

ПРИНЦИПЫ РАБОТЫ БИОЛОГИЧЕСКИХ «МОЛЕКУЛЯРНЫХ МАШИН»

Андрей Борисович Рубин

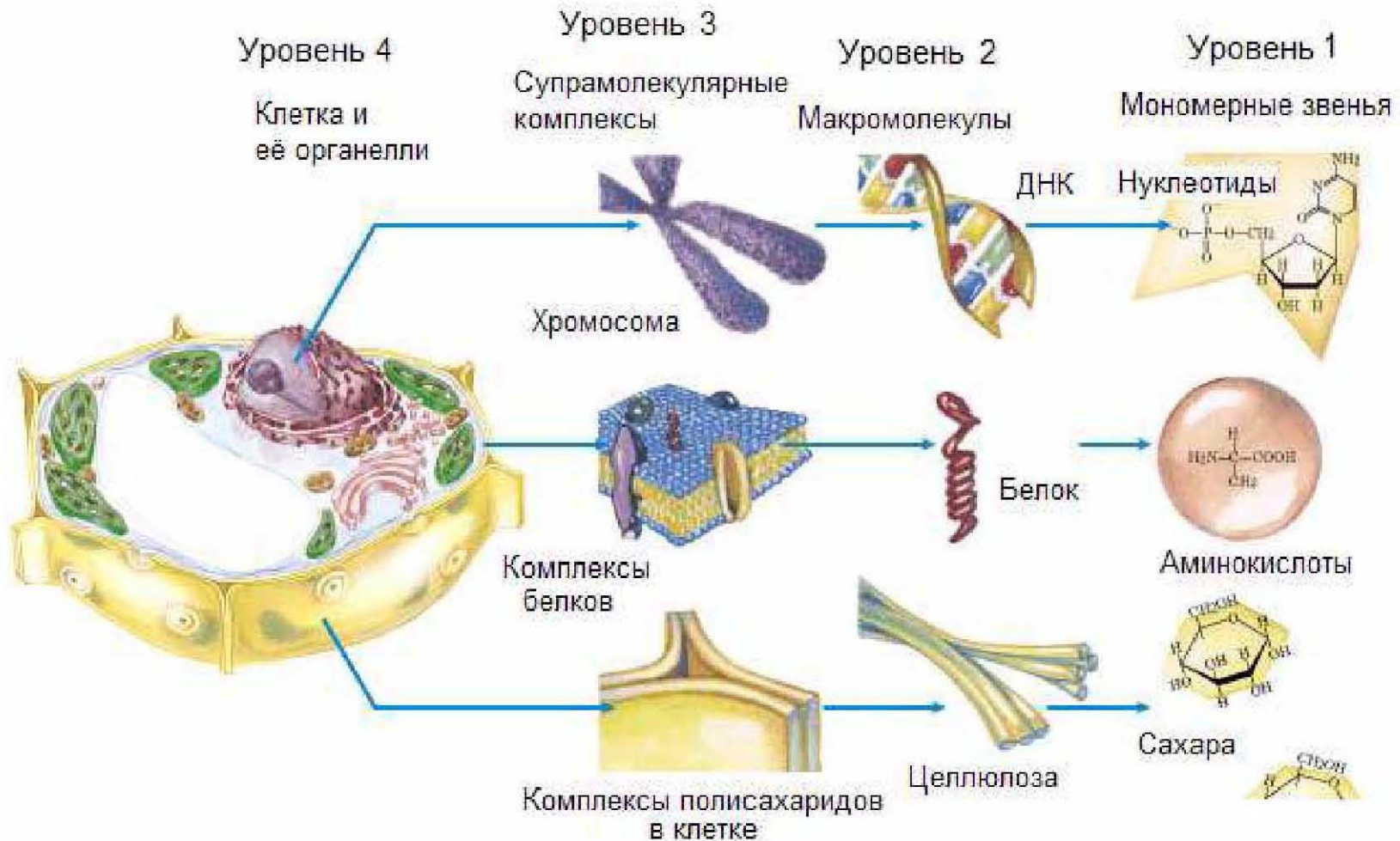
член-корреспондент РАН

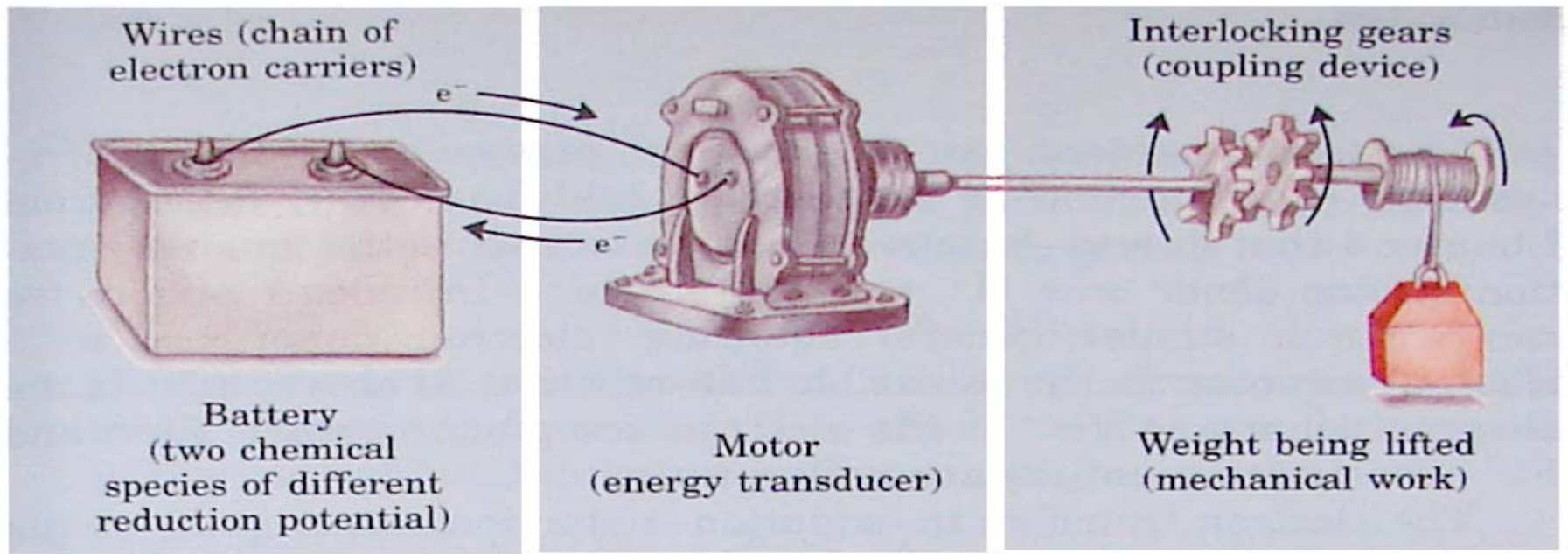
МГУ, Биологический факультет

каф. биофизики

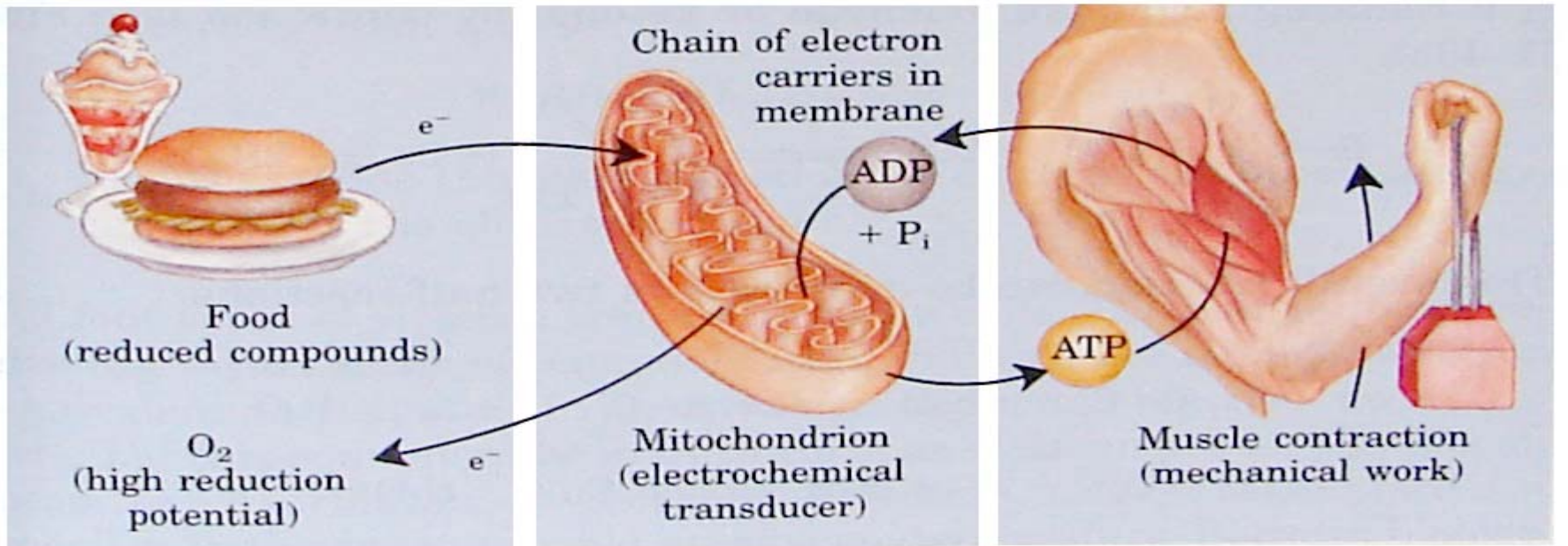
Полимеры вокруг нас

Живые системы

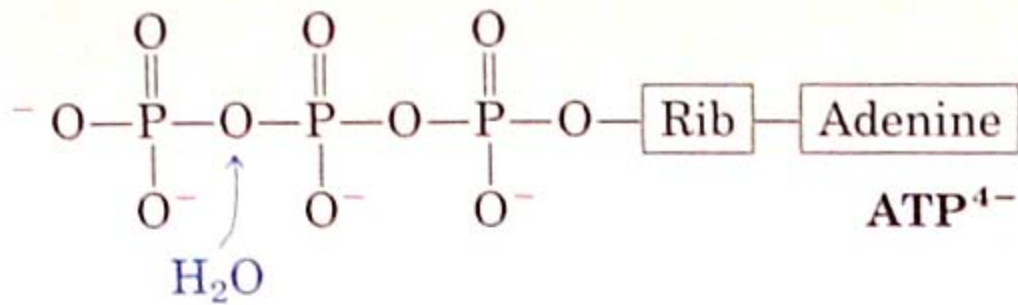




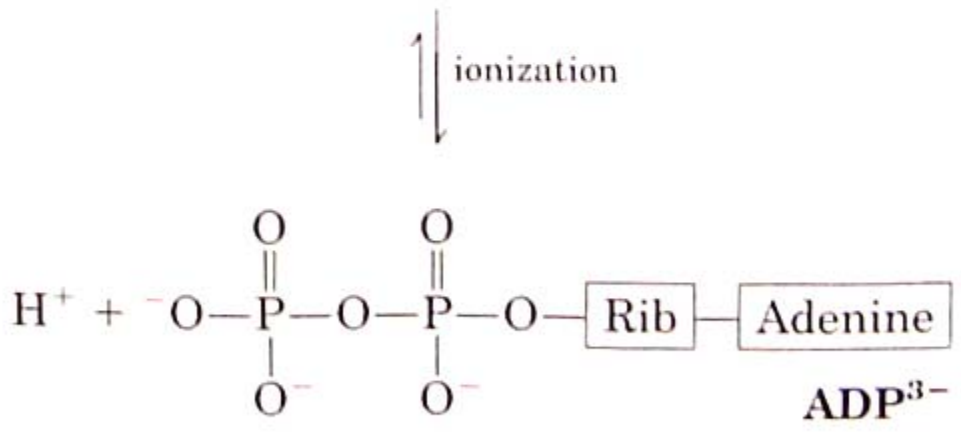
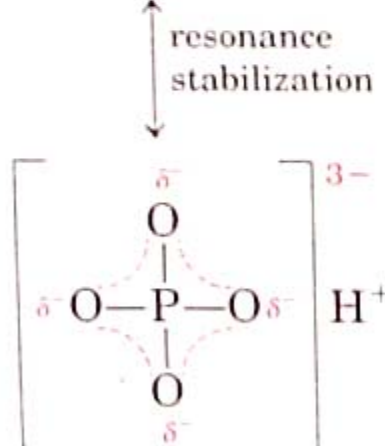
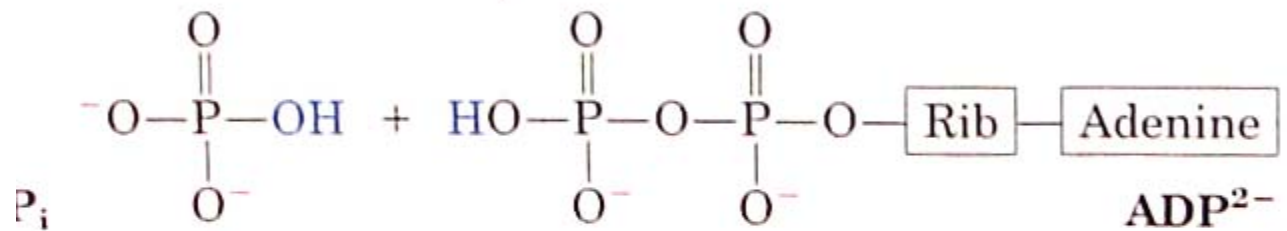
(a)



(b)

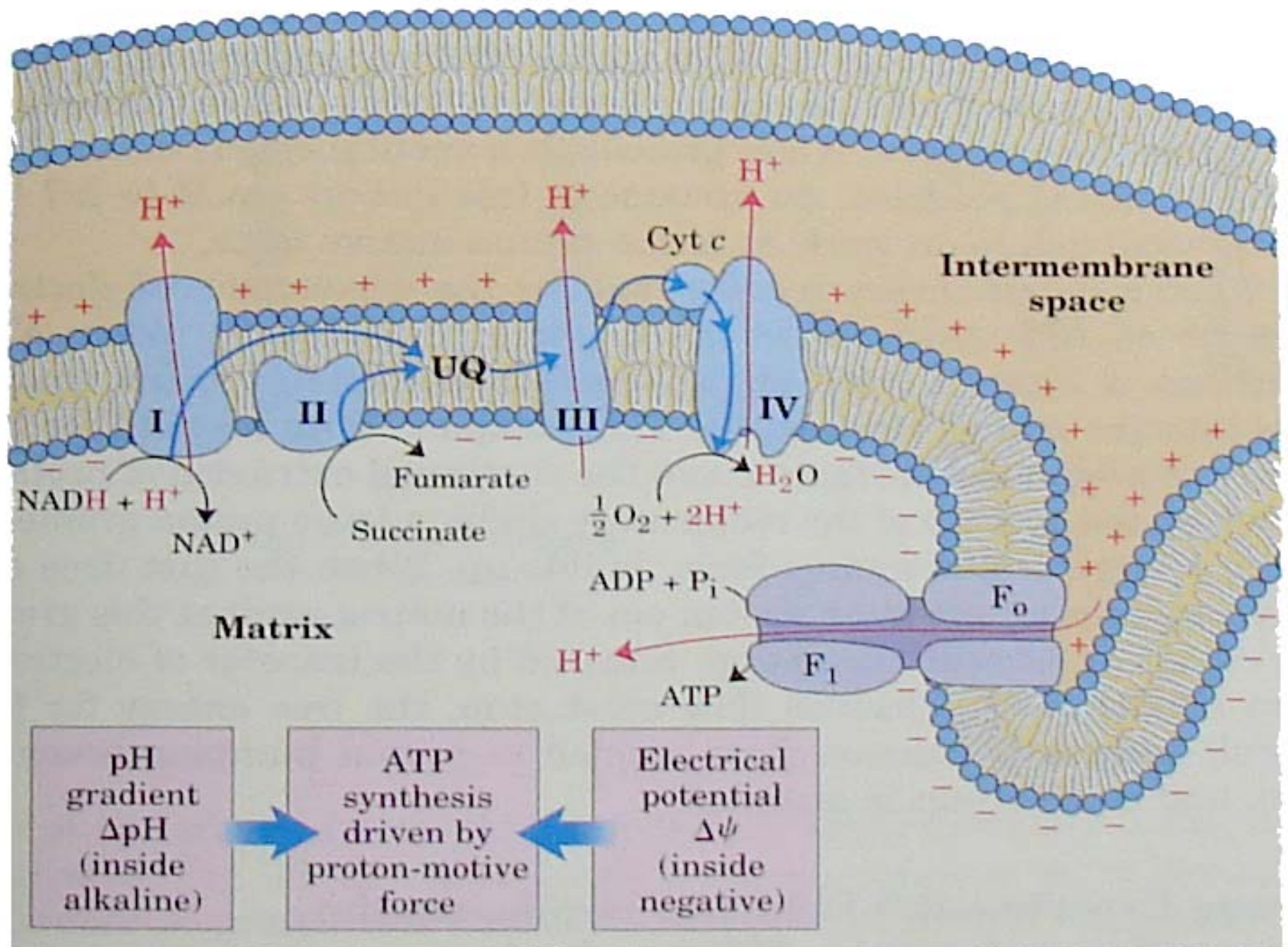


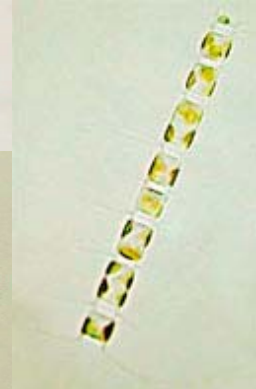
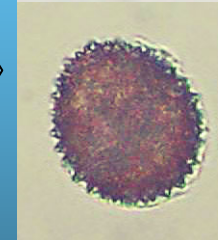
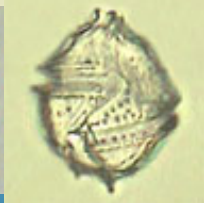
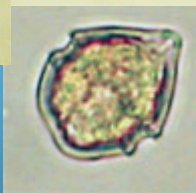
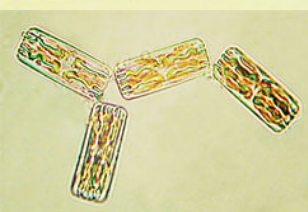
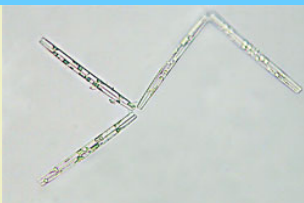
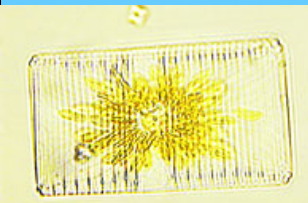
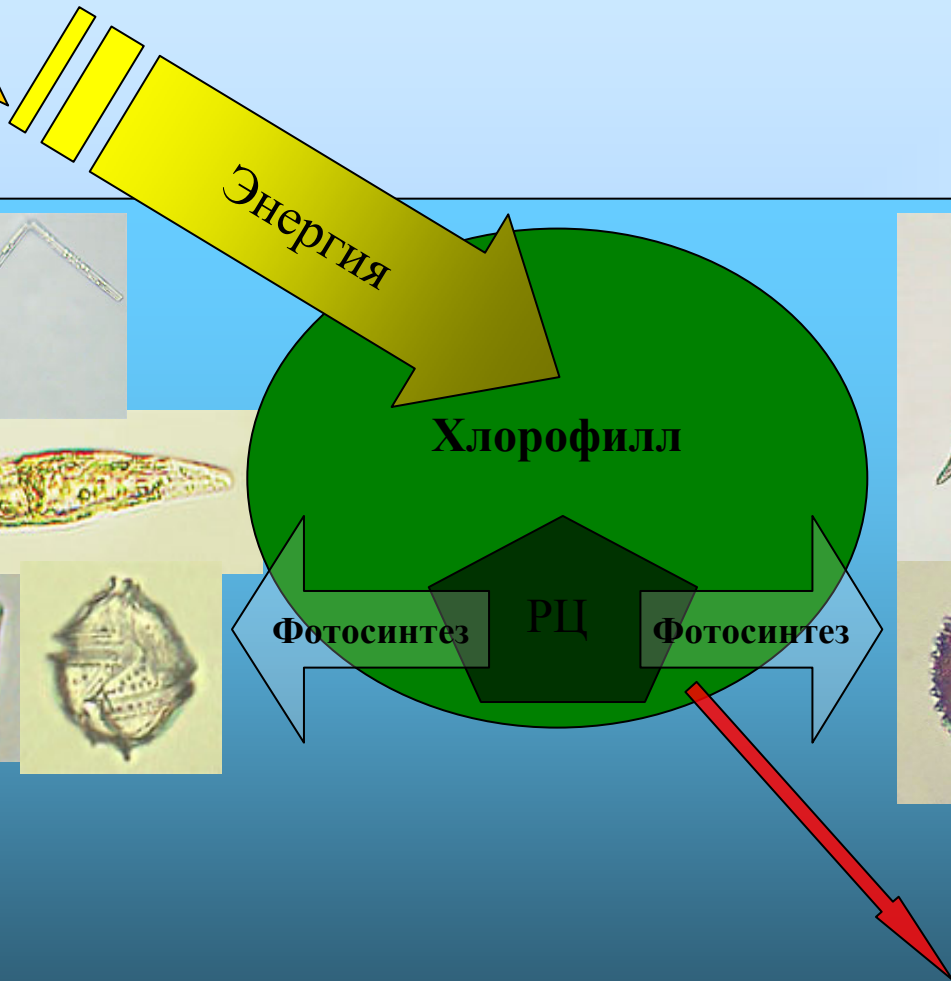
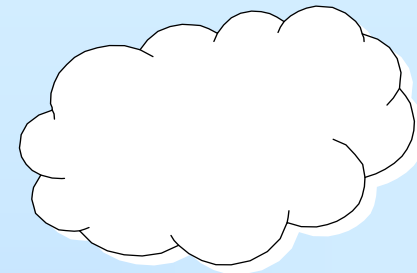
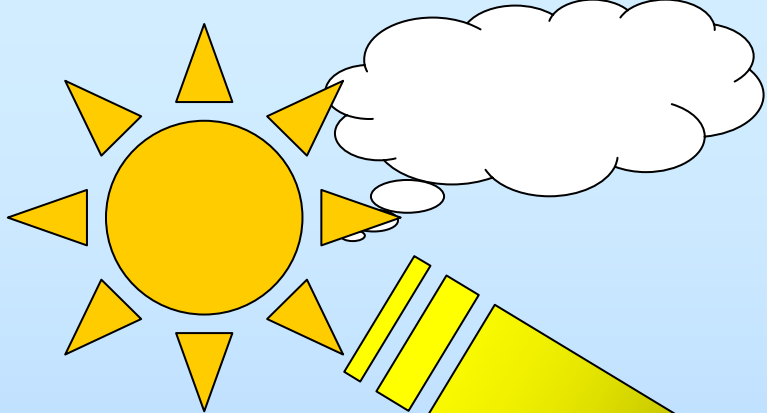
↓ hydrolysis, with
 relief of charge repulsion



$$\text{ATP}^{4-} + \text{H}_2\text{O} \longrightarrow \text{ADP}^{3-} + \text{P}_i^{2-} + \text{H}^+$$

