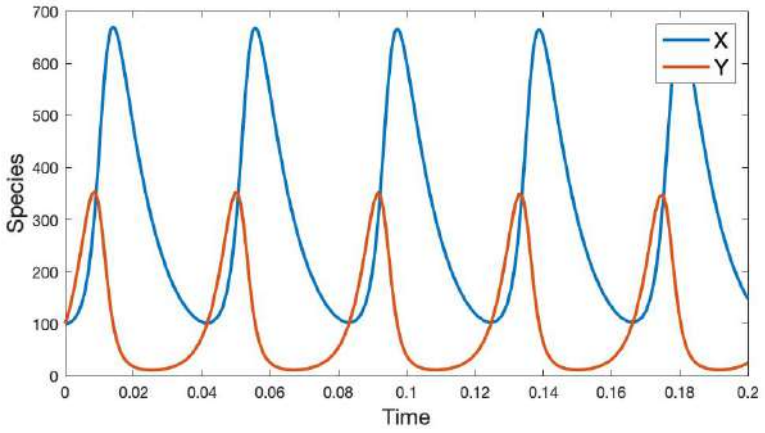
$$\frac{dX}{dt} = r3 * X * Y - r1 * X;$$

$$\frac{dY}{dt} = r2 * Y - r3 * X * Y;$$

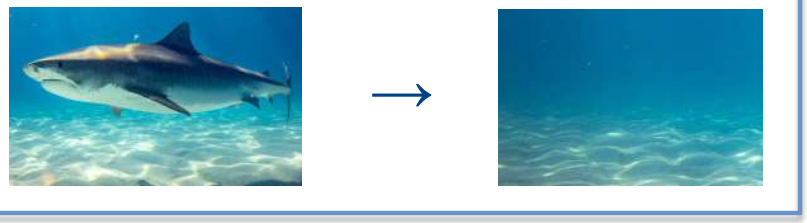
Lotka – Volterra

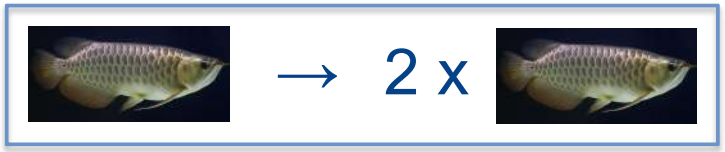


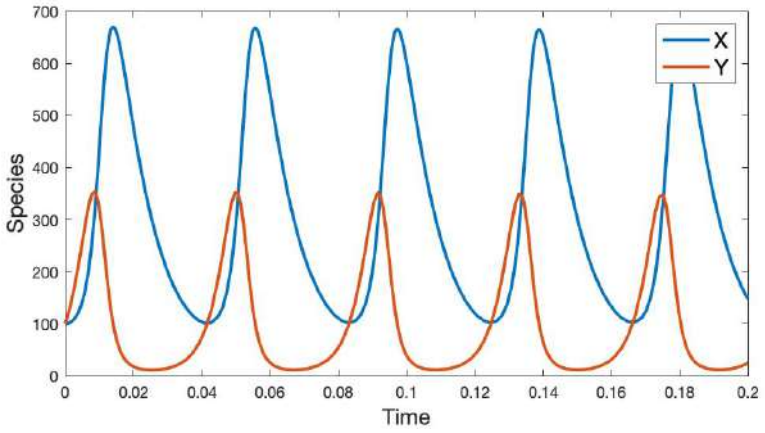


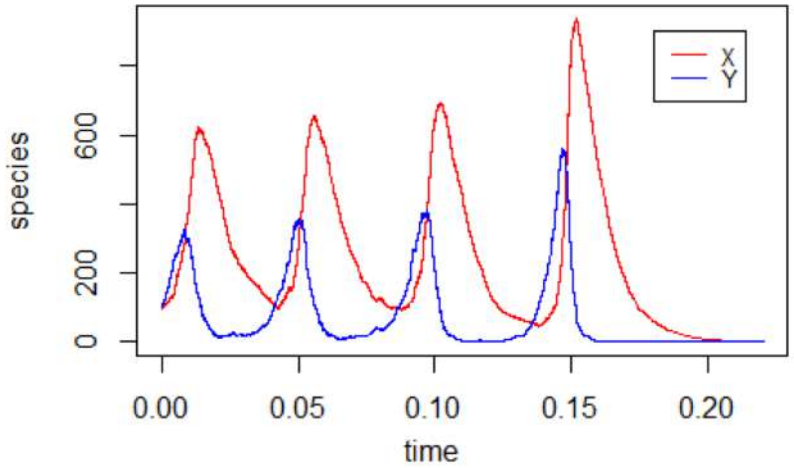


Lotka – Volterra









Infectious Disease - SIR models

Infectious Disease - SIR models

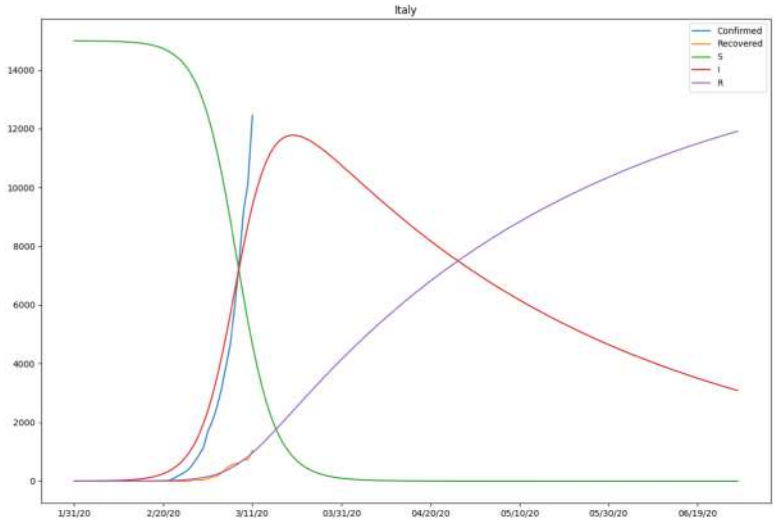
Susceptible + **I**nfectious → 2 x **I**nfectious

Infectious → **R**ecovered

$$dS/dt = - beta * I * S;$$

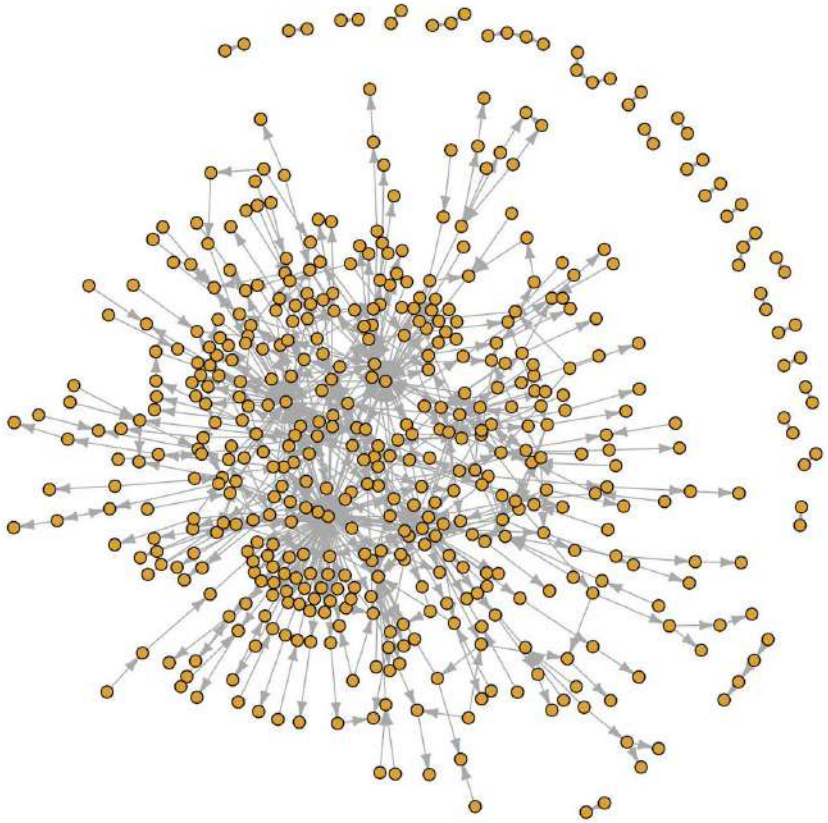
$$dI/dt = beta * I * S – gamma * I;$$

$$dR/dt = gamma * I$$

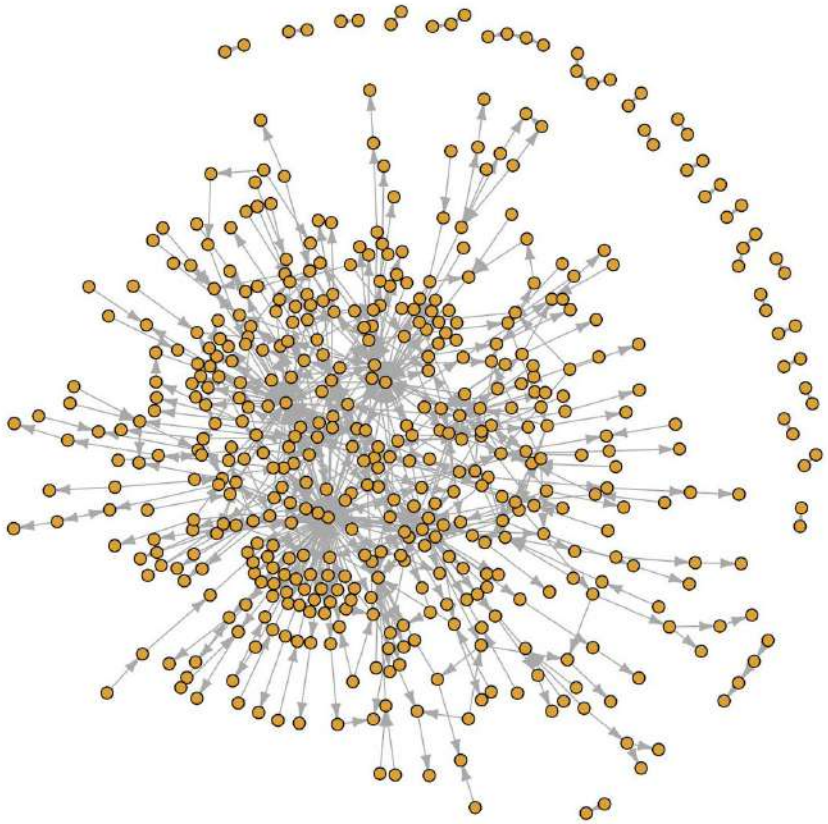


https://www.lewuathe.com/covid-19-dynamics-with-sir-model.html

Infectious Disease - SIR models – scale-free networks



Infectious Disease - SIR models – scale-free networks



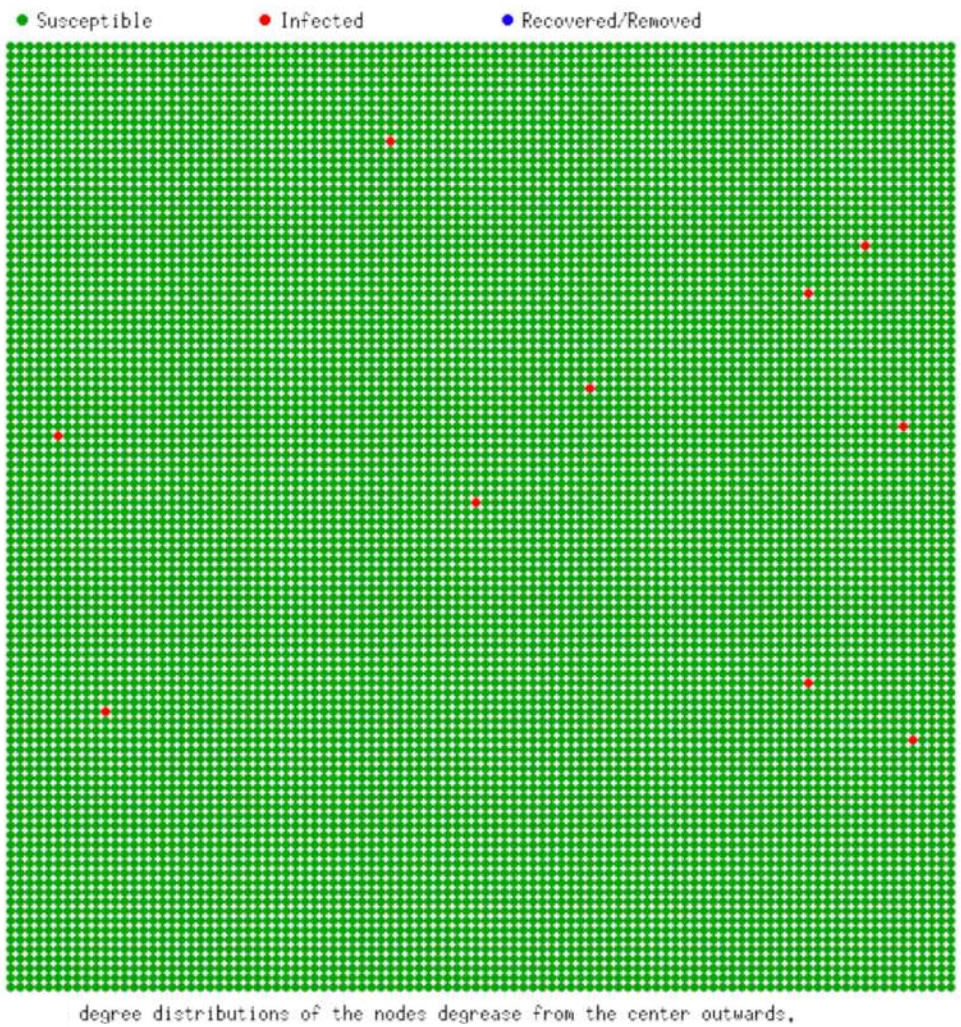
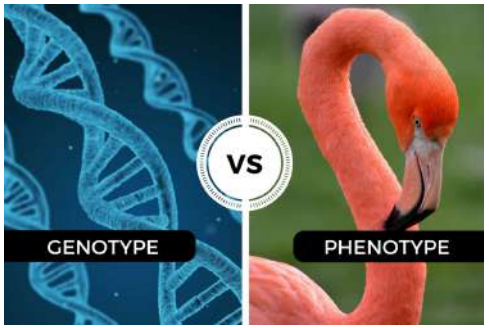


