

Bioquímica Estrutural:

Estudo da estrutura das moléculas biológicas e dos princípios que a regem.

(~ **Biologia Estrutural**)

Macromoléculas biológicas

- **DNA:** repositório da informação genética na maioria dos organismos vivos
- **RNA:** transferência (e repositório) de informação genética, matriz para a síntese proteica, funções estruturais, etc...
- **Proteínas:** componentes estruturais (pele, ossos, músculo, cabelo, etc...), catálise de reacções bioquímicas (enzimas), transmissão de sinais, regulação, transdução de energia, etc.,etc., etc.!..
- **Lípidos:** componentes essenciais das membranas biológicas, sinalização
- **Polissacáridos:** armazenamento de energia, função estrutural

Sequência



Estrutura



Função

Fluxo de informação biológica

vírus de RNA

→ DNA

...TTAATAAGT...

↓ transcrição

- RNA

...UUAAUAAGU...

↓ splicing, tradução

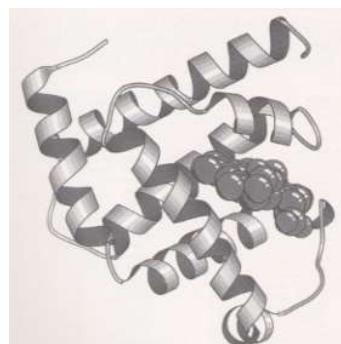
cadeia
polipeptídica

...LISVHDN...

↓ modificações pós-translacionais

proteína

priões

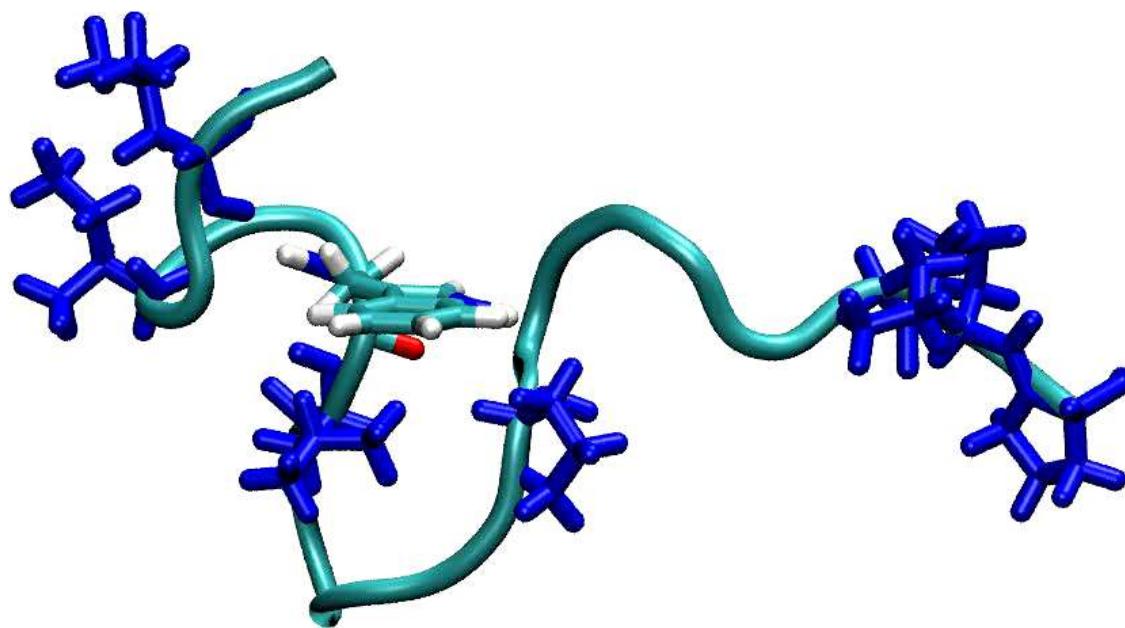


Dogma central da
biologia molecular

Excepções: vírus de RNA,
priões, ribozimas (?)

Sequência->Estrutura

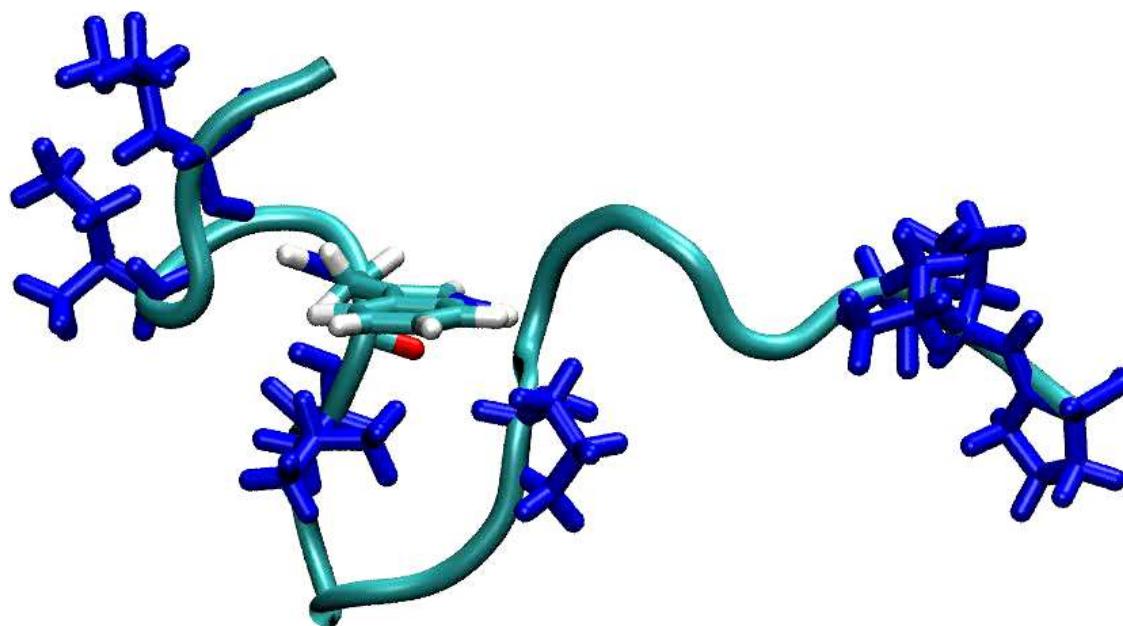
Folding da mini-proteína Trp-cage em solução aquosa:



Muitas protéinas adquirem a sua estrutura tridimensional *espontâneamente (folding)*

Sequência->Estrutura

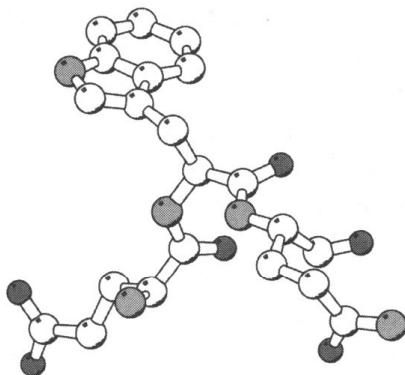
Folding da mini-proteína Trp-cage em solução aquosa:



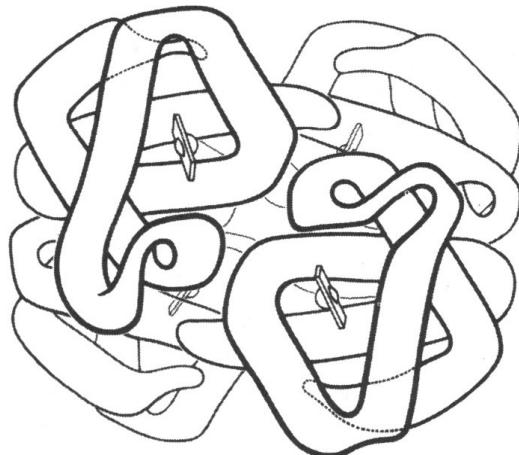
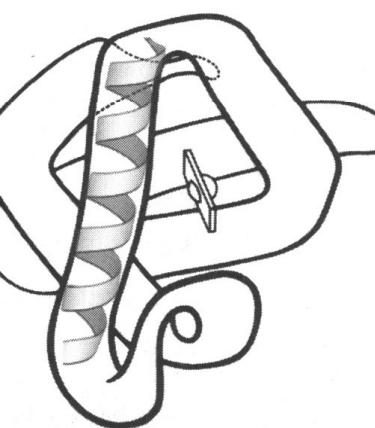
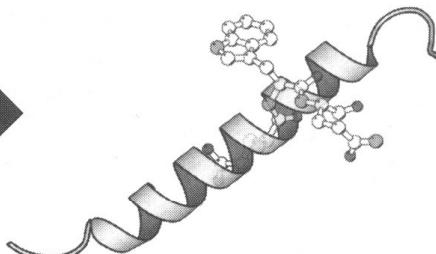
Muitas protéinas adquirem a sua estrutura tridimensional *espontâneamente (folding)*