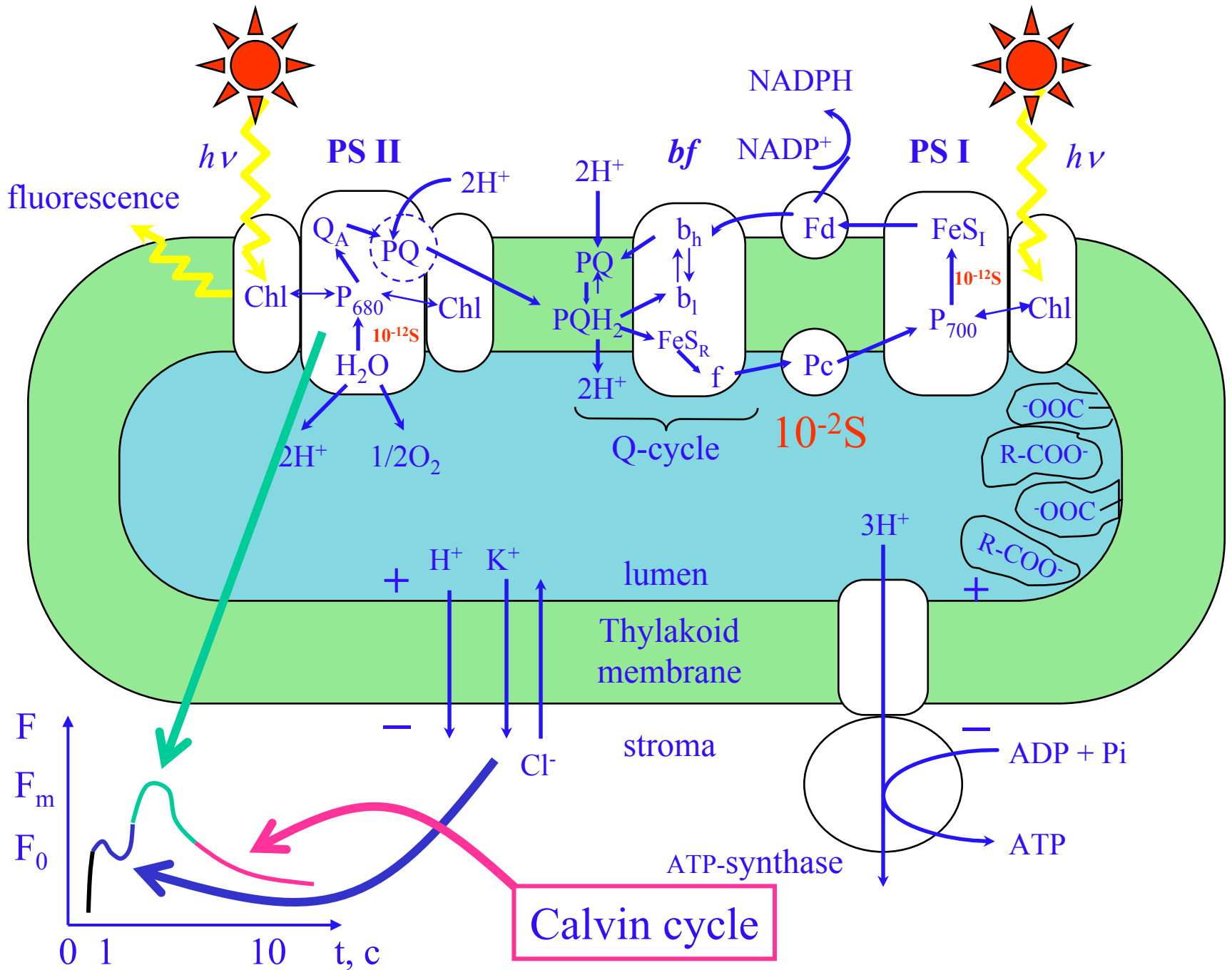
$$\Delta G^{\circ'} = -30.5 \text{ kJ/mol}$$

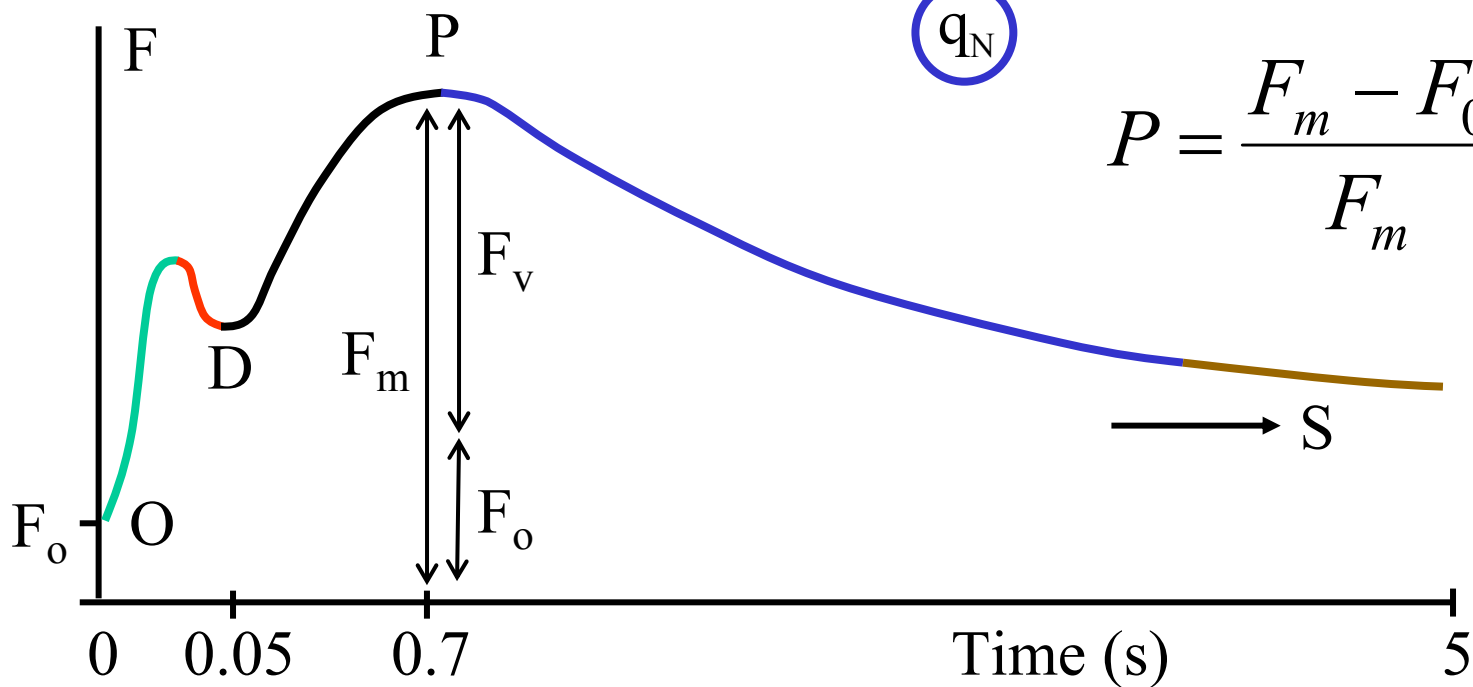
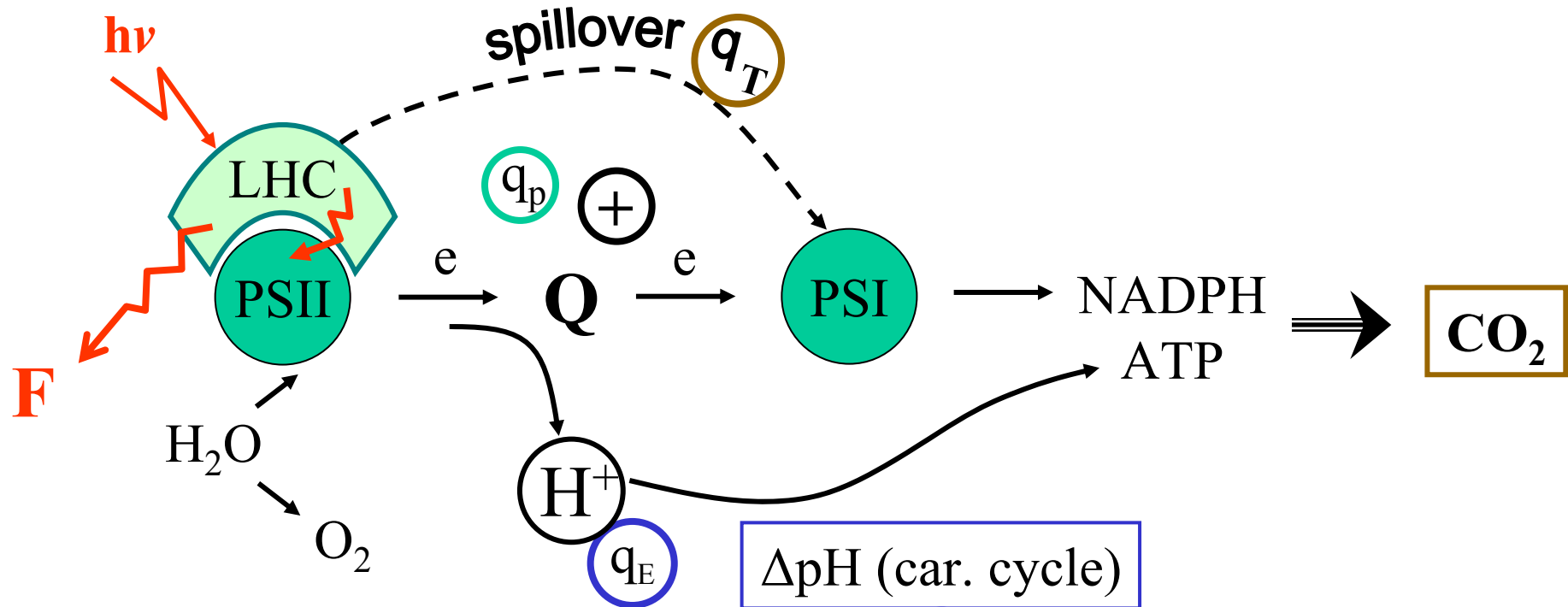




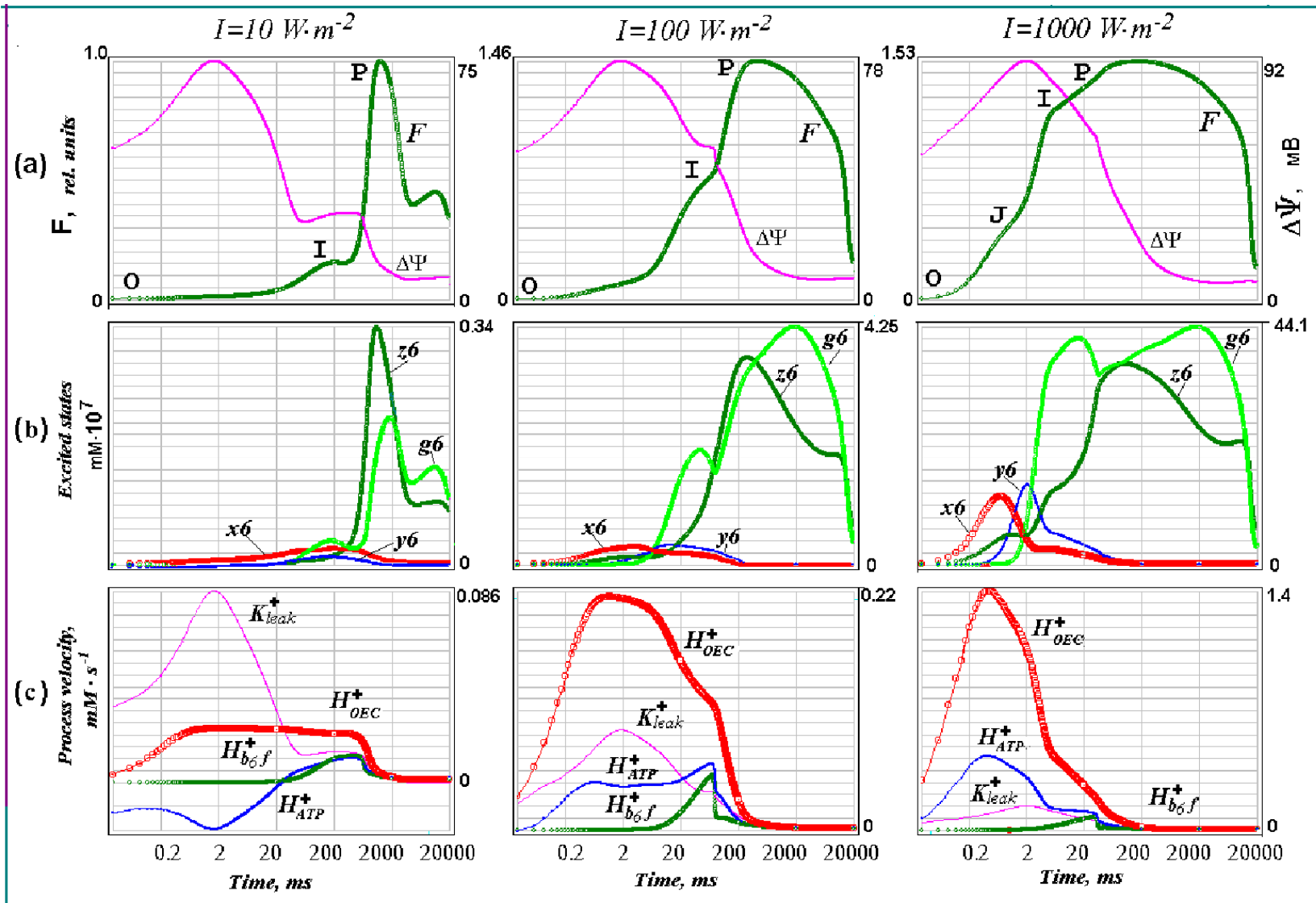
Флуоресценция

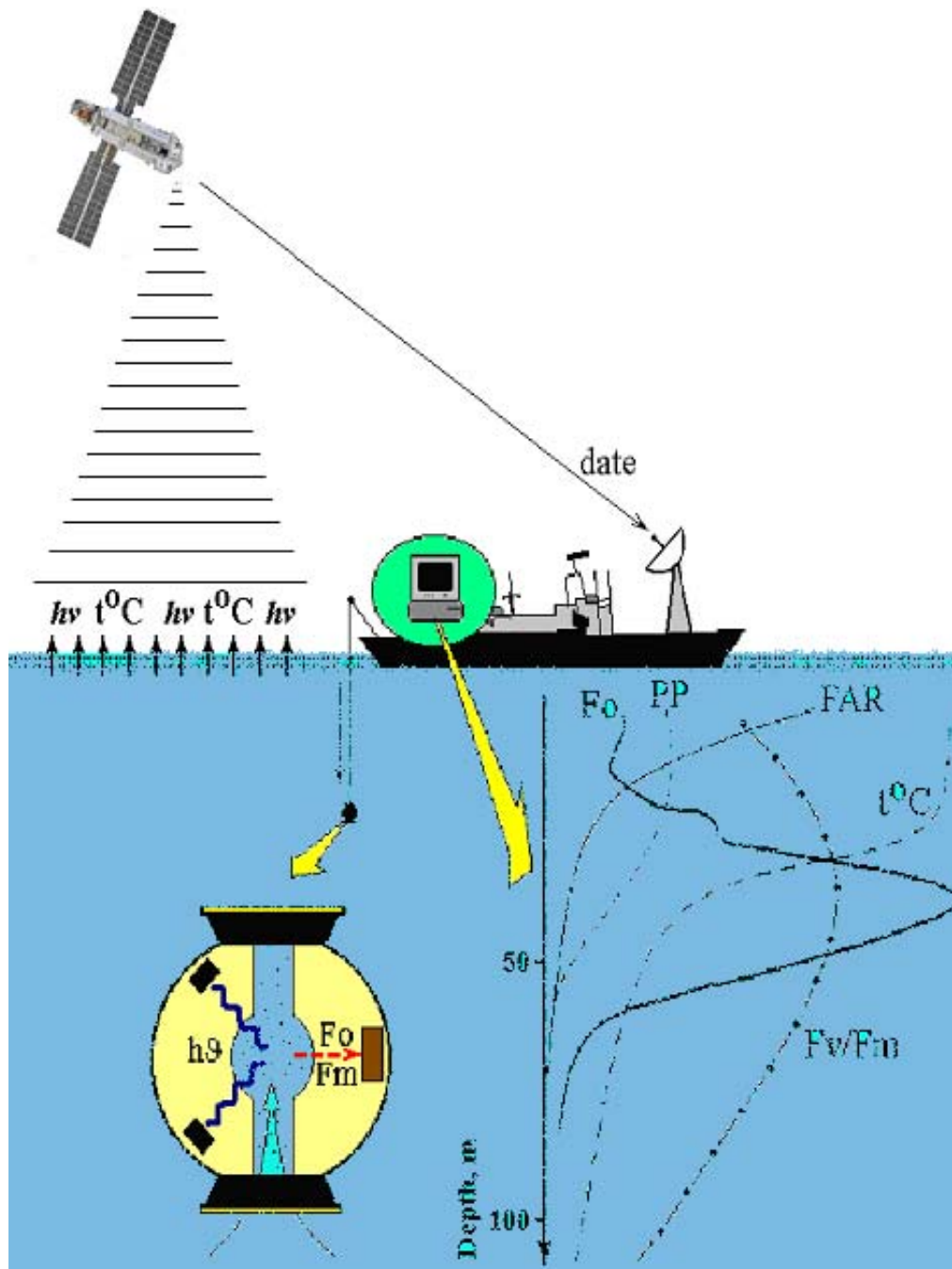
Трансформация энергии в фотосинтетической мембране