Photo credits: Lorenzo Bramanti

Phenotype = Genotype + Physical Environment

A fundamental question in biology:

What are the mechanisms that govern the phenotype?



In the organisms with bilateral symmetry:

morphology ~ genome

physical environment >>> growth process >>> variety of structural forms.

Corallium rubrum

Octocoral species, endemic to Mediterranean and neighboring habitats.

- Found on rocky bottoms,
  between 10*m* and 800*m* depth.
- Slow growing: ~ 100 years.
- High economic value:
  extensively harvested.
- The three-dimensional structuring
  of coralligenous assemblages.

Credits: Lorenzo Bramanti

- Local extirpation influences the habitat and biodiversity.

Corallium rubrum

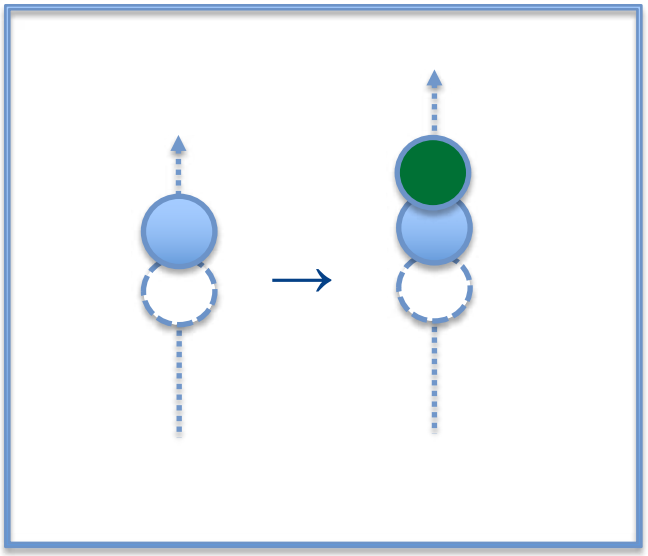
- The colony skeleton has a branching form.
- Calcium carbonate deposited by polyps.
- The colonies exhibit wide variability in growth forms.

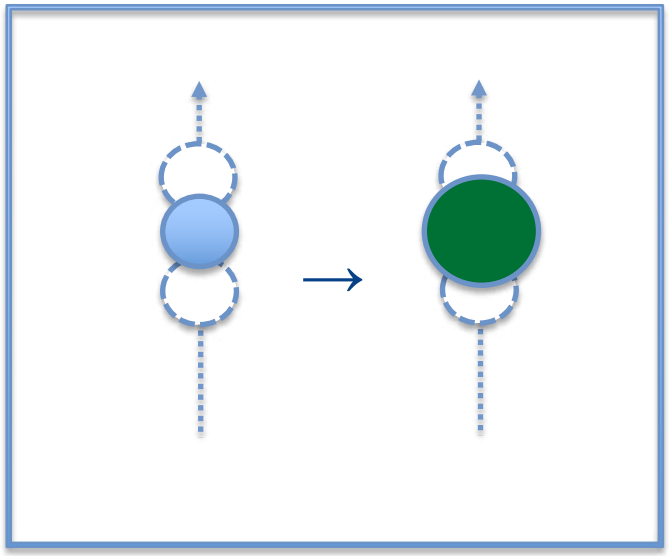
Credits: Lorenzo Bramanti

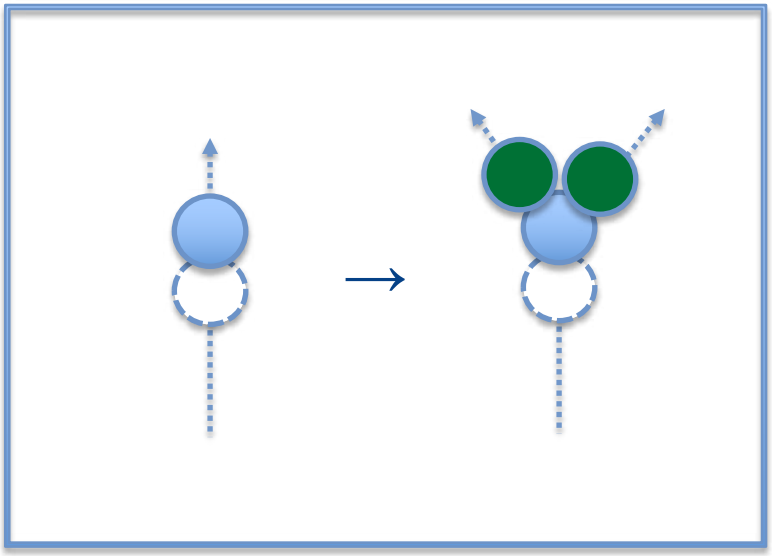
Credits: Lorenzo Bramanti

The variations are linked to local environmental conditions.