Níveis de organização da estrutura das proteínas

Estrutura primária



Estrutura secundária

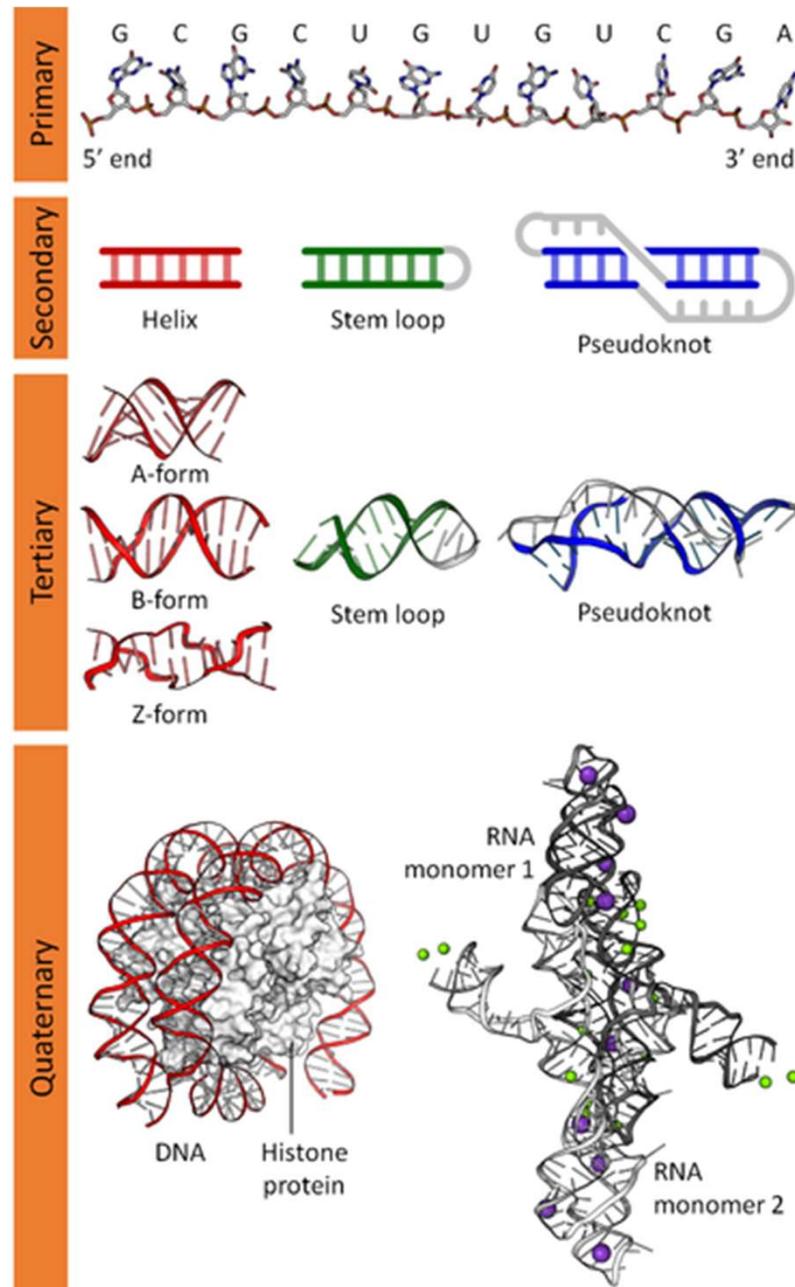


Estrutura quaternária

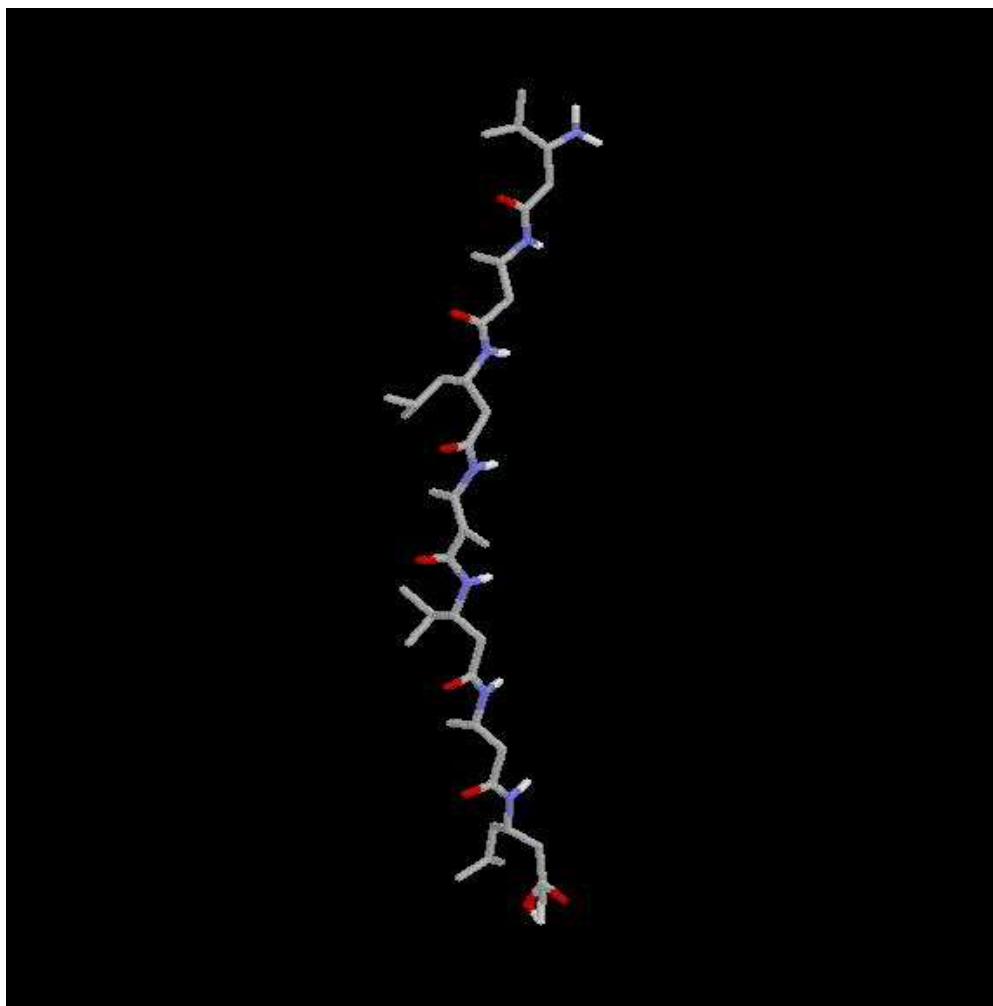
Estrutura terciária

Níveis de organização da estrutura de ácidos nucleicos

Estrutura quaternária pode envolver moléculas de proteína

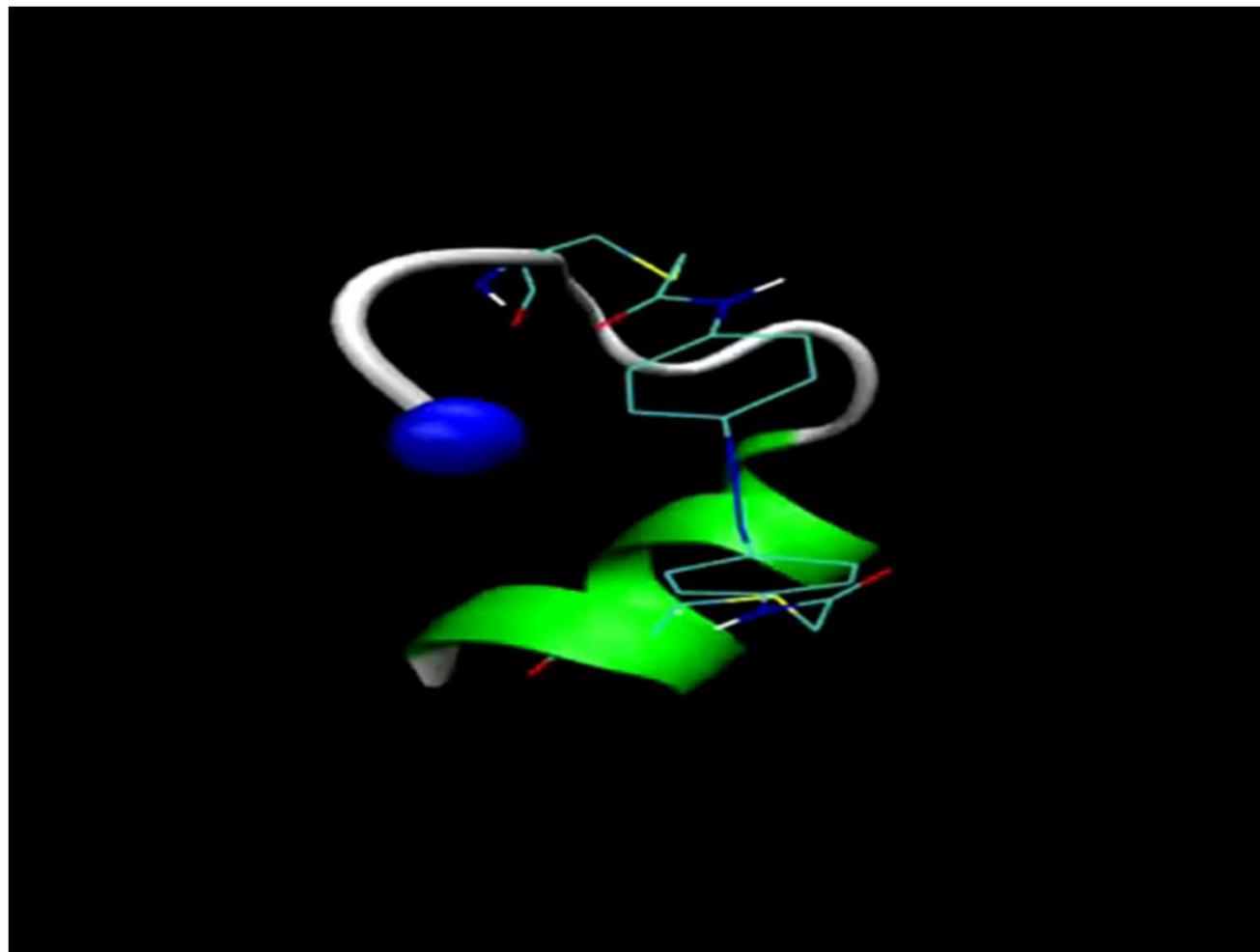


Formação hierárquica da estrutura



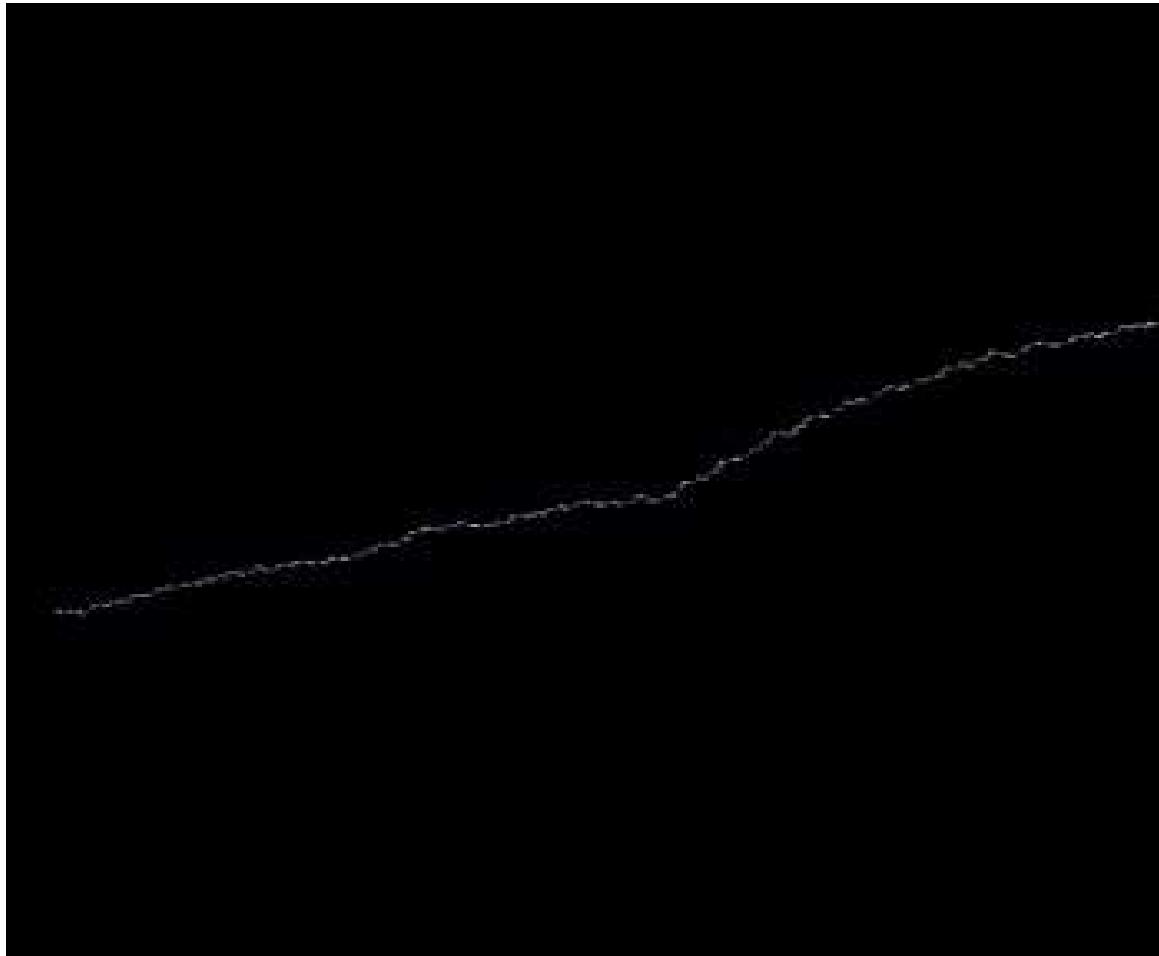
Formação espontânea de uma hélice α
(simulação)

Formação hierárquica da estrutura



Formação espontânea de uma hélice α
(simulação)

Formação hierárquica da estrutura



“Simulação” do *folding* ubiquitina

De onde provêm a informação estrutural ?

Combinação de vários tipos de conhecimento:

- Teoria da ligação química
- Geometria de moléculas pequenas
- Métodos experimentais para a determinação da estrutura:
 - ❖ Cristalografia de raios X
 - ❖ Ressonância Magnética Nuclear (NMR)
 - ❖ Microscopia Electrónica
 - ❖ Outros métodos (difração de neutrões, SAXS, etc)

Que informação temos disponível ?

(dados do Protein Data Bank em [5/02/2024](#))

Número de estruturas tridimensionais (coordenadas atómicas):

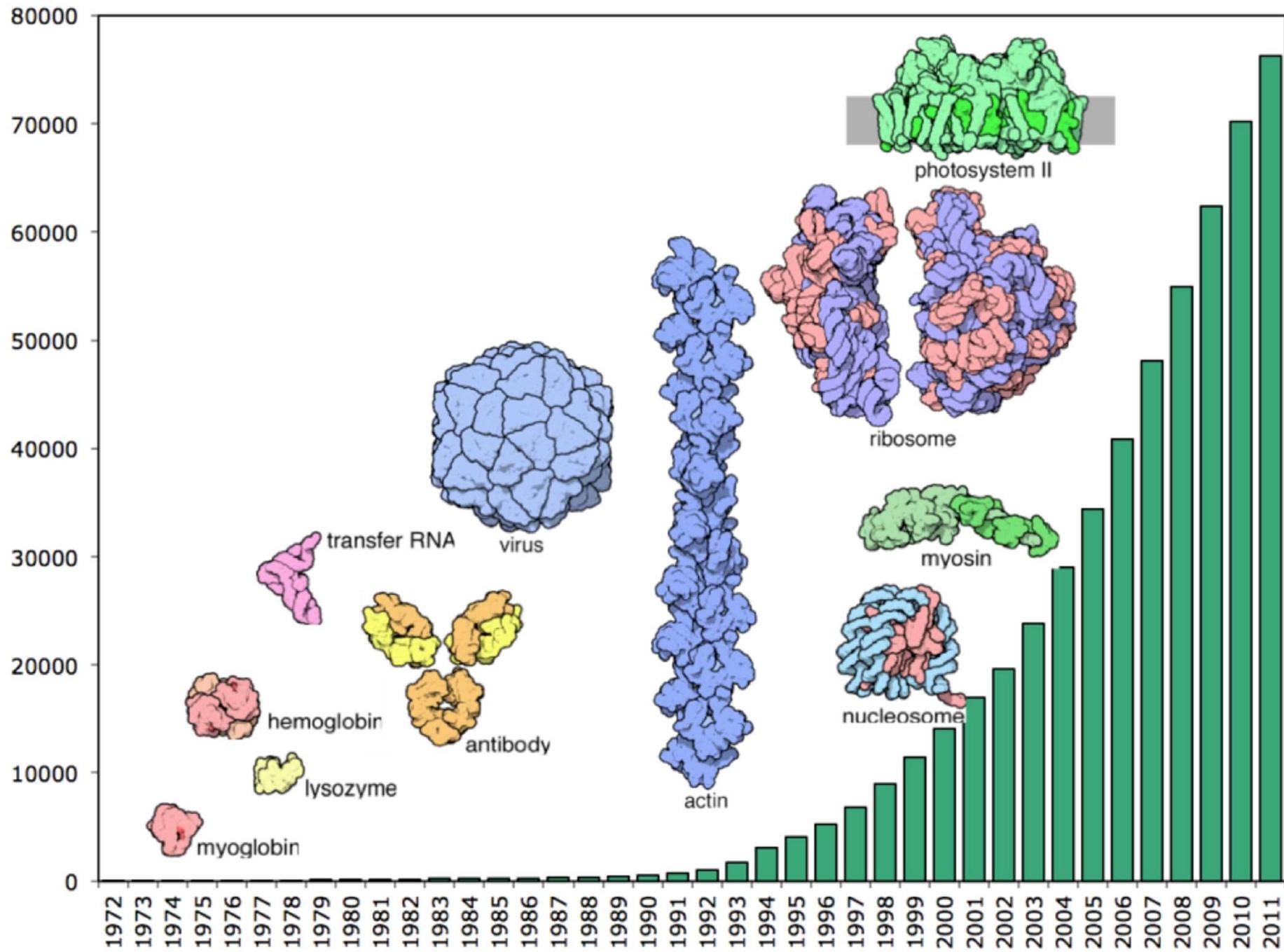
- Proteínas: 186680
- Ácidos Nucleícos: 4373
- Complexos ácido nucleíco-proteína: 12606
- Proteína/Oligossacárido: 11514
- Outros: 228

Total: **215401** estruturas

Métodos experimentais de determinação da estrutura:

- Cristalografia de raios X: 181272 (**84.6%**)
- Microscopia electrónica: 18720 (8.69%)
- NMR em solução aquosa: 14164 (6.58%)
- Métodos híbridos: 229
- Outros: 116

Progresso na determinação das estruturas





215,401 Structures from the PDB

1,068,577 Computed Structure Models (CSM)

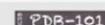
3D Structures

Enter search term(s), Entry ID(s), or sequence

Include CSM



Help



Access Computed Structure Models (CSMs) of all available model organisms

Learn more

Welcome

Deposit

Search

Visualize

Analyze

Download

Learn

RCSB Protein Data Bank (RCSB PDB) enables breakthroughs in science and education by providing access and tools for exploration, visualization, and analysis of:

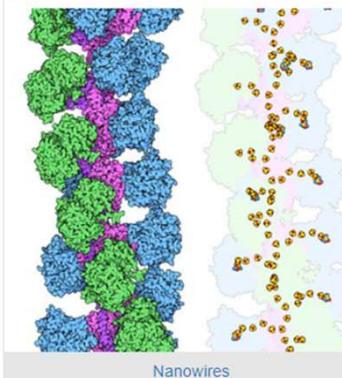
Experimentally-determined 3D structures from the **Protein Data Bank (PDB)** archive

Computed Structure Models (CSM) from AlphaFold DB and ModelArchive

These data can be explored in context of external annotations providing a structural view of biology.



February Molecule of the Month



Nanowires

Latest Entries

As of Tue Jan 30 2024



8GLK

The Type 9 Secretion System dGdL peak II, NucA substrate bound complex

Features & Highlights



Register for the February 5 RCSB.org Office Hour

Have questions about how to use RCSB.org? Join us for a virtual Office Hour.



Notice: NGL Viewer Deprecation

As of June 28, 2024, the NGL molecular viewer will be removed from RCSB.org. Users are encouraged to use Mol* for 3D visualization.



Take the CSM User Survey and Win

Please take this brief survey about Computed Structure Models at RCSB.org to be entered into a drawing for a set of Bound Playing Cards.

News

Publications



February 4 is World Cancer Day

PDB structures reveal how cell growth is normally controlled, and how cancer cells circumvent these essential controls

» 02/01/2024



Register for VIZBI 2024 (March 13–15)

Learn the latest data visualization methods and techniques

» 01/30/2024



Register for the February 13 Mol* Webinar

Join RCSB PDB to learn how to Visualize Biomolecular structures with Mol*: From Atoms to Movies

» 01/19/2024

PDB at a Glance

66,758 Structures of Human Sequences

17,179 Nucleic Acid Containing Structures

More Statistics

CSM at a Glance

999,251 AlphaFoldDB

69,326 ModelArchive

About[About Us](#)[Citing Us](#)[Publications](#)[Team](#)**Help**[Contact Us](#)[Documentation](#)[Website FAQ](#)[Glossary](#)**RCSB PDB (citation)
is hosted by****RUTGERS****RCSB PDB is a
member of the****WORLDWIDE
PDB
PROTEIN DATA BANK****RCSB Partners**[Nucleic Acid
Knowledgebase](#)[www.pdb.org](#)

Princípios que regem a estrutura das biomoléculas

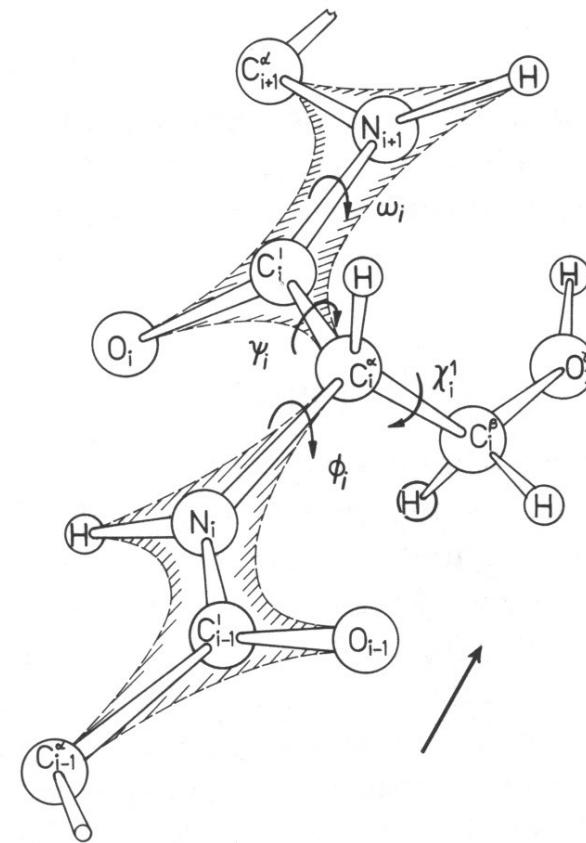
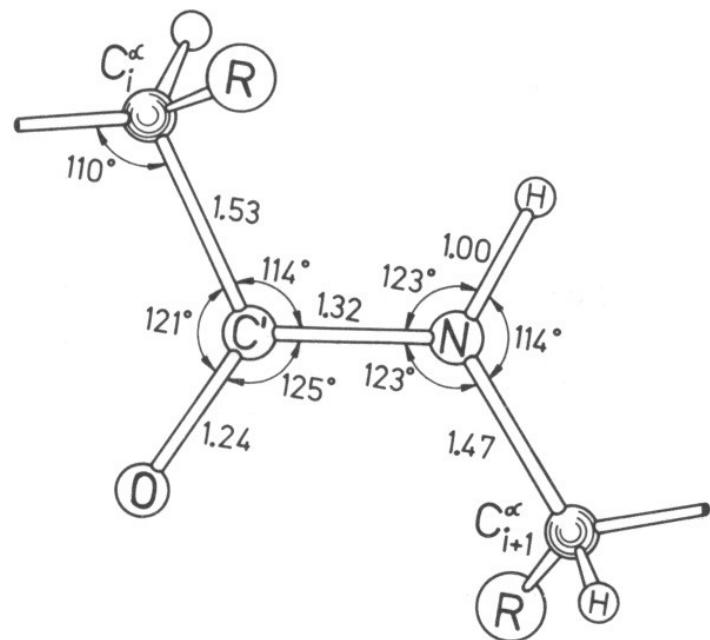
“Perhaps the most remarkable features of the molecule are its *complexity* and *lack of symmetry*. The arrangement seems to be almost totally lacking the kind of regularities which one instinctively anticipates and it is more complicated than has been predicted by any theory of protein structure”

