

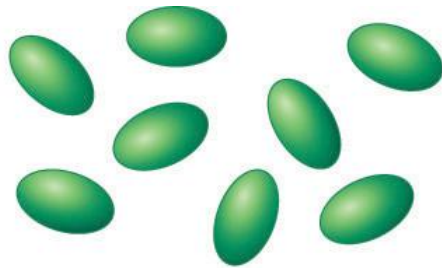
# PROTEINS

*Luca Quaroni*

*Wydział Chemii, Zakład Chemii Fizycznej i Elektrochemii*

*luca.quaroni@uj.edu.pl*

# Proteins are Polymers

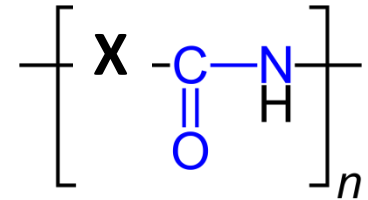


Monomers

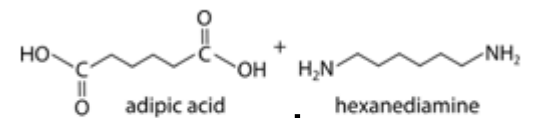
Polymerization



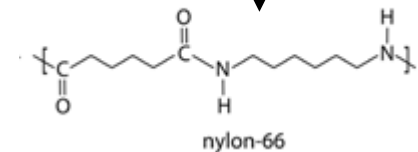
Polymer