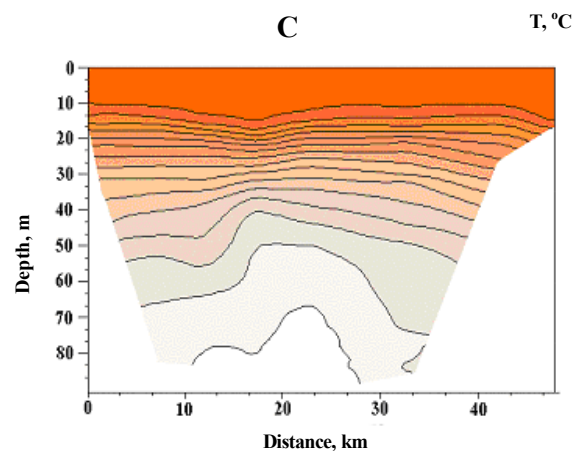
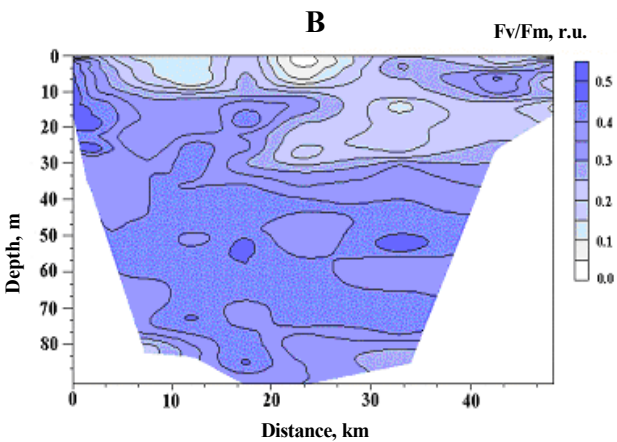
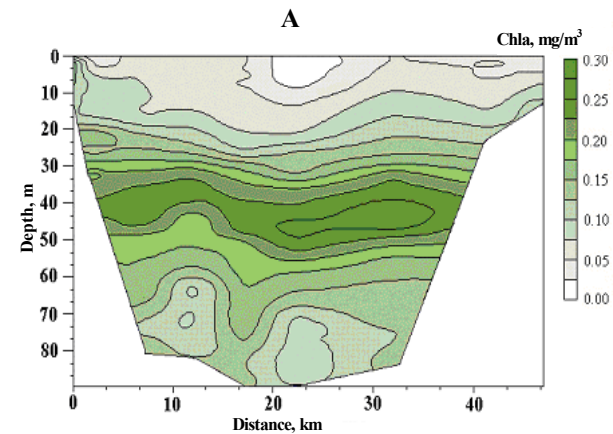


Kinetics of the variables of the model





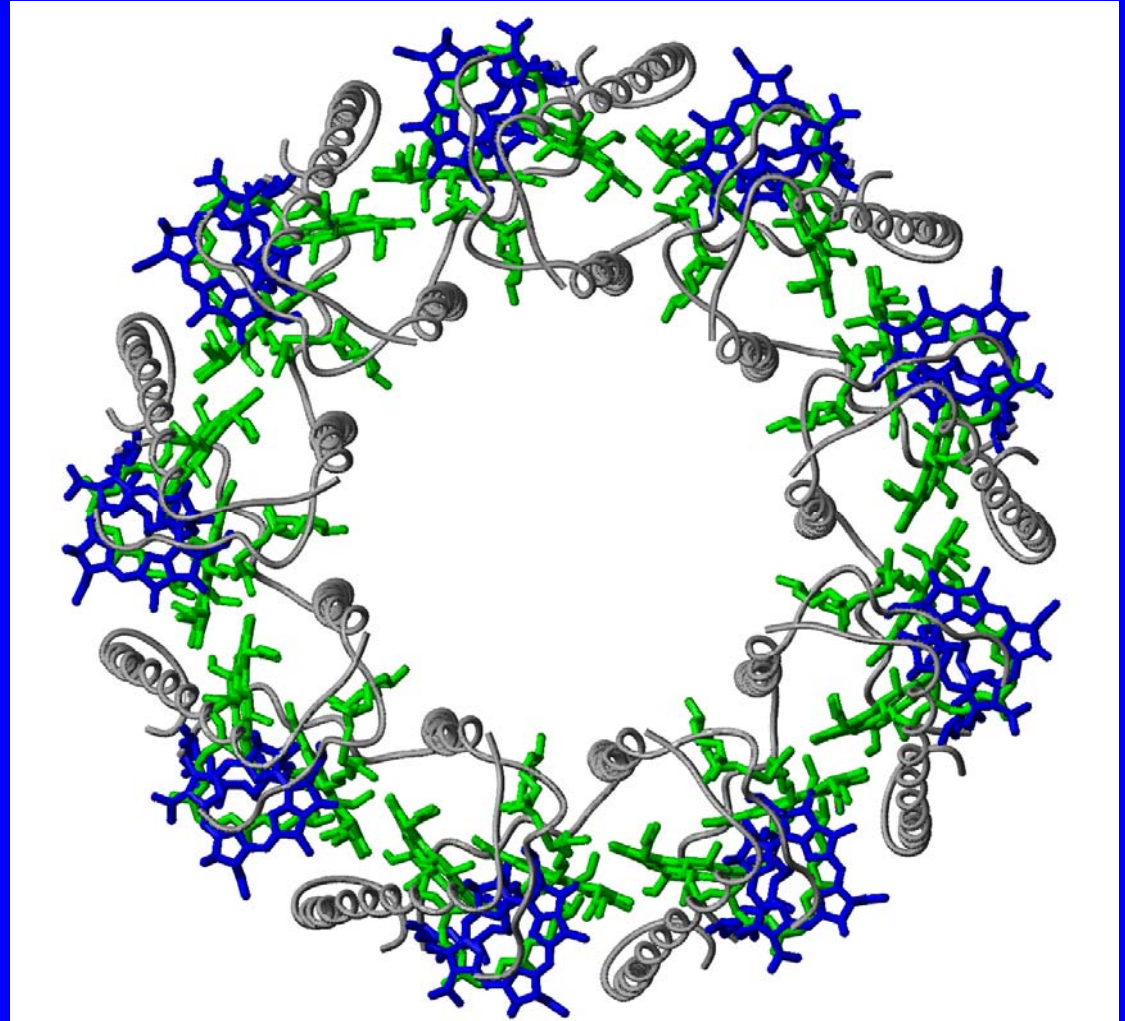
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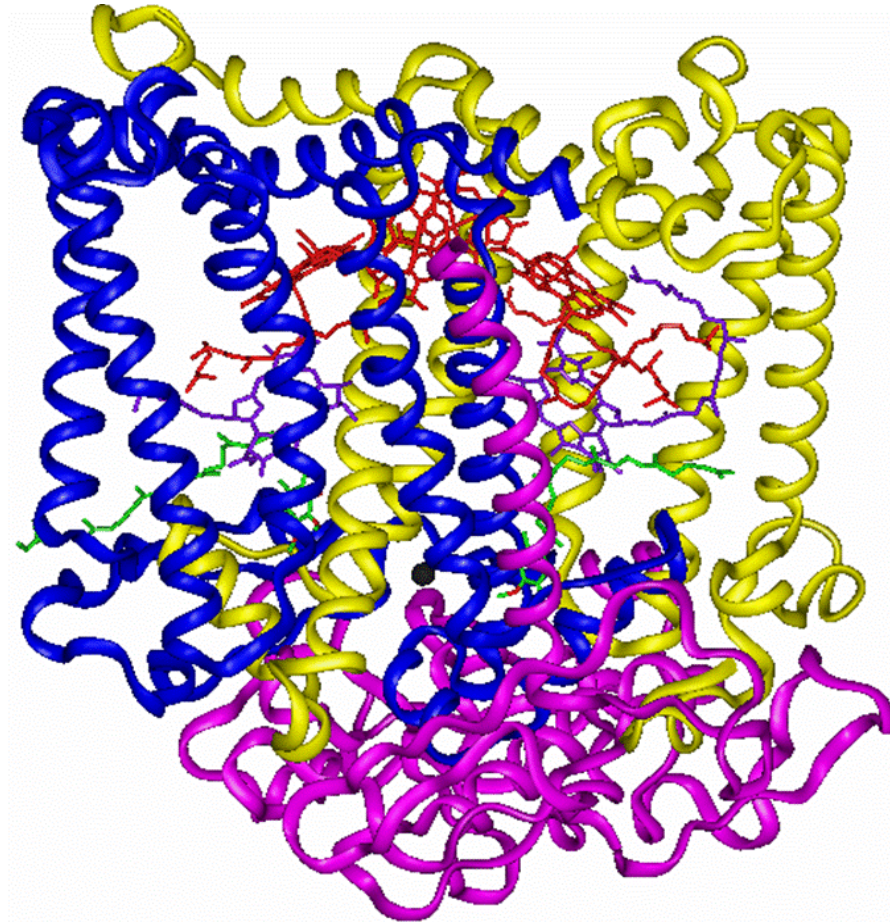
Phytoplankton concentration (*Fo*) (A) and photosynthetic activity (*Fv/Fm*)(B), as well as water temperature (C) in the cross section of Issik-Kul Lake (Tamga-Grigor'evka). Data were obtained with using submersible fluorometer in July 1999.

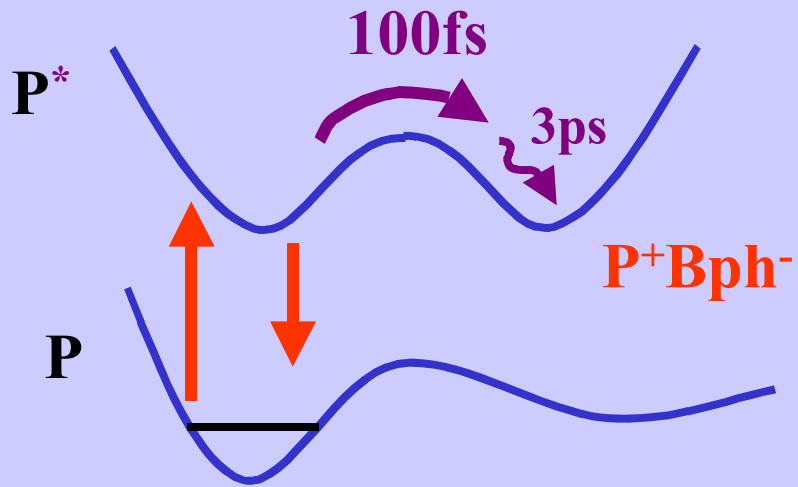
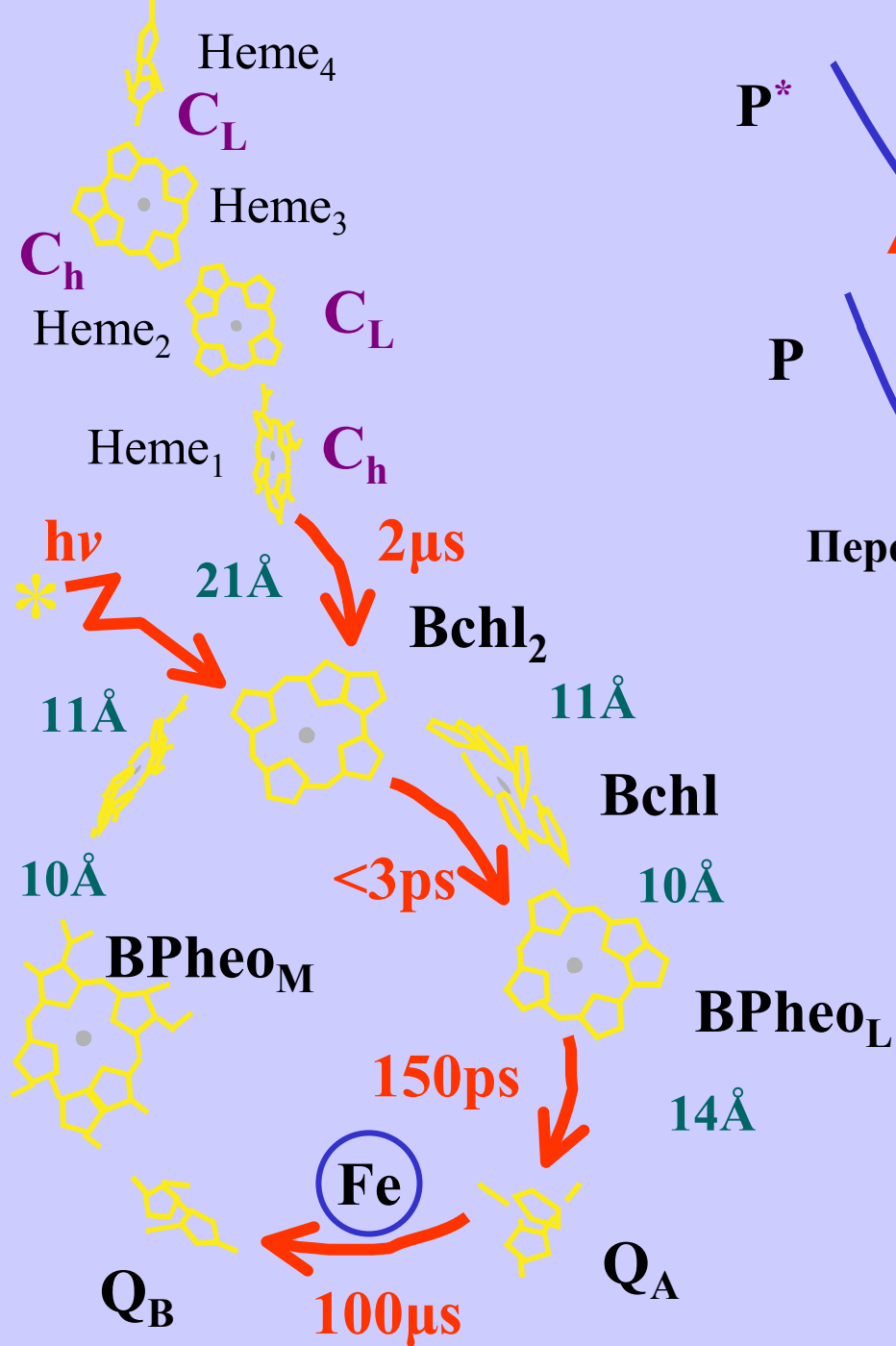
Investigation of the vertical distribution of phytoplankton in oligotrophic Issyk-Kul Lake showed a complex structure of phytoplankton, which is due to pronounced water stratification. The lowest values of the abundance and photosynthetic activity were found in the upper layer under conditions of a high solar irradiation and low content of mineral nutrients. High abundance and high activity of algal cells were found in the deep layers of the photic zone indicating the presence of active algae, adapted to low light condition.

Светособирающая антенна.

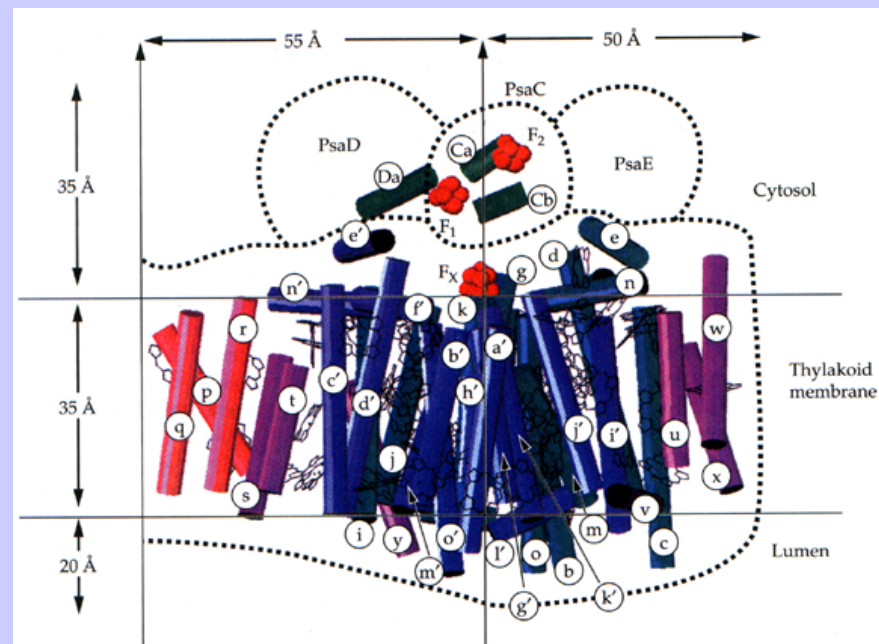


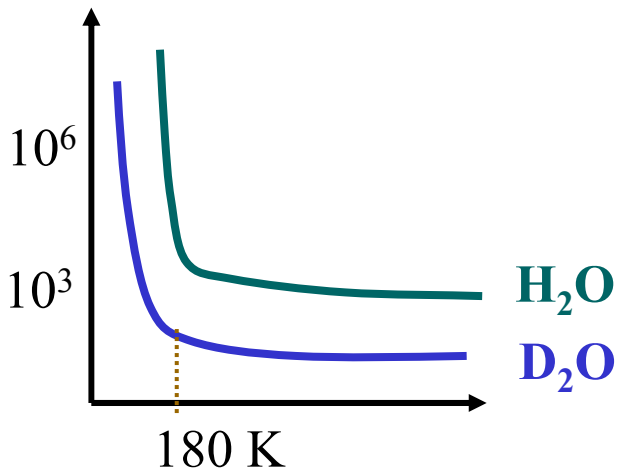
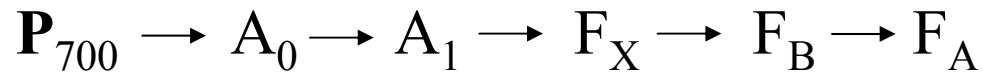
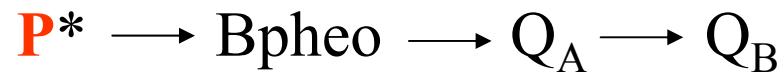
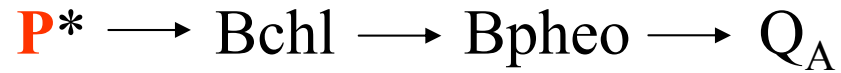
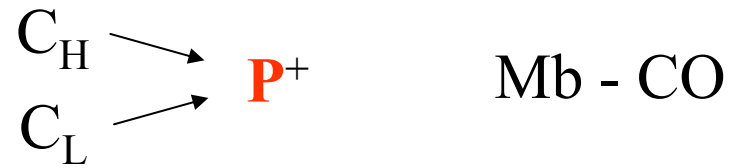
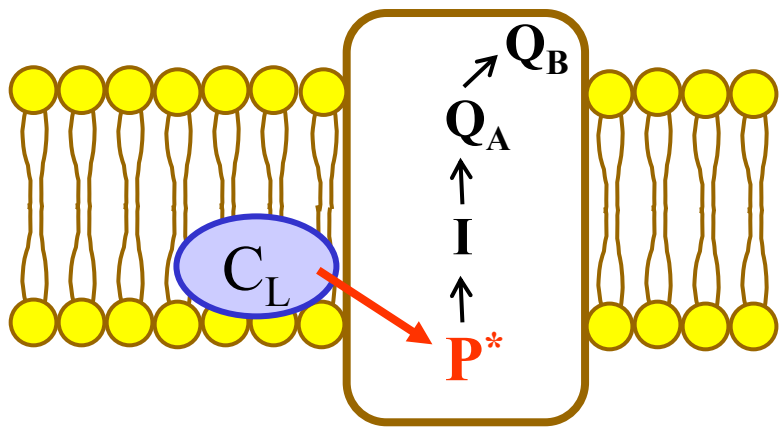
Белок реакционного центра



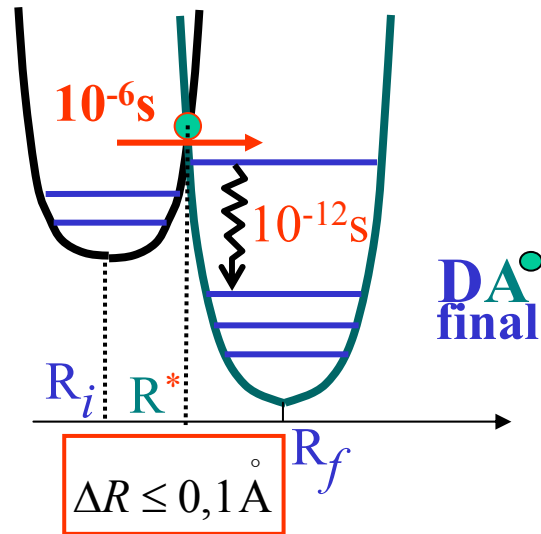


Перенос электрона в реакционном центре





$D^{\bullet}A$
 init.

