

Corso di Studio in
SCIENZE DELLE ATTIVITÀ MOTORIE E SPORTIVE
Insegnamento:
CHIMICA, BIOCHIMICA E FISICA APPLICATA ALLE SCIENZE
MOTORIE

Modulo di Insegnamento: CHIMICA E BIOCHIMICA

Dott.ssa Claudia Rossi

Dipartimento di Scienze Psicologiche, della Salute e del Territorio (DiSPuTer)
Laboratorio di Biochimica Analitica e Proteomica
Centro di Studi e Tecnologie Avanzate CAST
Università degli Studi "G. d'Annunzio"
Tel. 0871 541596 – 0871 541333

claudia.rossi@unich.it

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Modulo: Chimica e Biochimica → Programma del Corso

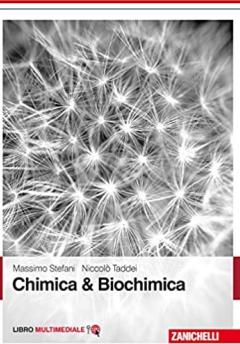
Contenuti

MODULO DI CHIMICA: Elementi di chimica generale. Principali contenuti: equilibri in soluzione, reazioni redox, proprietà colligative ed elementi di base di chimica del carbonio
 MODULO DI BIOCHIMICA: Le biomolecole. Metabolismi di base di glucidi, lipidi e proteine. Caratteristiche principali dei metabolismi energetici

Testi di riferimento

MODULO DI CHIMICA:
 Massimo Stefani, Niccolò Taddei, Chimica & Biochimica (Zanichelli)
 MODULO DI BIOCHIMICA:
 David L Nelson, Michael M Cox Introduzione alla biochimica di Lehninger (Zanichelli)
 Antonio Di Giulio Amelia Fiorilli Claudio Stefanelli, Biochimica per Scienze motorie (Casa Editrice Ambrosiana. Distribuzione Zanichelli)

Massimo Stefani, Niccolò Taddei
Chimica & Biochimica
 2017



David L Nelson, Michael M Cox
Introduzione alla biochimica di Lehninger
 Sesta edizione
 A cura di Edon Meloni
 Trad. di A. De Donatis, R. Stefanese
 2018



Antonio Di Giulio, Amelia Fiorilli, Claudio Stefanelli
Biochimica per Scienze motorie
 Casa Editrice Ambrosiana. Distribuzione esclusiva Zanichelli
 2011

**BIOCHIMICA
PER LE SCIENZE
MOTORIE**



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Modulo: Chimica e Biochimica → Programma del Corso

BIOCHIMICA

Programma esteso

MODULO DI BIOCHIMICA: Le biomolecole: struttura e classificazione di glucidi, lipidi e proteine. Struttura e funzione dell'emoglobina e mioglobina. Classificazione e funzione delle vitamine. La variazione dell'energia libera DG e ruolo dell'ATP. Il sistema della creatina-fosfocreatina muscolare e suo ruolo nella sintesi veloce di ATP. Enzimi: definizione, classificazione, kinetica enzimatica allo stato stazionario e inibitori reversibili competitivi e non competitivi. Catabolismo dei glucidi: glicolisi, formazione dell'acido lattico, via dei pentosi e ciclo di Krebs. Catabolismo dei lipidi: corpi chetonici e beta ossidazione. Catabolismo delle proteine: proteasi, transdeaminazione, glutammmina, ciclo dellalanina e ciclo urea. Fosforilazione ossidativa e sintesi dell'ATP. Elementi dell'anabolismo dei glucidi, lipidi e proteine. Gluconeogenesi, glicogenosintesi e ciclo di Cori. Adattamenti del metabolismo glucidico, lipidico e proteico all'attività motoria aerobica ed anaerobica.

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BIOCHIMICA

- La scienza che spiega come le proprietà degli organismi viventi dipendano da migliaia di differenti biomolecole che seguono tutte le leggi fisiche e chimiche che regolano il comportamento della materia inanimata.
- Studio che mostra come tutte le molecole che costituiscono gli organismi viventi interagiscono tra loro per mantenere la vita utilizzando soltanto quelle leggi fisiche e chimiche che governano l'universo non vivente.