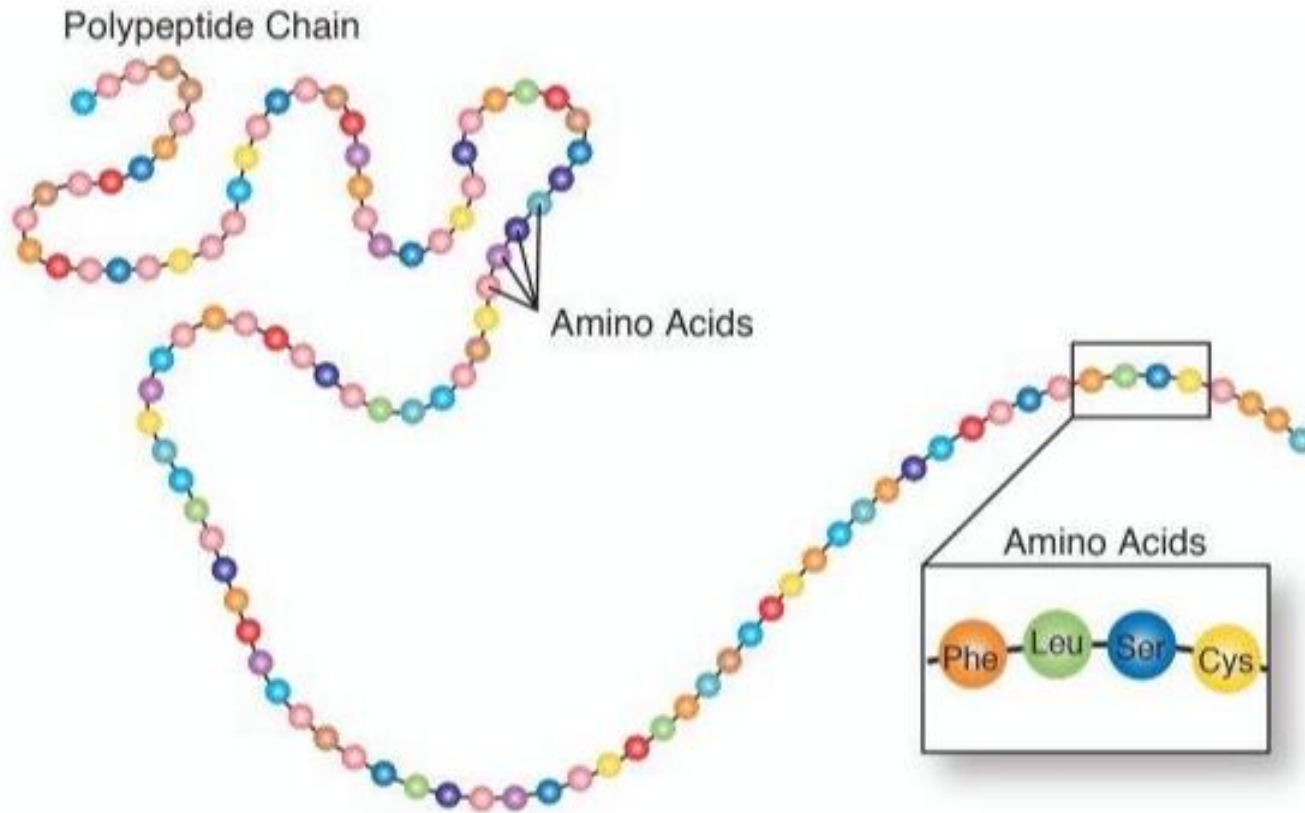
Polyamide

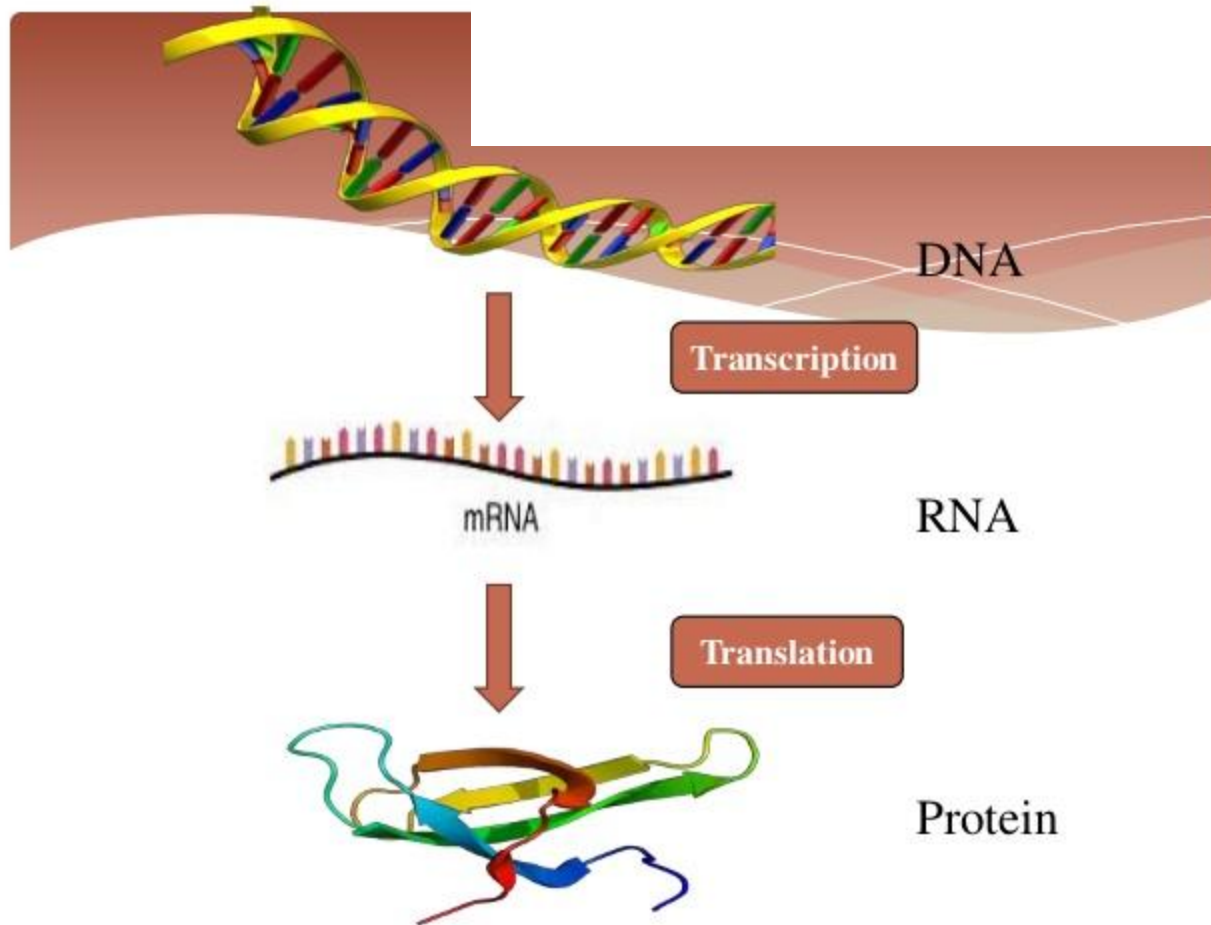


$\text{H}_2\text{O}$       **Condensation**



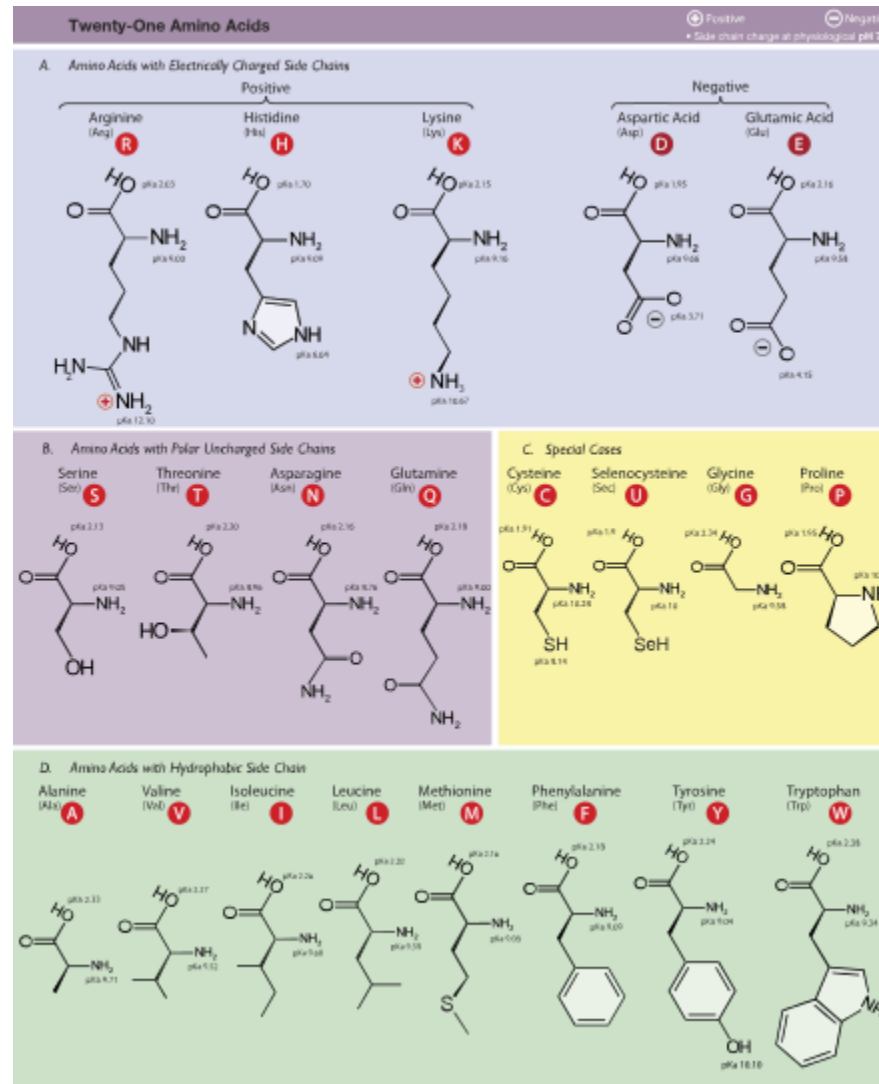
# Proteins are Composed of Amino Acids





# How Many Amino Acids ?

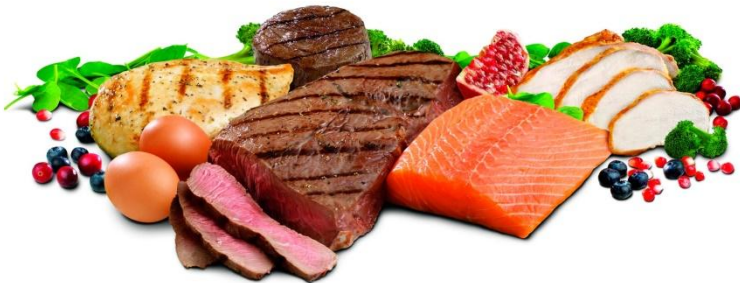
## 21 Amino Acids “Translated” into Proteins