J.C. Kendrew *et al.*, 1958

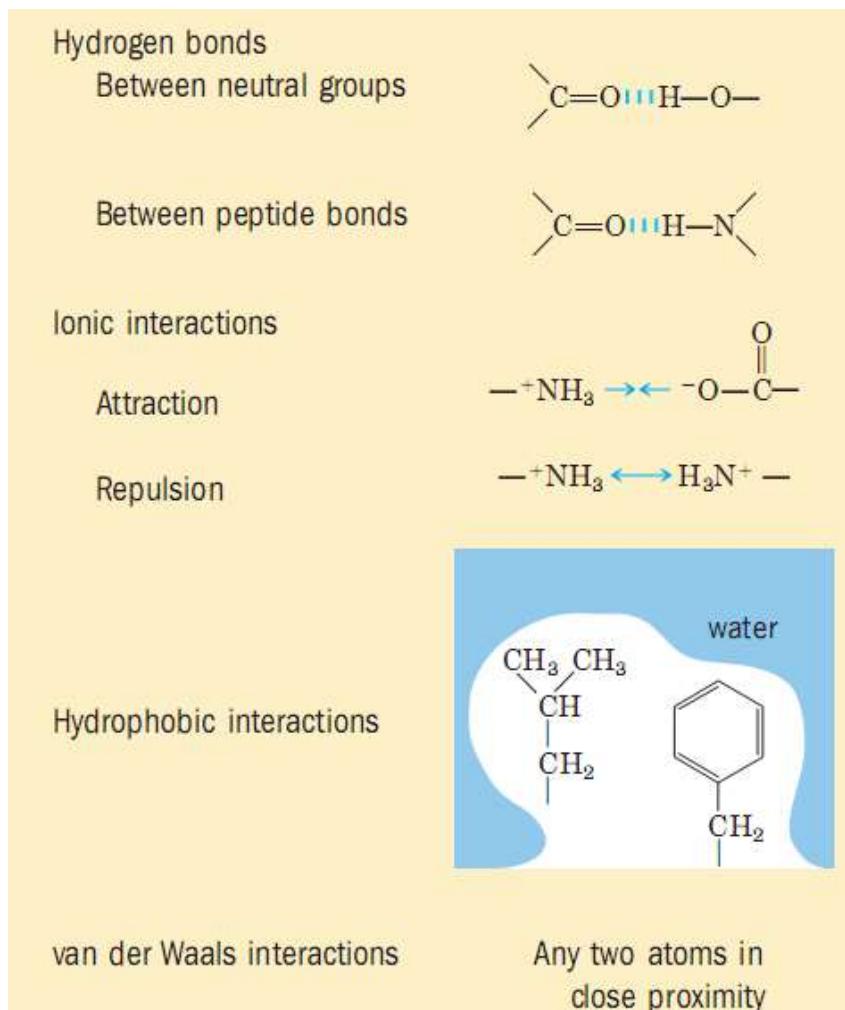


- As macromoléculas biológicas parecem, numa primeira análise, distanciar-se dos princípios simples de geometria e simetria que sabemos reger a estrutura das moléculas pequenas.

- Ligações covalentes, geometria molecular:



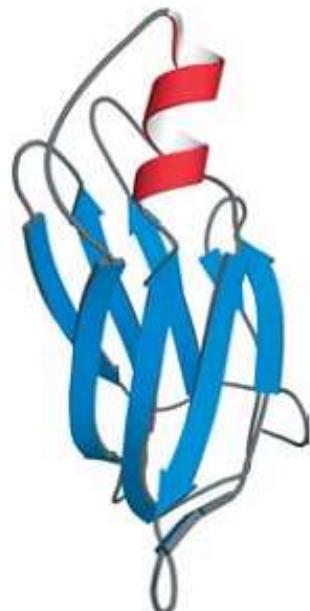
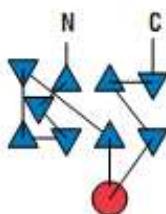
- Interações não-covalentes:



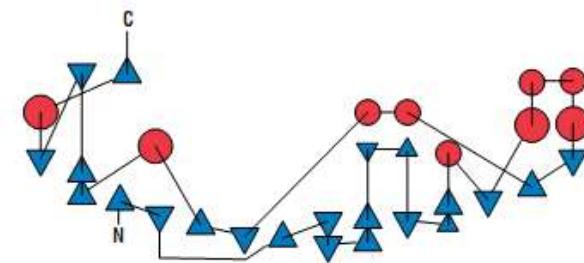
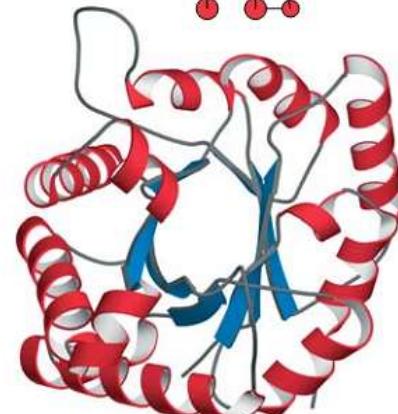
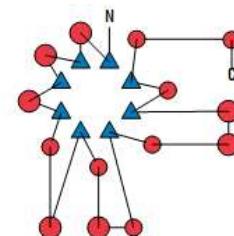
- Princípios arquitectónicos



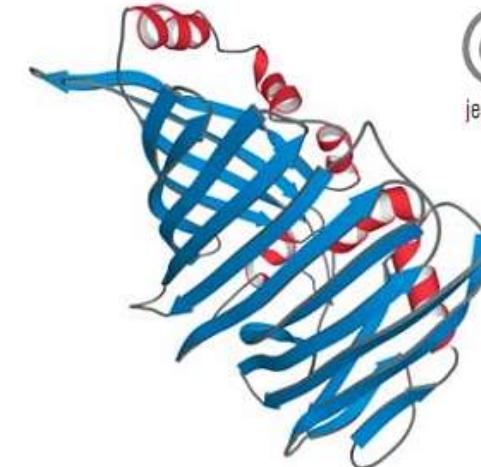
Greek key



...

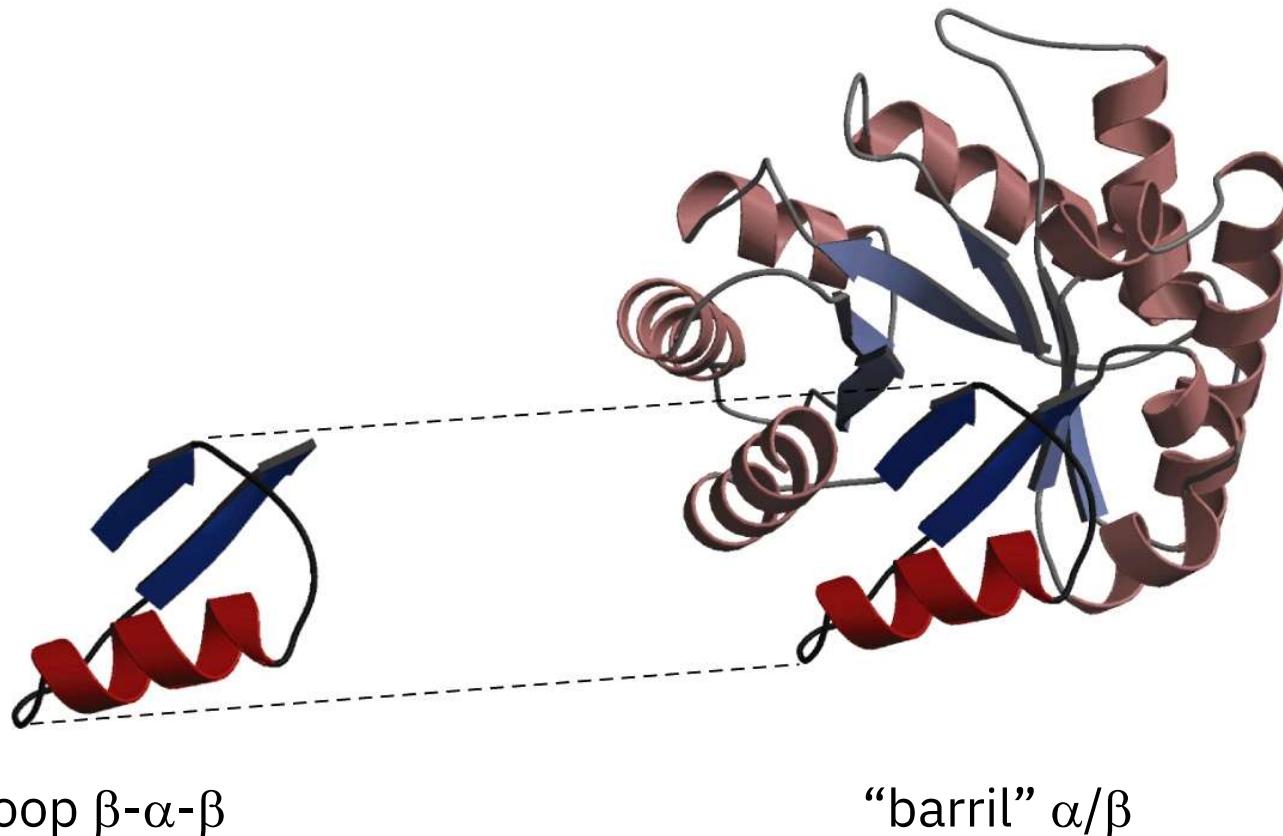


jelly roll



Recorrência de padrões estruturais na arquitectura das biomoléculas.

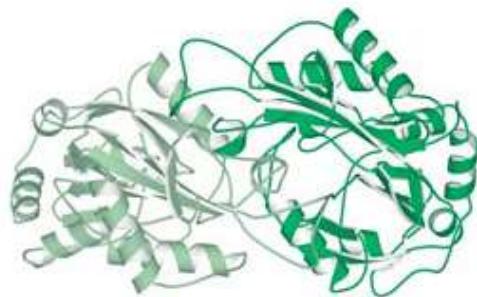
- Princípios arquitectónicos (cont.):



Formação de estruturas a partir da associação de unidades estruturais

- Oligomerização:

(a) dimer



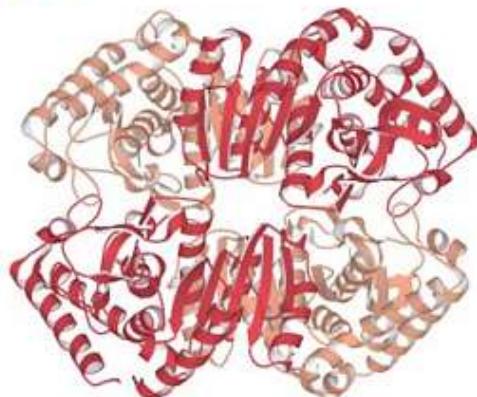
(b) trimer



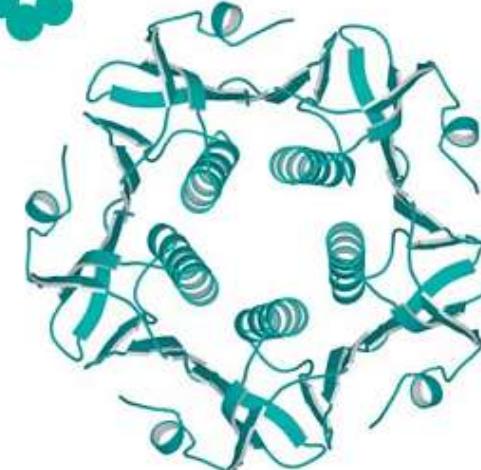
(c) planar tetramer



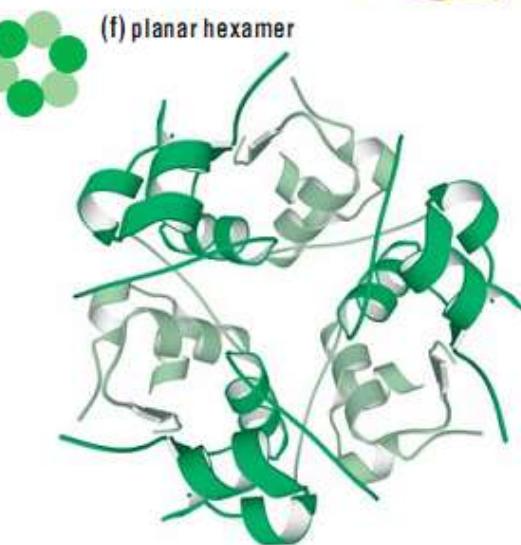
(d) tetramer



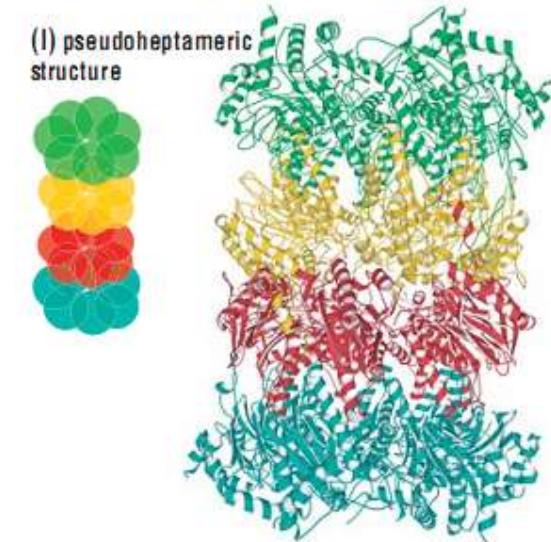
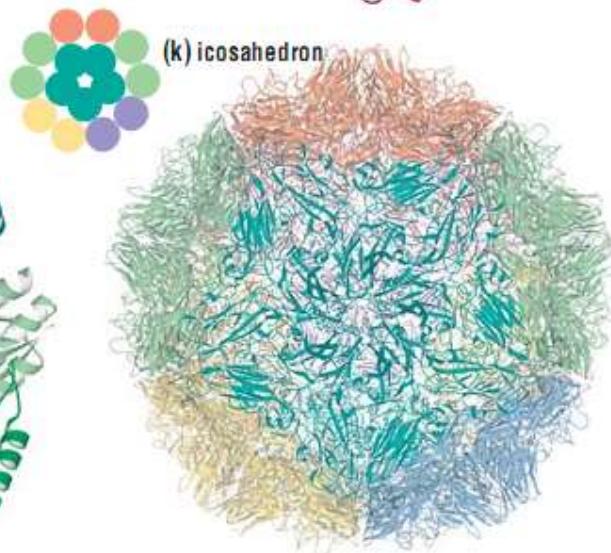
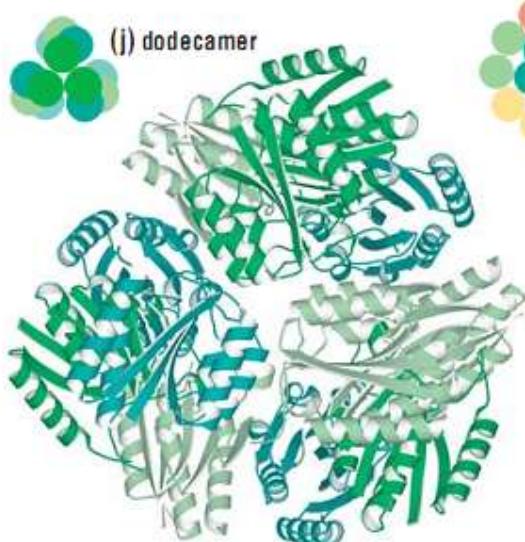
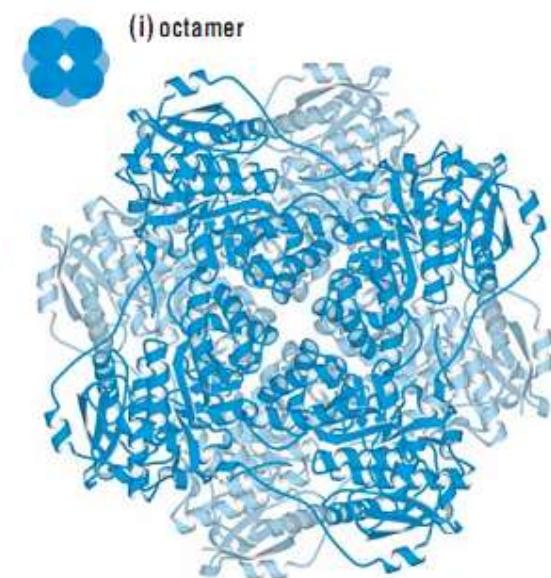
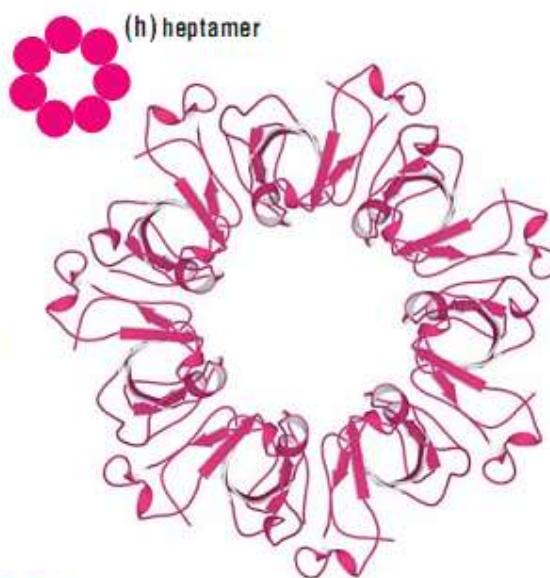
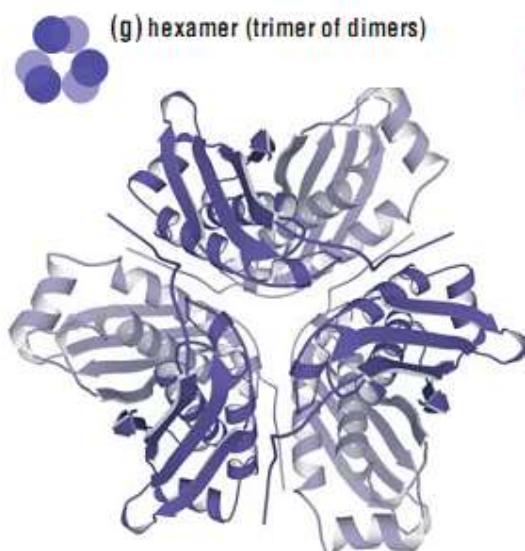
(e) pentamer



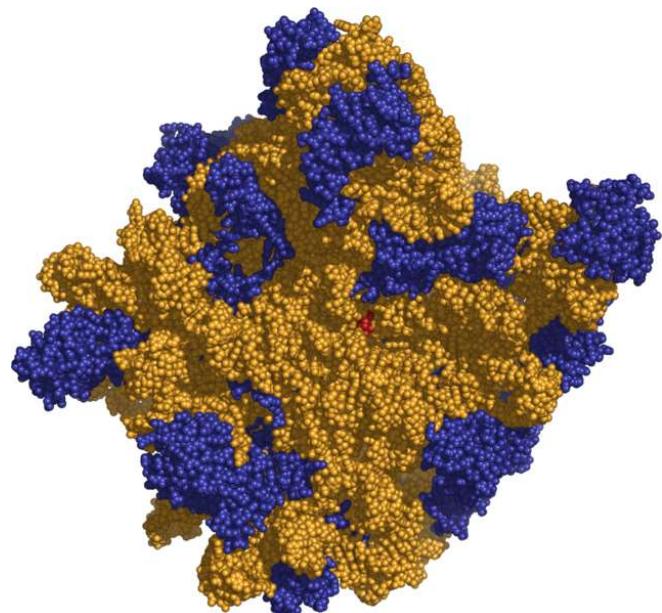
(f) planar hexamer



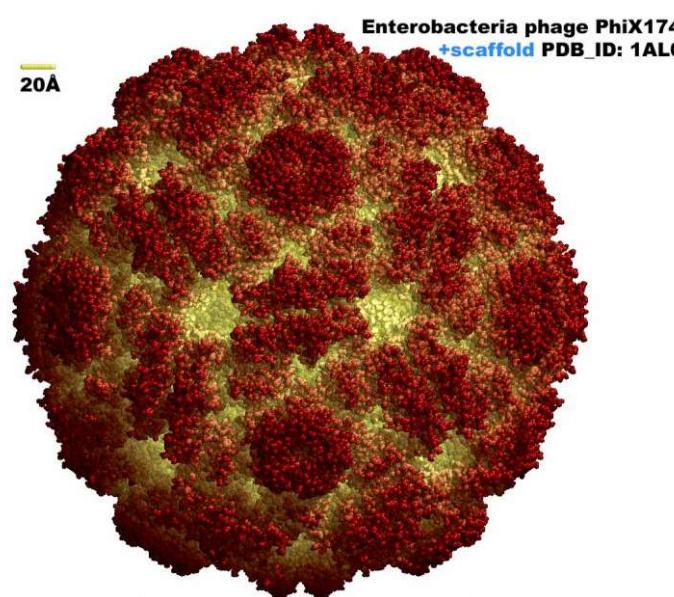
- Oligomerização(cont.):



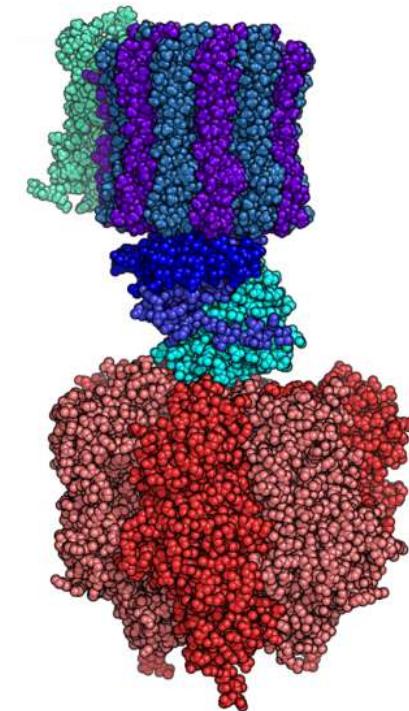
- Formação de estruturas supramacromoleculares



Ribossoma



Vírus

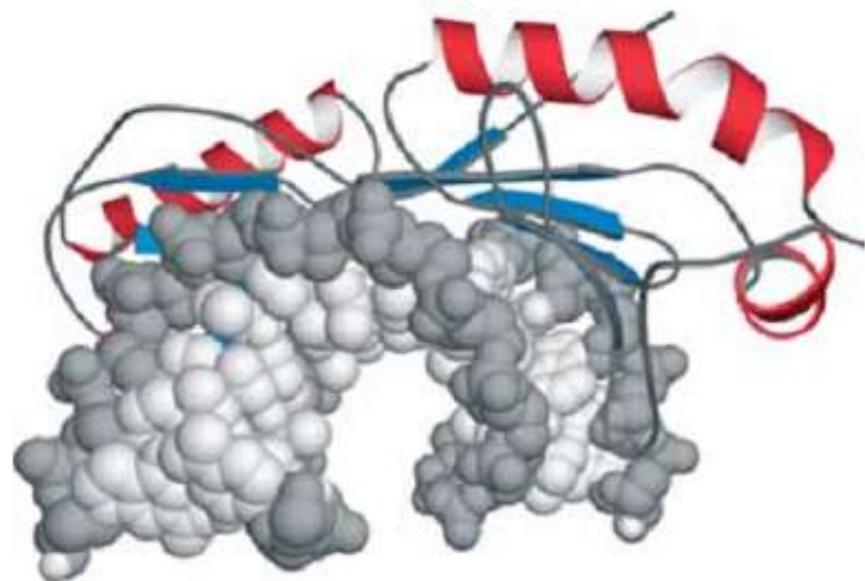


ATPase

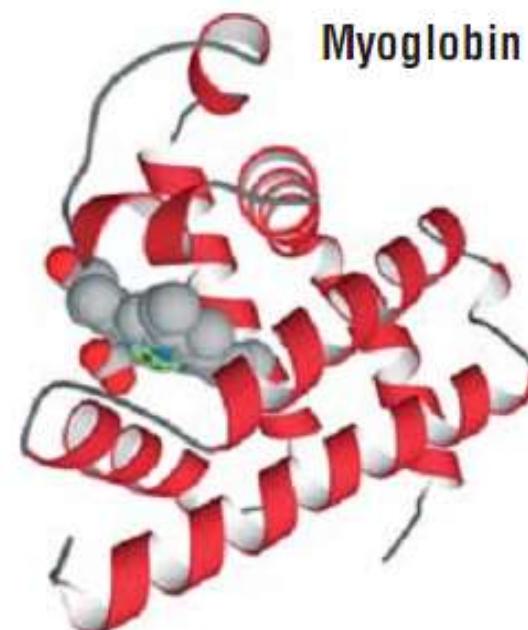
Função

Associação a ligandos

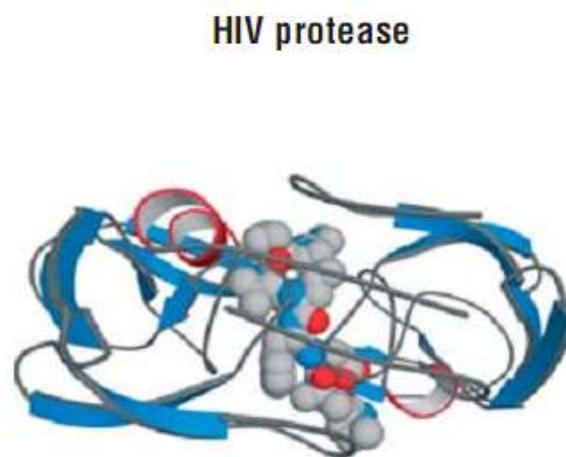
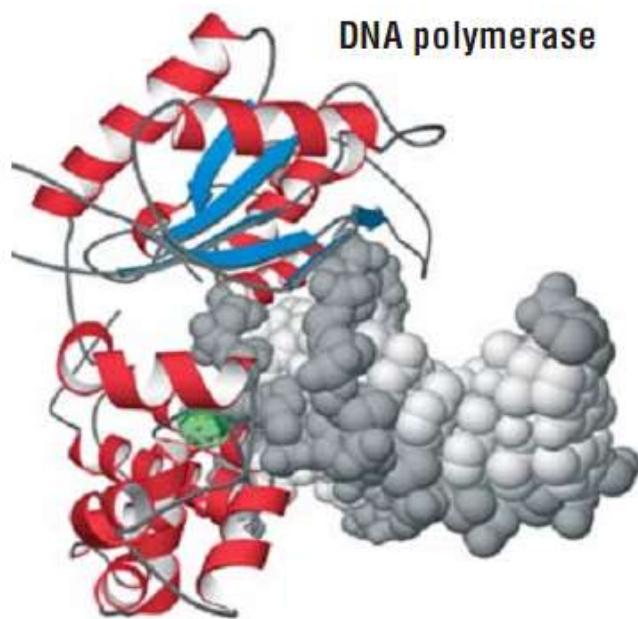
TATA binding protein



Myoglobin

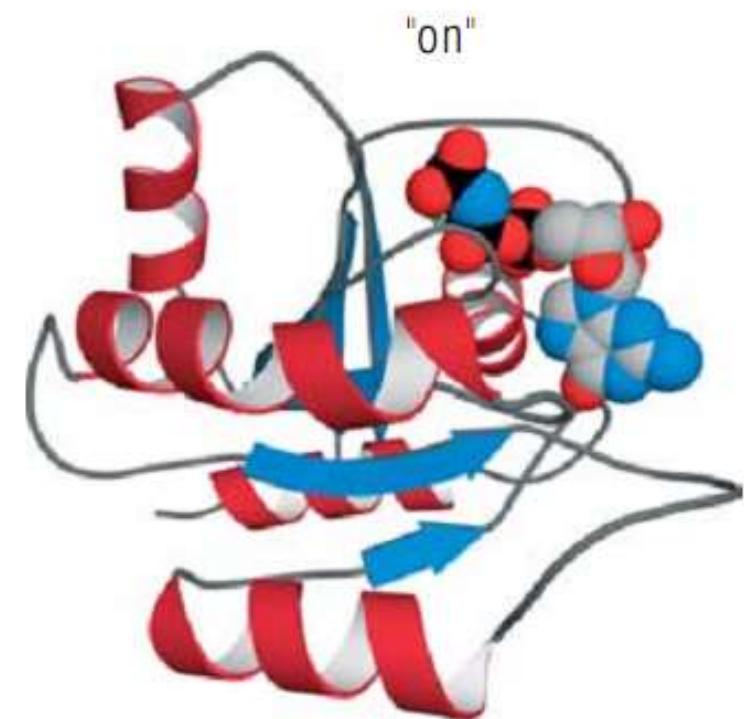
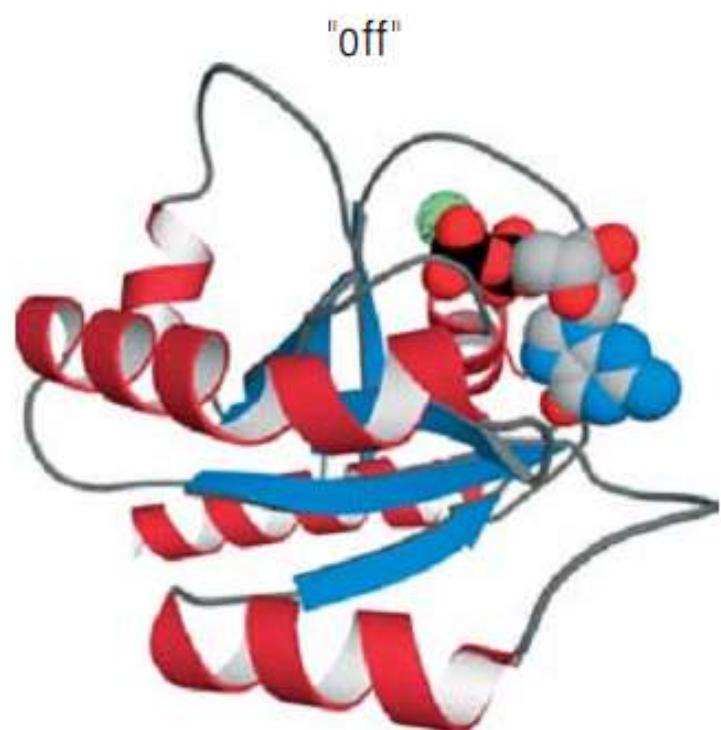