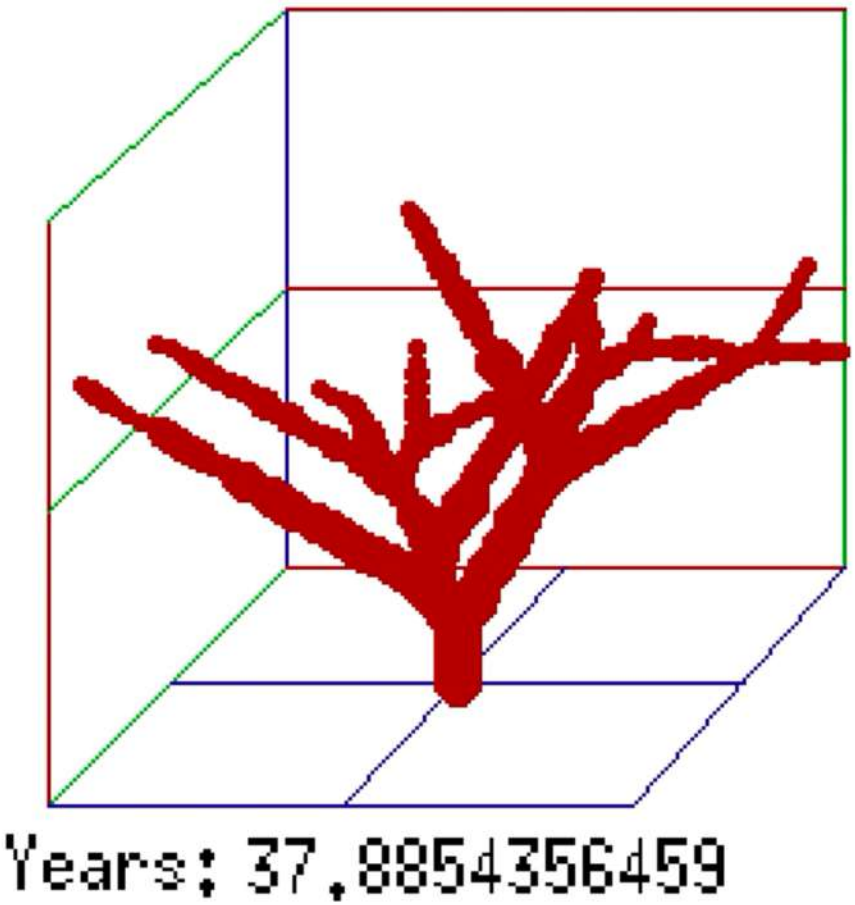
A SIMPLE MODAL OF GROWTH AND BRANCHING





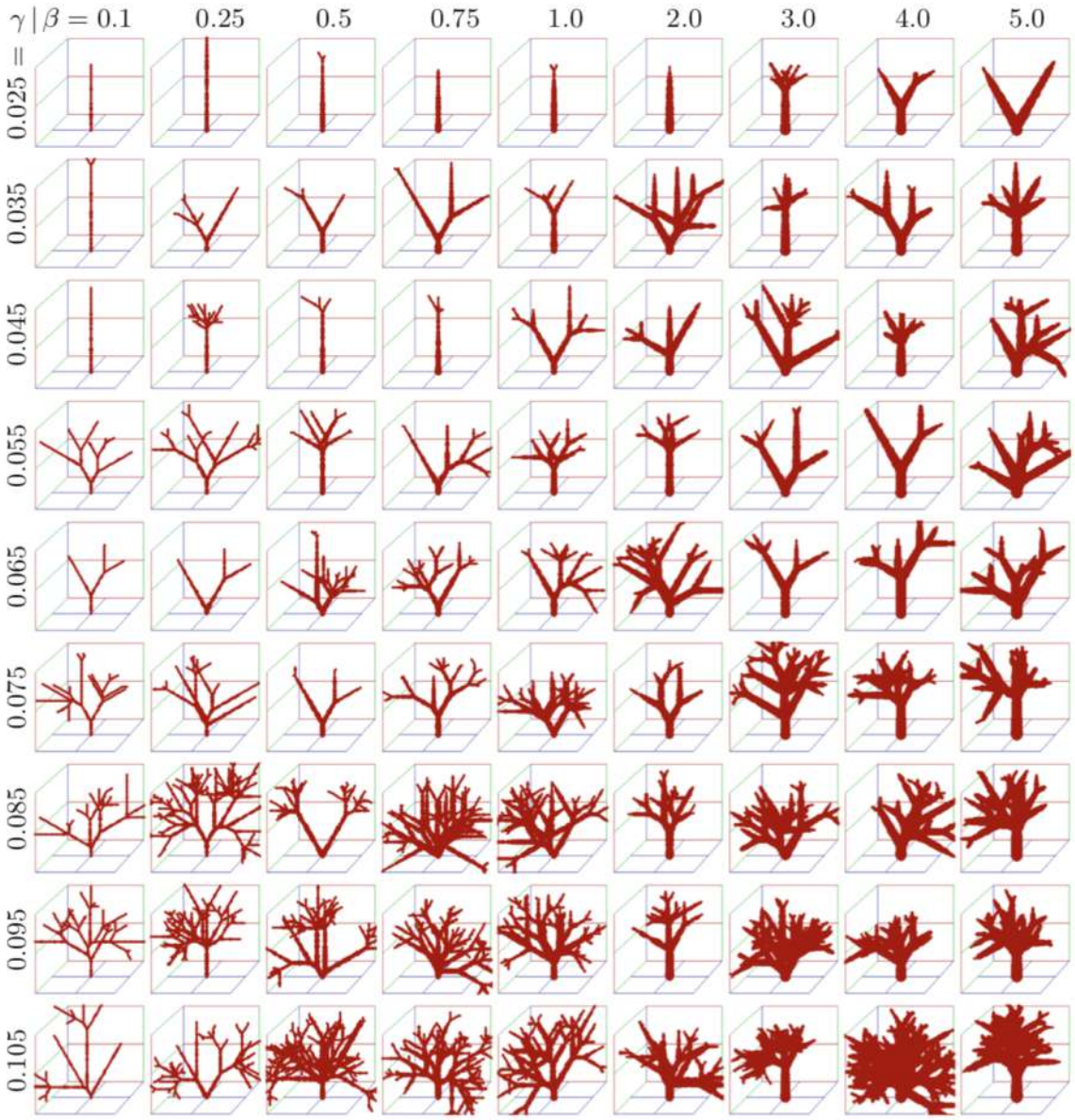


A SIMPLE MODAL OF GROWTH AND BRANCHING

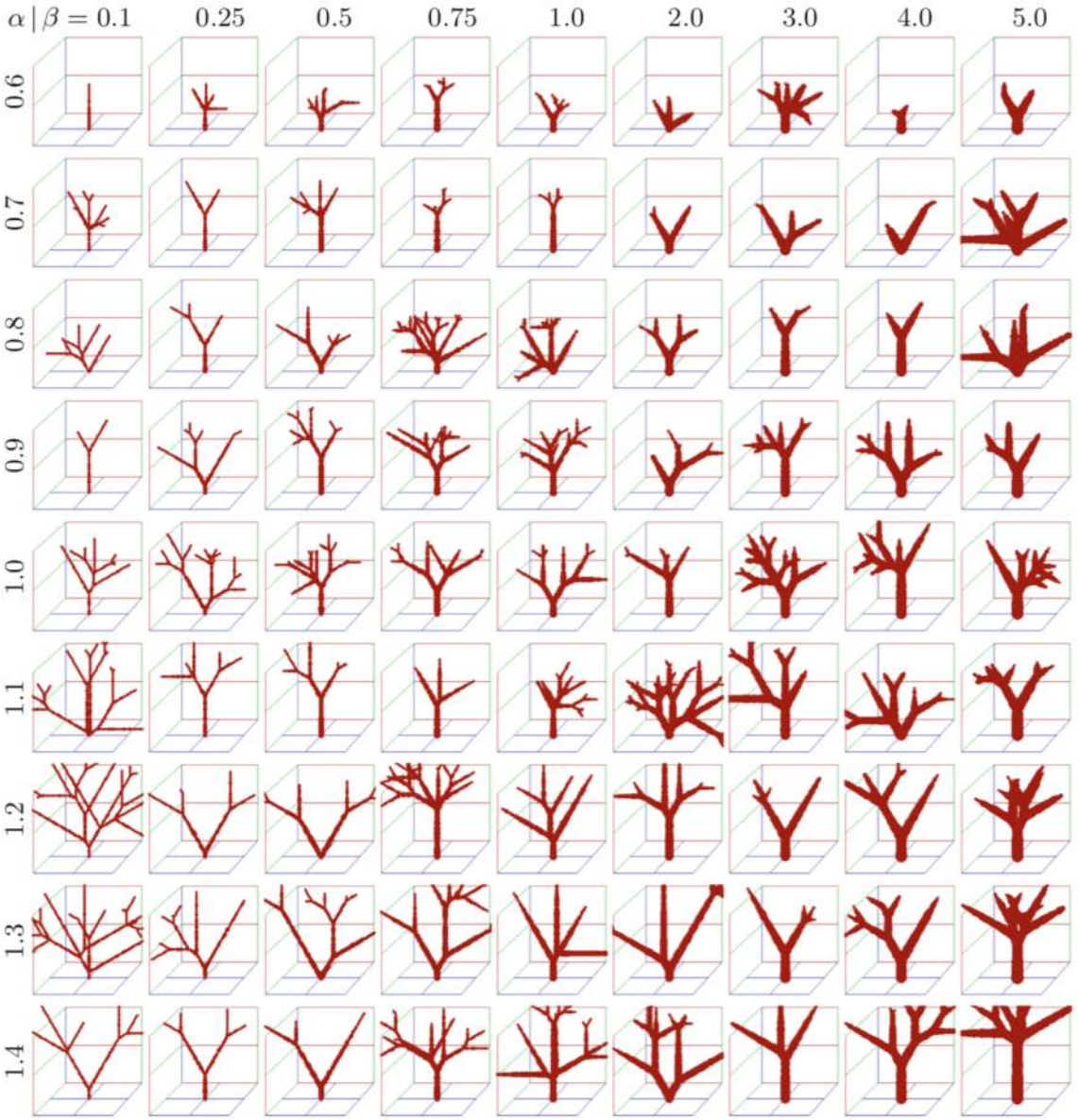


https://youtu.be/FAH1DgqUO8w

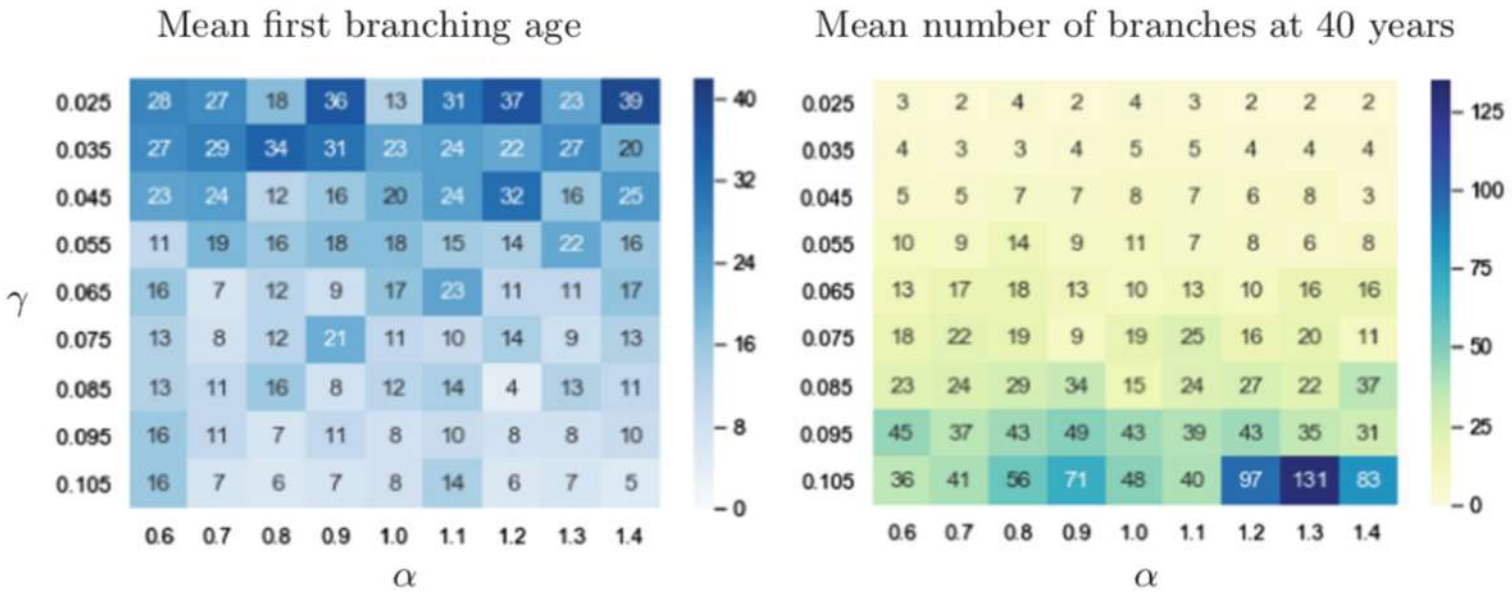
STOCHASTIC SIMULATIONS

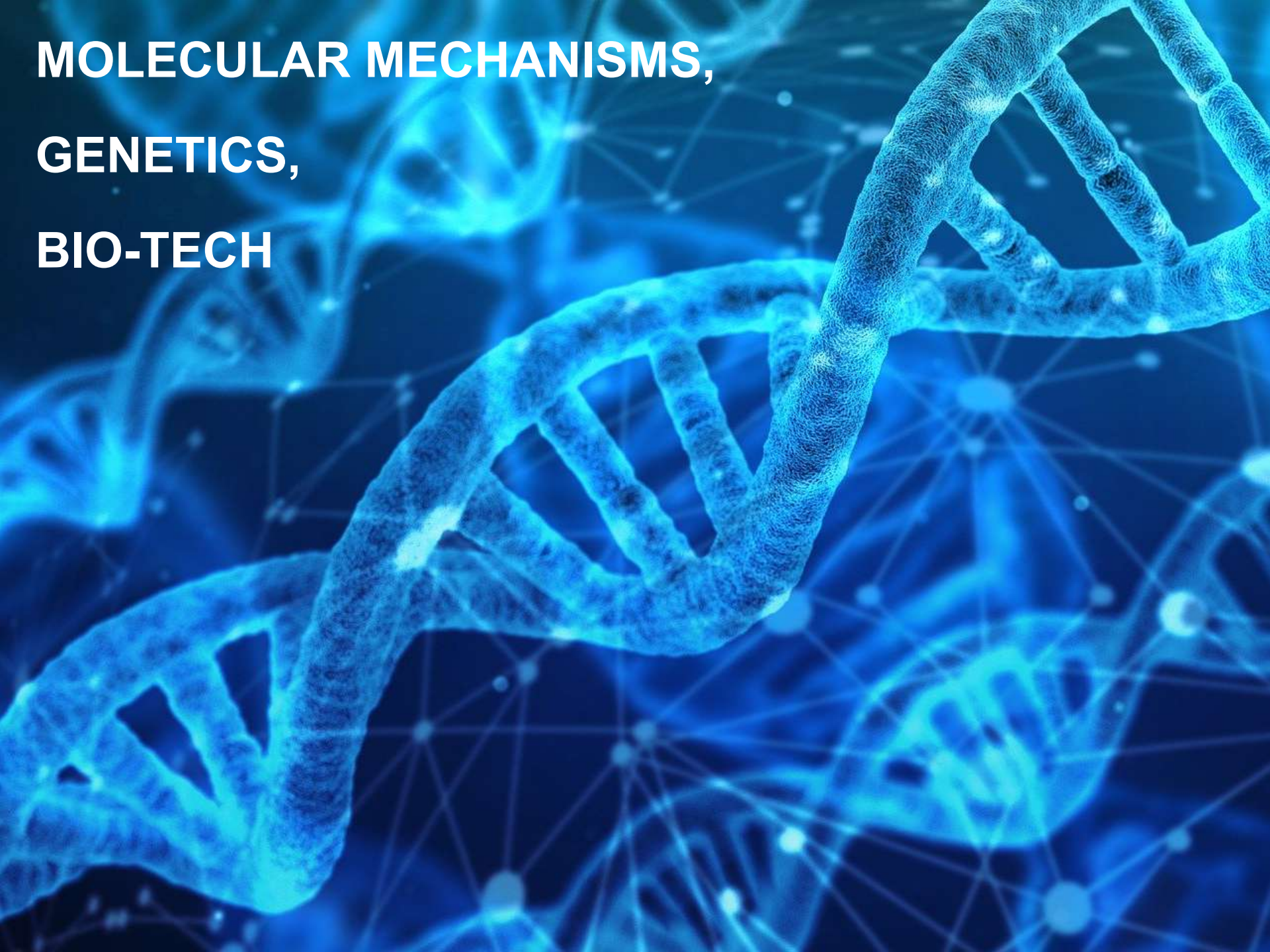


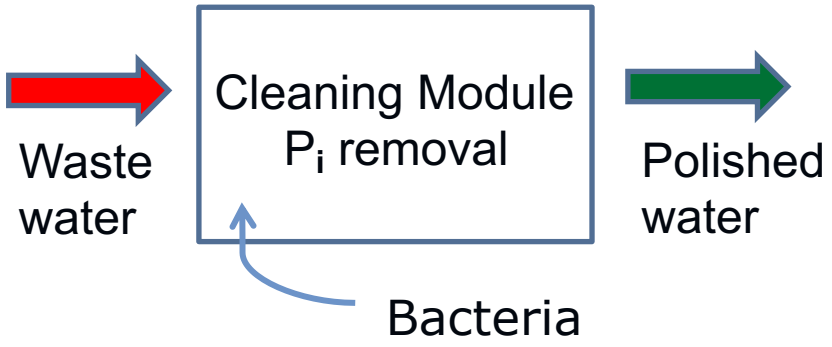
STOCHASTIC SIMULATIONS



STOCHASTIC SIMULATIONS