# Where do we get Amino Acids from?

## 1 - Metabolism

## 2 – Food (essential aa's)



Amino Acid	Main Food Sources
Histidine	soy protein, eggs, parmesan, sesame, peanuts
Isoleucine	eggs, soy protein & tofu, whitefish, pork, parmesan
Leucine	eggs, soy protein, whitefish, parmesan, sesame
Lysine	eggs, soy protein, whitefish, parmesan, smelts
Methionine	eggs, whitefish, sesame, smelts, soy protein
Cysteine	eggs, soy protein, sesame, mustard seeds, peanuts
Phenylalanine	eggs, soy protein, peanuts, sesame, whitefish
Tyrosine	soy protein, eggs, parmesan, peanuts, sesame
Threonine	eggs, soy protein, whitefish, smelts, sesame
Tryptophan	soy protein, sesame, eggs, winged beans, chia seeds
Valine	eggs, soy protein, parmesan, sesame, beef

# Why So Many Amino Acids?

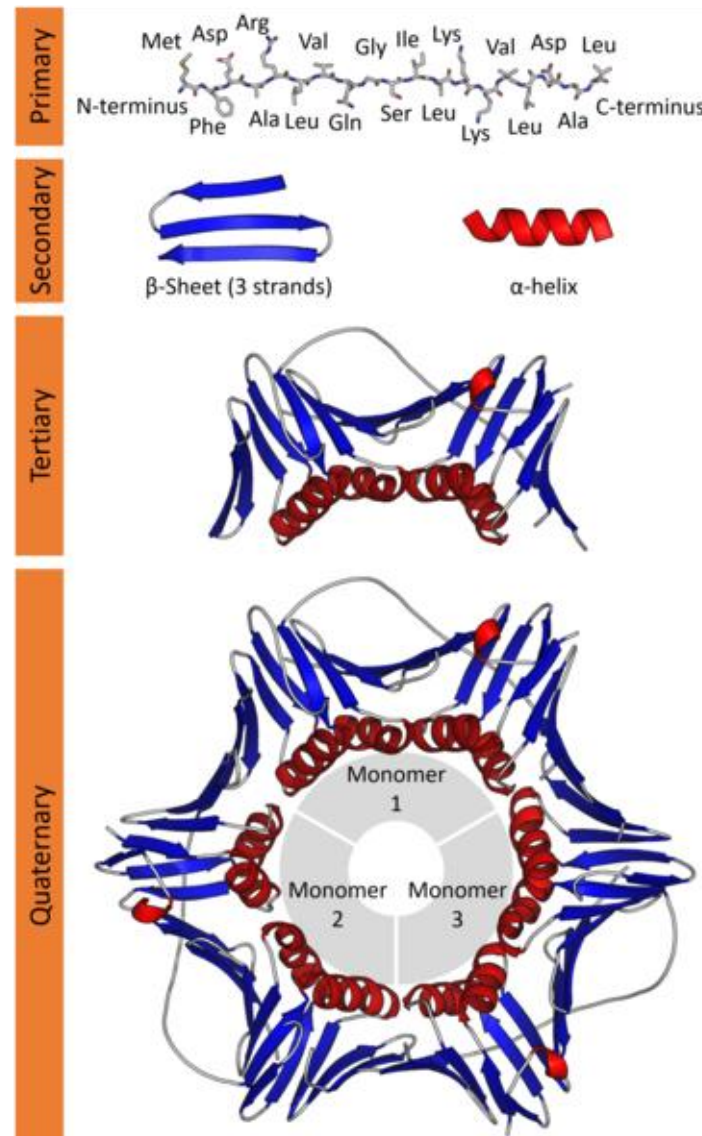
Permutations of 21 amino acids in a protein  
with 50 amino acids:

$$1.3 \times 10^{66}$$

Possible proteins with 50 aa

## Structure = Function

# Protein Structure: Nomenclature





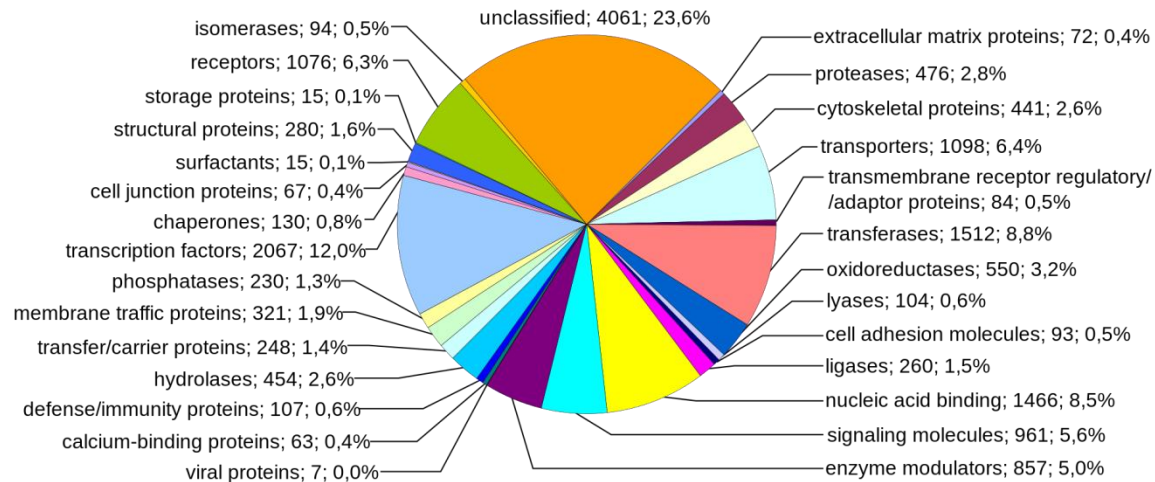
# **Protein Structures**

<https://www.rcsb.org/>

**147073 protein structures!**

# How many human proteins?

**19,000-20,000 human protein-coding genes**



## How big/long?

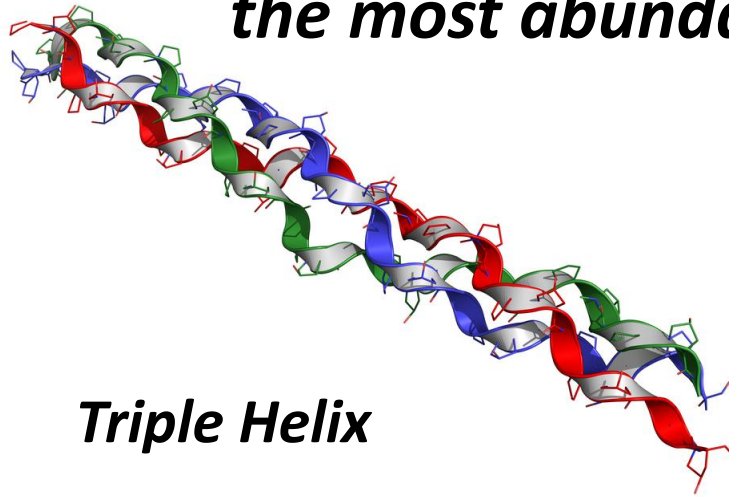
**Titin (Connectin): ~27,000 to ~33,000 amino acids: ~ 1  $\mu$ m in size**