Catálise



Sinalização

Ras

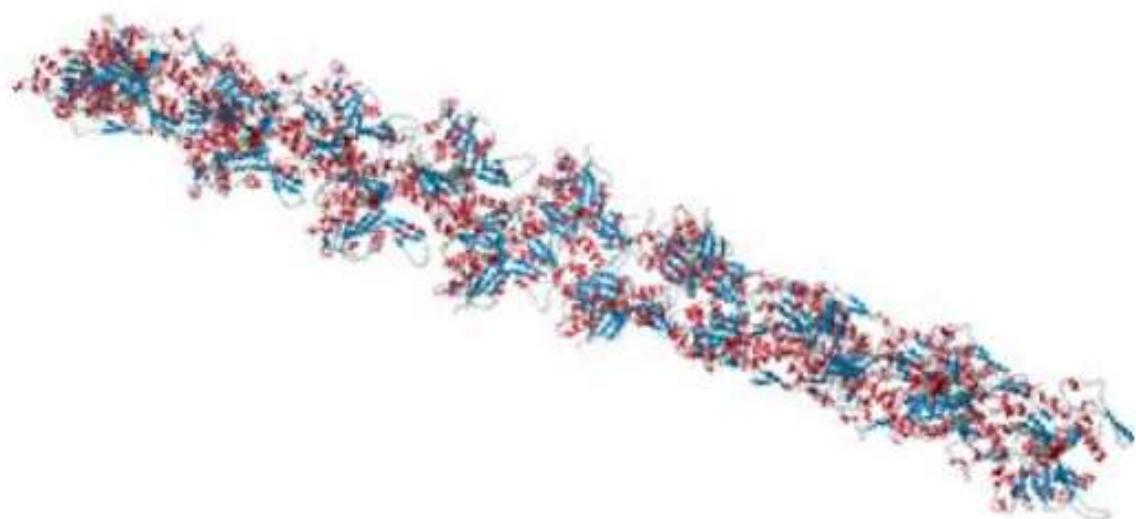


Estrutura

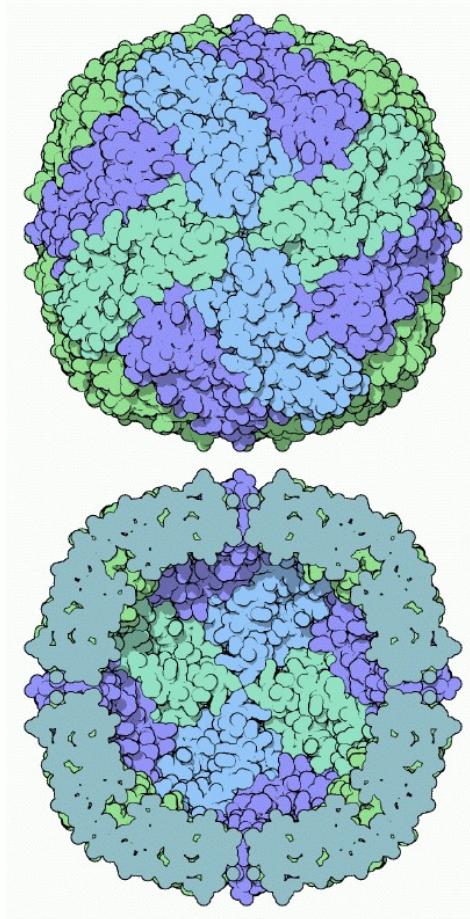
Silk



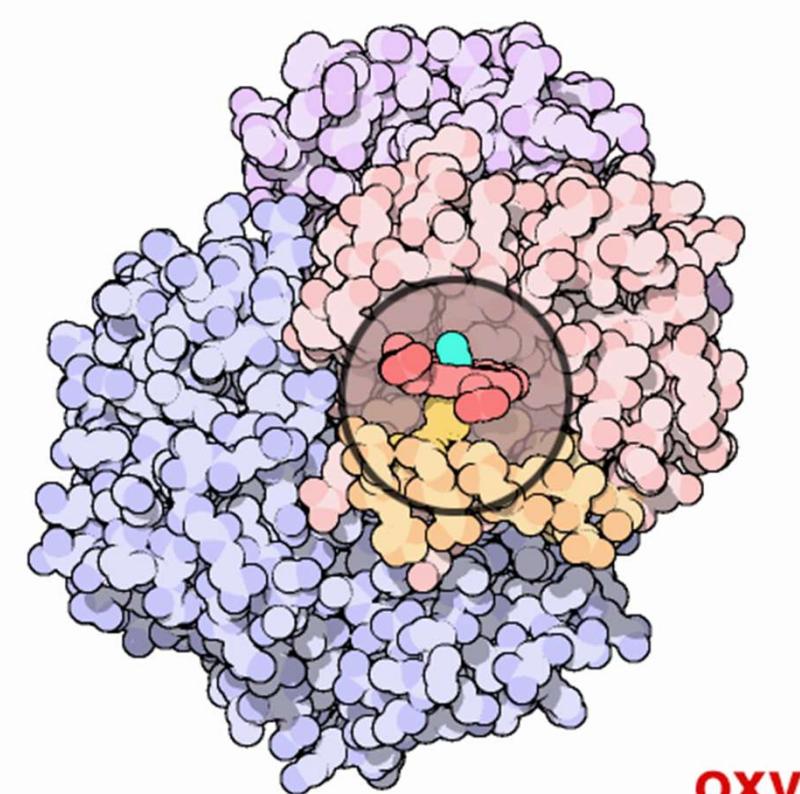
F-actin



Transporte

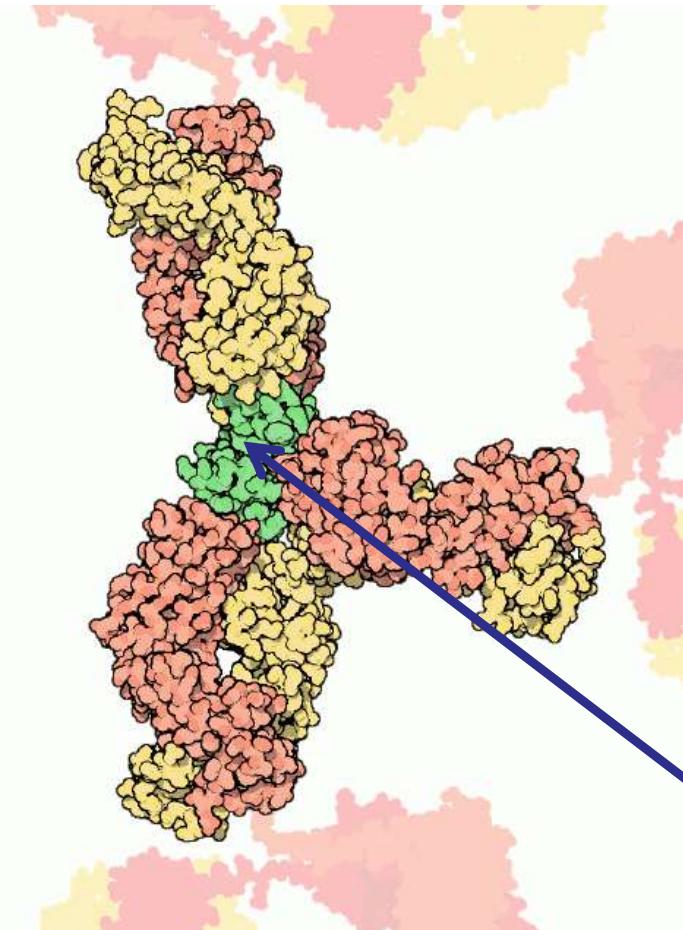


Ferritina (ferro)

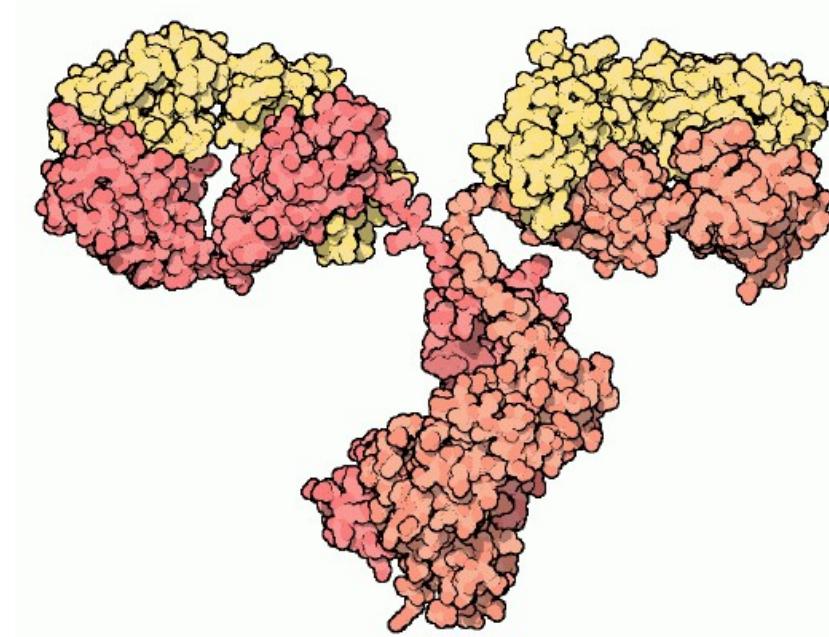


Hemoglobina (oxigénio)

Defesa

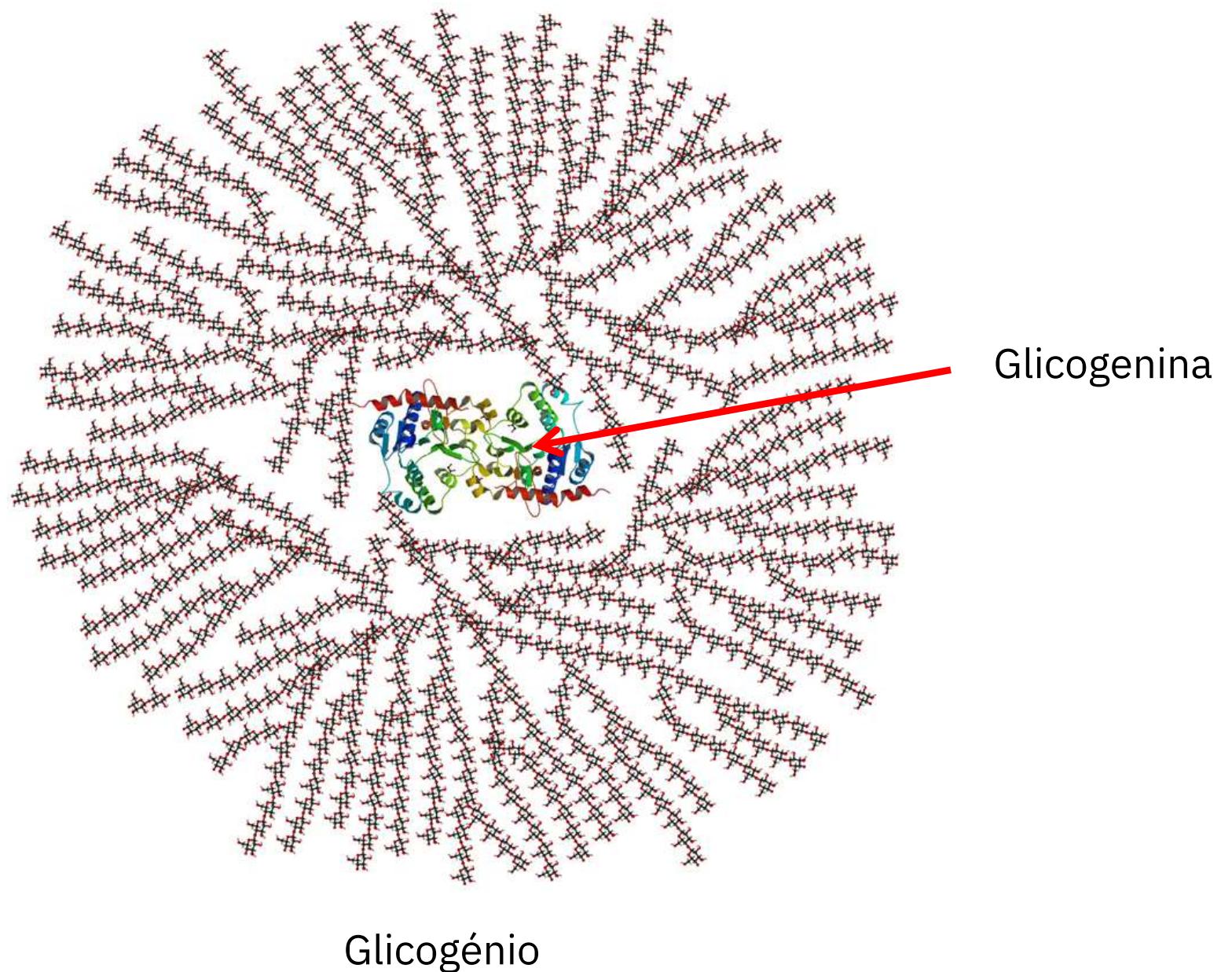


lisozima

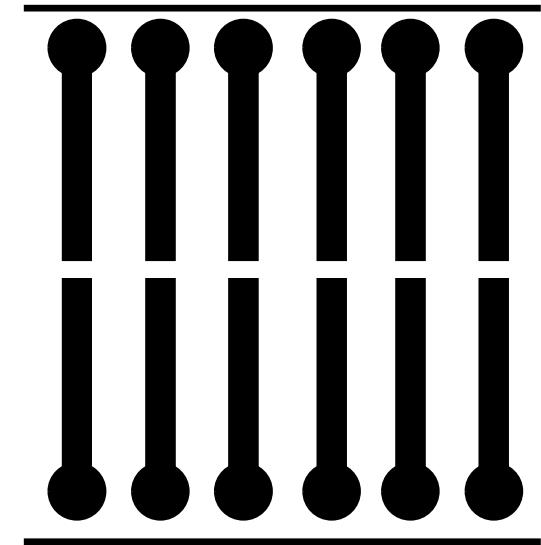
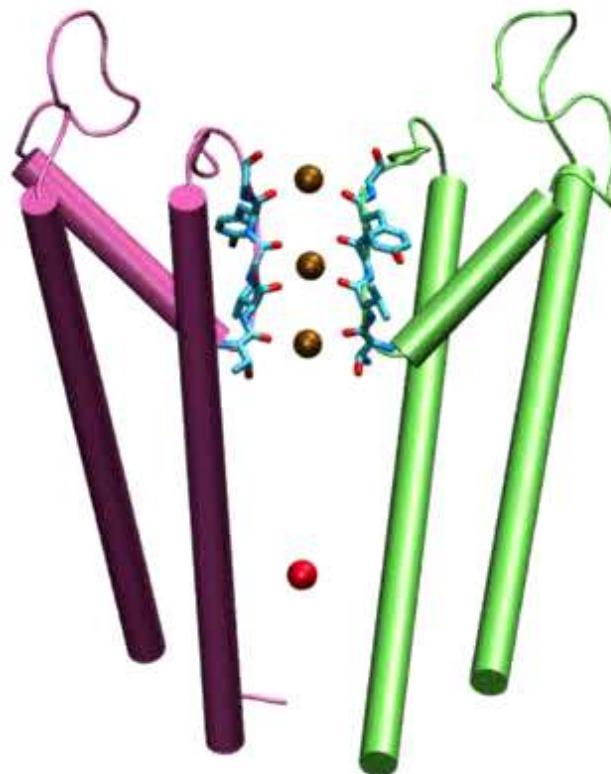
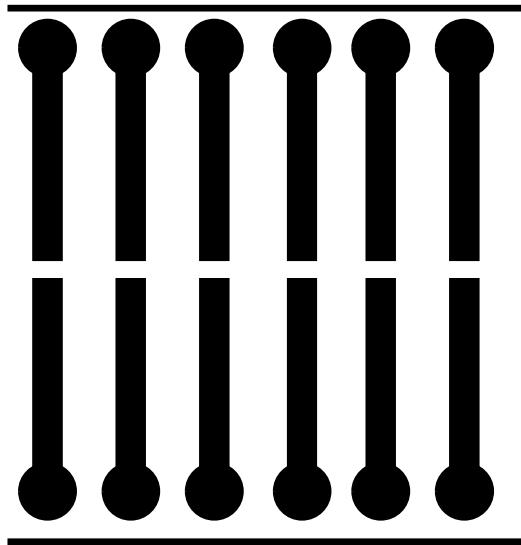