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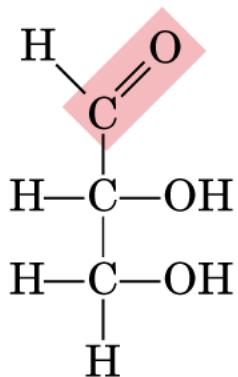
Glucidi
(carboidrati o zuccheri)
polialcoli con una funzione carbonilica
 $(CH_2O)_n$

5

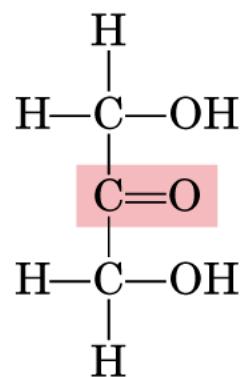
Monosaccaridi

- Aldosi
- Chetosi

6

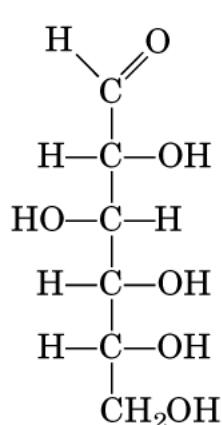


Gliceraldeide
un aldotrioso

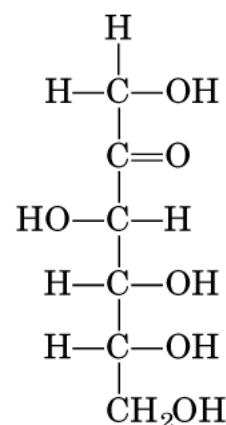


Diidrossiacetone
un chetonioso

7

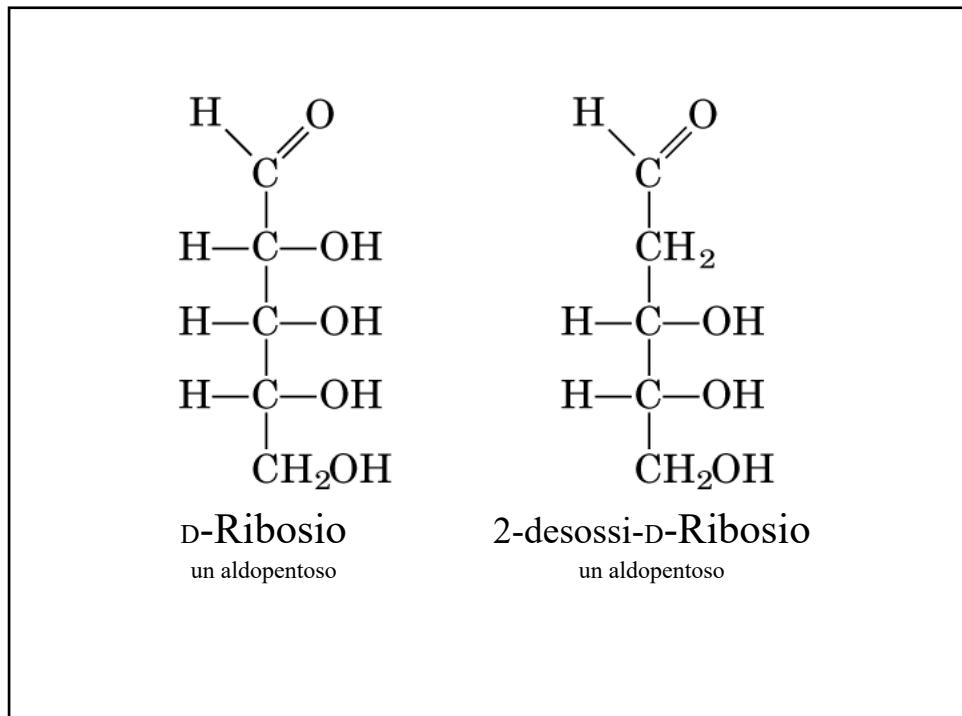


D-Glucosio
un aldoesoso

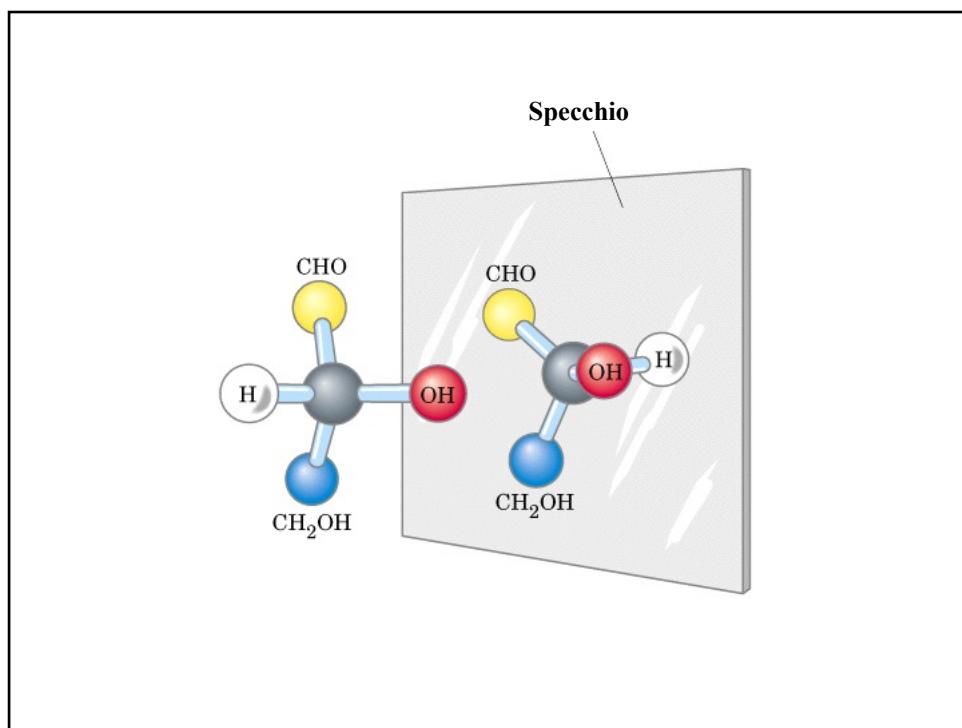