**Phospholamban: ~52 amino acids: <1 nm in size**

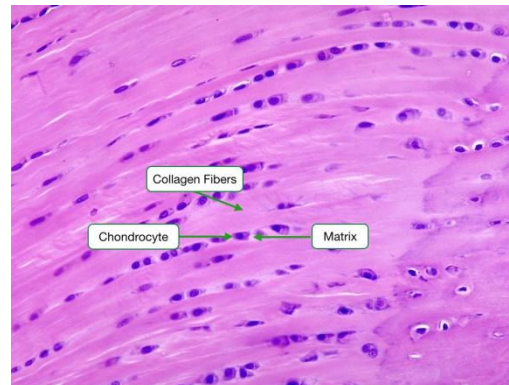
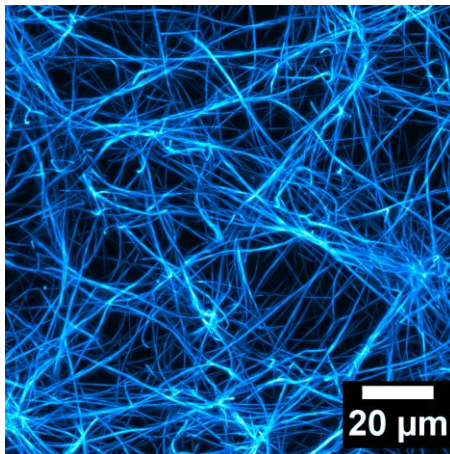
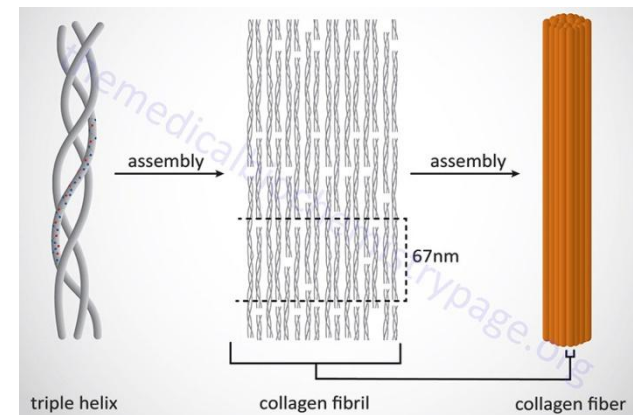
# **What Do Proteins Do?**

# Support Collagen:

*the most abundant protein in humans*



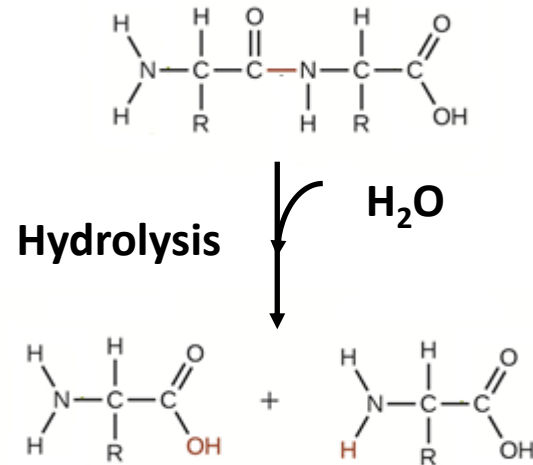
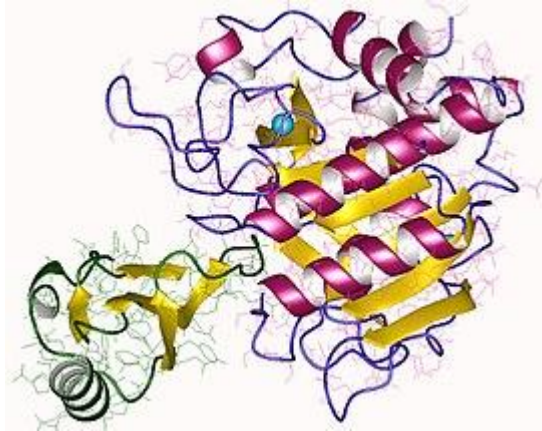
***Triple Helix***



# Catalysts (Enzymes)

A Catalyst Accelerates a Reaction without Being Consumed in it.

## Subtilisin



**Protease: Protein Hydrolysis**

CONTACT LENS CLEANER



**Meat Softening**

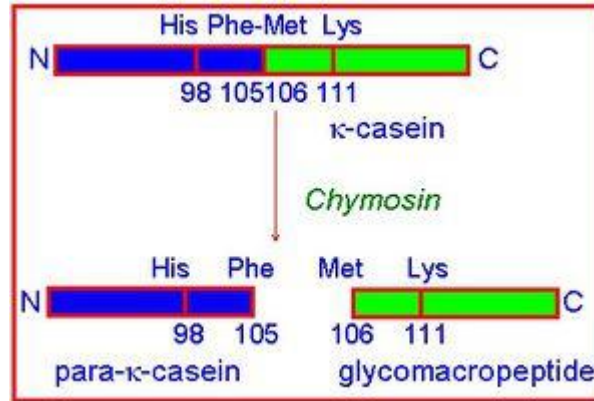
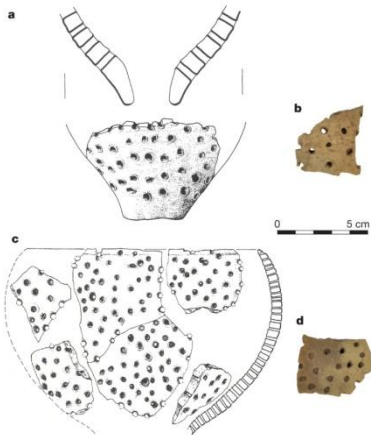