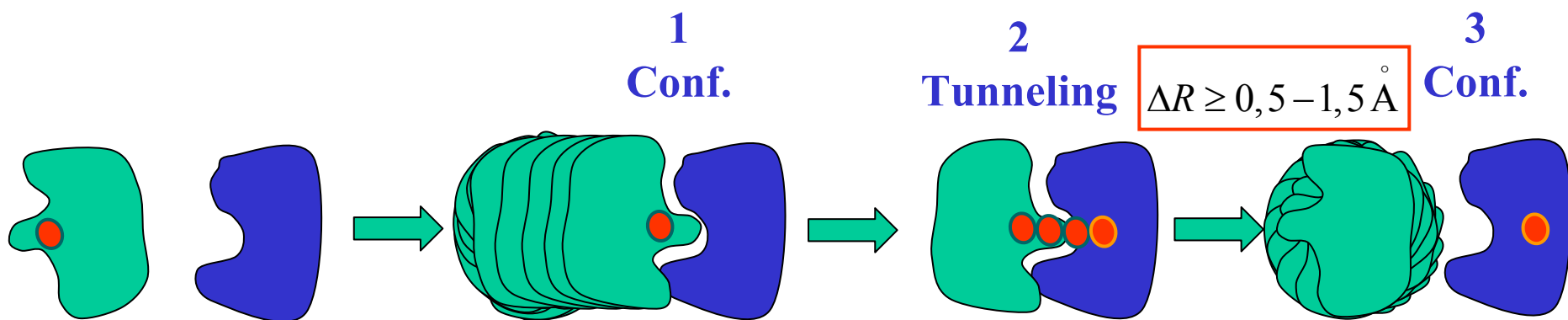


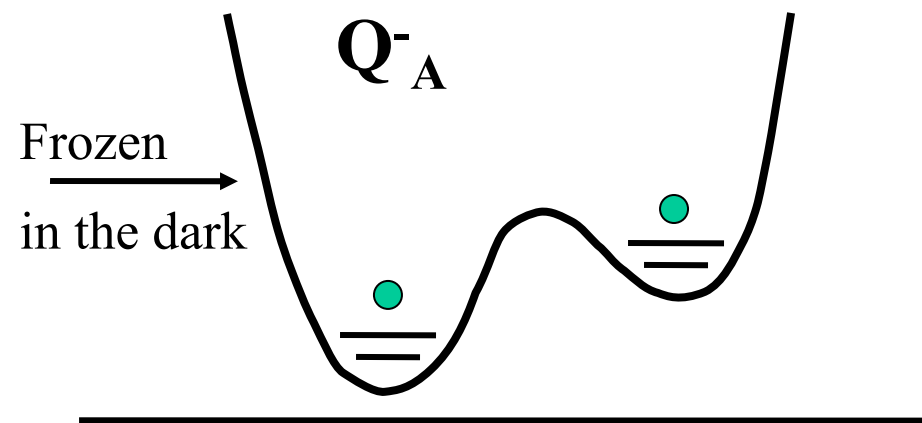
$k_{tunn} > k_{act}$
 at $T < 700K$

$$\frac{e^{-\frac{L}{\hbar}\sqrt{2m\varepsilon}}}{e^{-\varepsilon/kT}} > 10$$

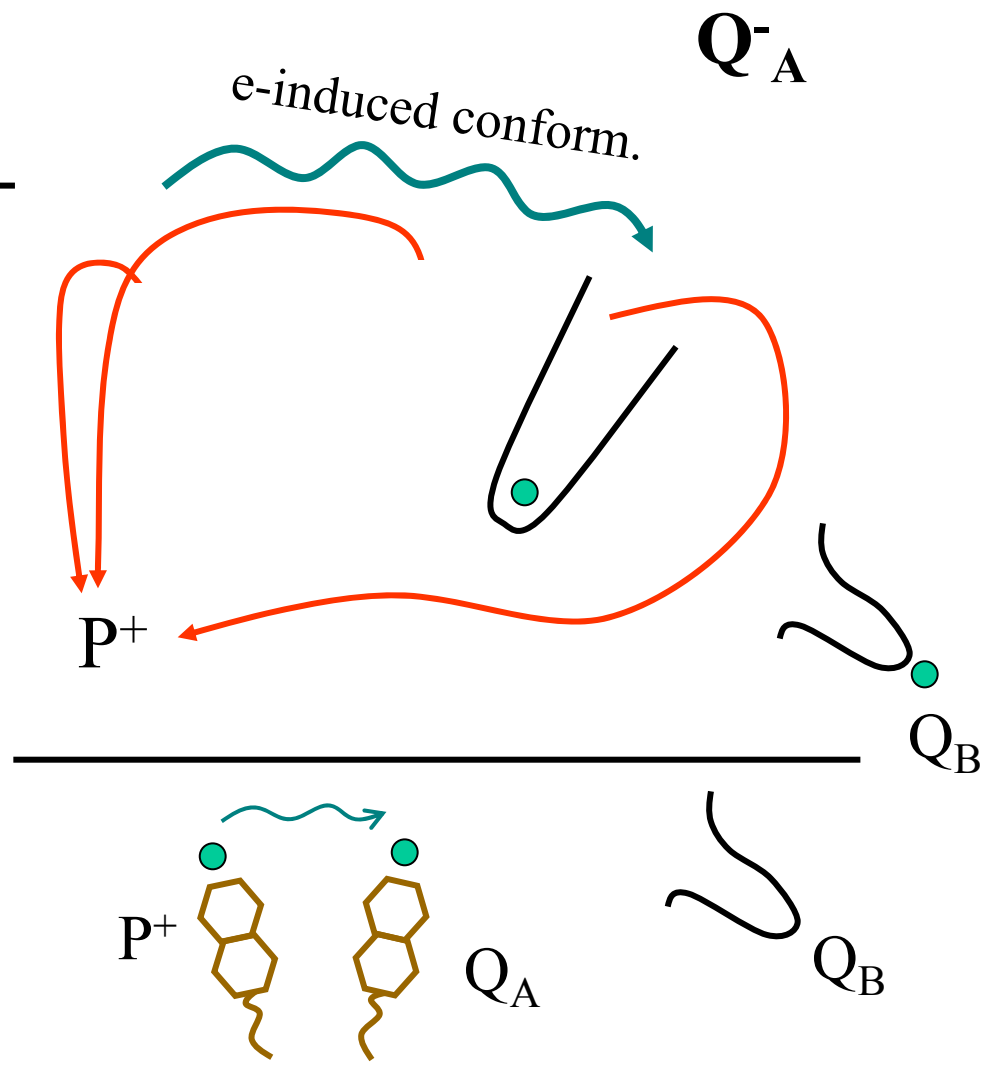
Туннелирование электрона в реакционном центре

Каскад конформационных изменений в реакционном центре





Frozen under
illumination



The scheme of time scales of protein molecular dynamics

Primary events in photosynthesis and vision	$10^{-13} - 10^{-12}$ s
Local dynamics of atoms and small groups	$10^{-12} - 10^{-11}$ s
-of side chains and polypeptide chain segments	$10^{-11} - 10^{-7}$ s
Motions of domains and subunits	$10^{-8} - 10^{-5}$ s
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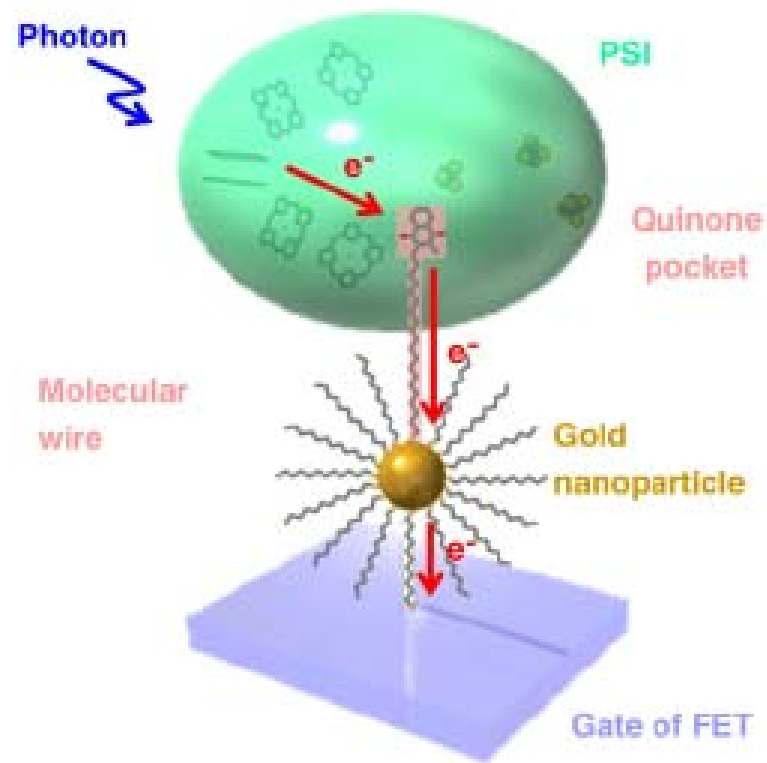


Fig. 1. The concept of the bio-photosensor made of PSI coupled with transistor via molecular wire.

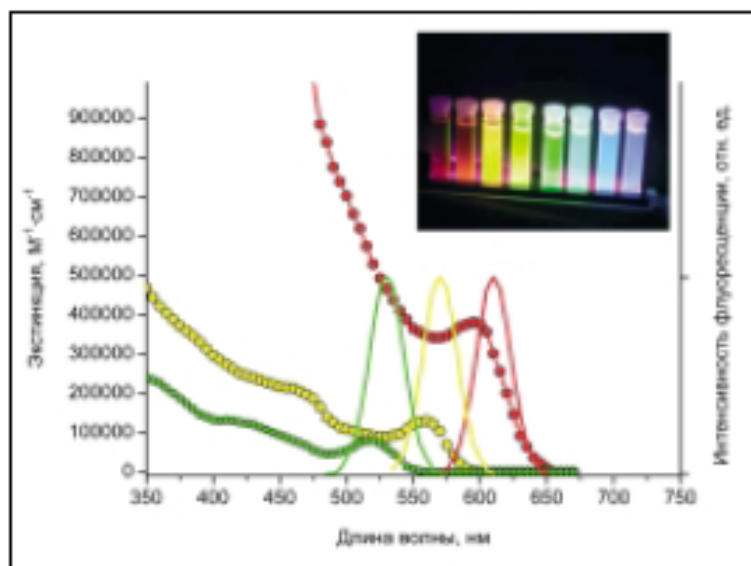
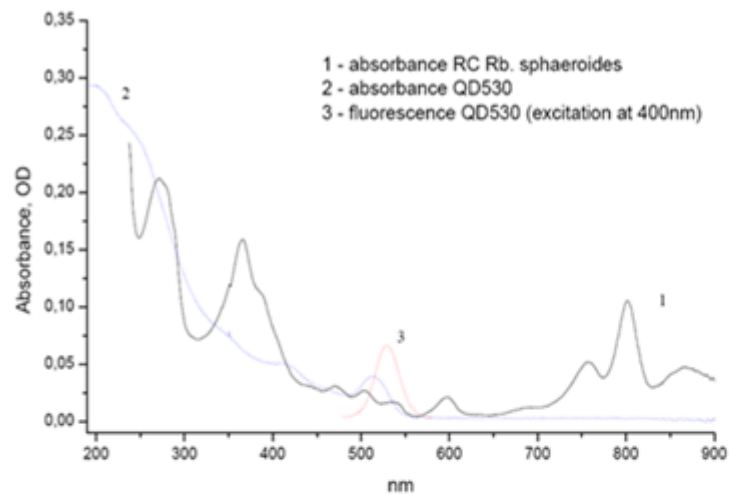


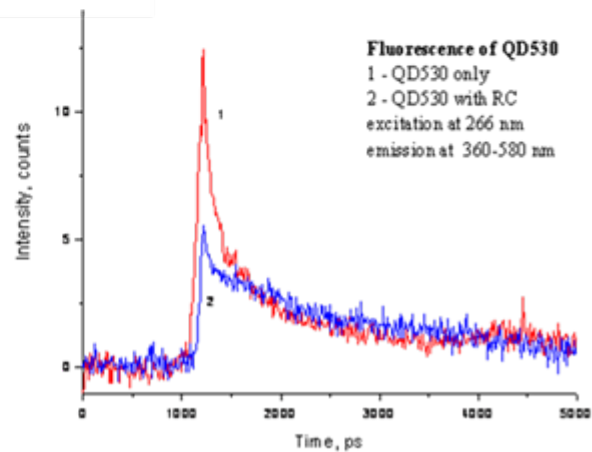
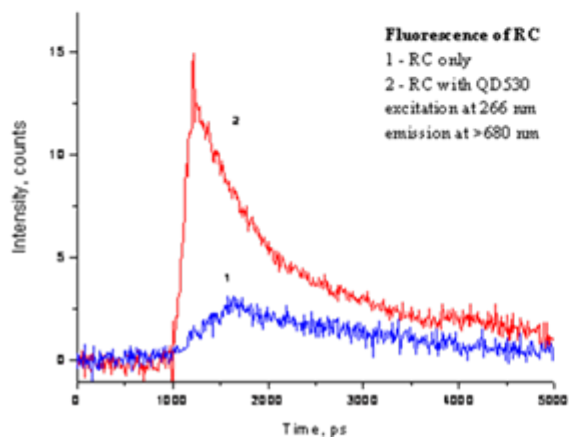
РИСУНОК 1 | Спектры поглощения и флуоресценции сферических CdSe/ZnS нанокристаллов структуры ядро/оболочка. Диаметр CdSe ядер: 2.5 нм (зеленые), 3.3 нм (желтые) и 4.8 нм (красные). На вставке — флуоресценция CdSe/ZnS нанокристаллов разных размеров. Для всех нанокристаллов использован один источник возбуждения — ртутная лампа.

ТАБЛИЦА 1 | Спектральные свойства материалов квантовых точек [3, 20, 55–59]

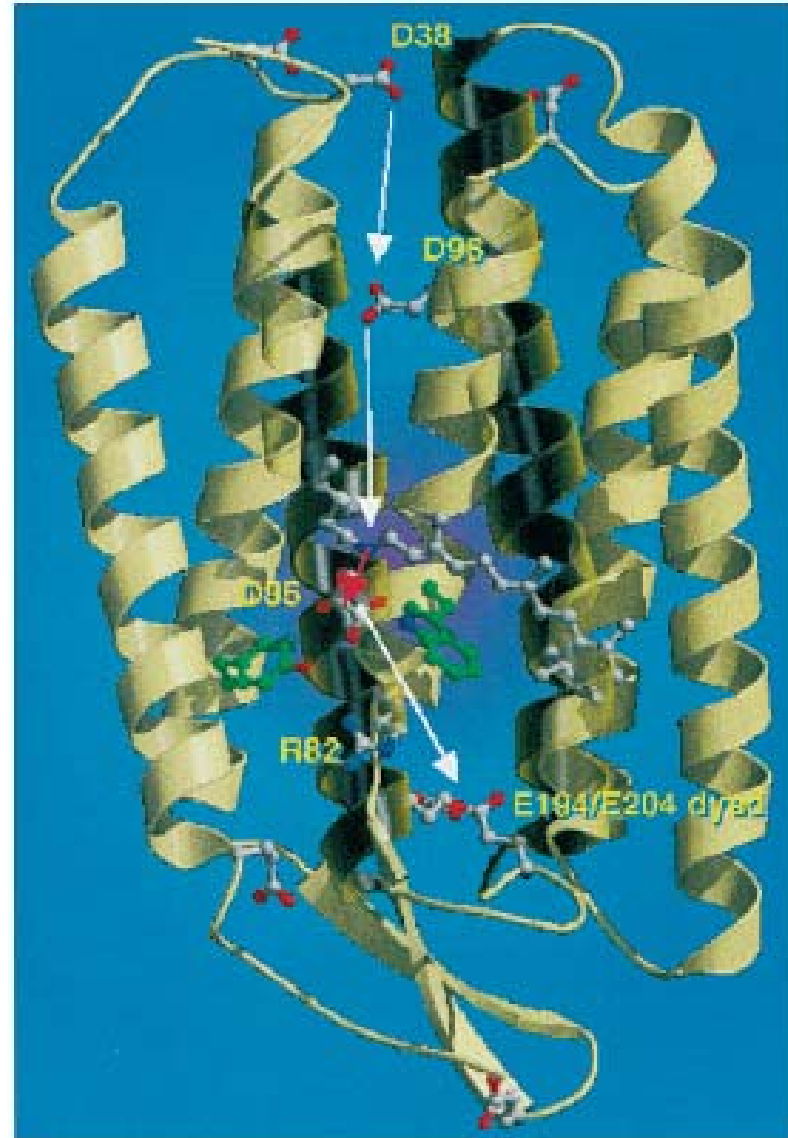
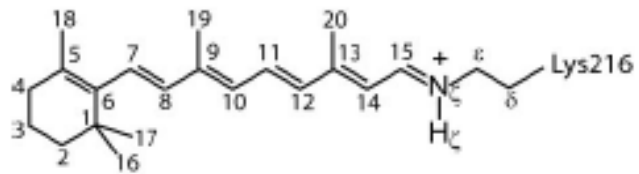
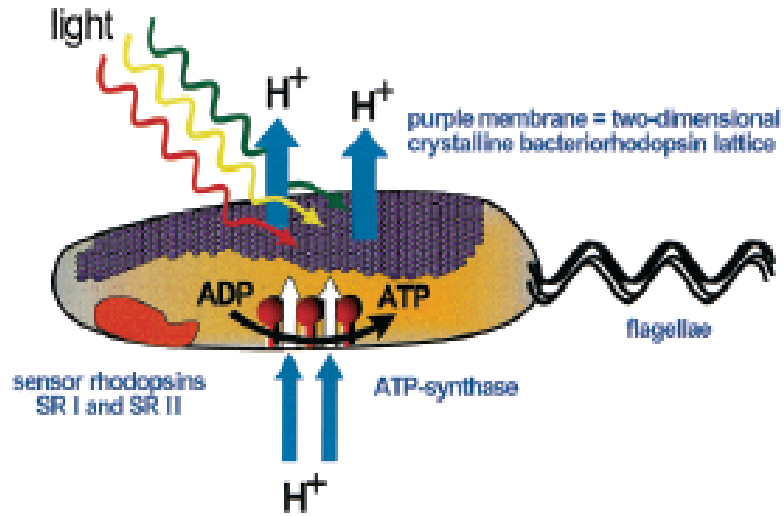
Материал нанокристалла	Оптический диапазон эмиссии, нм
ZnS	300–380
CdS	380–460
ZnSe	360–500
CdSe	480–660
CdSe/Te CdHg Te сплав	550–1000
CdTe	600–1000
CdHgTe/ZnS	630–860
InP	650–750
PbS	700–1600
InAs	830–1350
PbSe/Te	1000–2500



В.З. Пащенко, Е.П. Лукашев
 Кафедра биофизики биологического
 ф-та МГУ
 И.Р. Набиев, университет г. Реймса, Франция.