D-Fruttosio
un chetoesoso

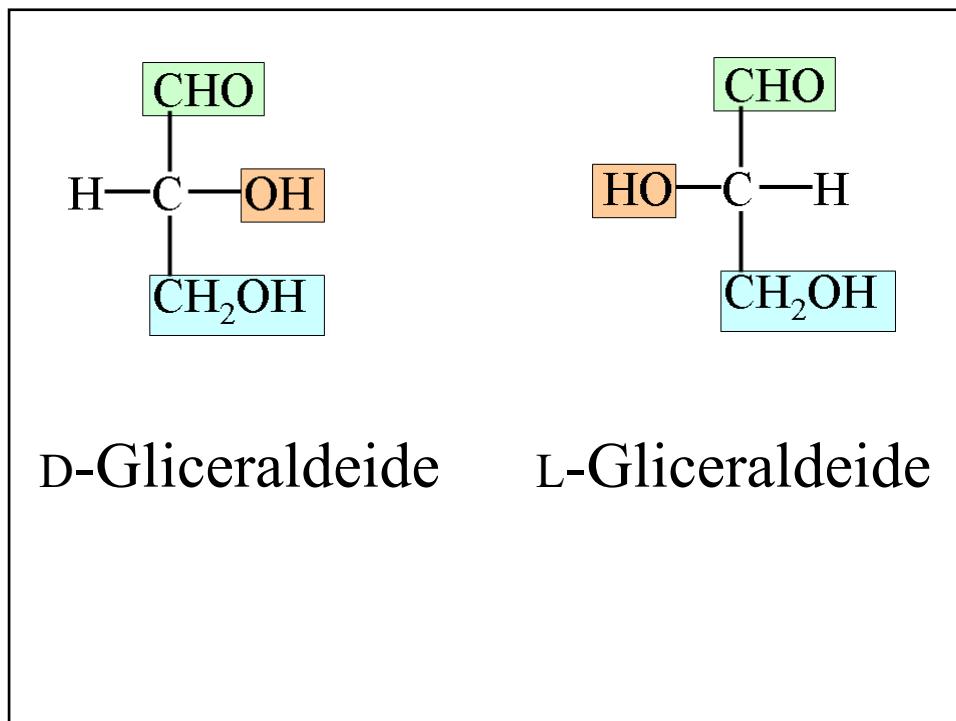
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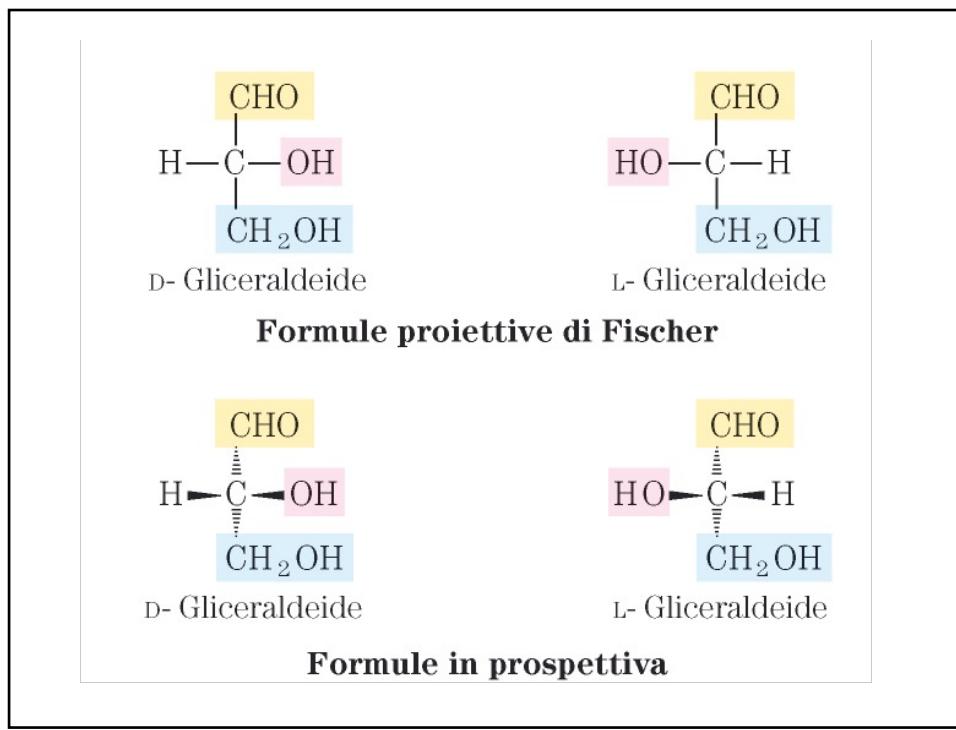
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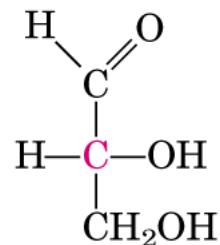
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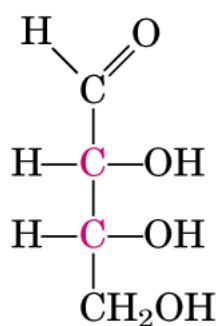
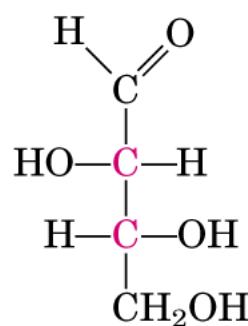
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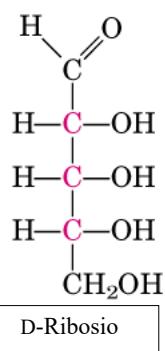
Tre atomi di carbonio**D-Gliceraldeide**