**Detergents**



**Chymosin**

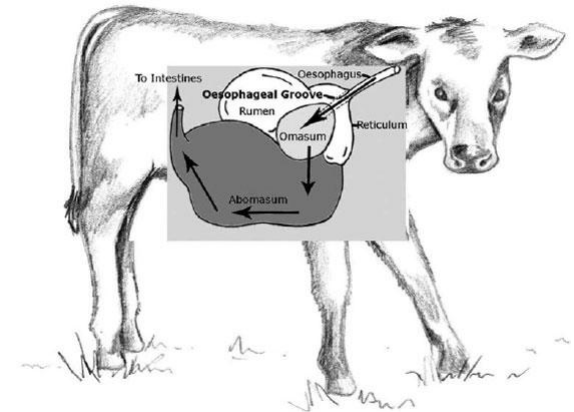
**Another Protease**



**6<sup>th</sup> Millenium BC  
sieve vessels from of Kuyavia**

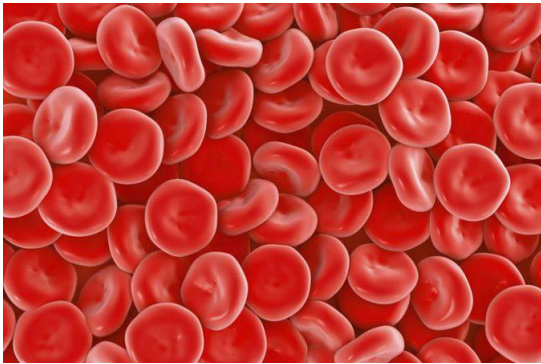


**Rennet  
(Podpuszczka, Reneta)**



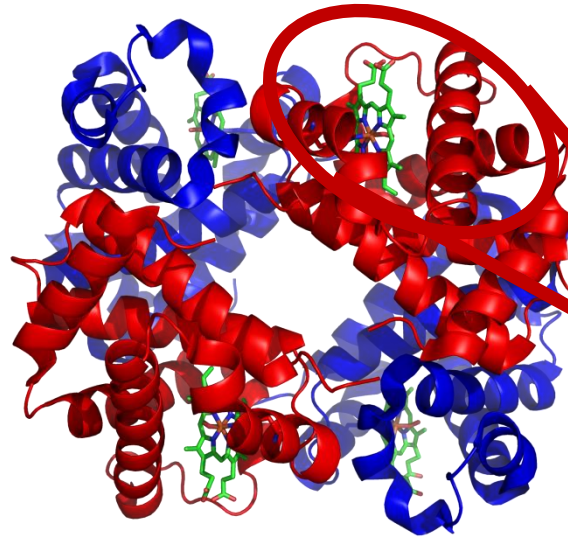


# Transporters: Hemoglobin Hb

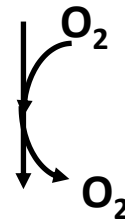


Red Blood Cells

Oxygen Transport

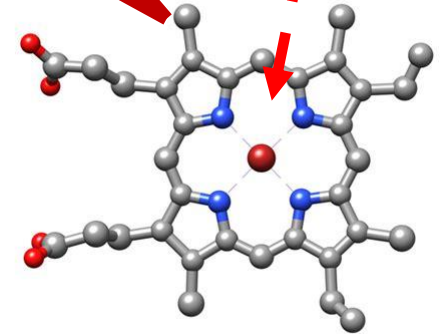


High Oxygen Concentration  
(Lungs)



Low Oxygen Concentration  
(Muscles)

Oxygen  
Binding Site  
Fe (II/III)

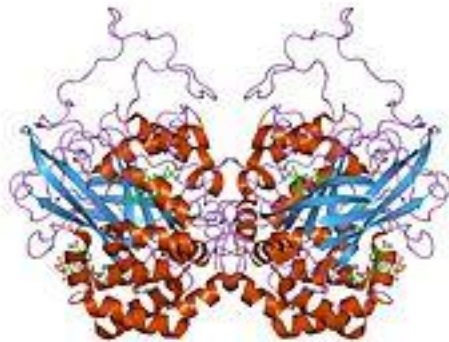
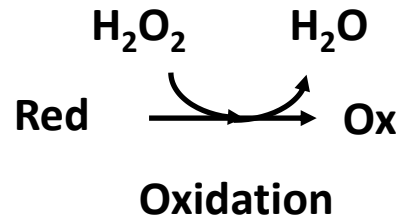


Heme (Prosthetic Group)

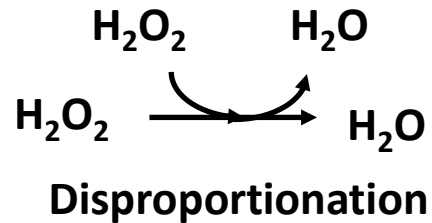
# More Enzymes: Oxidation



Horseradish (chrzan)  
Peroxidase (HRP)



Catalase



Catalase CA-540  
for Bio-Bleaching

- \*Activity:  $\geq 200,000\text{U/ml}$
- \*Technical Grade
- \*Halal & Kosher Certified
- \*Liquid



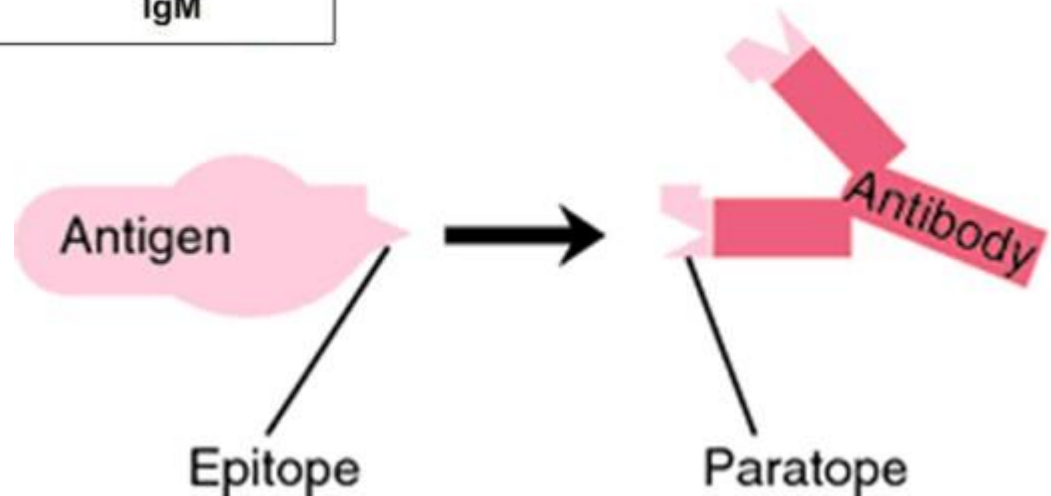
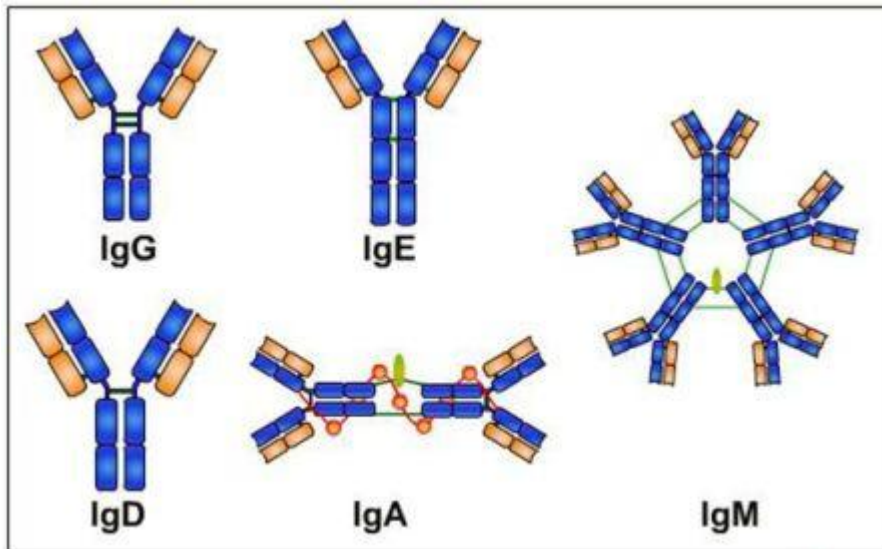
Jiangsu Boli Bioproducts Co., Ltd.  
Manufacturer from China [china.yang@bolibio.com](mailto:china.yang@bolibio.com)