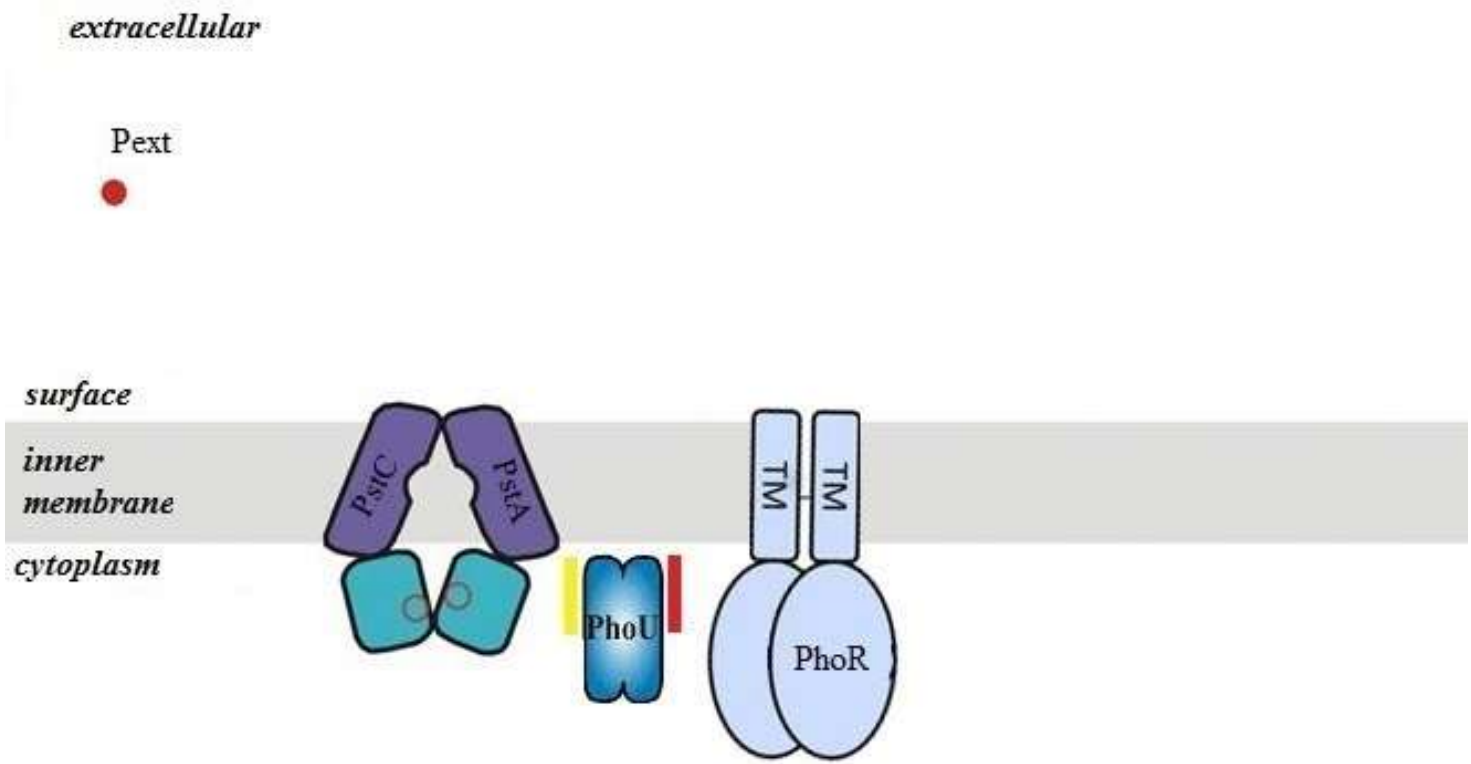



MOLECULAR MECHANISMS,
GENETICS,
BIO-TECH



SOLUTION:
removing inorganic phosphate (P_i)

How does *E. coli* sense the environmental stimuli?



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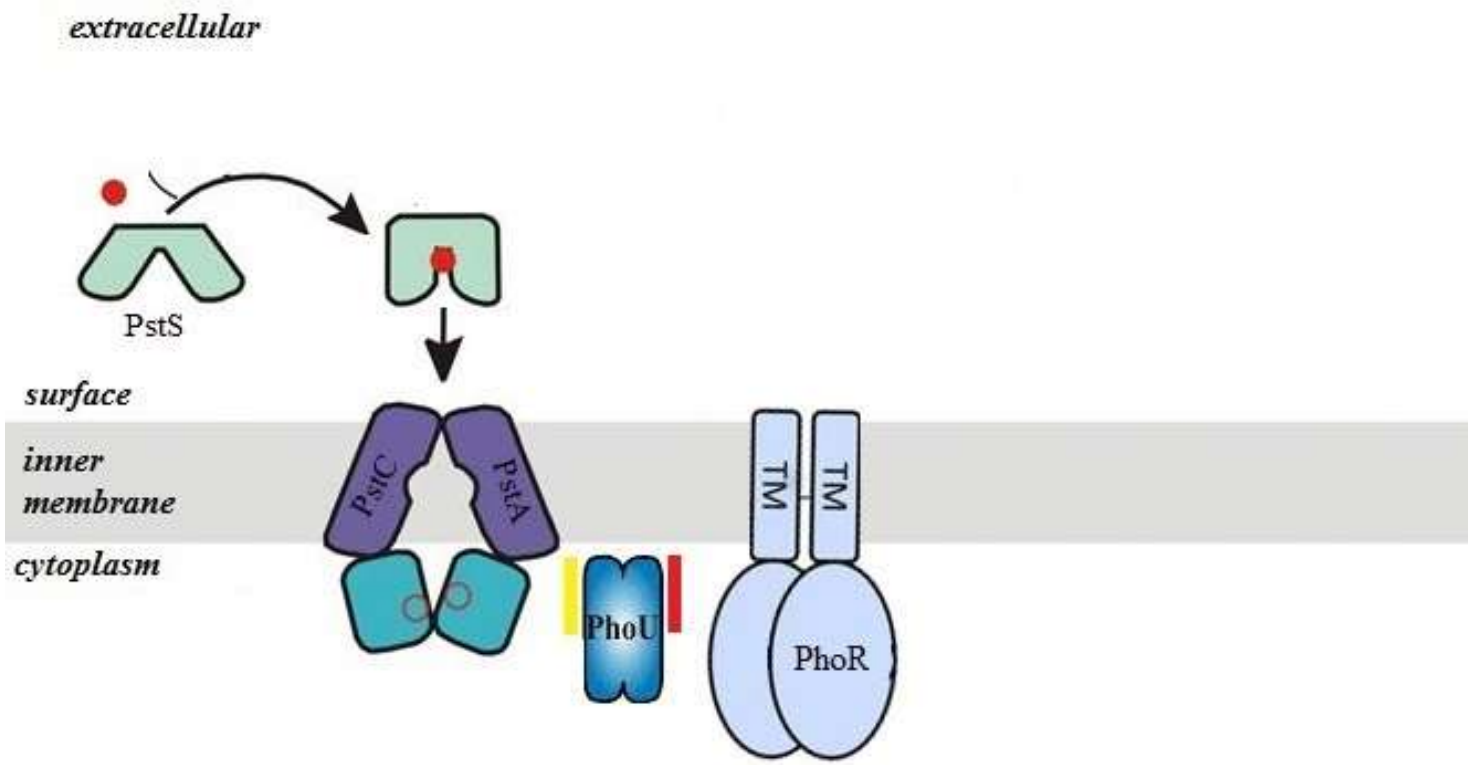

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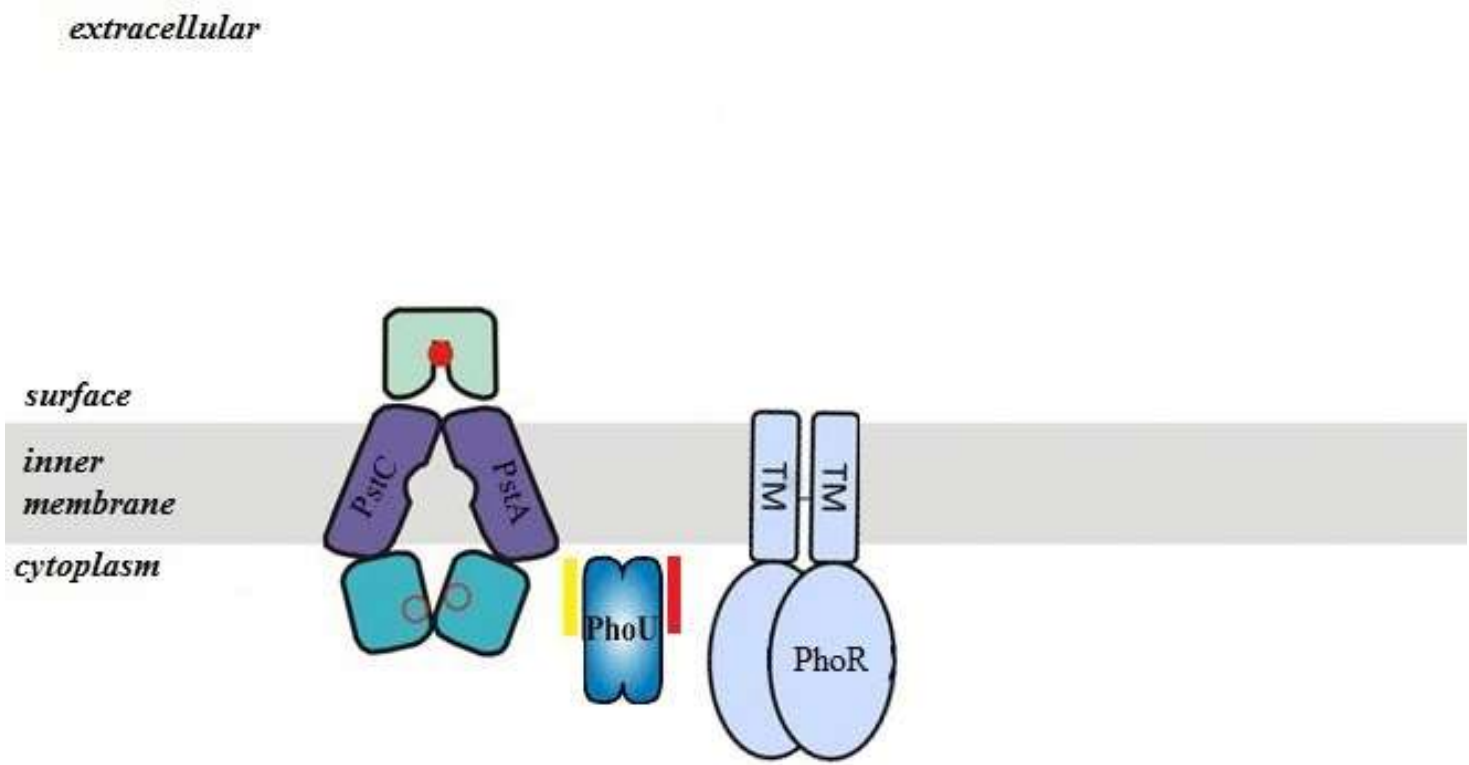

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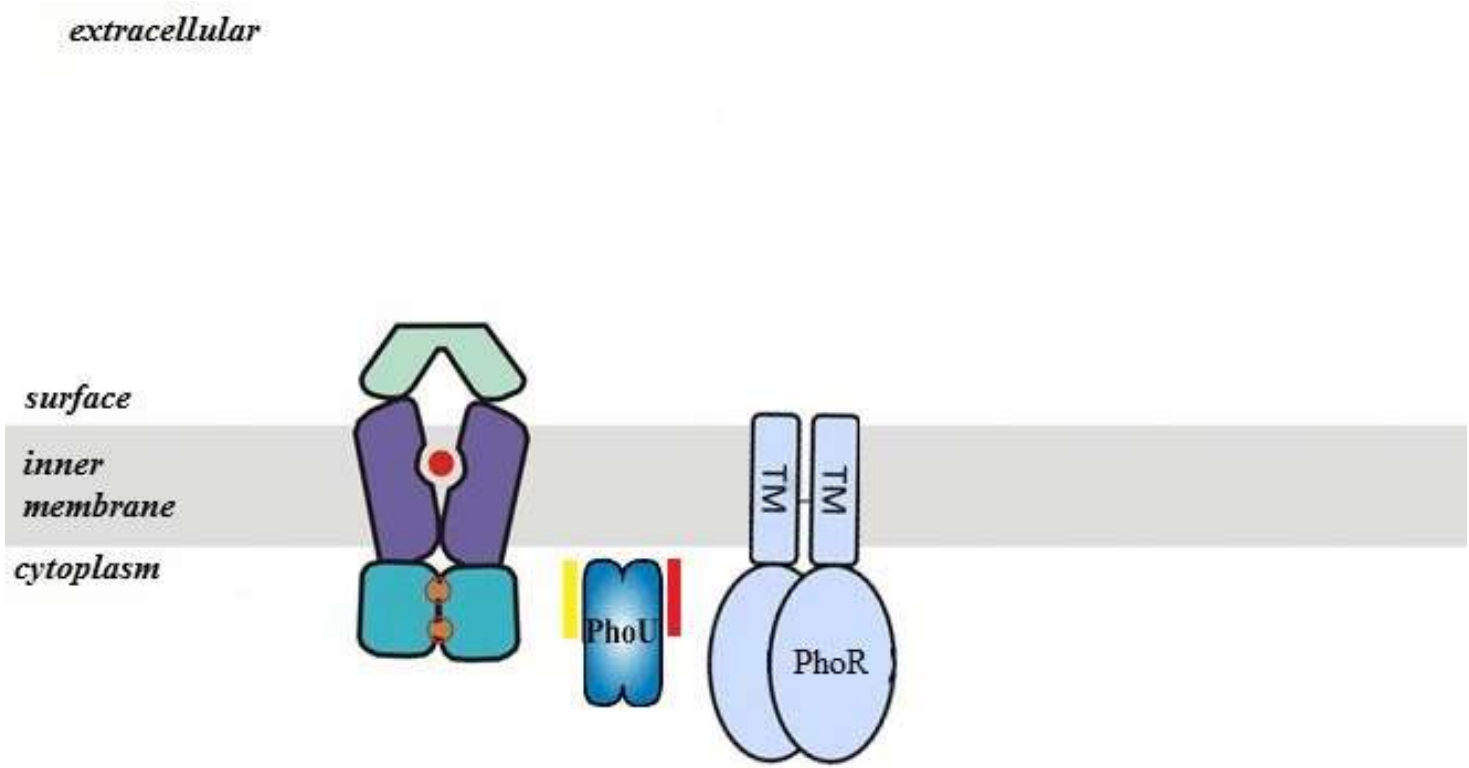