13

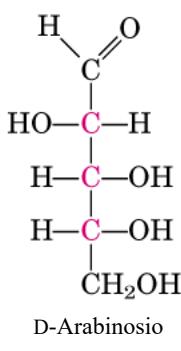
Quattro atomi di carbonio**D-Eritrosio****D-Treosio**

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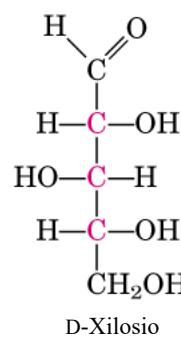
Cinque atomi di carbonio



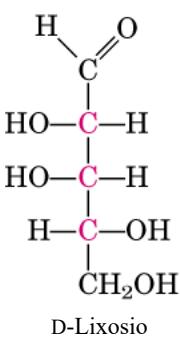
D-Ribosio



D-Arabinosio



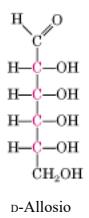
D-Xilosio



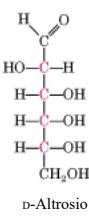
D-Lixosic

15

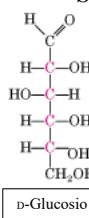
Sei atomi di carbonio (aldosi)



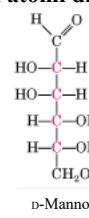
d-Allosio



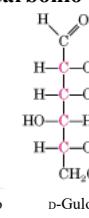
d-Altrosi



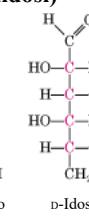
D-Glucosidase



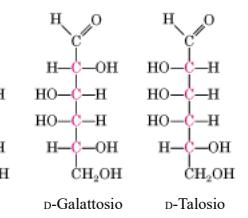
d-Mann



D-Glut



D-Id

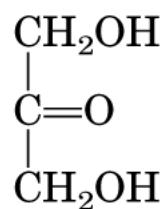


D-Galattosio D-Talosio

D-Aldosi

16

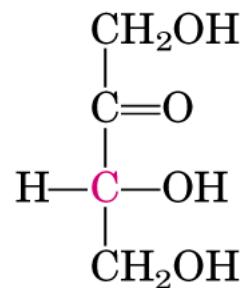
Tre atomi di carbonio (chetoso)



Diidrossiacetone

17

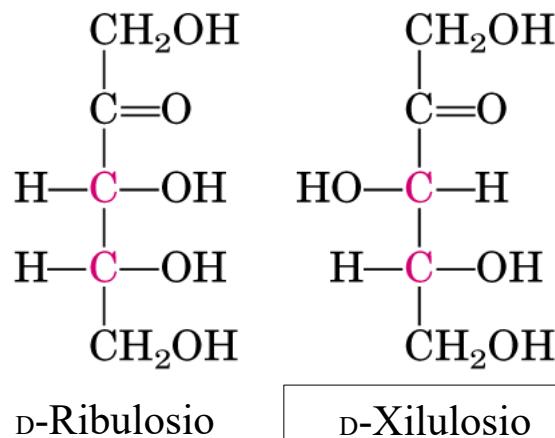
Quattro atomi di carbonio
(chetoso)