Фотоцикл бактериородопсина



Фоточикл бактериородопсина

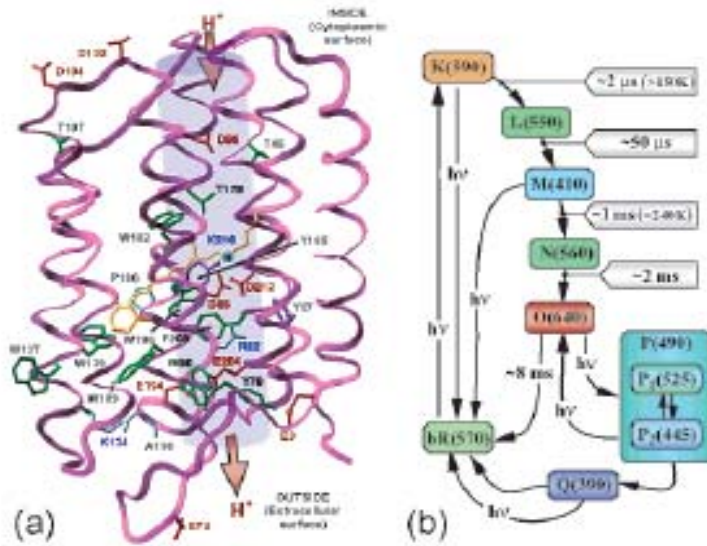
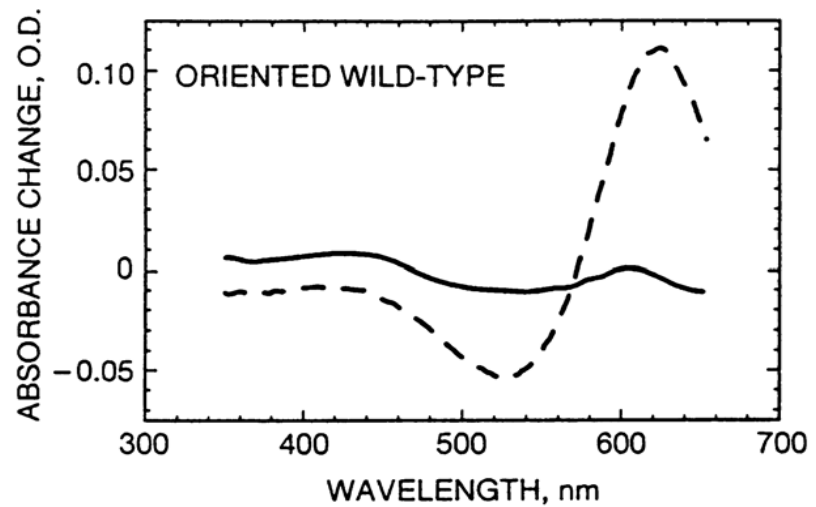
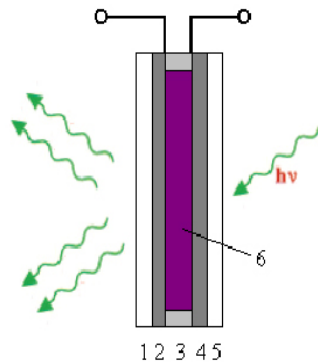
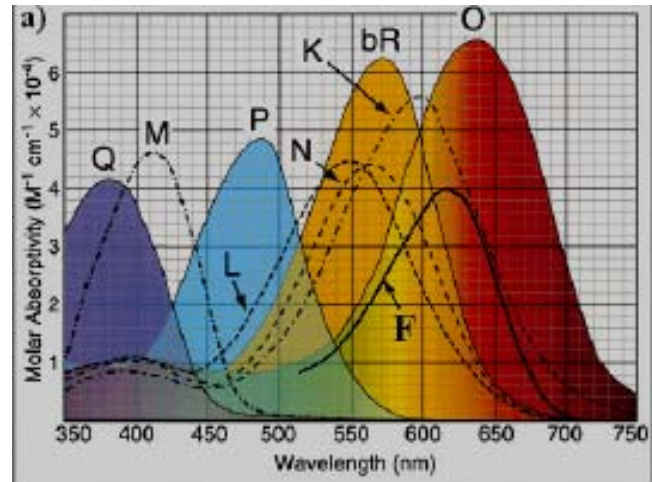
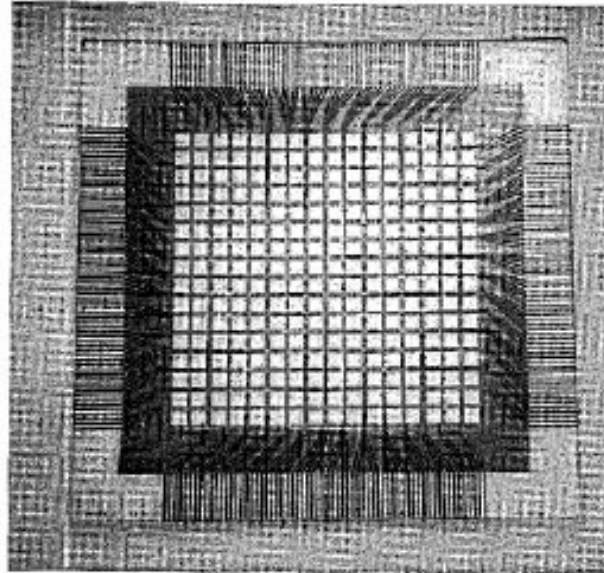


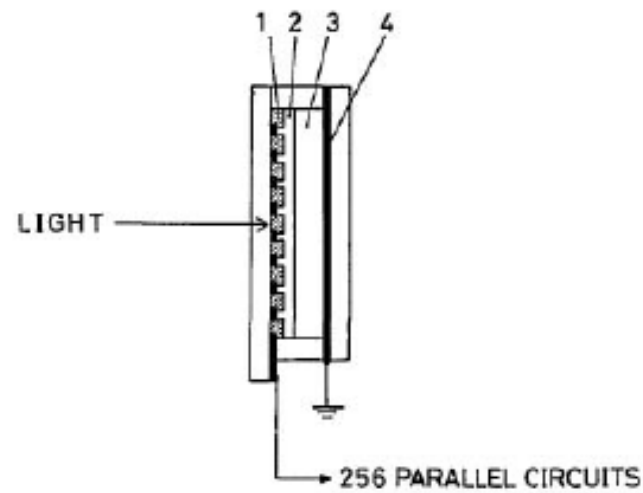
Figure 1. A schematic representation of (a) the bacteriorhodopsin tertiary structure and (b) the main photocycle and the branching reactions studied here. The structure is based on the crystal coordinates,¹ the proton pumping channel is shown in blue, and selected residues are indicated for reference. The chromophore is shown in yellow.



256-pixel bacteriorhodopsin photoreceptor



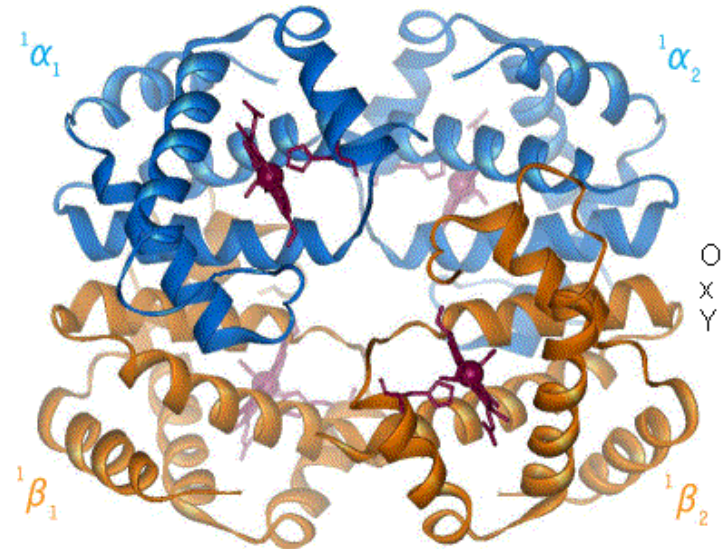
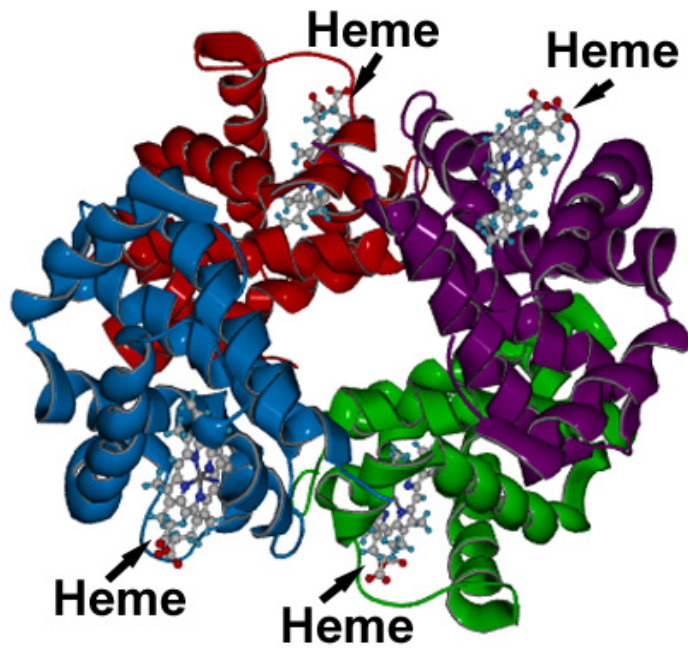
(a)



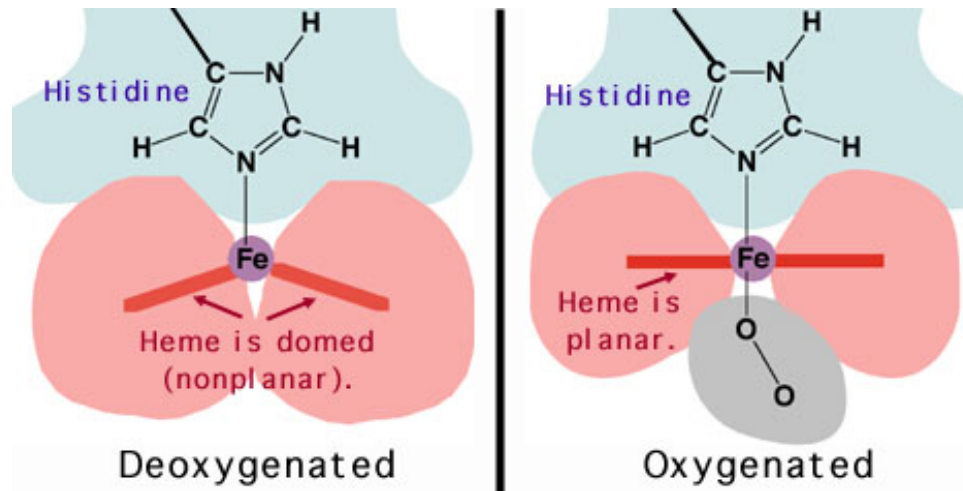
The scheme of time scales of protein molecular dynamics

Primary events in photosynthesis and vision	$10^{-13} - 10^{-12}$ s
Local dynamics of atoms and small groups	$10^{-12} - 10^{-11}$ s
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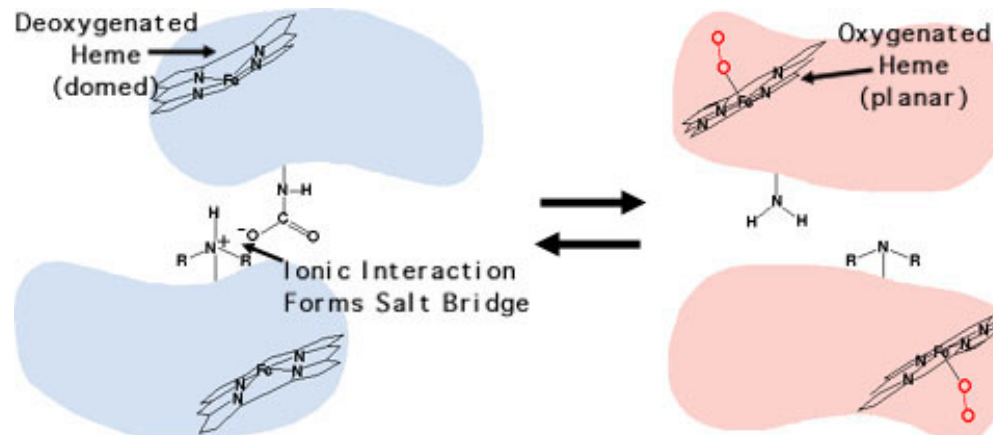
Структура гемоглобина



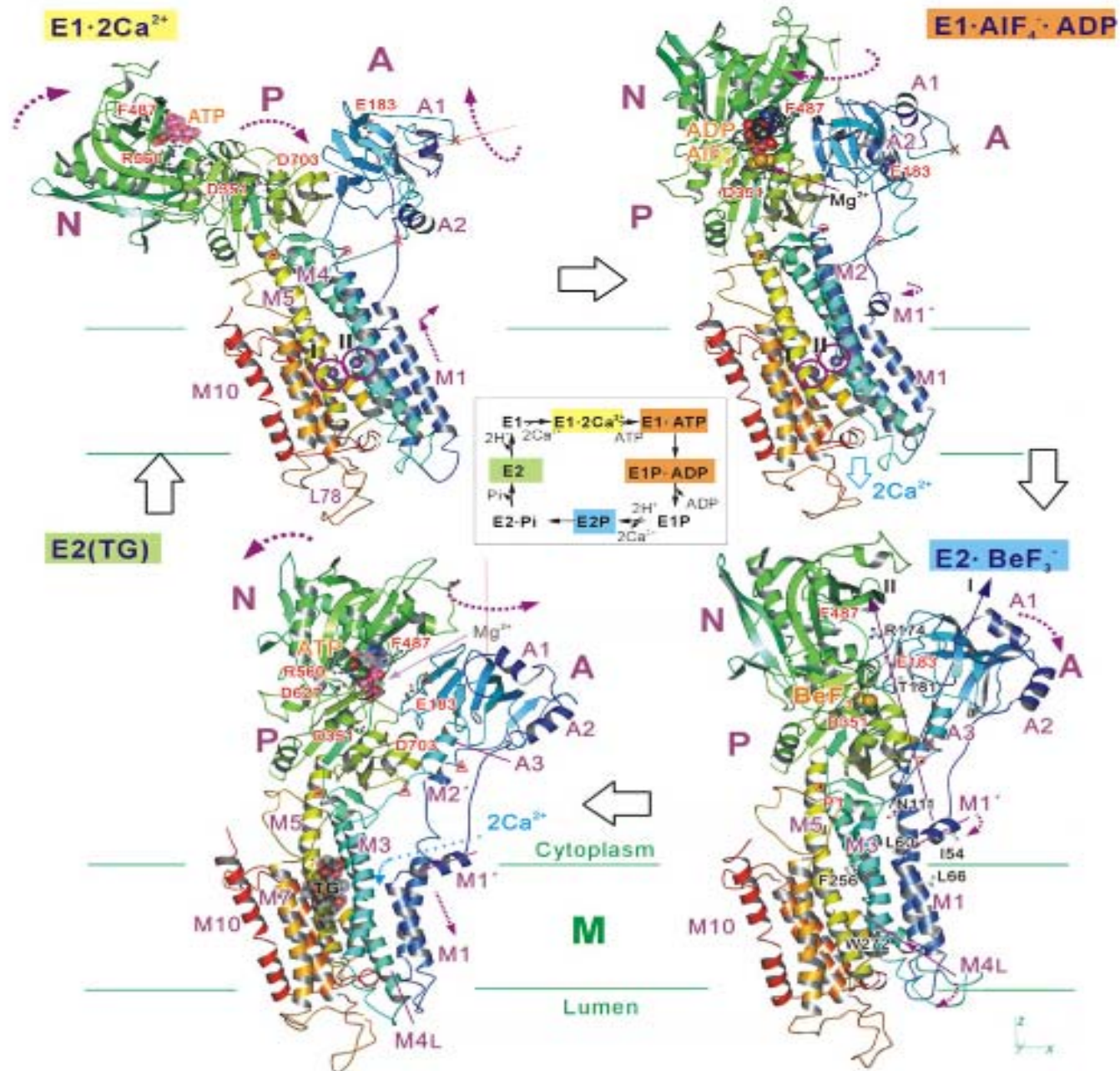
Конформационные изменения гемоглобина в области гемопорфирина



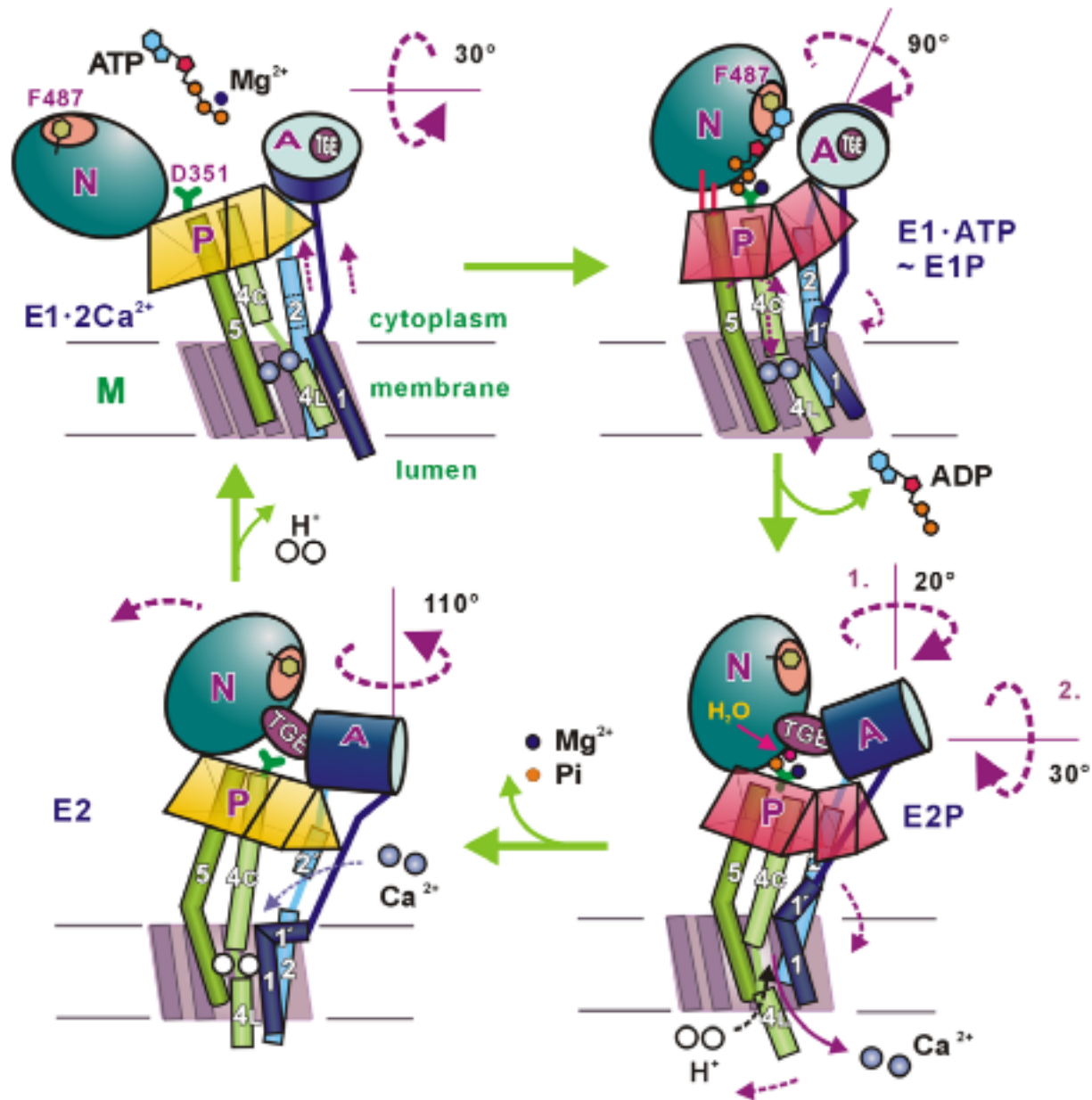
Конформационные изменения гемоглобина в области контакта субъединиц