imunoglobulina

Armazenamento



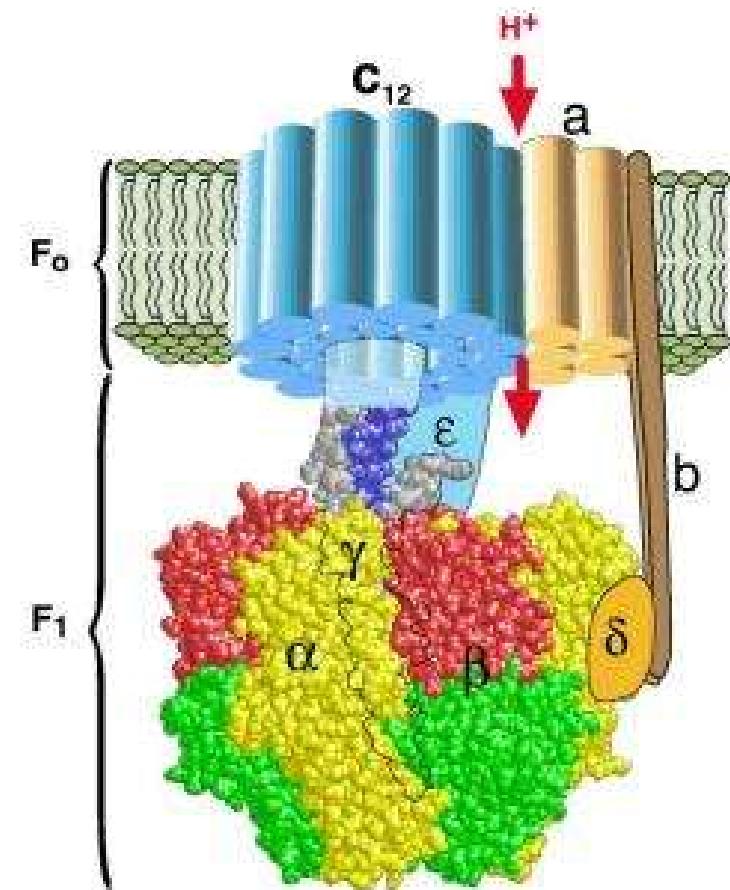
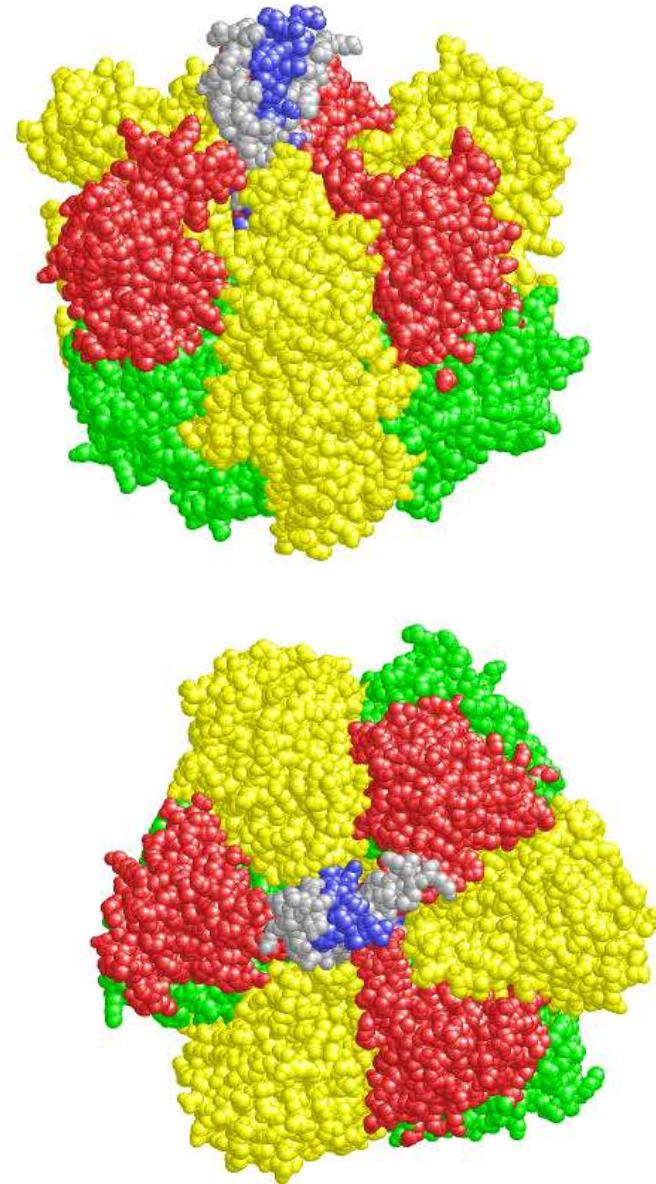
Permeabilidade



As macromoléculas biológicas funcionam como máquinas moleculares

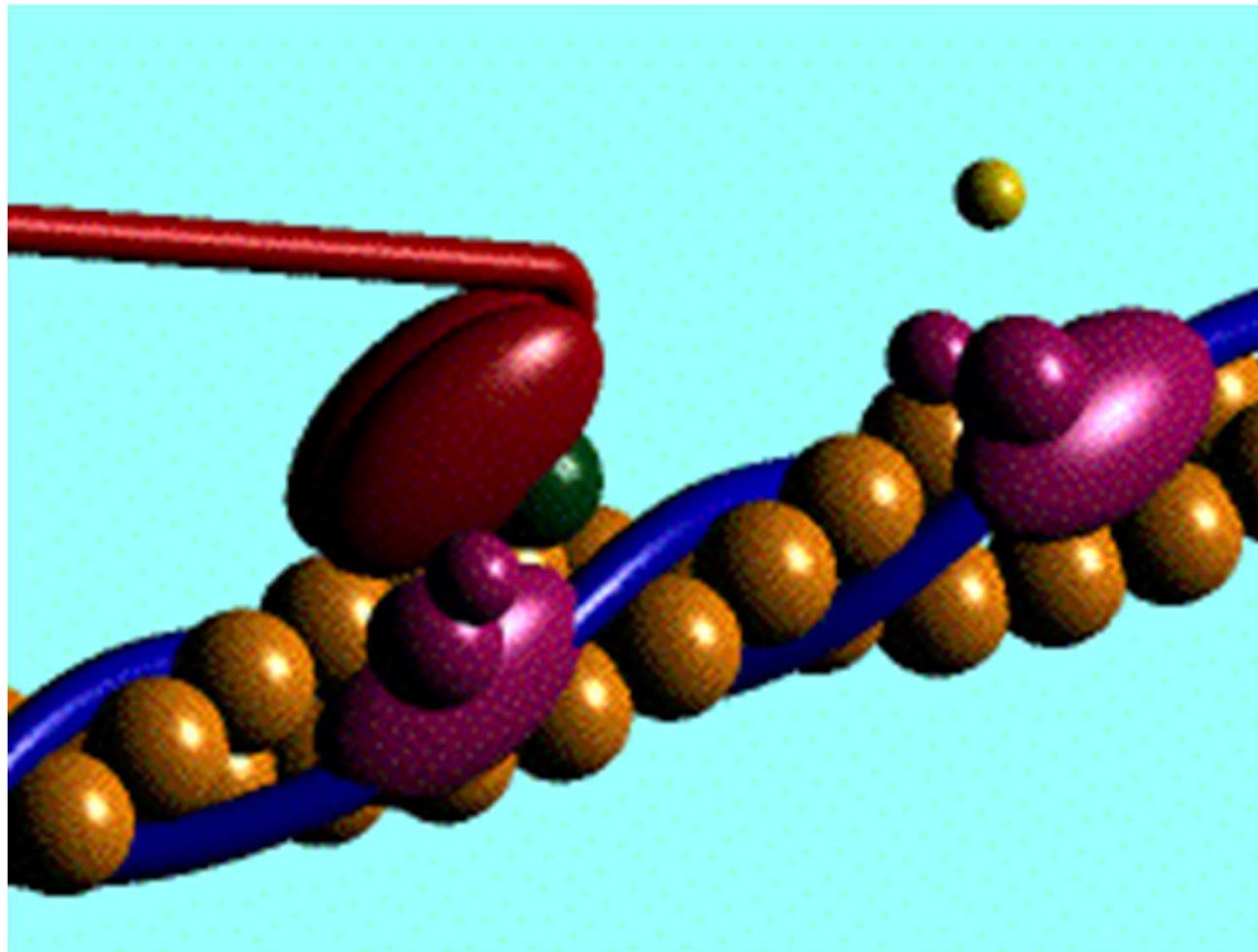
Conversão de energia

ATPsintase



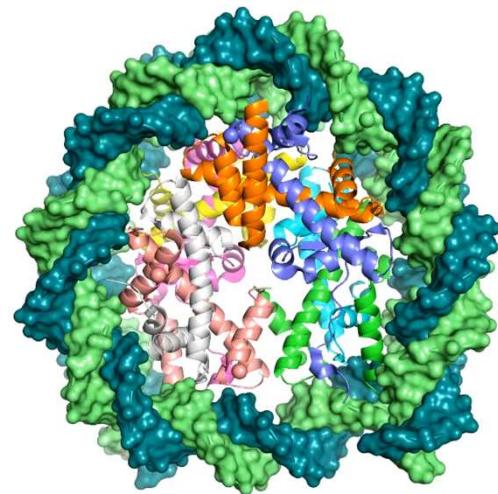
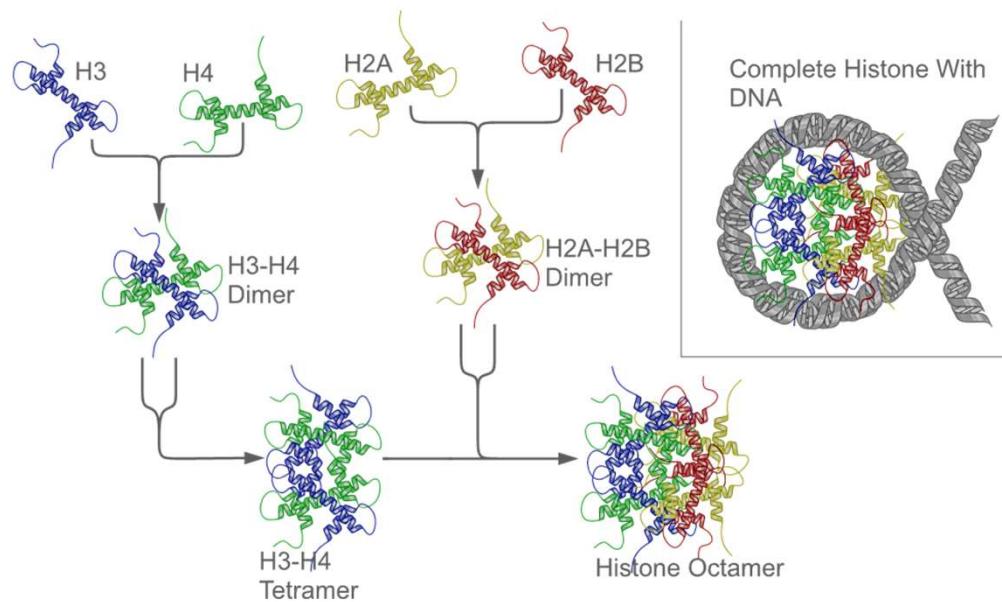
H. Wang and G. Oster (1998). Nature 396:279-282.