D-Eritulosio

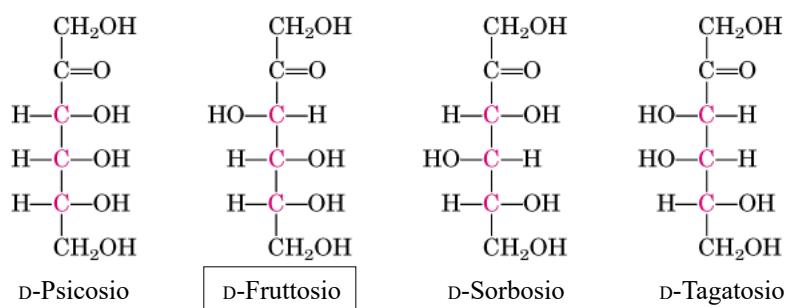
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Cinque atomi di carbonio (chetosi)

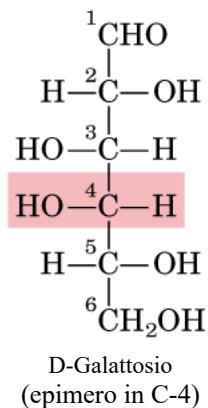
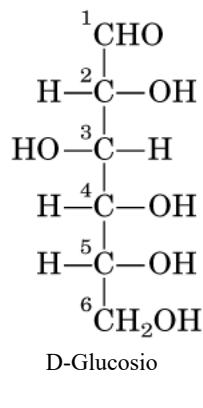
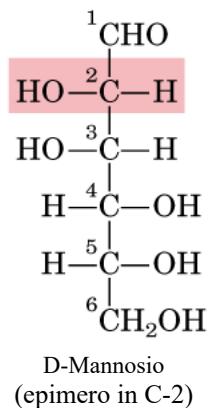


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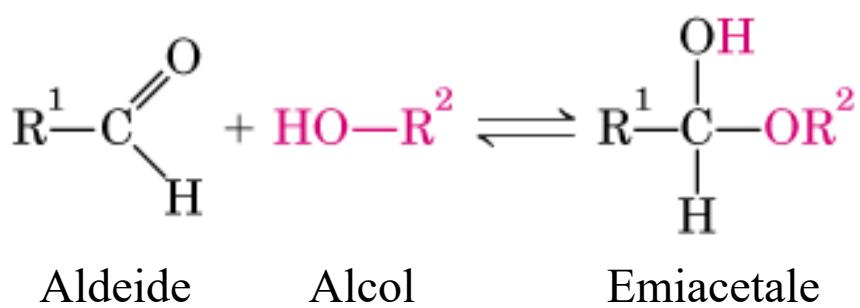
Sei atomi di carbonio (chetosi)



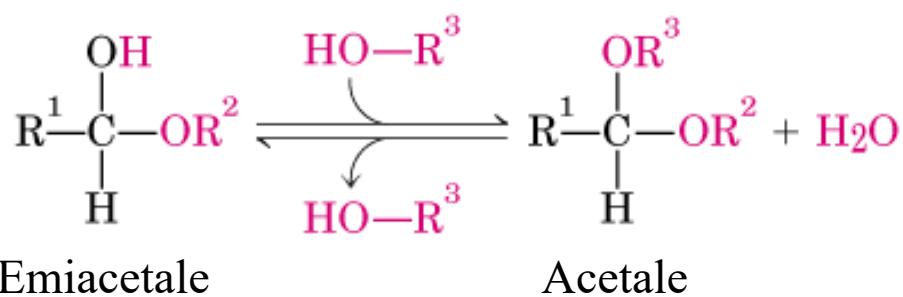
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EPIMERI