“Bio” Bleaching



# Recognition

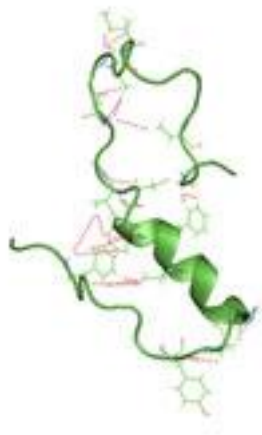
*Immunoglobulins (Ig): antibodies*



# Change of Structure

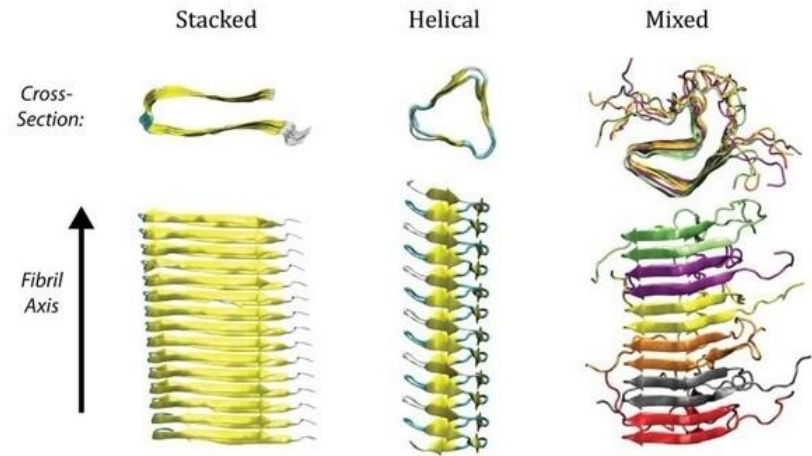
## Is it Dangerous?

Amyloid beta peptide (beta-APP)