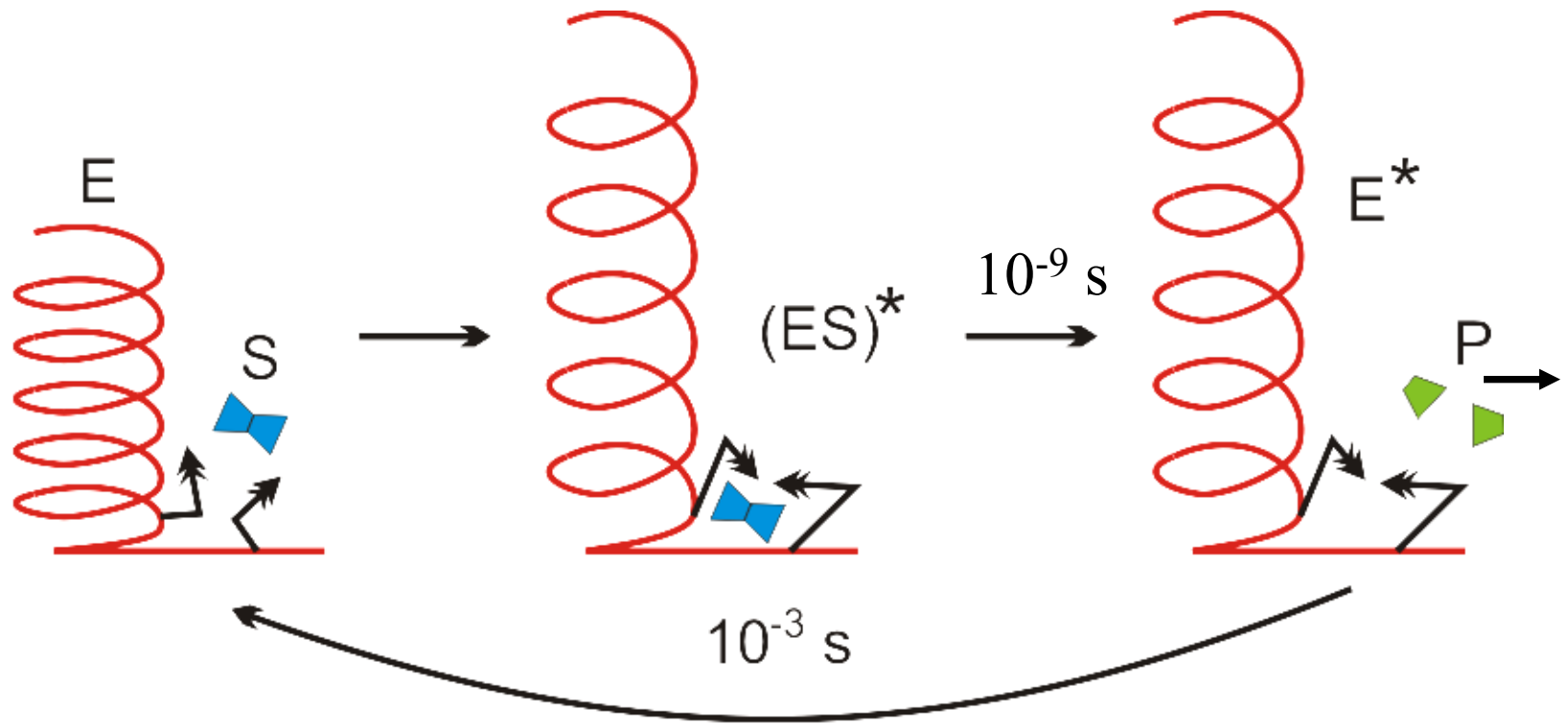
Цикл Ca^{2+} насоса

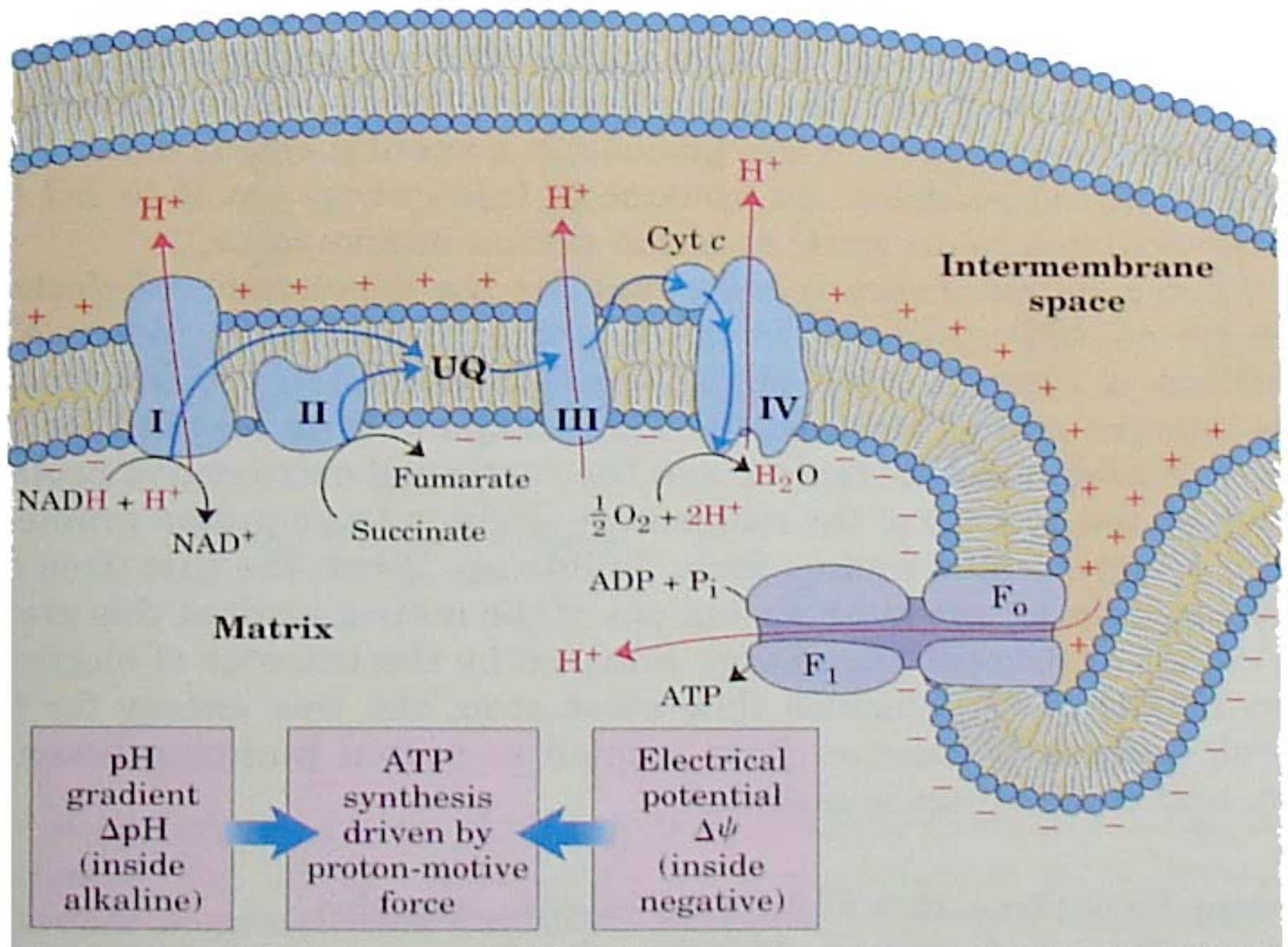


Цикл Ca^{2+} насоса

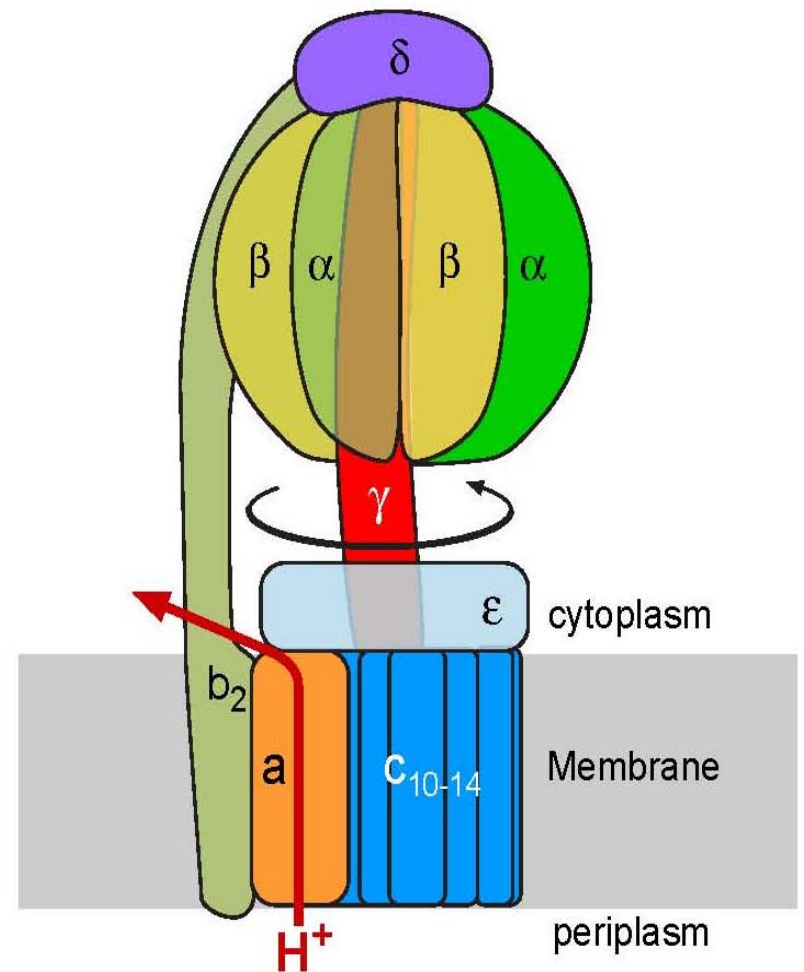
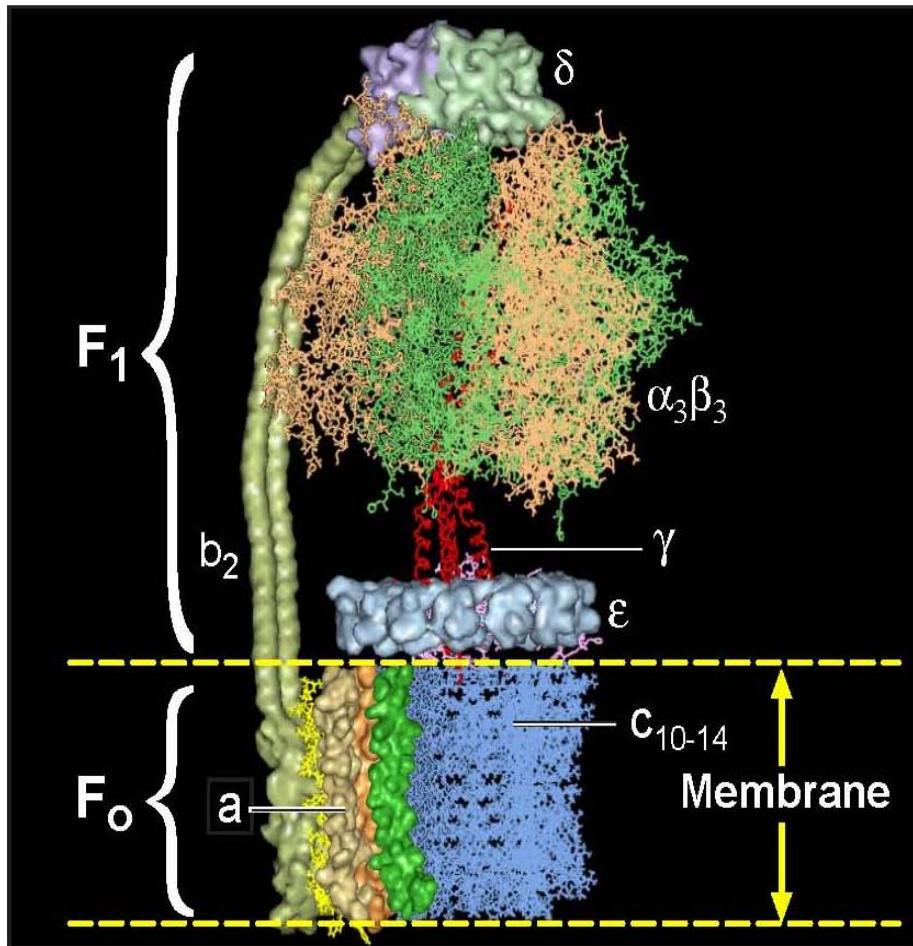


Электронно-конформационные взаимодействия в «работе» фермента

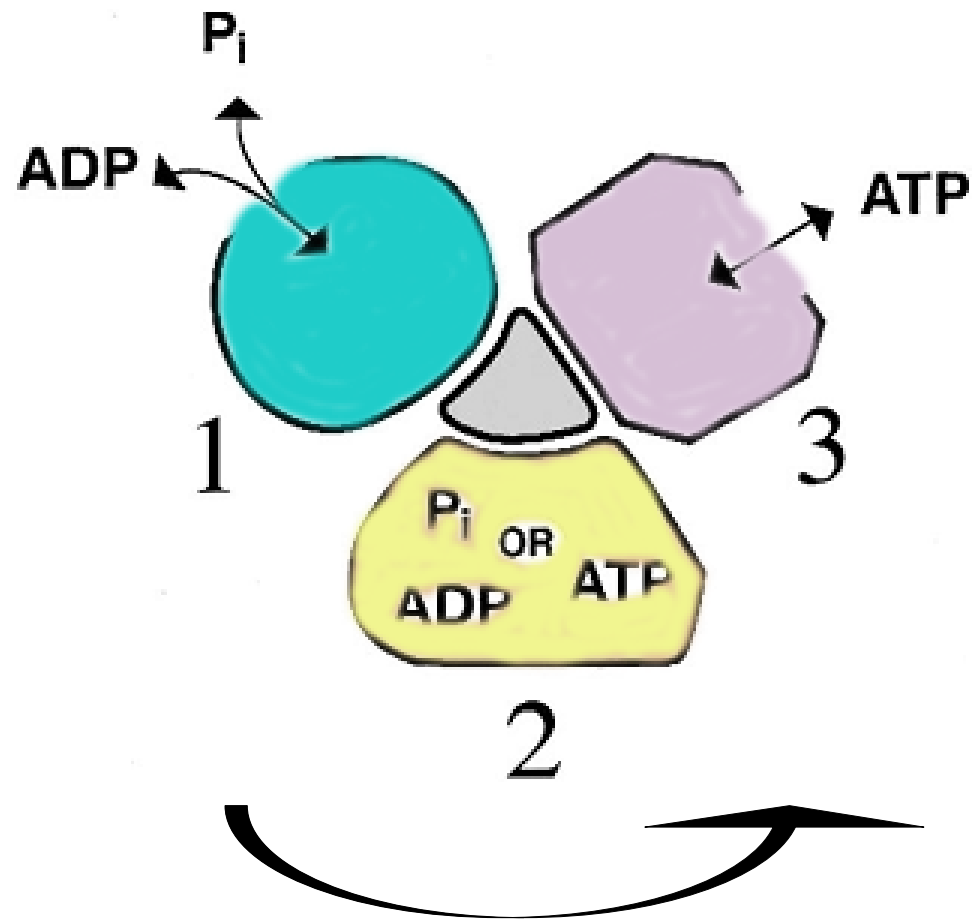


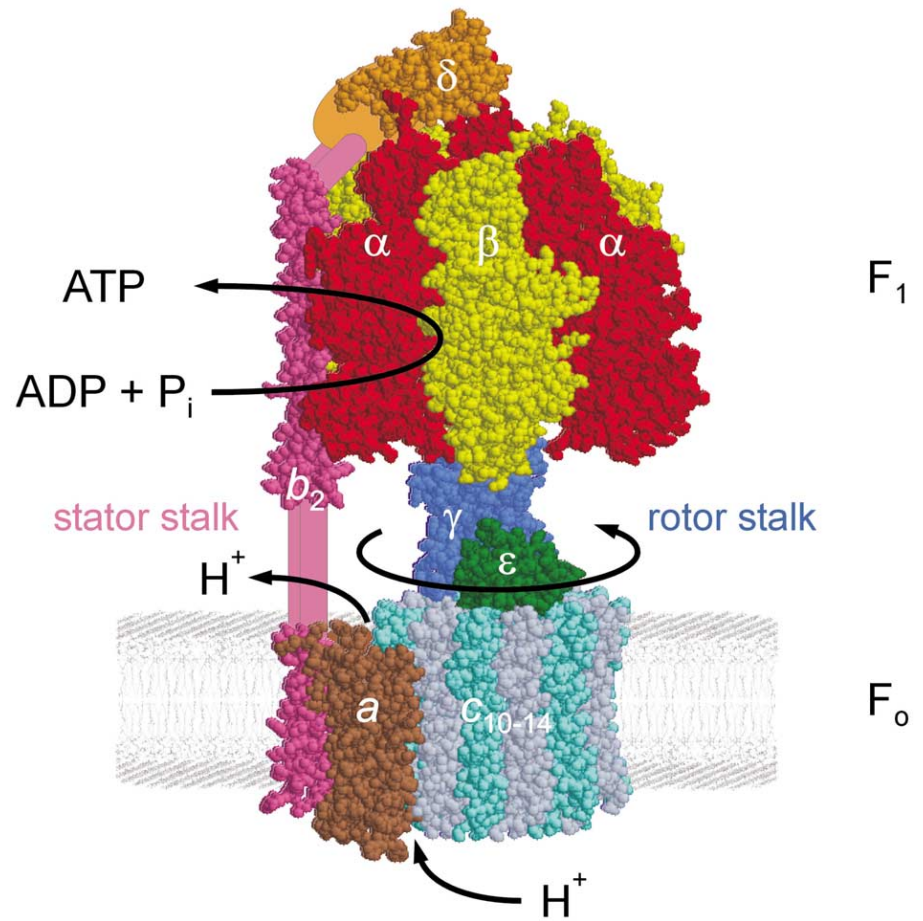


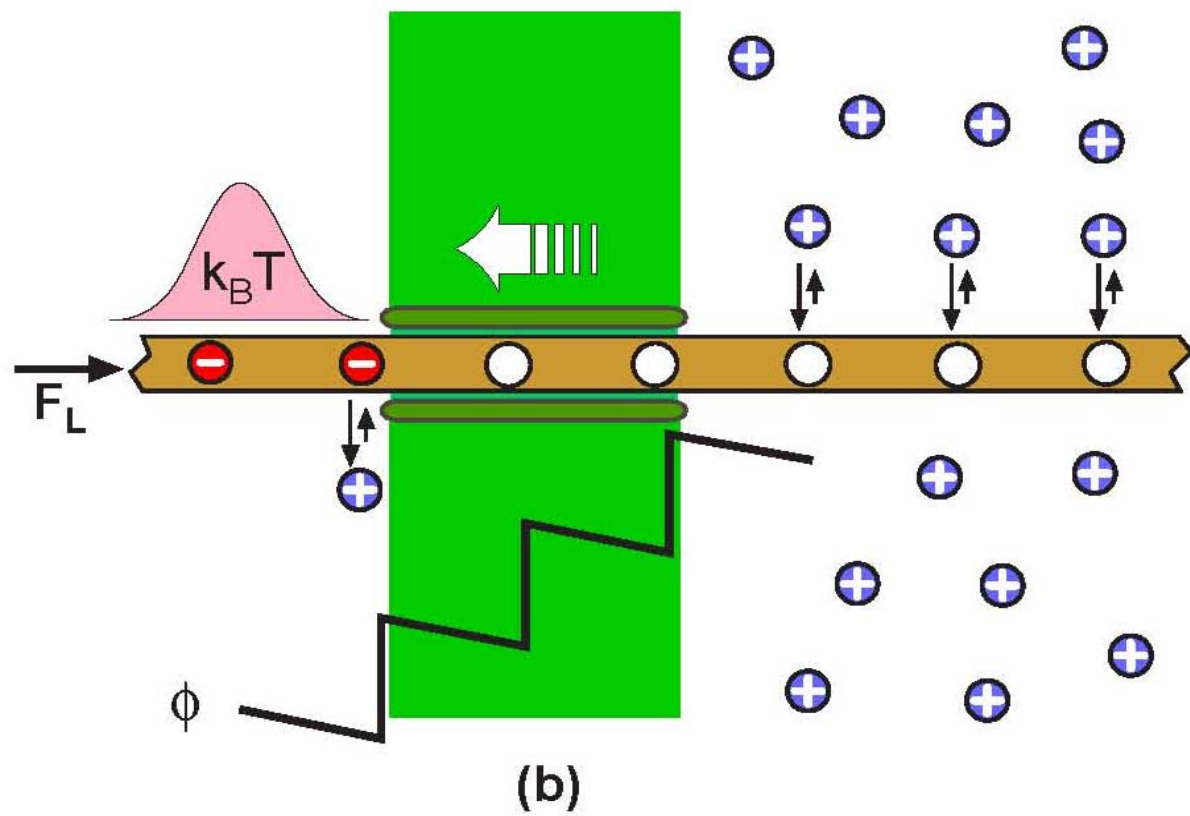
Структура АТФ-азы

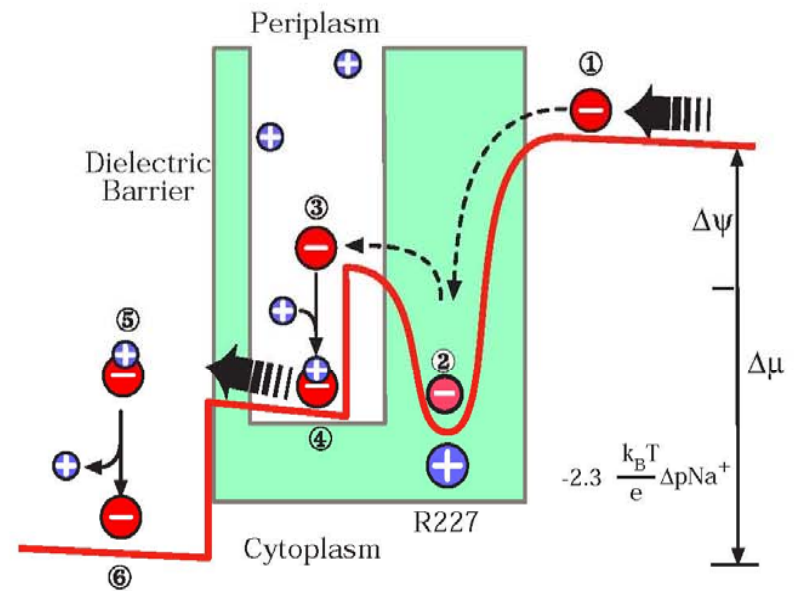
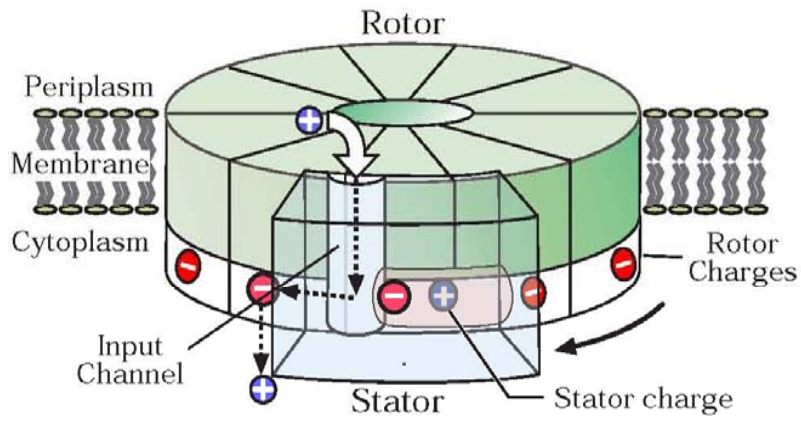