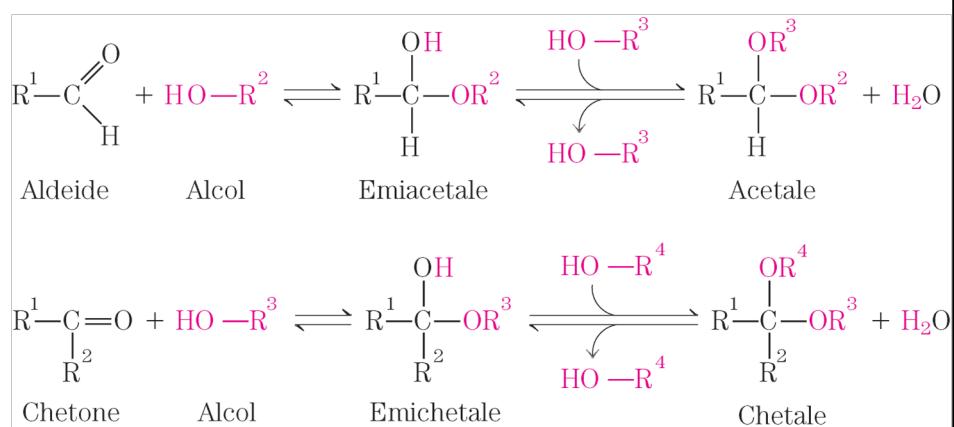
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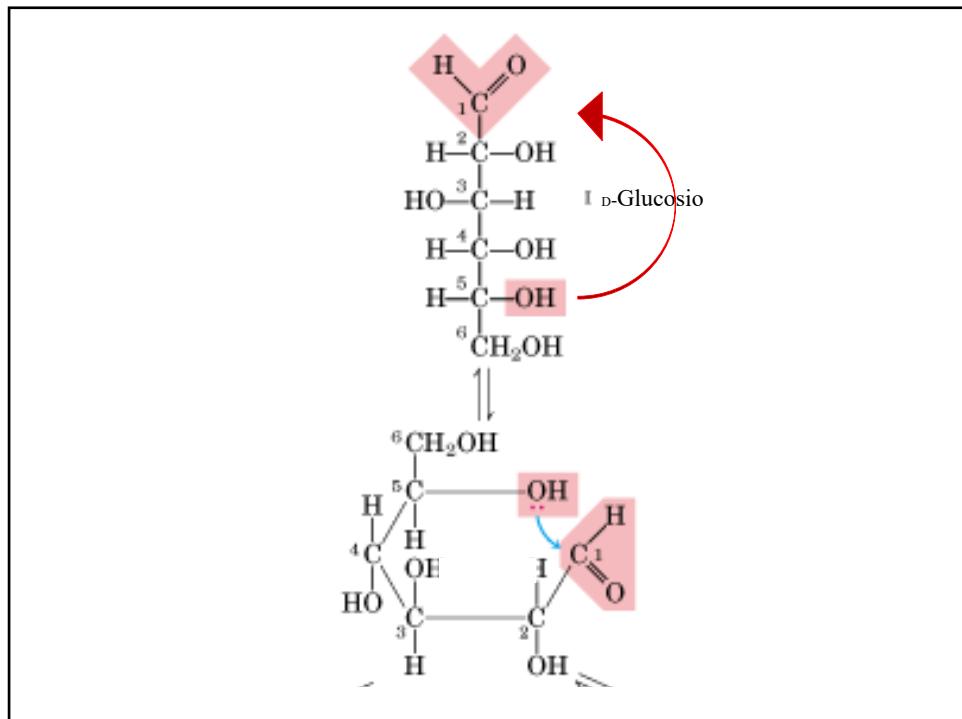
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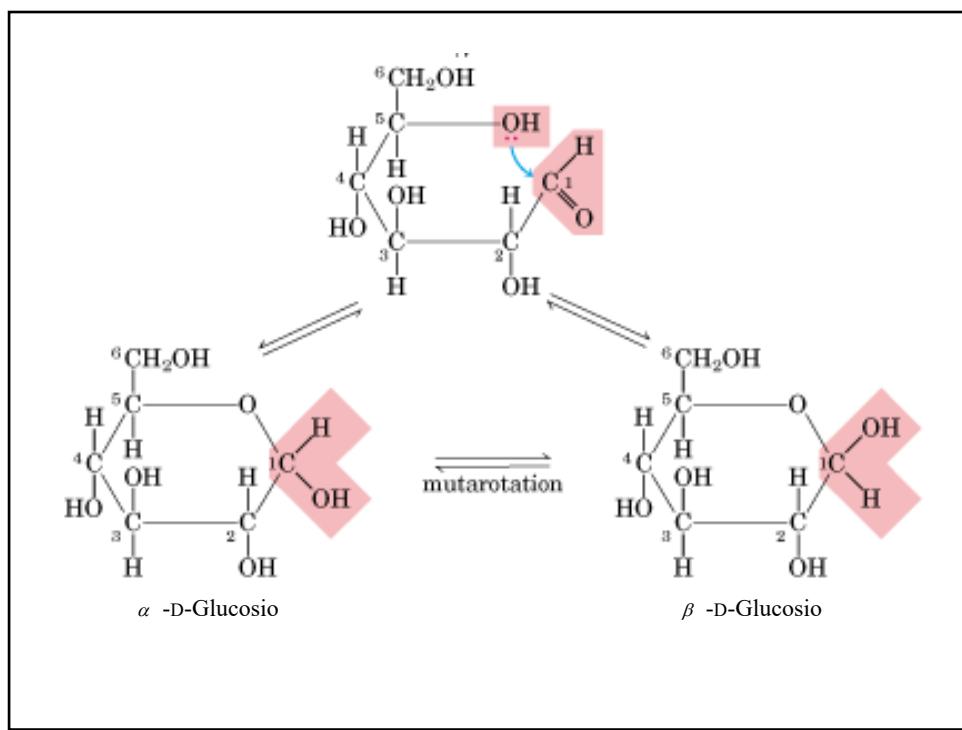