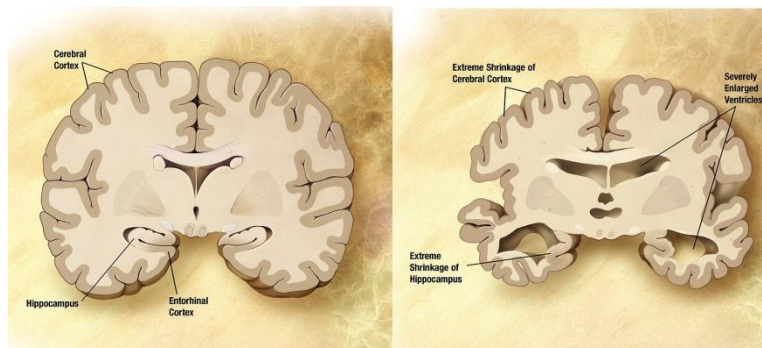


$\alpha$  helix  $\rightarrow$   $\beta$  sheet

Fibrils

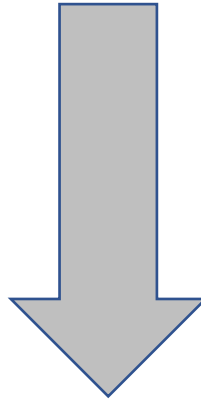


Alzheimer's disease



**Structure = Function**

**Change Structure to Control Function**

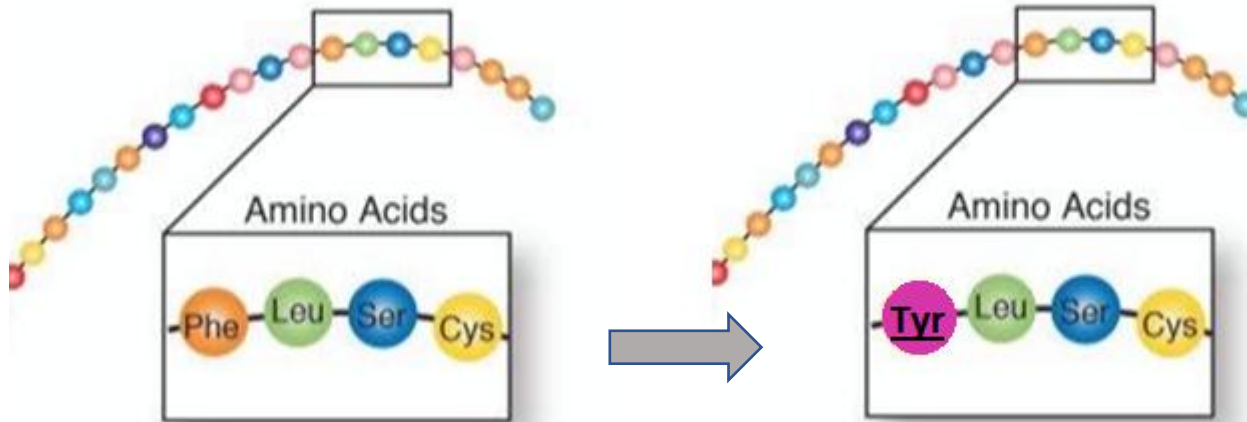


**Protein Engineering**

# Modify Proteins:

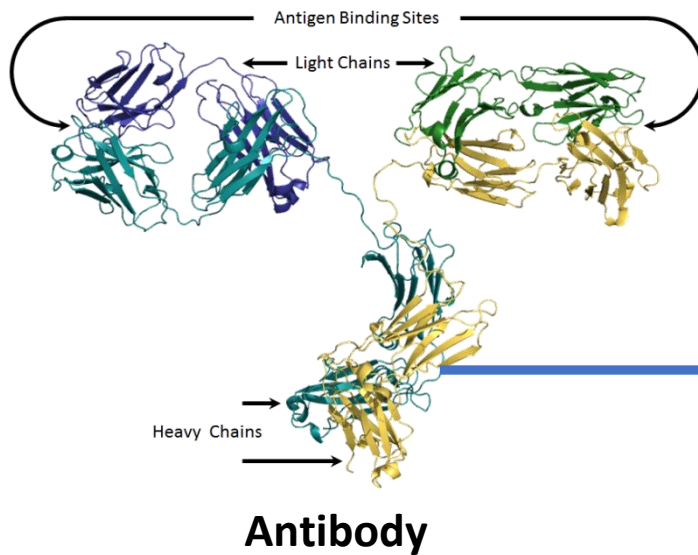
## Site-Directed Mutagenesis

Example: Phe to Tyr Mutation

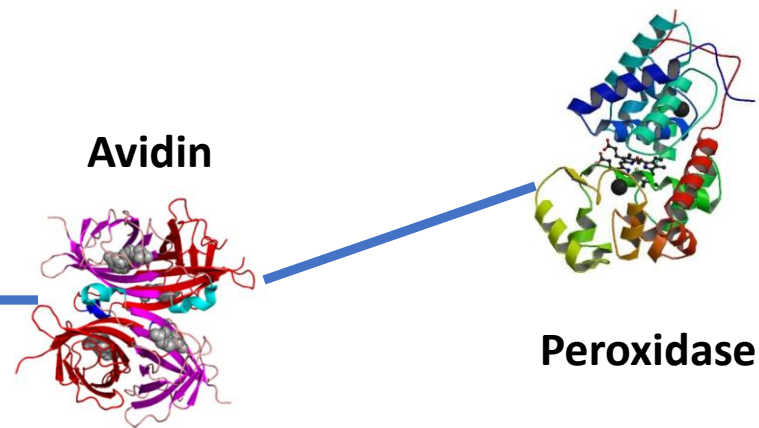


# Combine Proteins!

## Recognition



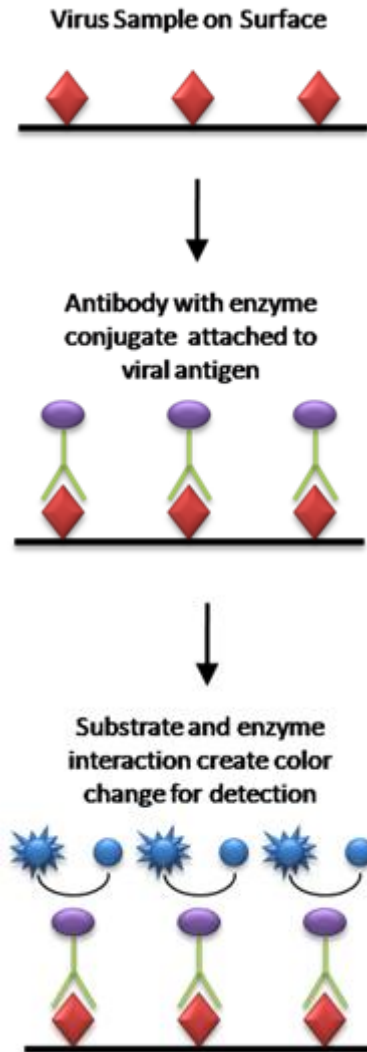
## Detection



## Link

# ELISA Test

(ELISA: Enzyme Linked Immunosorbent Assay)



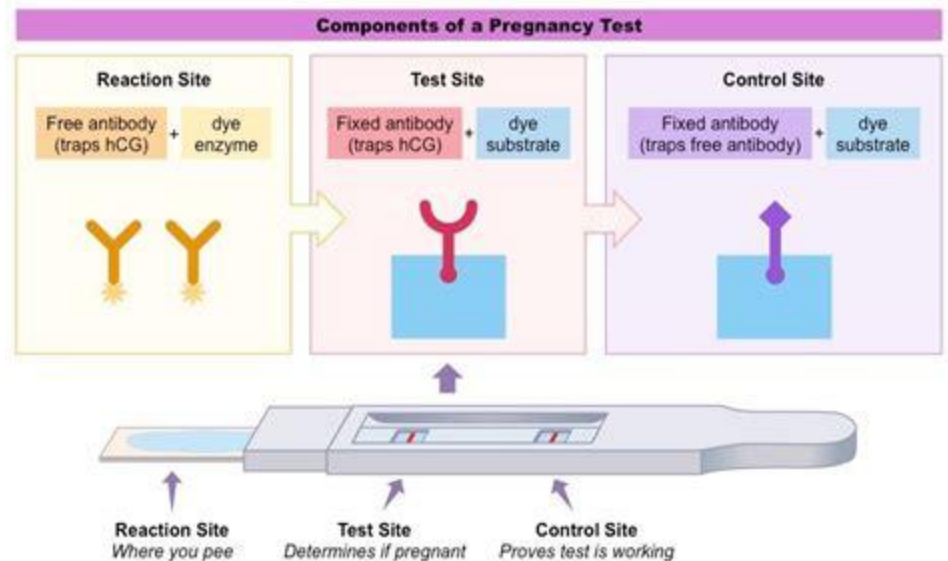
How it looks like:  
Colour develops only in the  
presence of compound of interest