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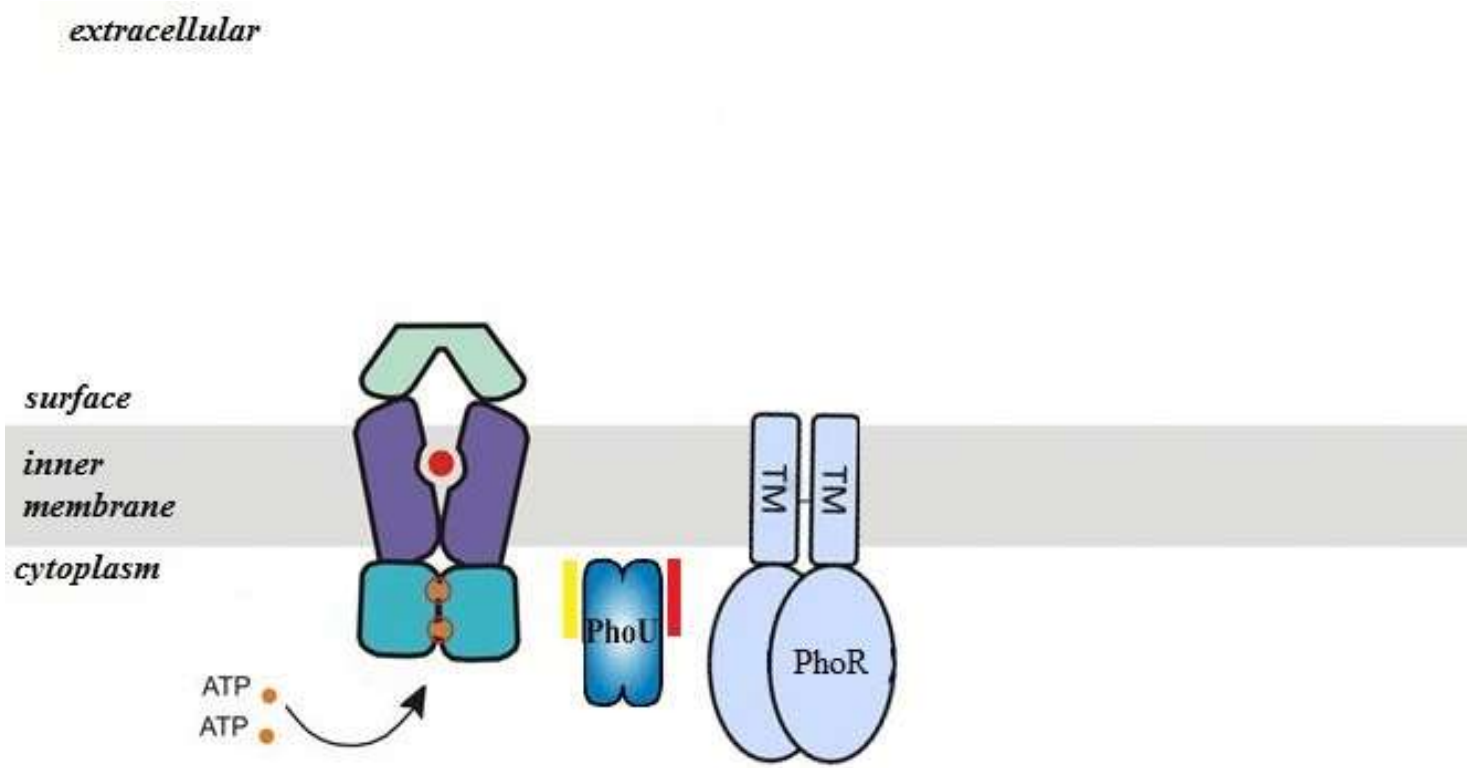

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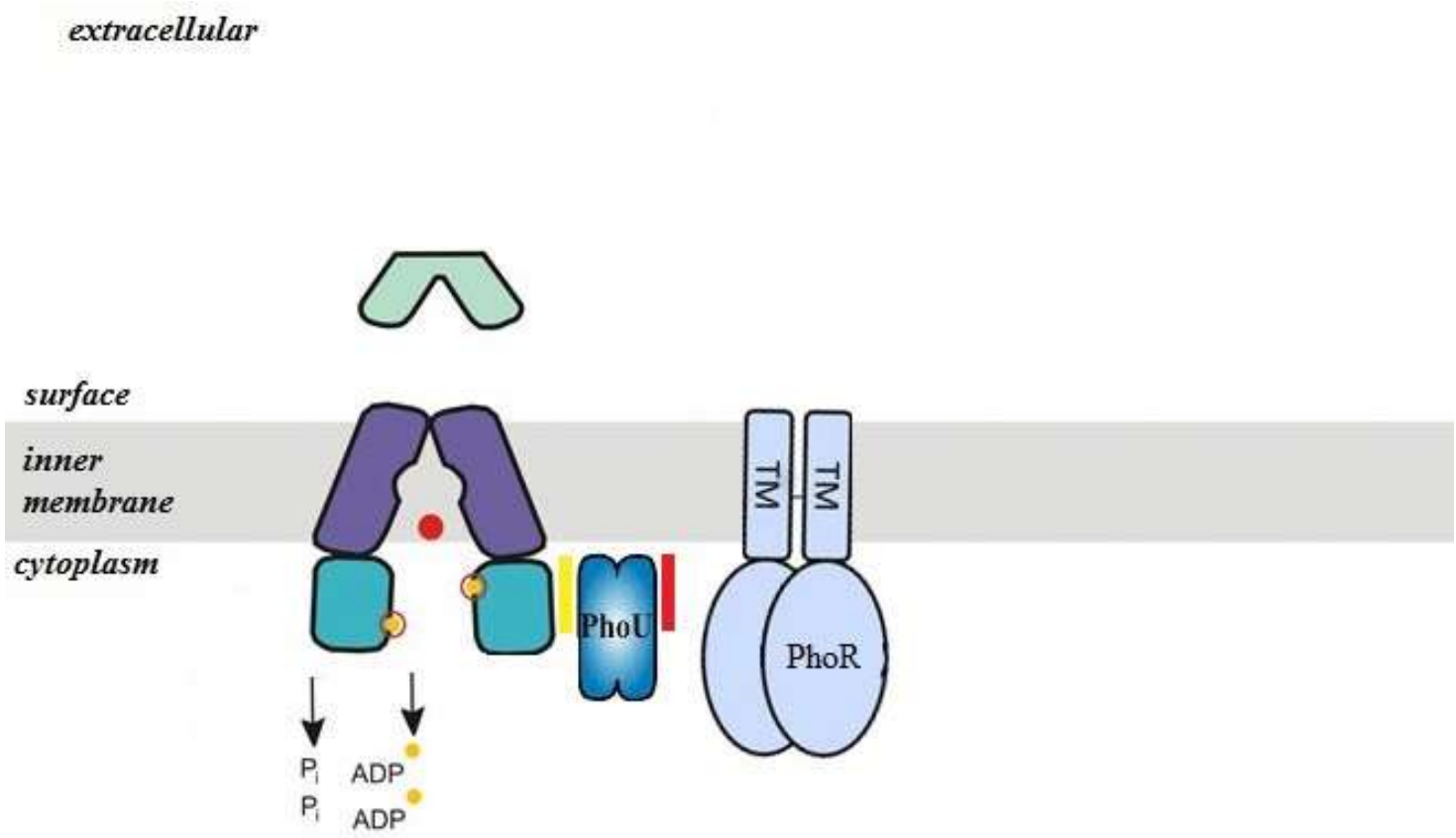

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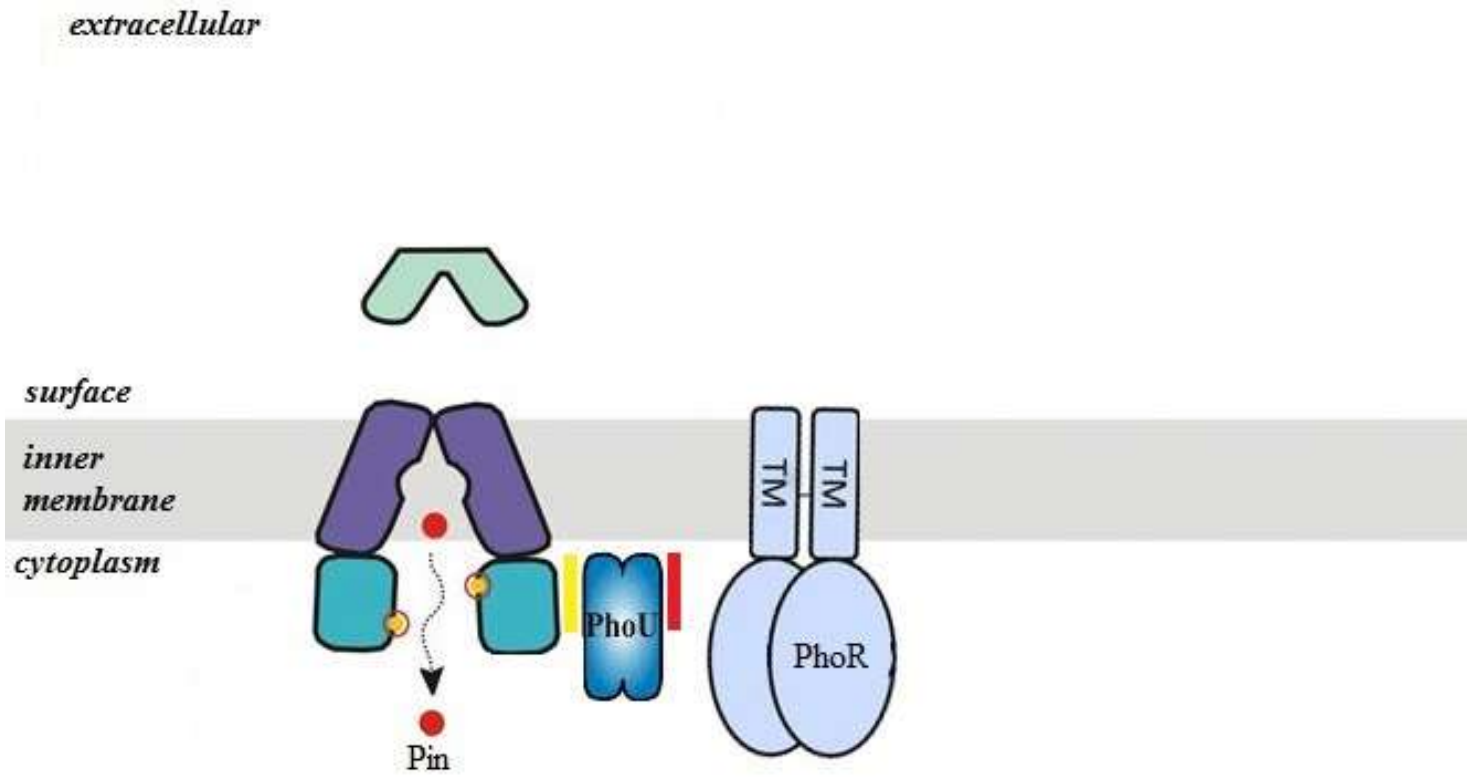