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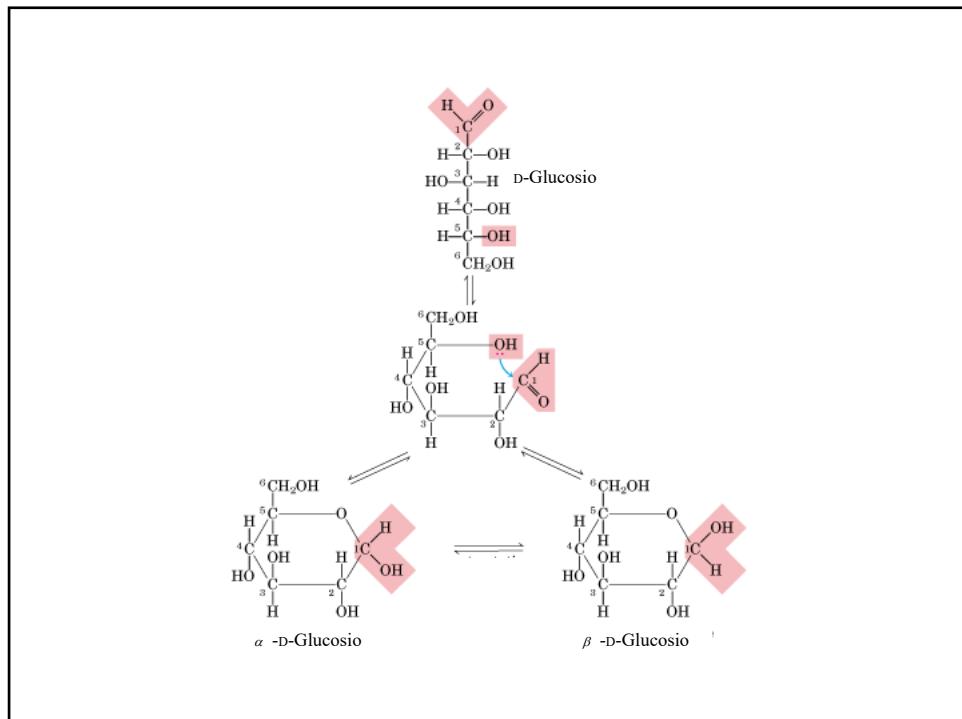
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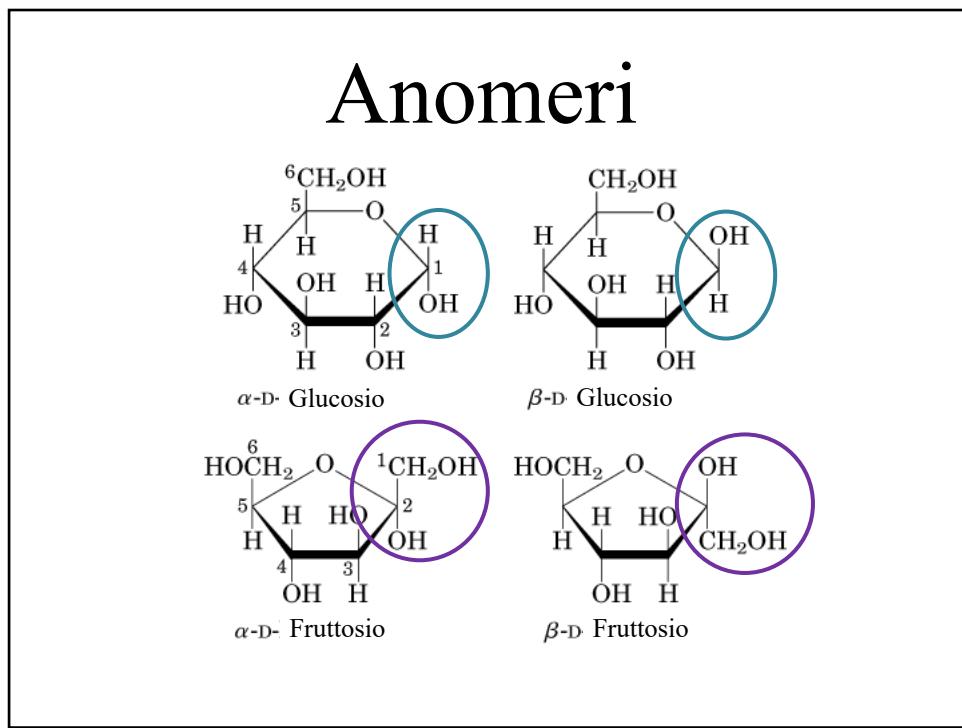