**Sensitive to ...  
... one molecule  
(in theory)**

# Human Chorionic Gonadotropin (hCG) Hormone



Pregnancy Test





## *Escherichia coli* 0157 - Bacteria



**C Reactive Protein - Inflammation**



**HIV**

**Mumps**

**Rubella**

**Herpes**

**Mitochondria**

**Vitamin B12**

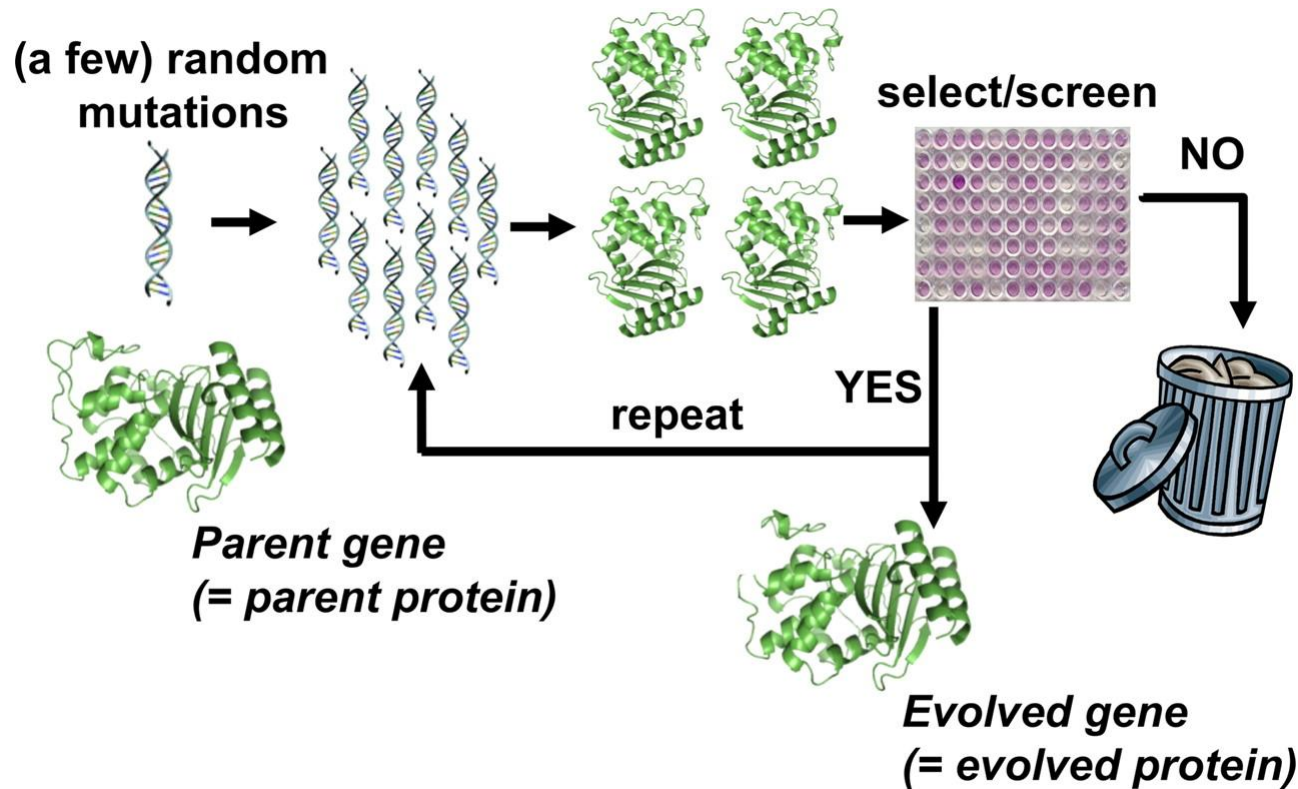
**Peanuts**



# Directed Evolution

Frances H. Arnold (Nobel Prize in Chemistry 2018)

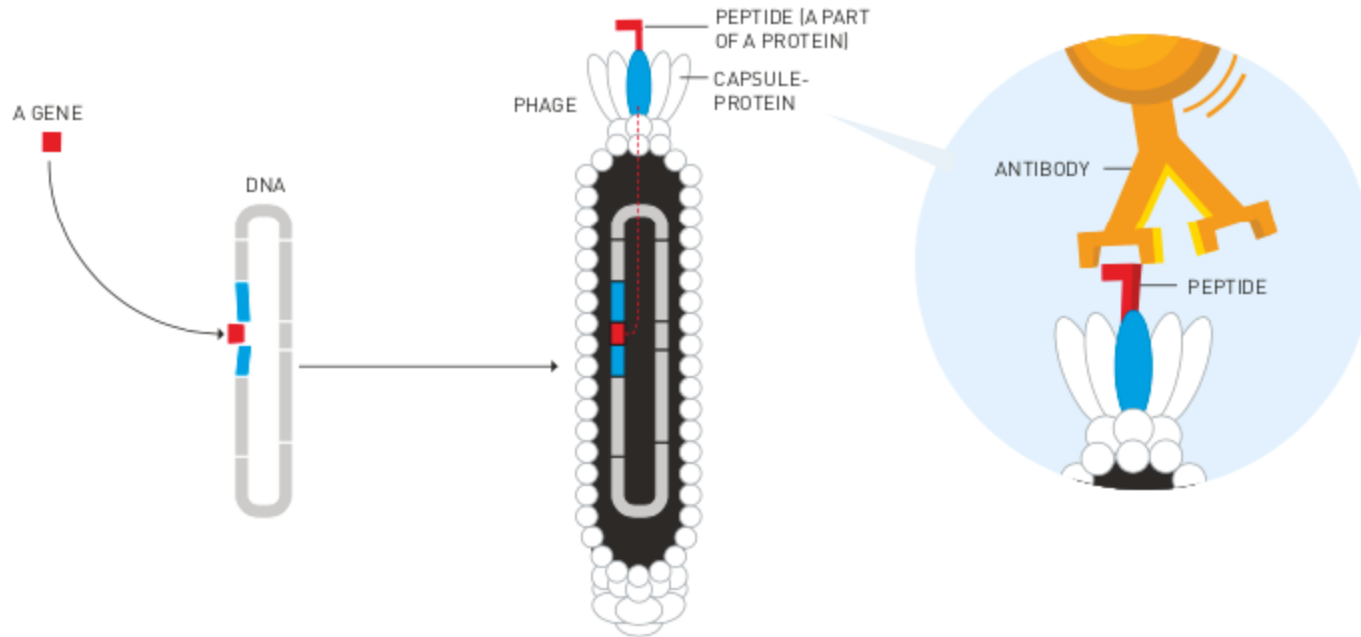
Site Directed Mutagenesis – on a grand scale



**Biotechnology**  
**Enzymes**

**Pharmaceuticals**

# Phage Display



1 Smith introduced a gene into the gene for a protein in the phage's capsule. The phage DNA was then inserted into bacteria that produced phages.

2 The peptide produced from the introduced gene ended up as part of the capsule protein on the surface of the phage.

3 Smith was able to fish out the phage using an antibody designed to attach to the peptide. As a bonus, he got the gene for the peptide.

©Johan Jarnestad/The Royal Swedish Academy of Sciences

**George P. Smith and Sir Gregory P. Winter**  
**Nobel Prize in Chemistry 2018**

**More questions?**

**luca.quaroni@uj.edu.pl**