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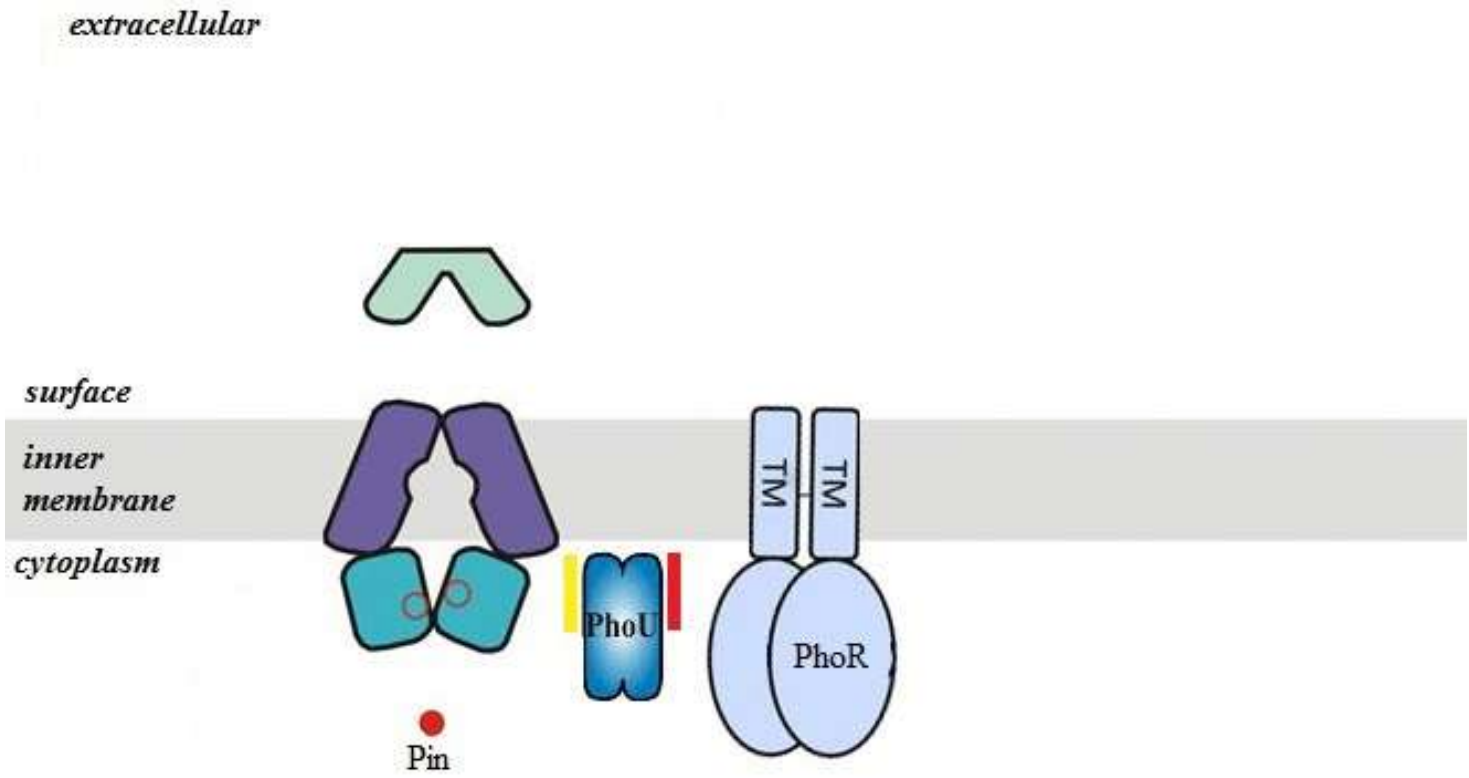

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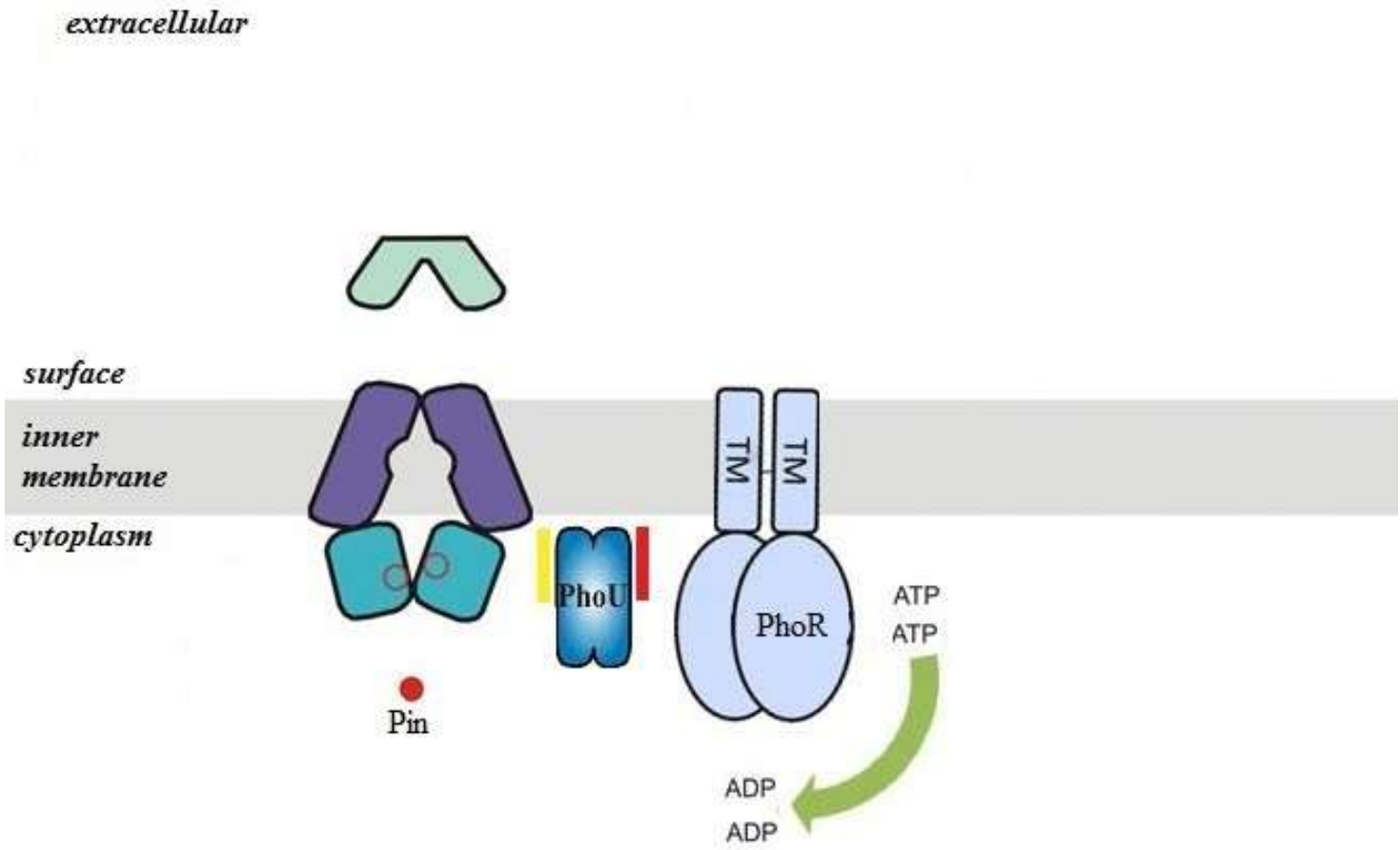

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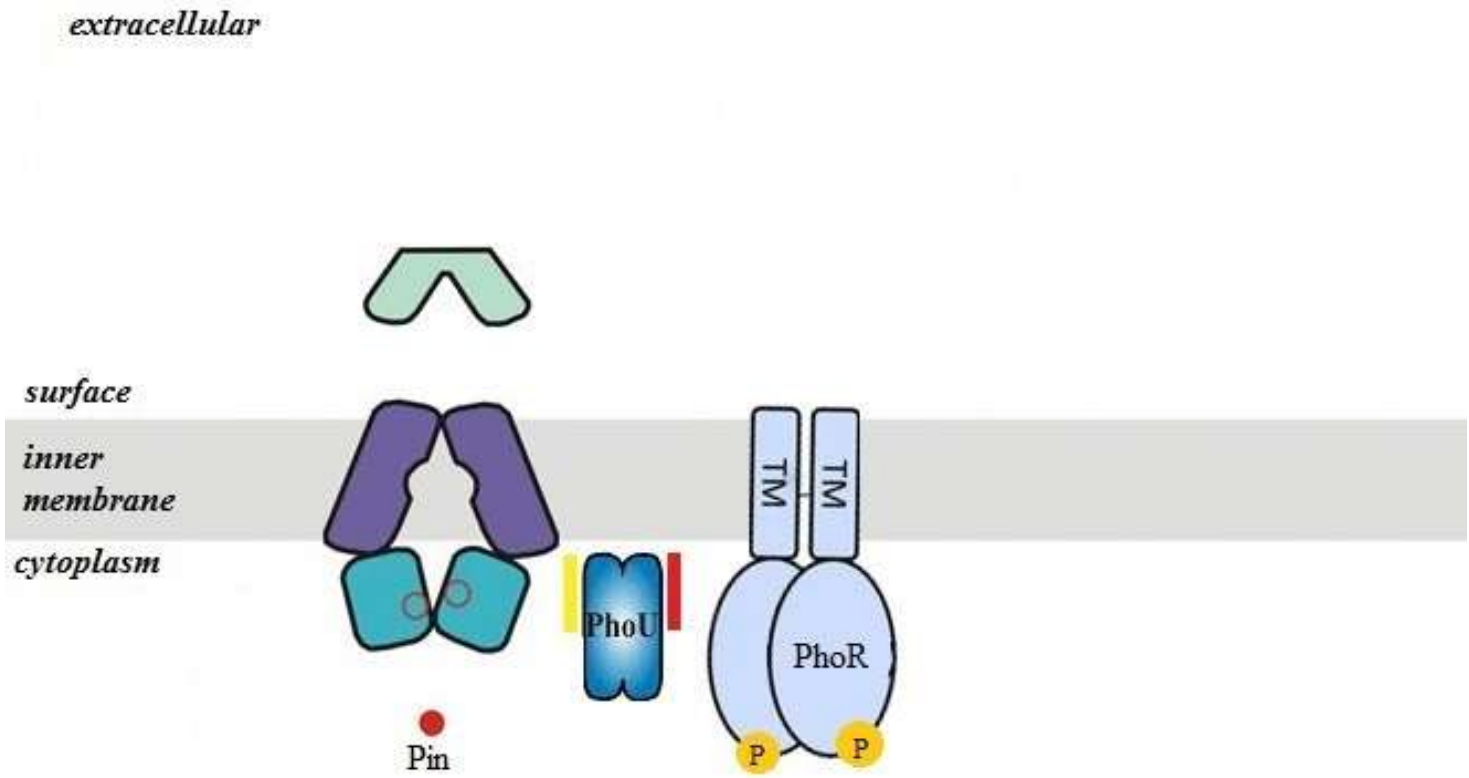

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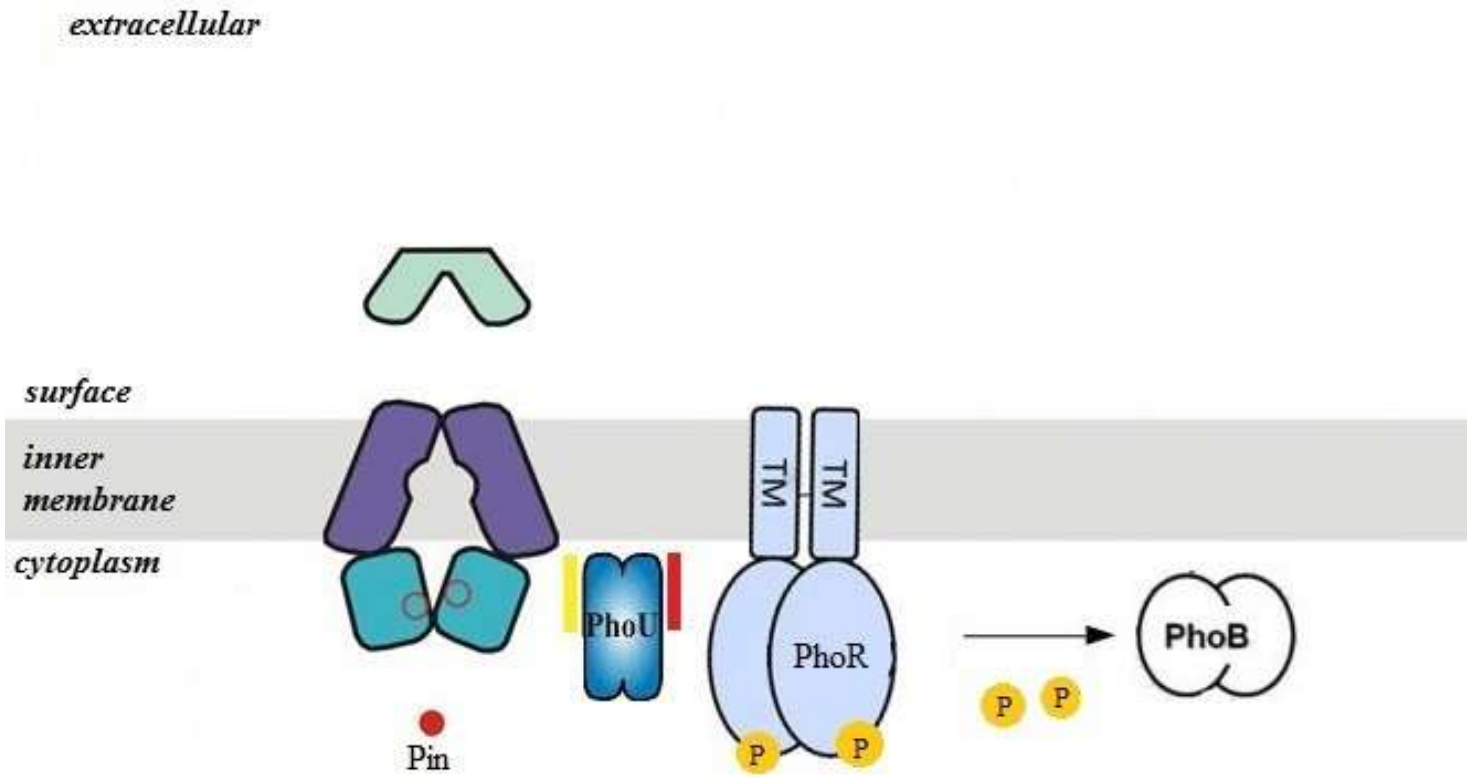