Активные центры АТФ-азы

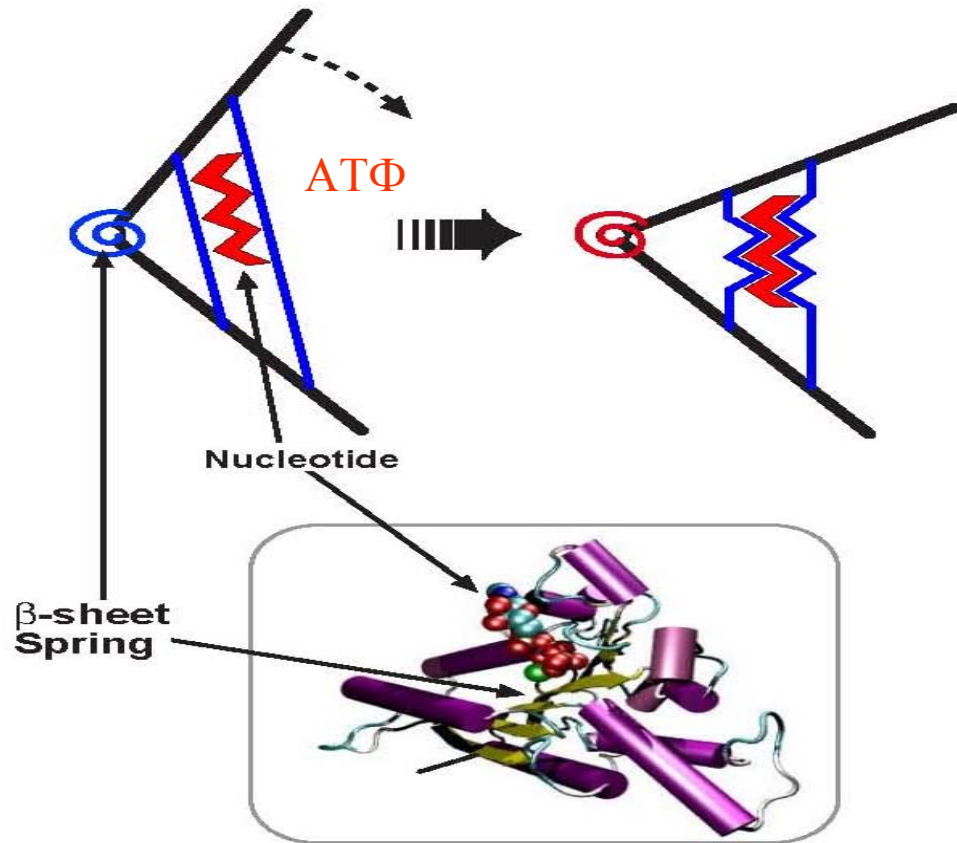


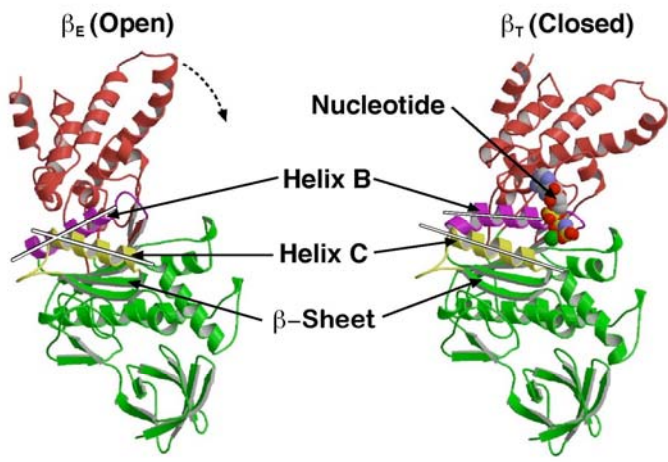




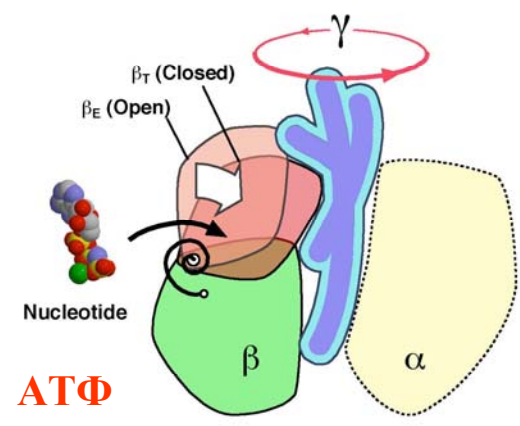


Oster/Wang
Figure 5

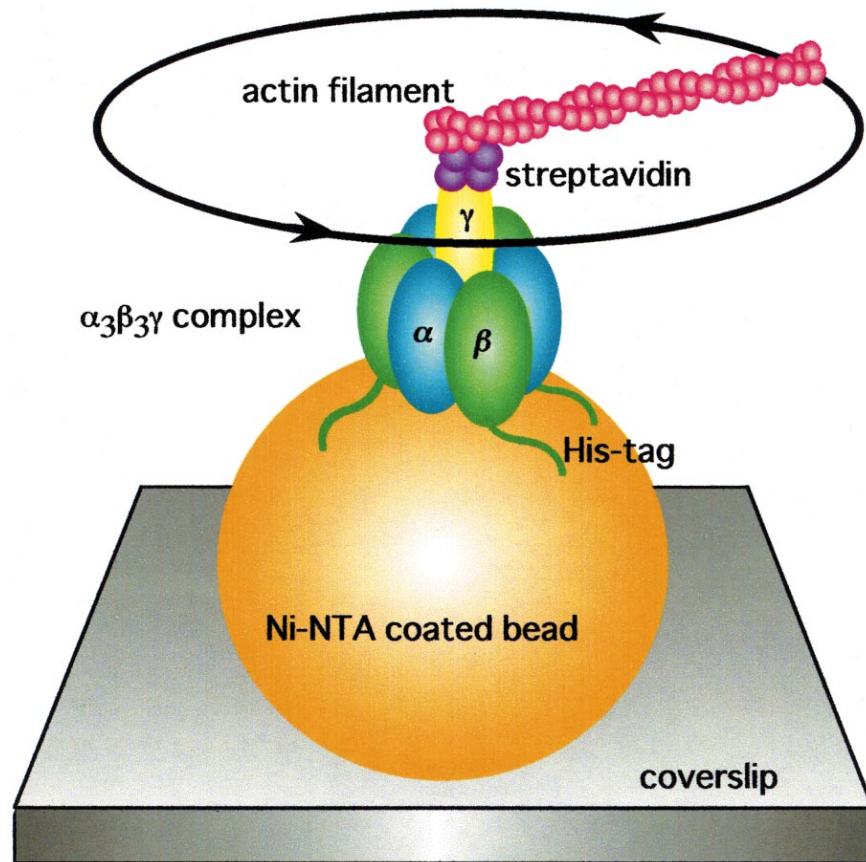




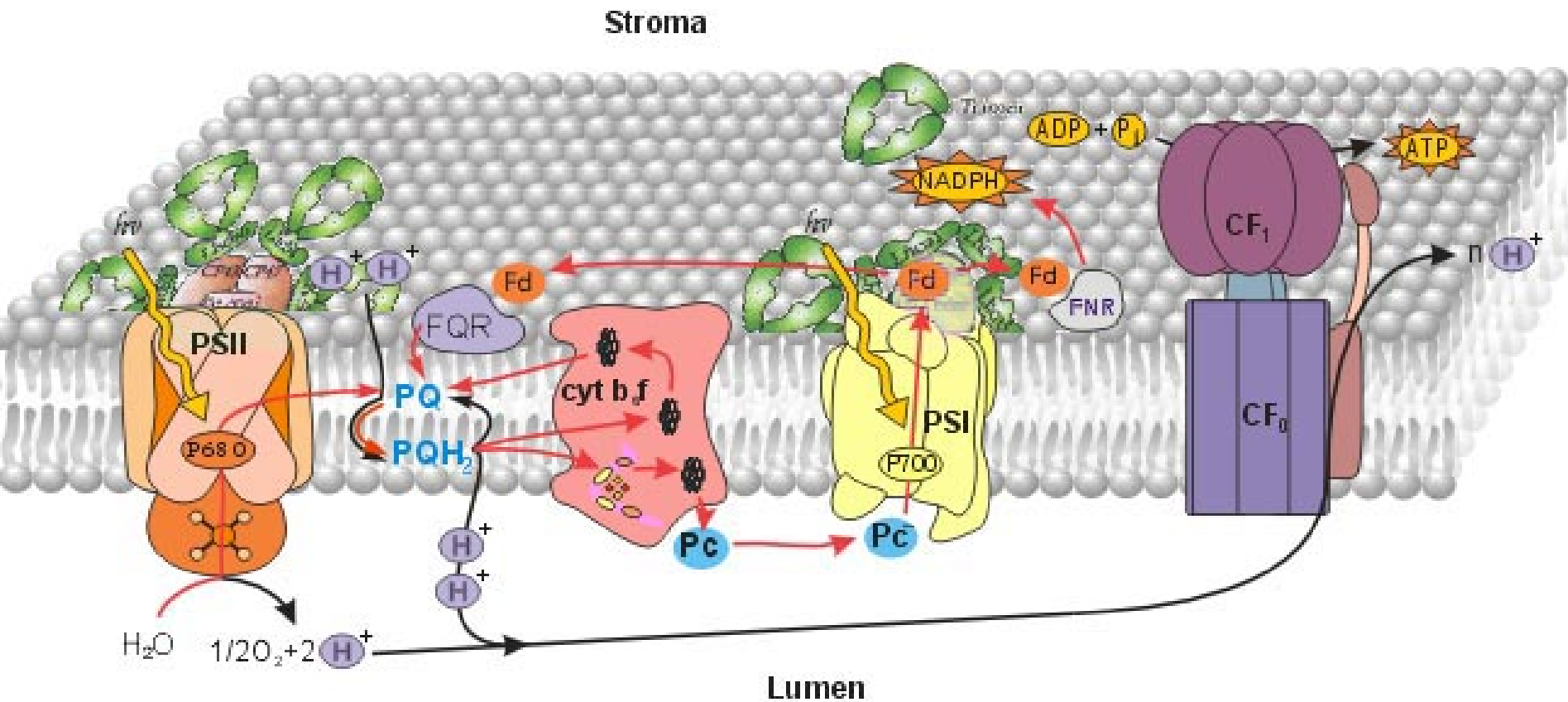
(a)

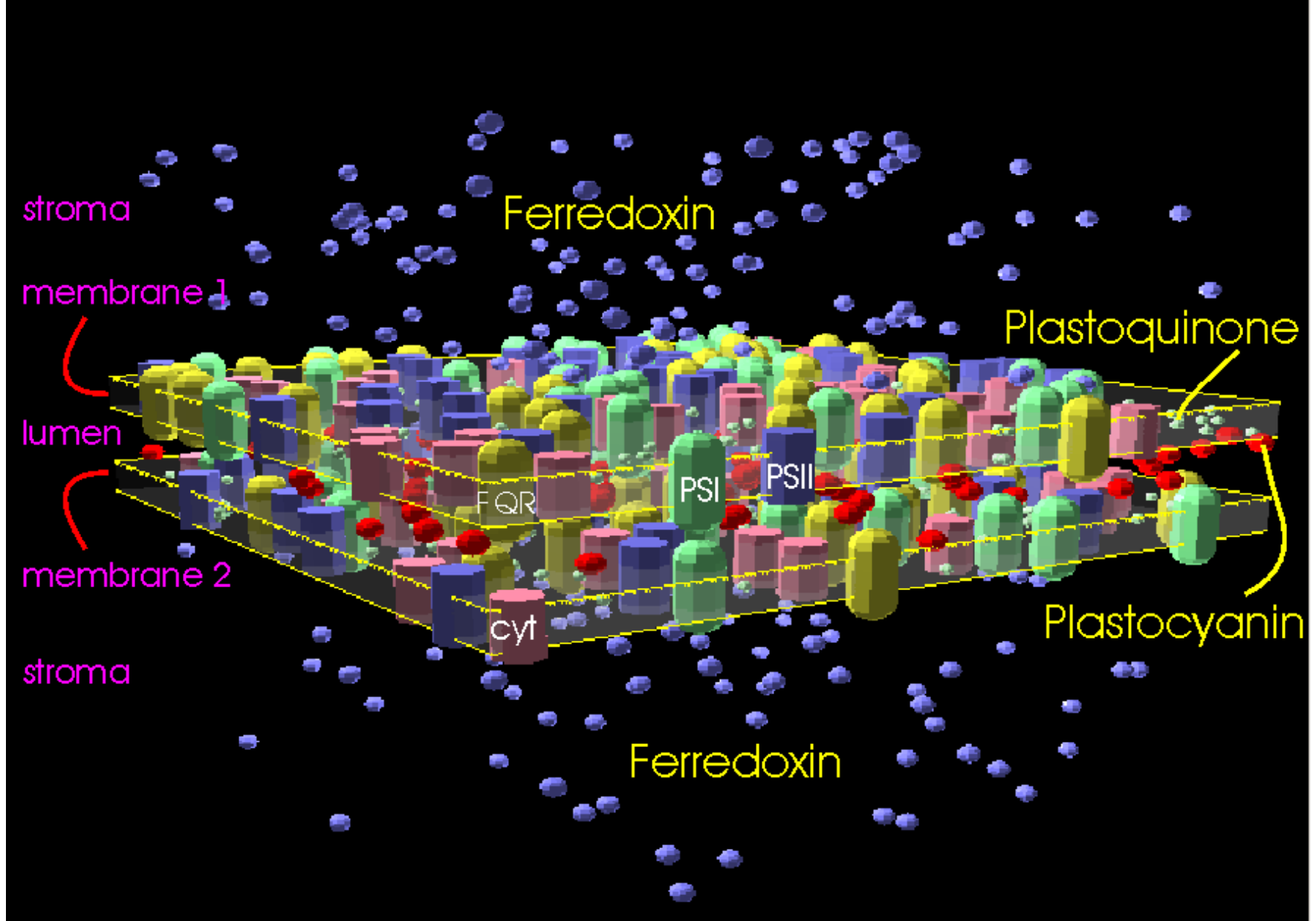


(b)



Пространственное расположение комплексов в мембране



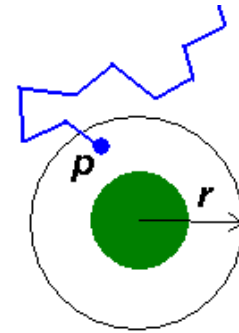


Scene of the direct model

Brownian motion of the mobile carrier

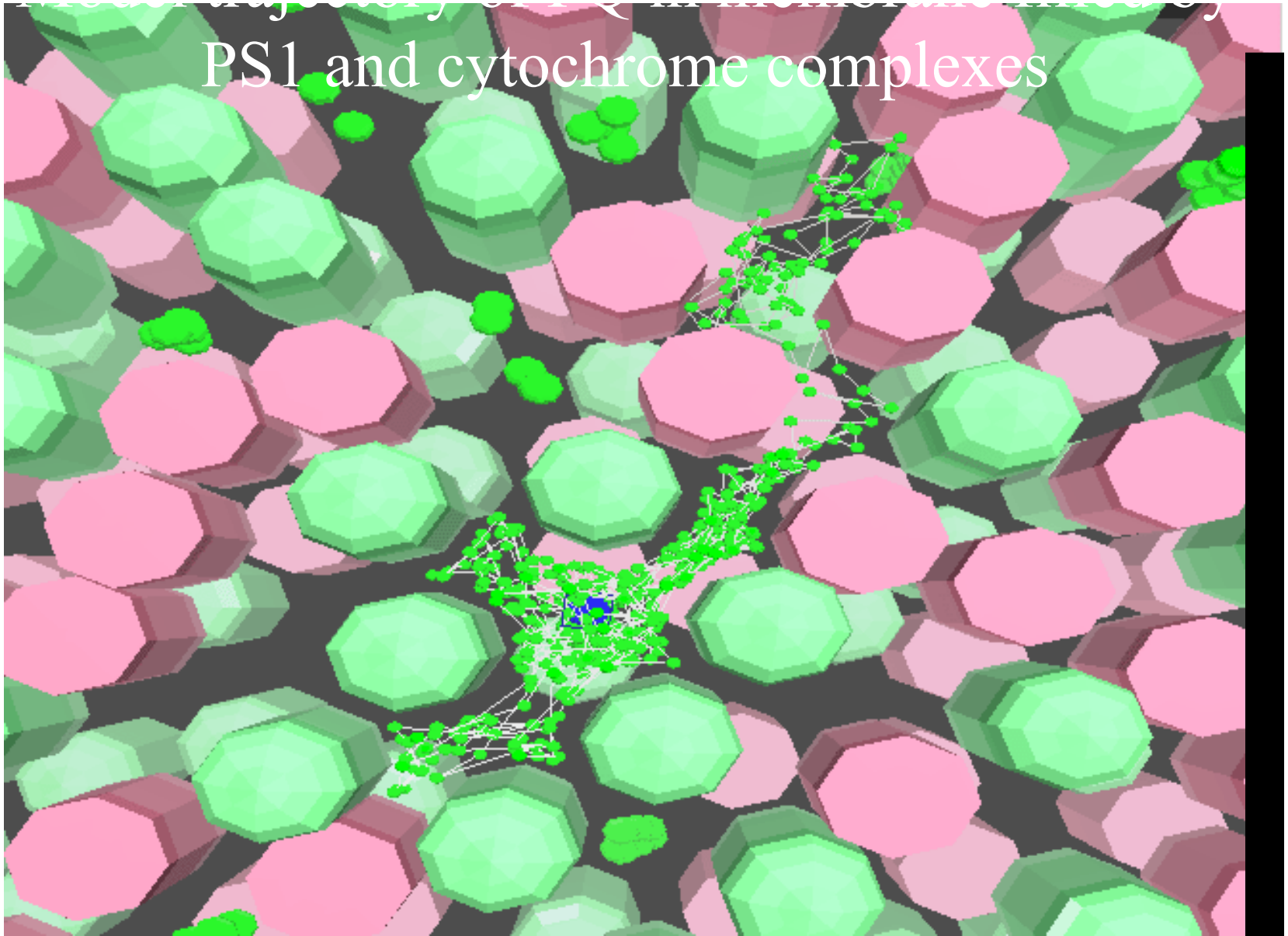
- Langeven Equation:

$$\xi \frac{dx}{dt} = f(t)$$

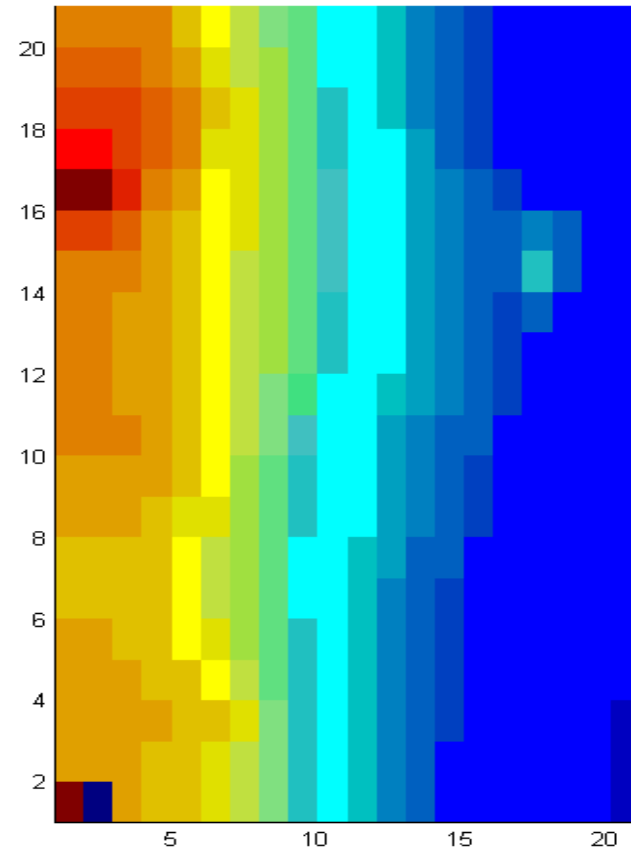
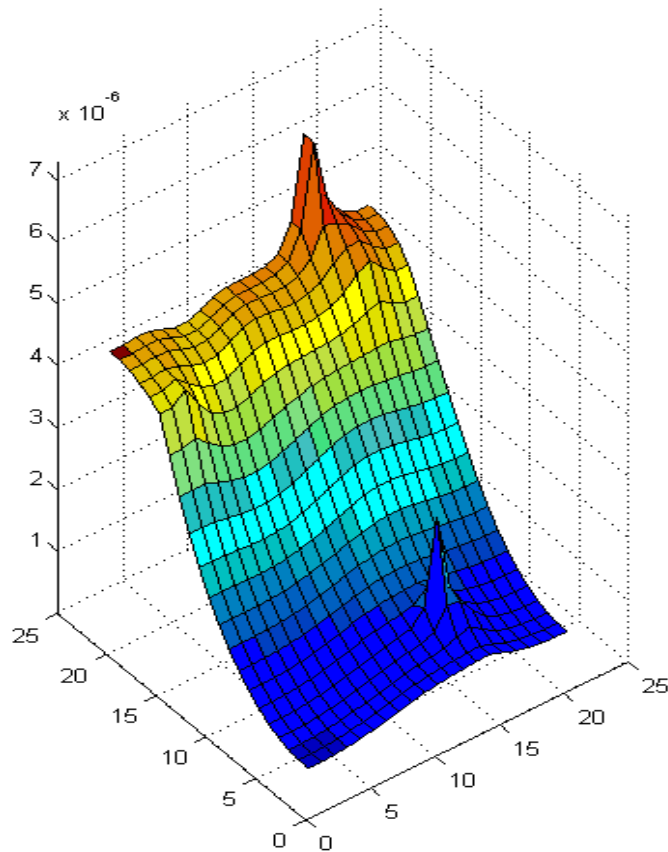


- $f(t)$ – casual force, distributed by Gauss
- average value - zero
- dispersion $2kT\xi$
- k – Boltzmann constant, T – temperature,
 ξ – friction coefficient of the media

PS1 and cytochrome complexes

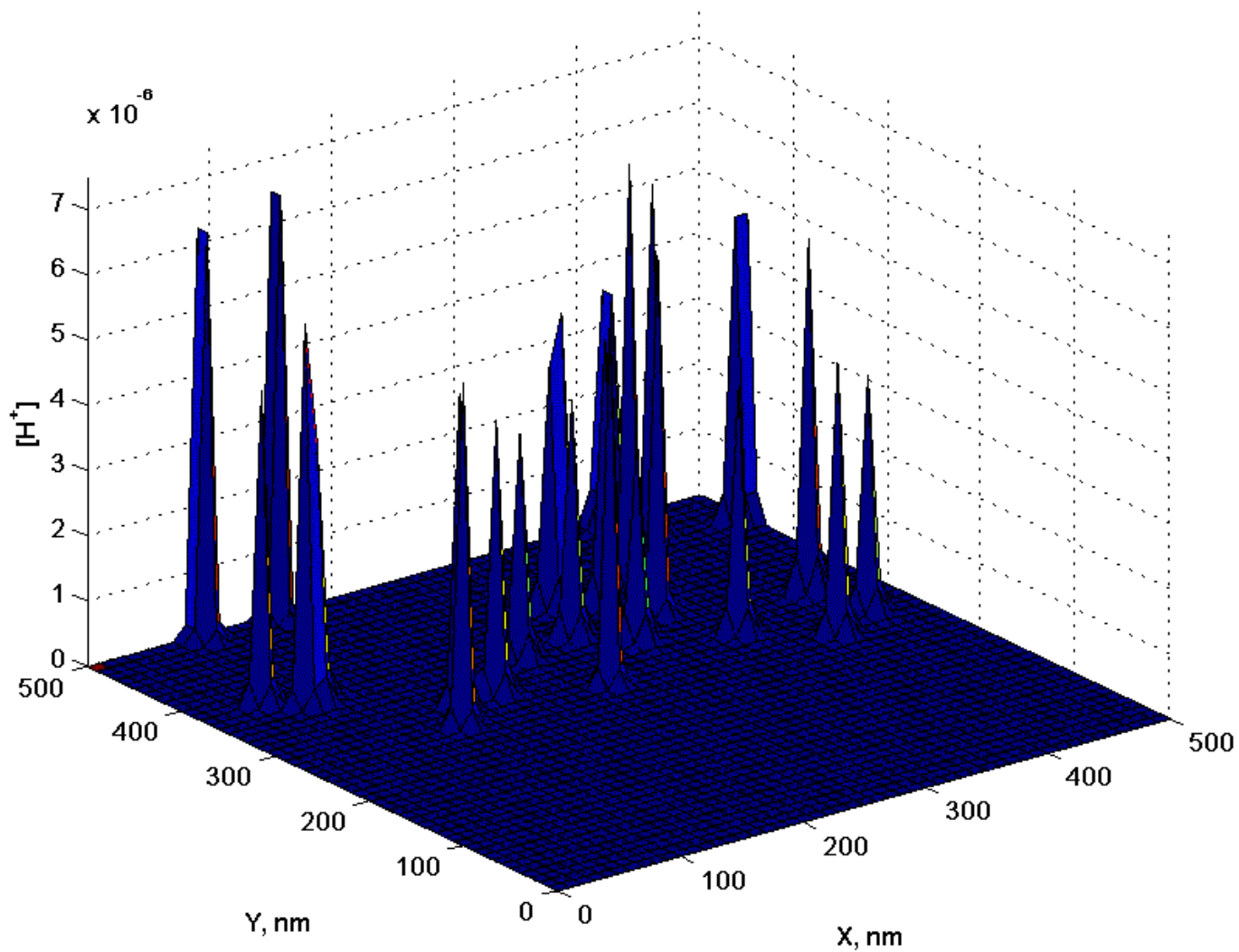


Накопление протонов

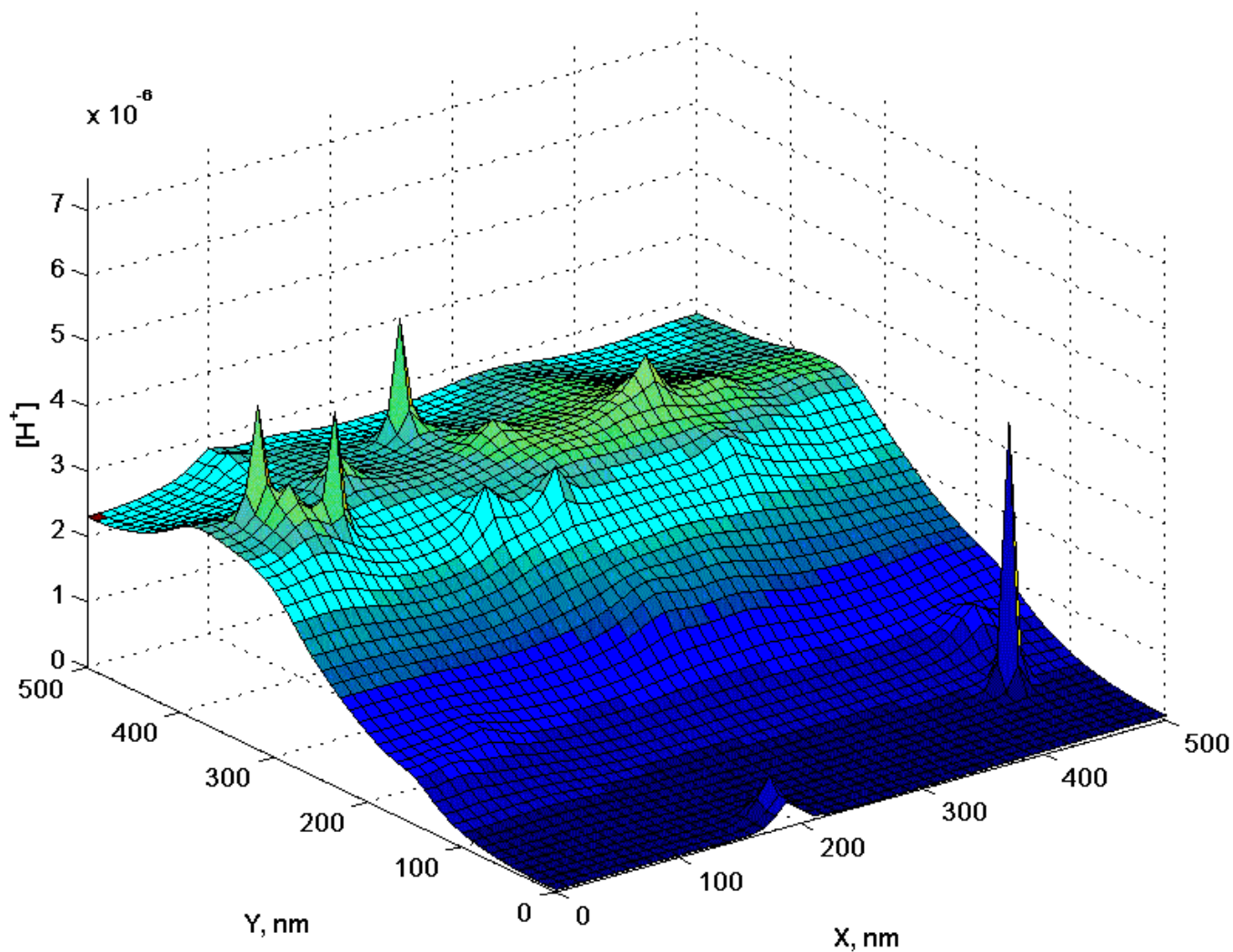


- Концентрация протонов в плоскости мембраны, через 5 миллисекунд после начала освещения

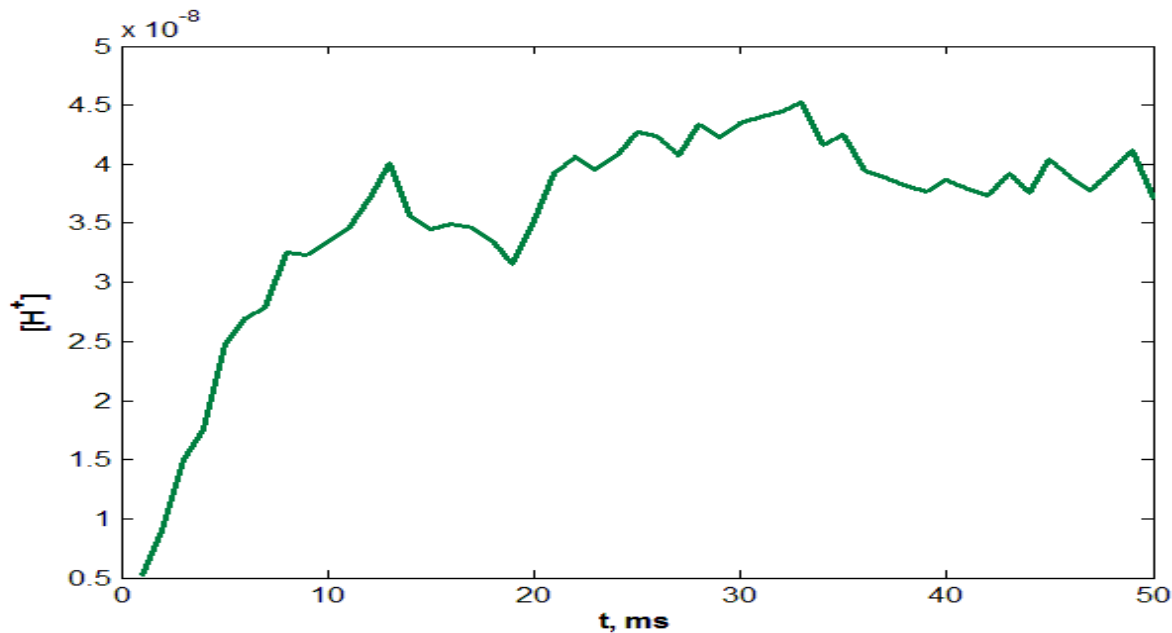
Профиль концентрации протонов в люмене в плоскости мембраны



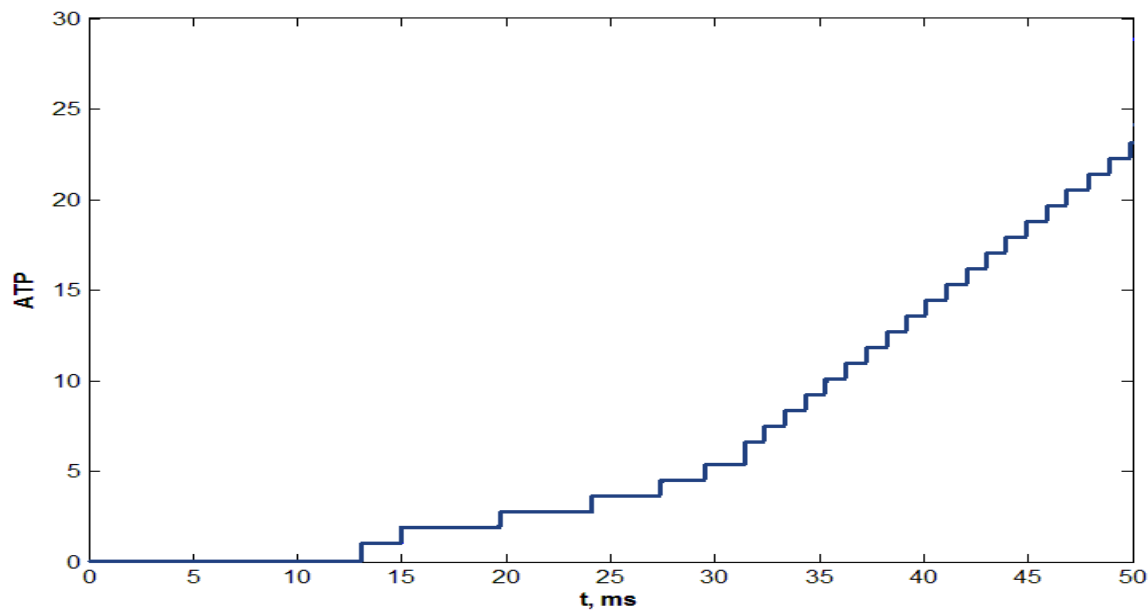
Профиль концентрации протонов в люмене в плоскости мембраны



Концентрация протонов в люмене и синтез АТФ

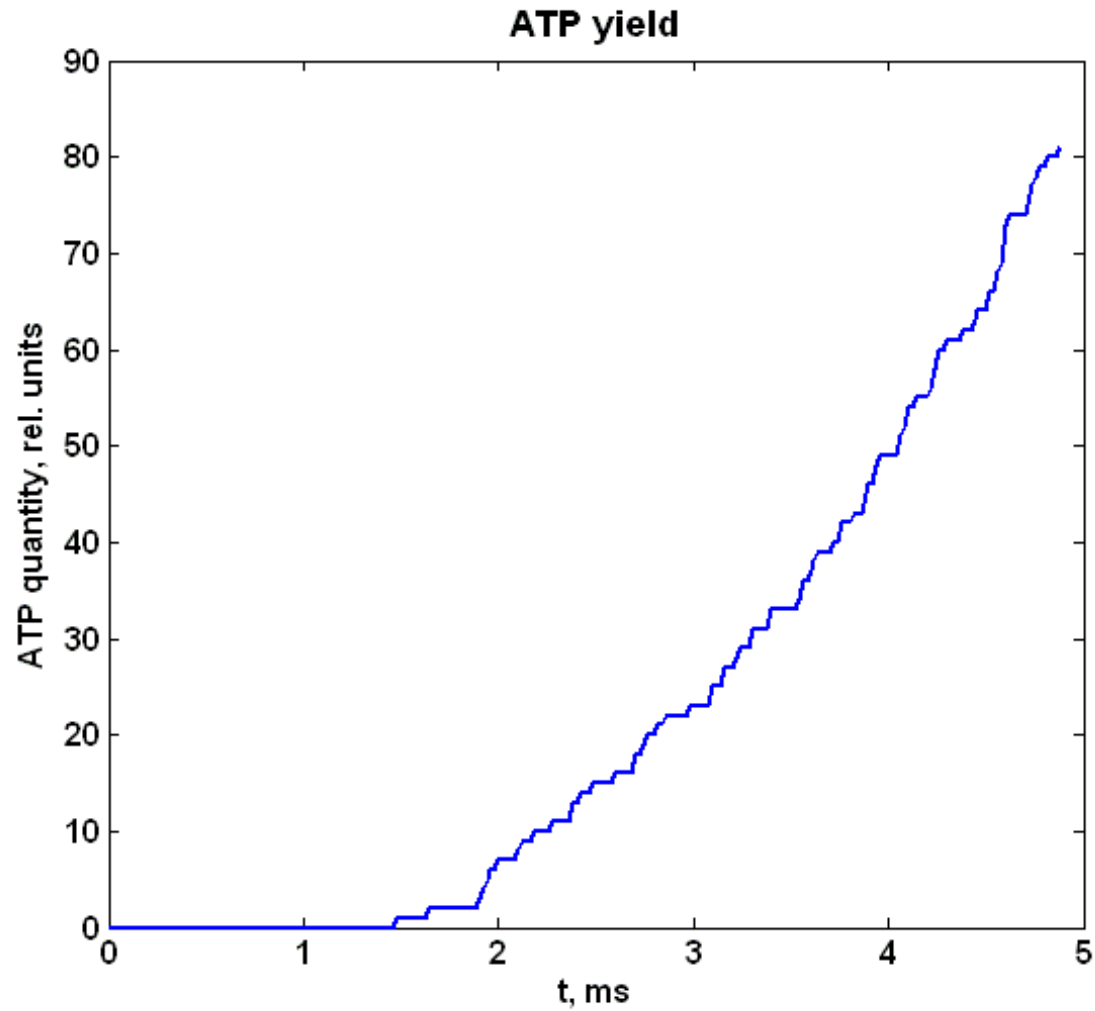


Общее количество протонов в люмене сначала нарастает, и со временем и выходит на постоянный уровень



С ростом рН в стромальной области АТФ-синтаза начинает производить АТФ. Сначала скорость синтеза лимитируется количеством доступных протонов, затем – временем поворота субъединиц.

Синтез АТФ



- Количество синтезированной АТФ в зависимости от времени