Motilidade

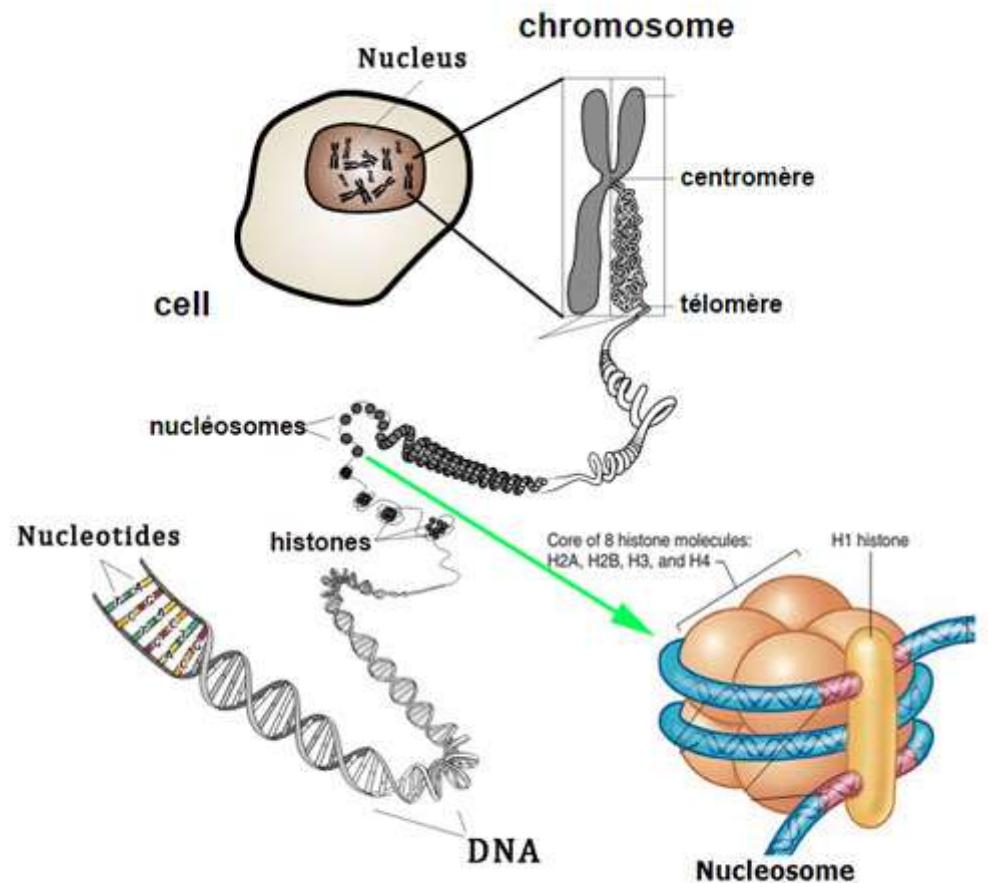


Actina+Miosina

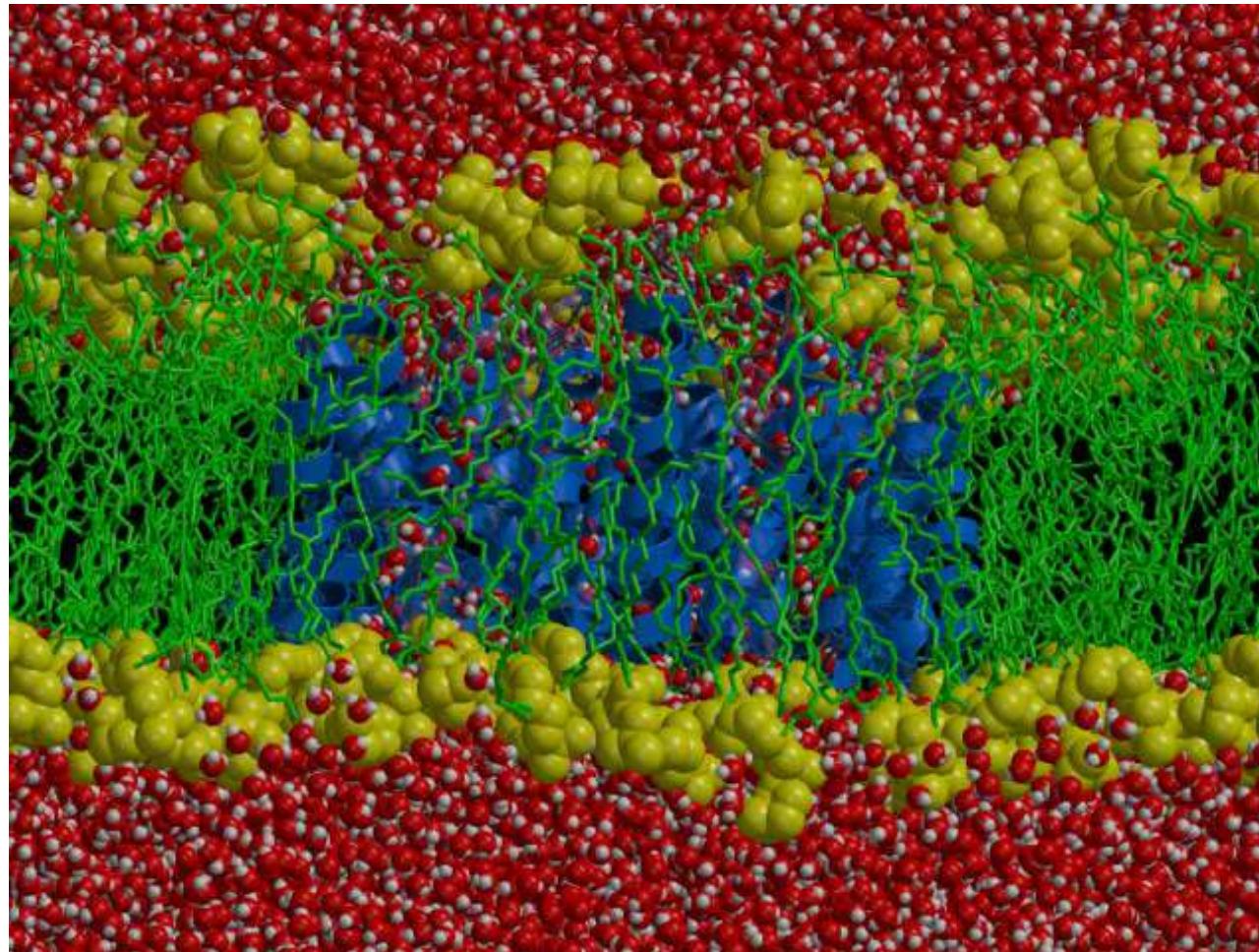
Informação



Nucleossoma

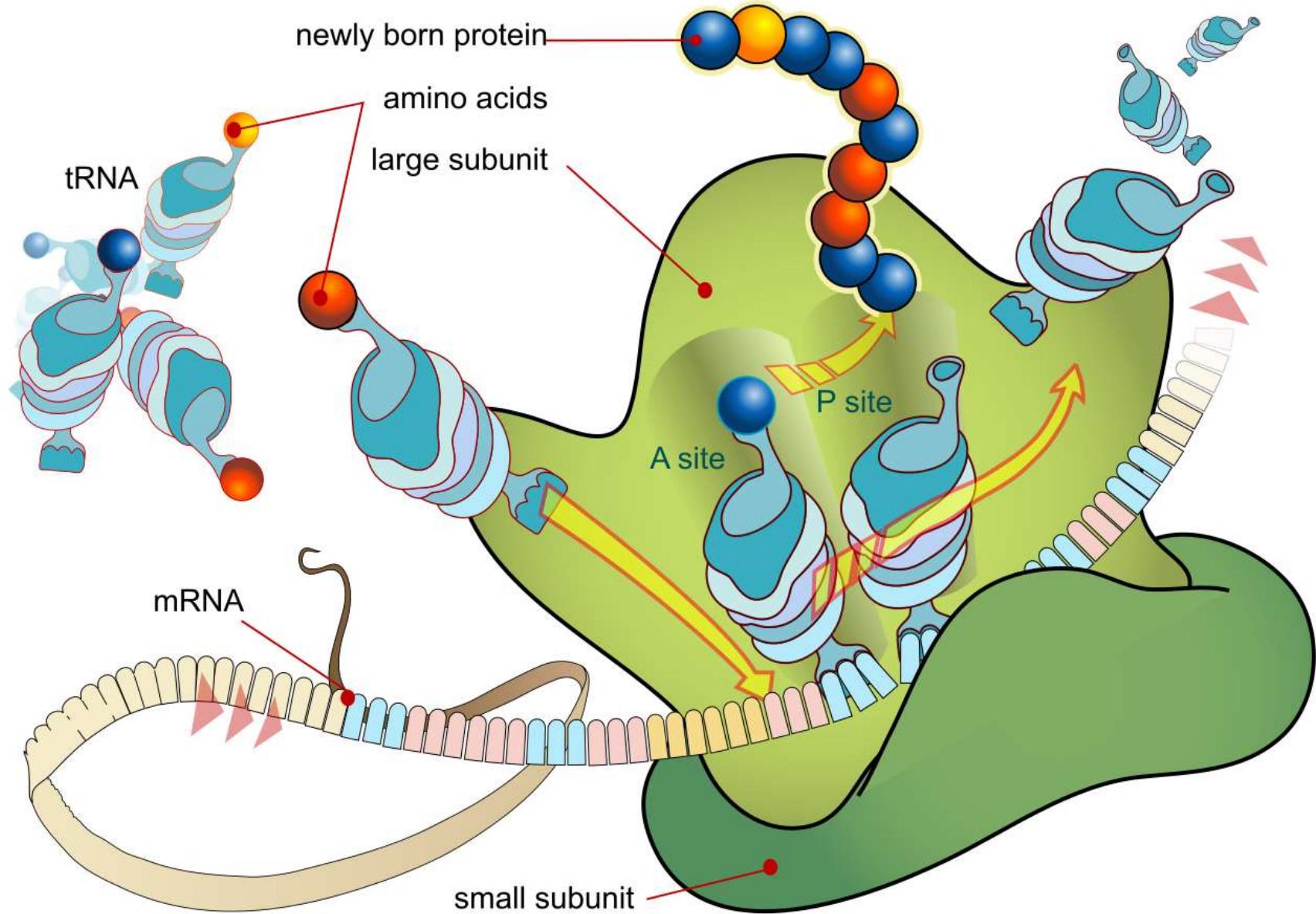


Compartimentação

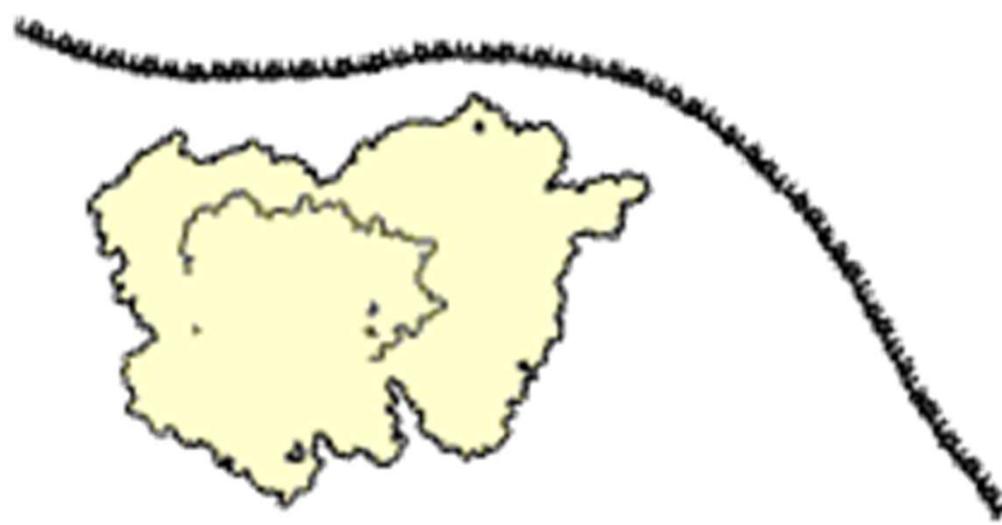


Membrana+aquaporina

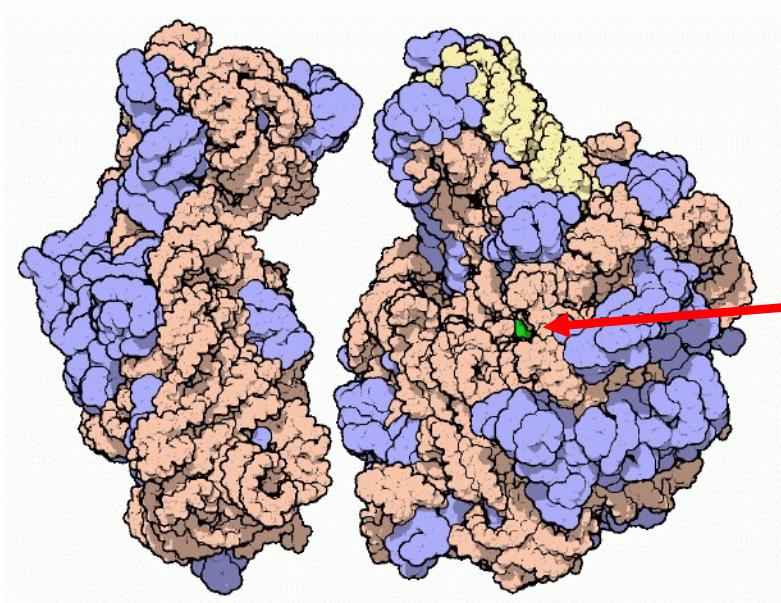
Síntese proteíca



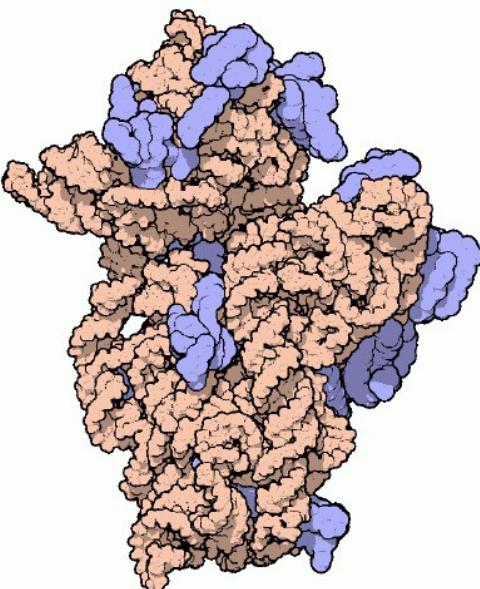
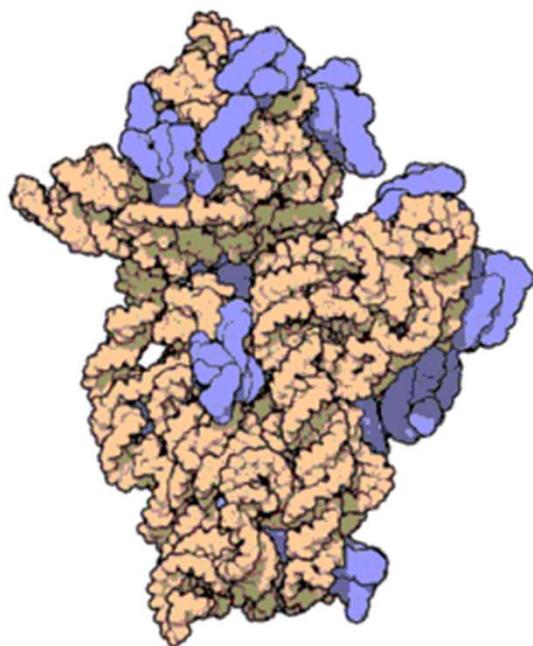
Síntese proteíca (animação)



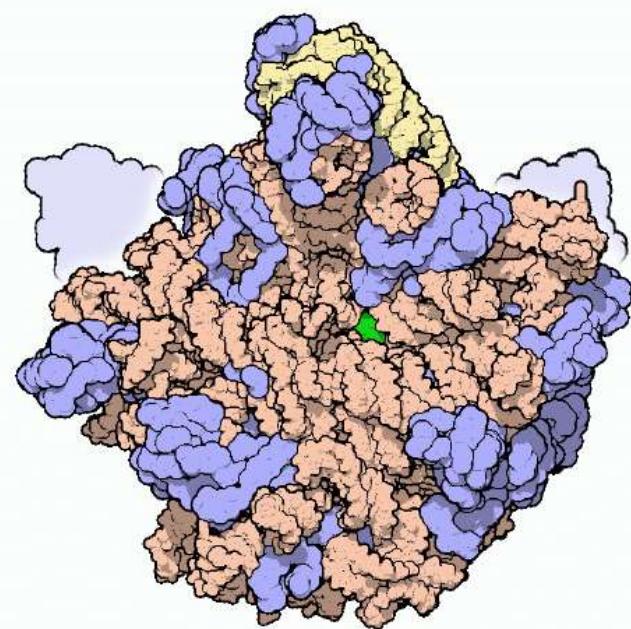
Estrutura do ribossoma bacteriano



RNA catalítico

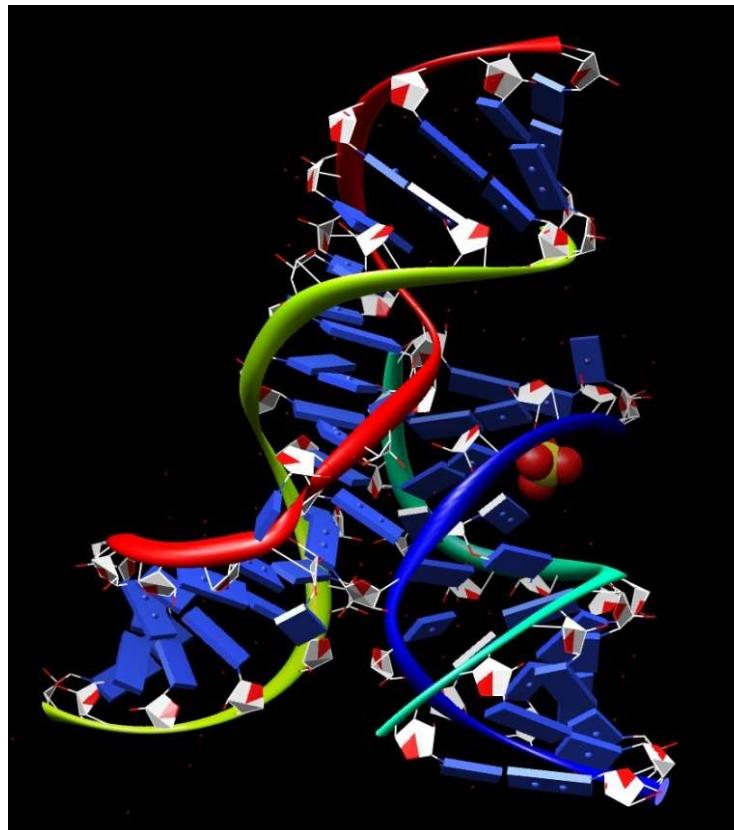
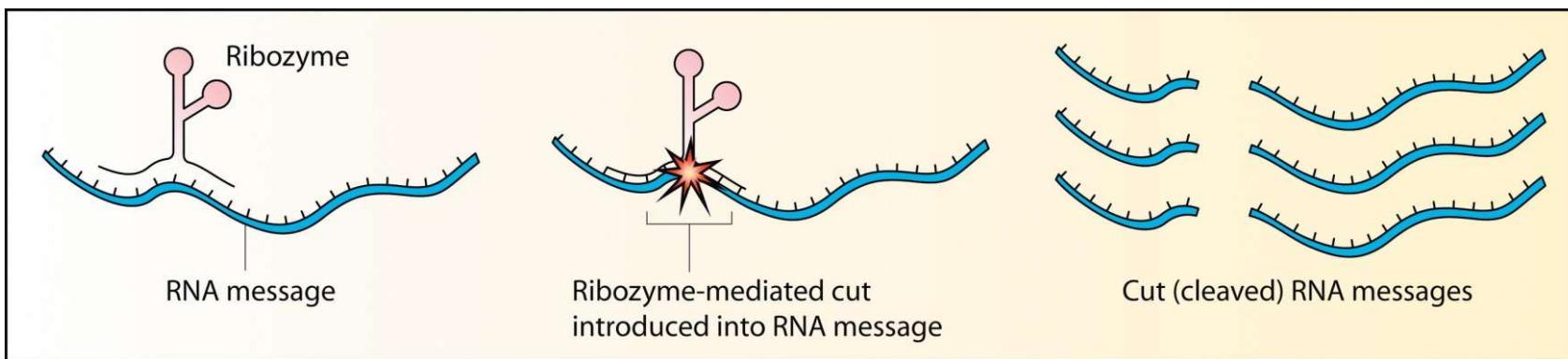