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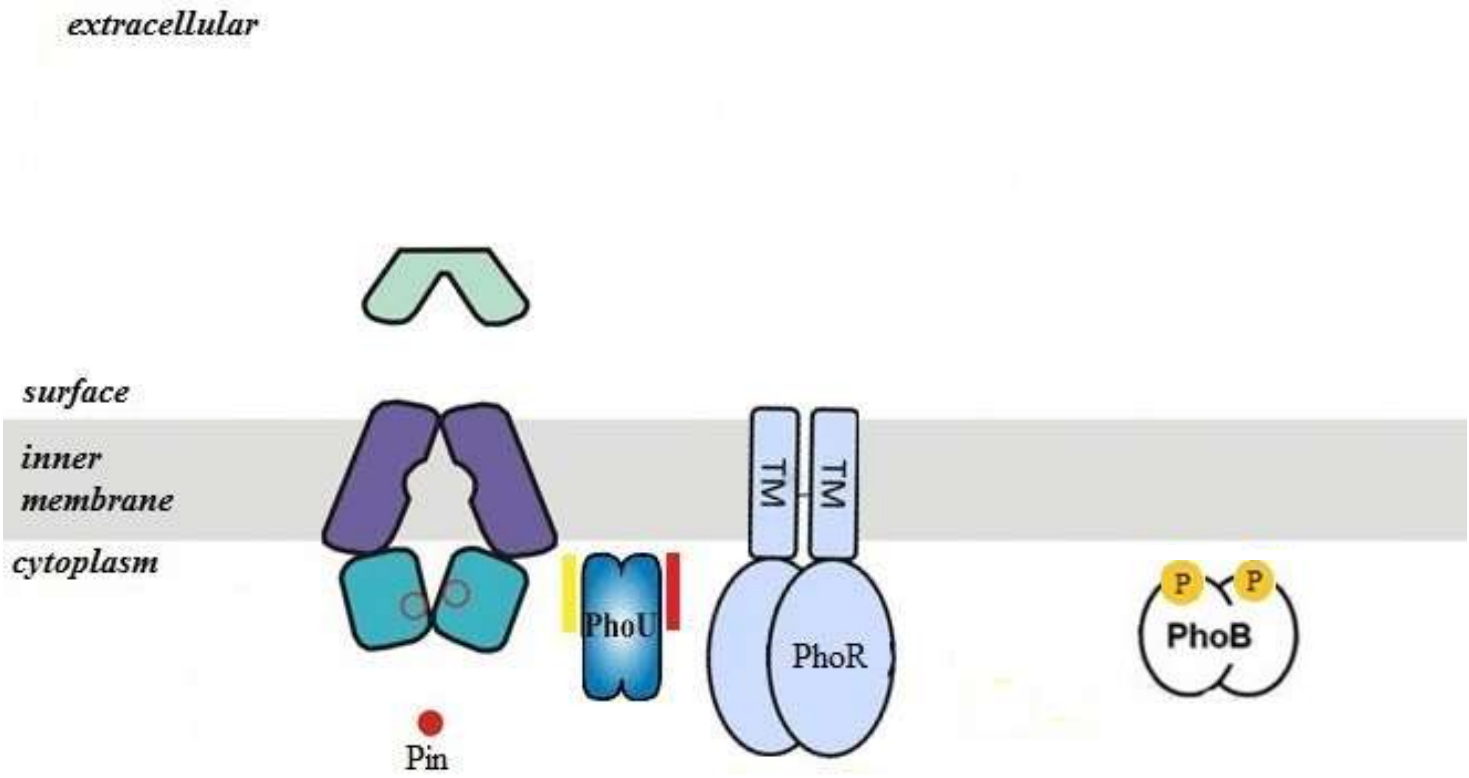

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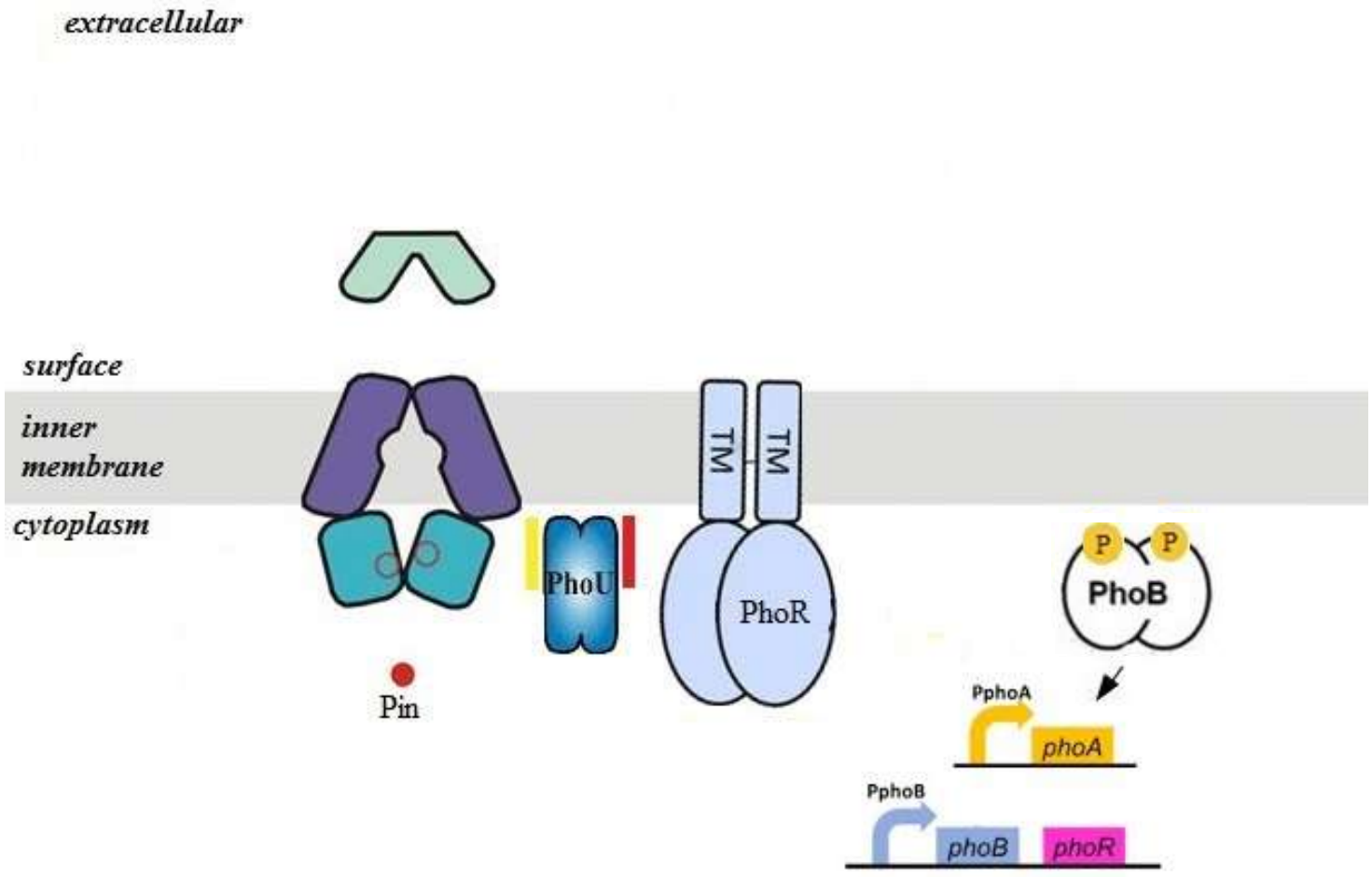

Modelling

Model ~ 29 reactions:

DiPhoR → DiPhoRp

DiPhoRp → DiPhoRpp

Modelling

Model ~ 29 reactions:

DiPhoR → DiPhoRp

DiPhoRp → DiPhoRpp

16 ODEs

$$\begin{aligned} \mathrm{d}DiPhoR(t)/\mathrm{d}t = & \, r_{6r}.DiPhoRp(t) - r_6.DiphoR(t) \\ & + r_{11}.DiPhoRp\text{-}PhoB(t) + r_{21}.mRNAb(t) \\ & - r_{24}.DiPhoR(t) - r_{13}.DiPhoR(t).PhoBp(t) \\ & + r_{13r}.DiPhoR\text{-}PhoBp(t) + r_{14}.DiPhoR\text{-}PhoBp(t) \end{aligned}$$

Modelling

Model ~ 29 reactions:

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⋮

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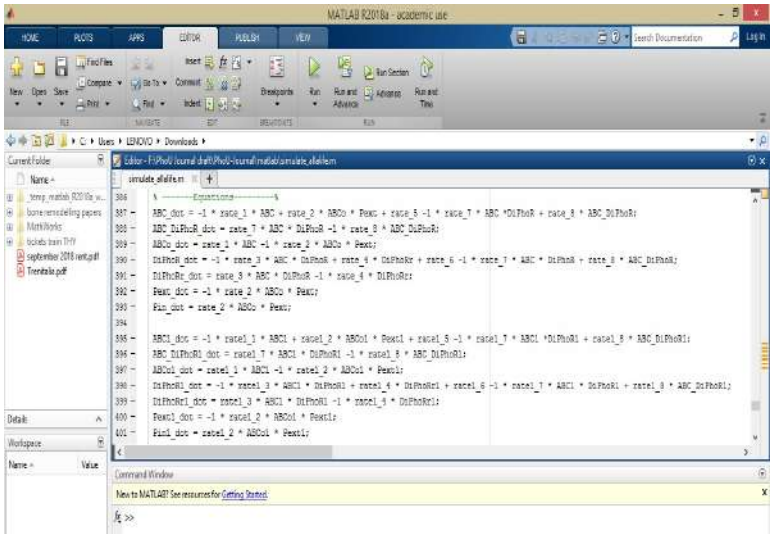
Matlab code



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⋮

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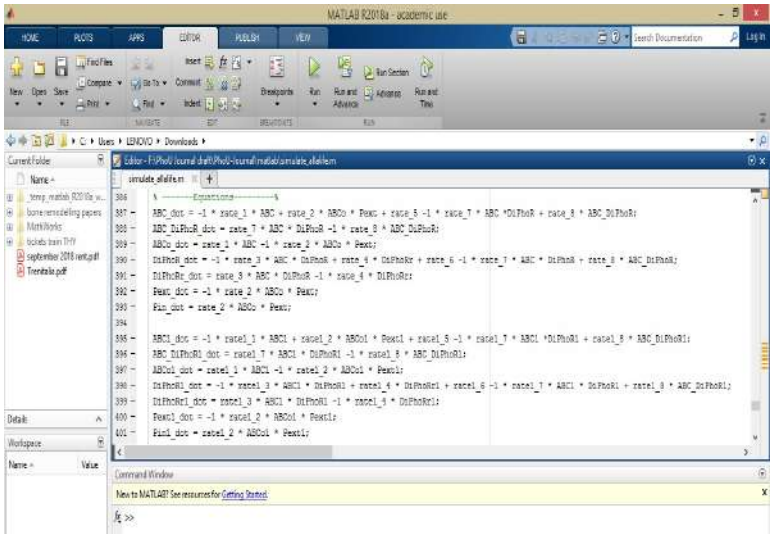
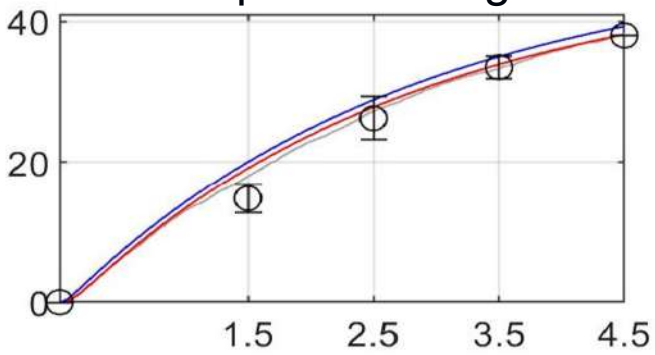
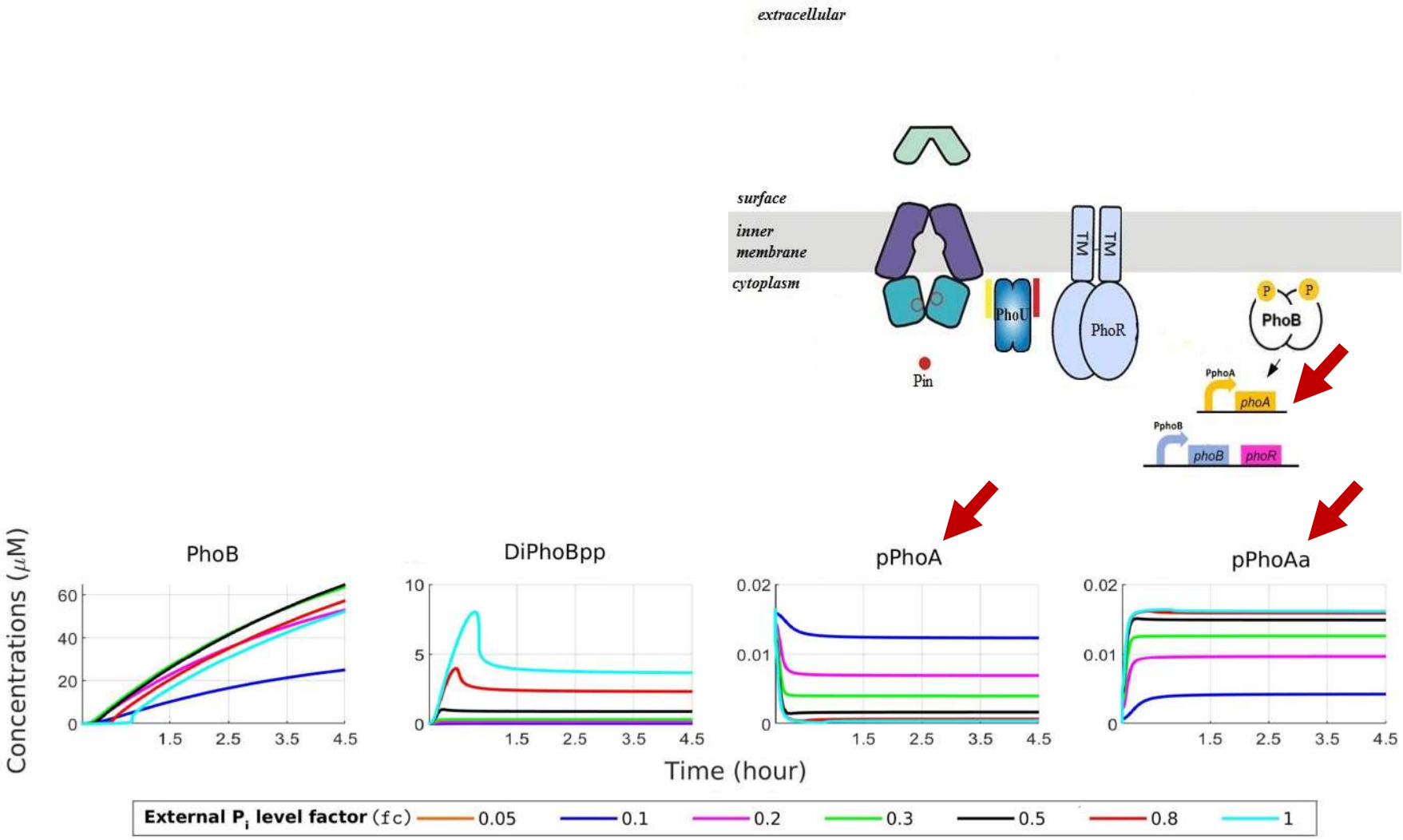


Least Squares Fitting



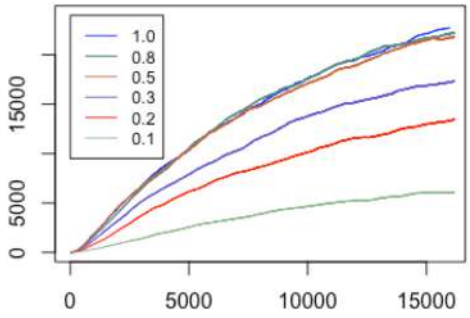
Simulation

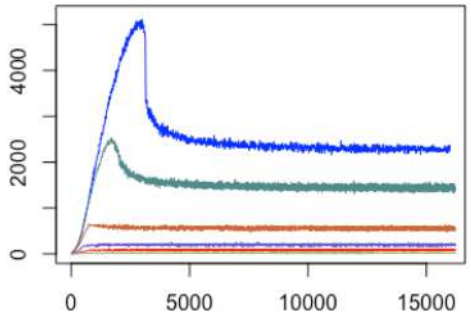


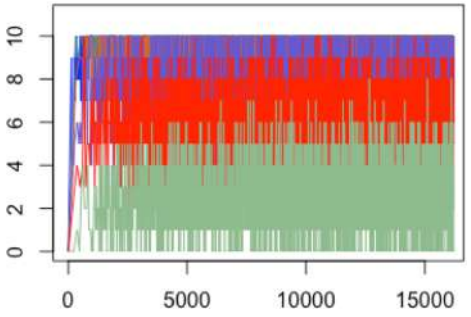
Uluşeker et al., *A Dynamic Model of the Phosphate Response System with Synthetic Promoters in E. coli*. **ECAL** 2017.

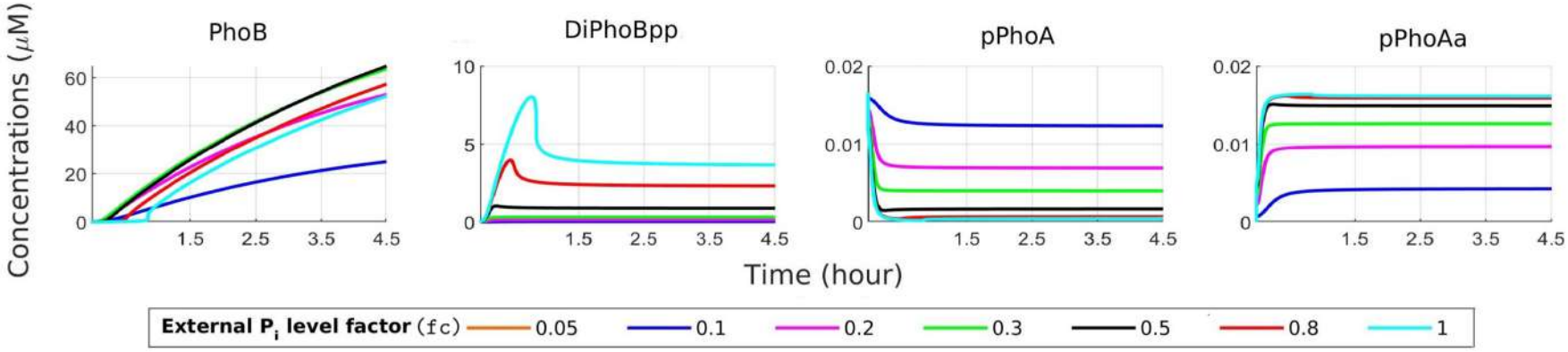
Uluşeker et al. Dynamic mechanisms of phosphate response with synthetic promoters in *Escherichia coli*, ***Scientific Reports***, *2019.*

Simulation









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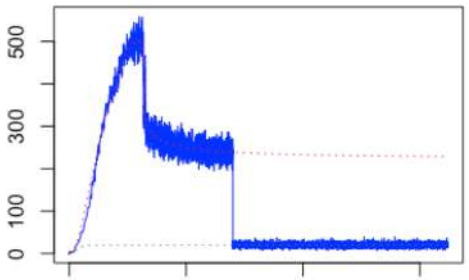
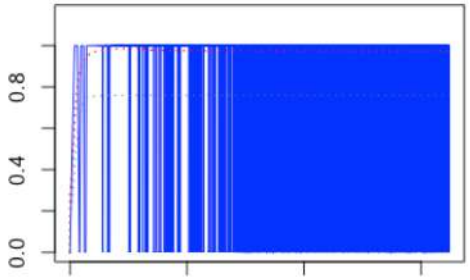
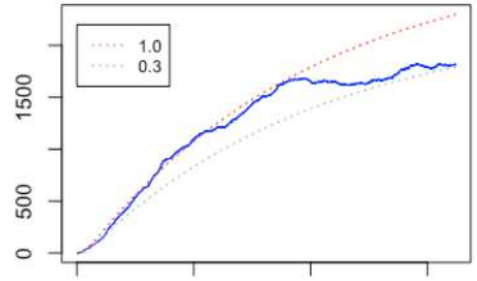
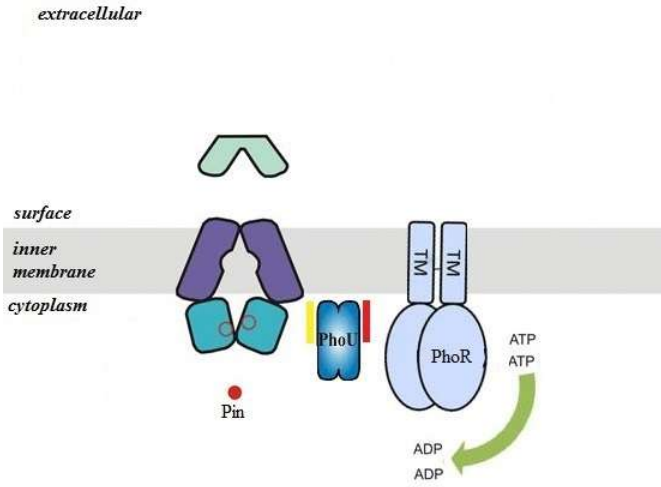
Information Flow

```
reactions
r01 : DiPhoR            -> DiPhoRp
r02 : DiPhoRp           -> DiPhoR
r03 : DiPhoRp           -> DiPhoRpp
r04 : DiPhoRpp          -> DiPhoRp
r05 : DiPhoRpp + PhoB   -> DiPhoRpp_PhoB
r06 : DiPhoRpp_PhoB     -> DiPhoRpp +  PhoB
r07 : DiPhoRpp_PhoB     -> DiPhoRp  +  PhoBp
r08 : DiPhoRp + PhoB    -> DiPhoRp_PhoB
r09 : DiPhoRp_PhoB      -> DiPhoRp  +  PhoB
r10 : DiPhoRp_PhoB      -> DiPhoR   +  PhoBp
r11 : PhoBp + PhoBp     -> DiPhoBpp
r12 : DiPhoBpp          -> PhoBp    +  PhoBp
r13 : DiPhoR + PhoBp    -> DiPhoR_PhoBp
r14 : DiPhoR_PhoBp      -> DiPhoR   +  PhoBp
r15 : DiPhoR_PhoBp      -> DiPhoR   +  PhoB
r16 : DiPhoBpp + pPhoA  -> pPhoAa
r17 : pPhoAa            -> DiPhoBpp +  pPhoA
r18 : DiPhoBpp + pPhoB  -> pPhoBa
r19 : pPhoBa            -> DiPhoBpp +  pPhoB
r20 : pPhoAa            -> pPhoAa   +  mRNAa
r21 : mRNAa             -> mRNAa    +  PhoA
r22 : pPhoBa            -> pPhoBa   +  mRNAb
r23 : mRNAb             -> mRNAb    +  PhoB
r24 : mRNAb             -> mRNAb    +  DiPhoR
r25 : PhoA              ->
r26 : PhoB              ->
r27 : DiPhoR            ->
r28 : mRNAa             ->
r29 : mRNAb             ->
```









6900 secs ..7000 sec