Subunidade 30S

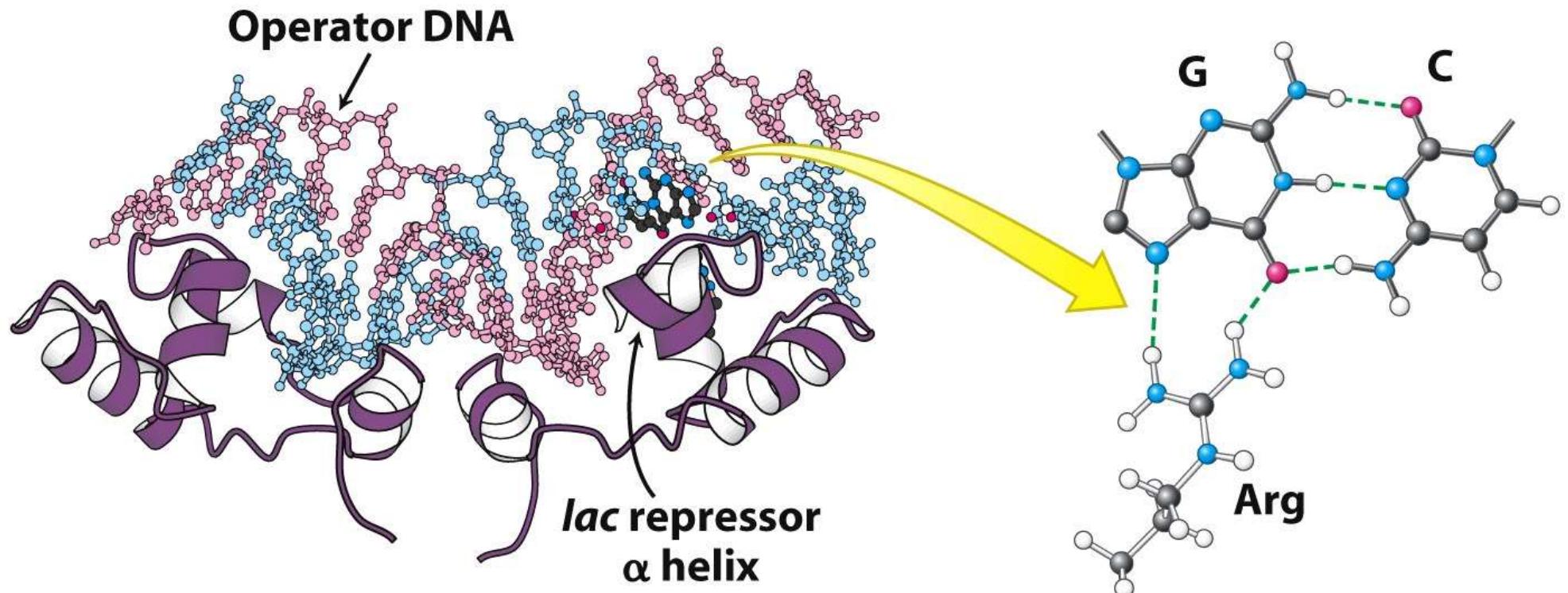


Subunidade 20S

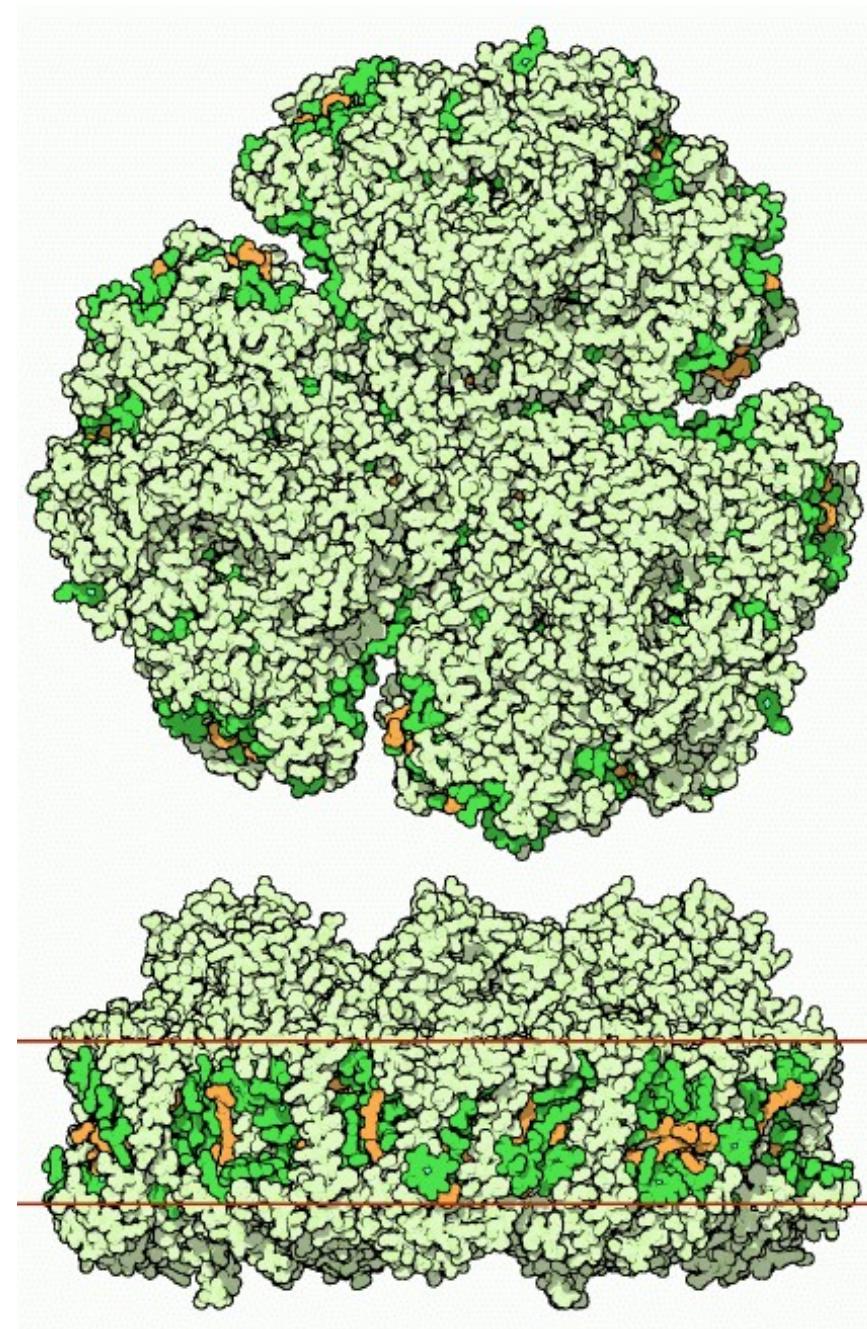
Ribozimas



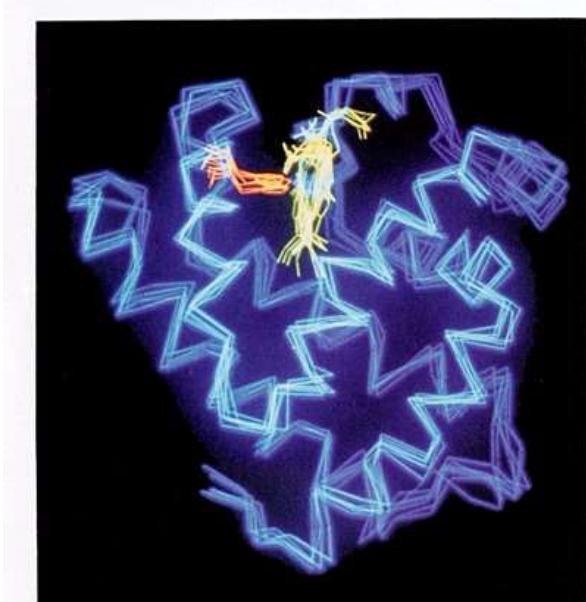
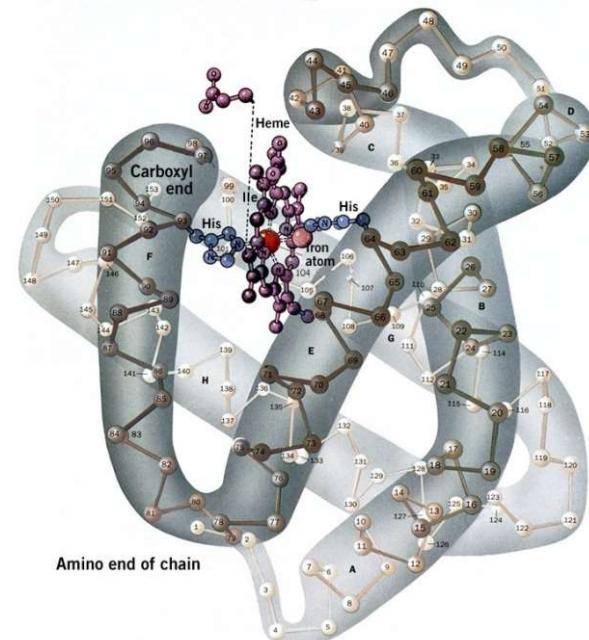
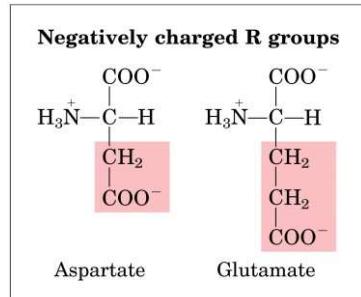
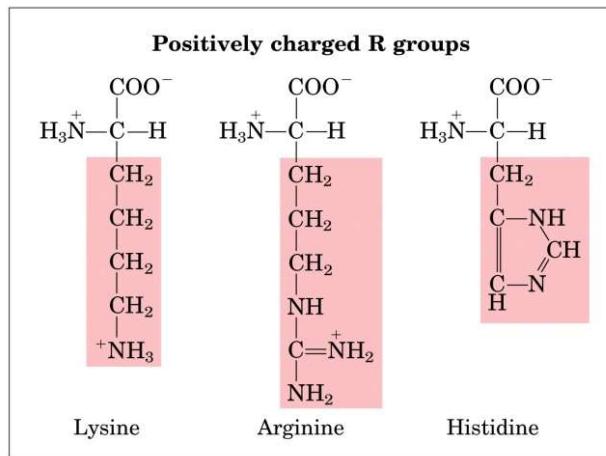
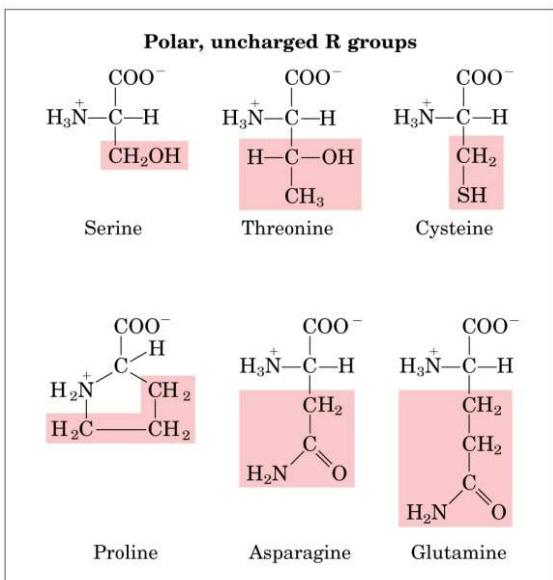
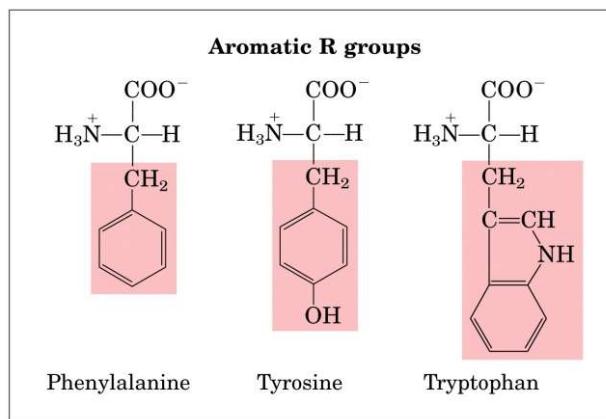
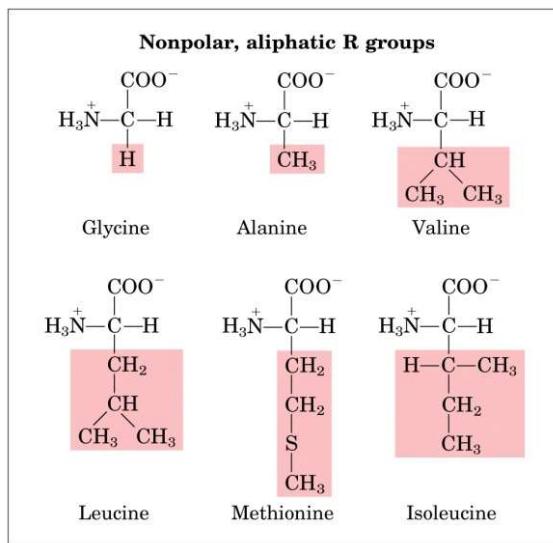
Regulação da transcrição



Fotossistema I



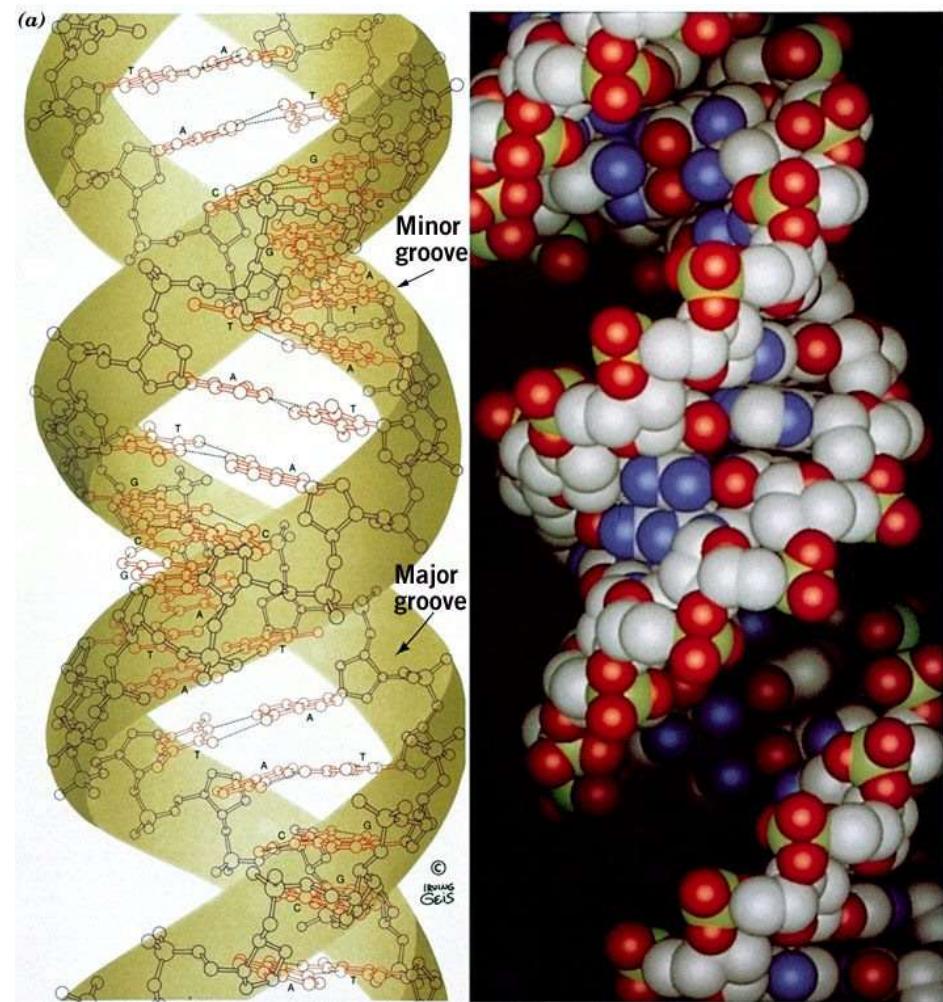
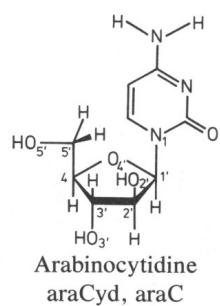
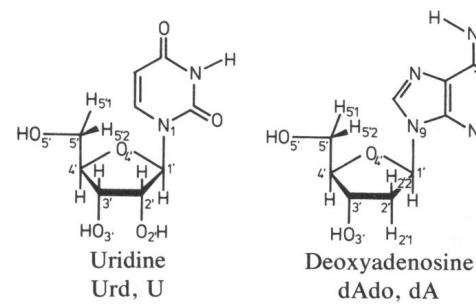
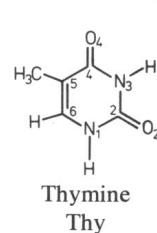
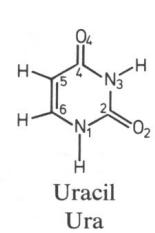
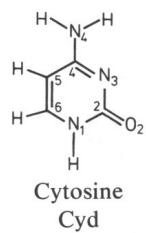
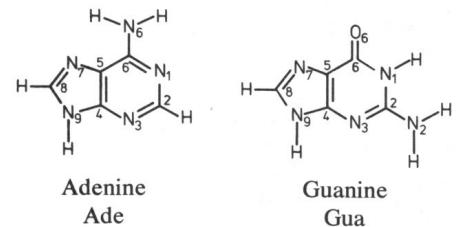
Proteínas



(a)

Mioglobina

Ácidos nucleicos



B-Dna