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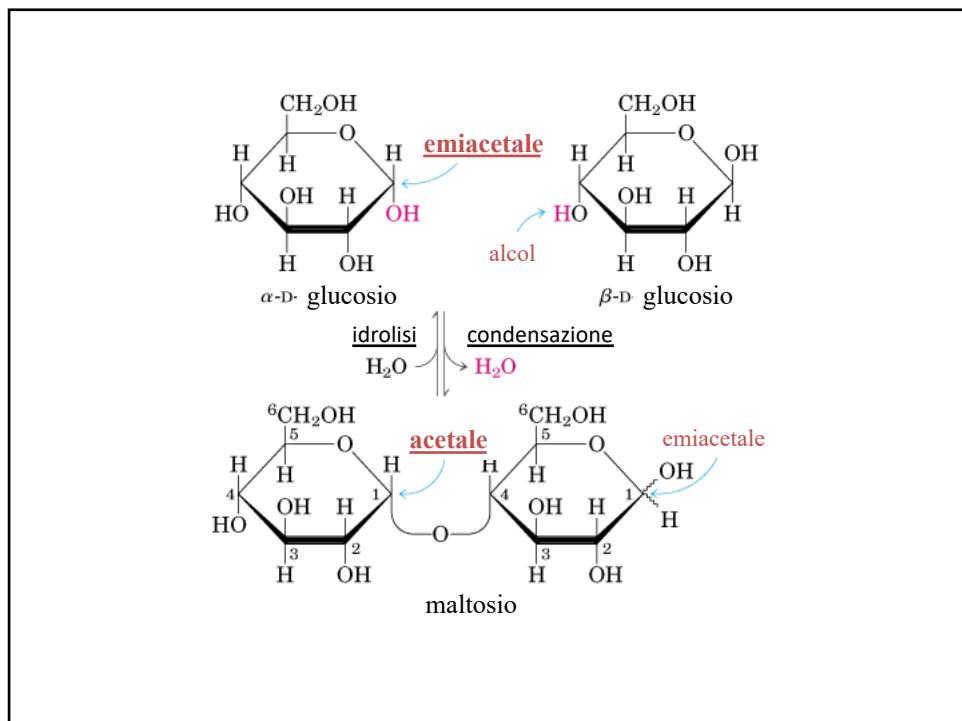
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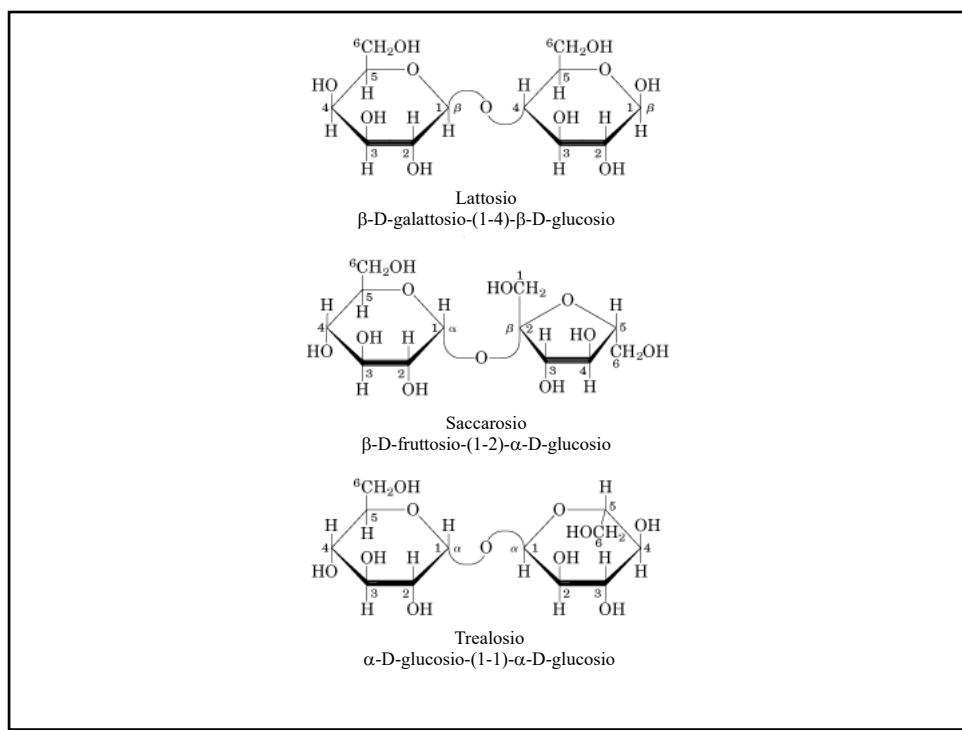
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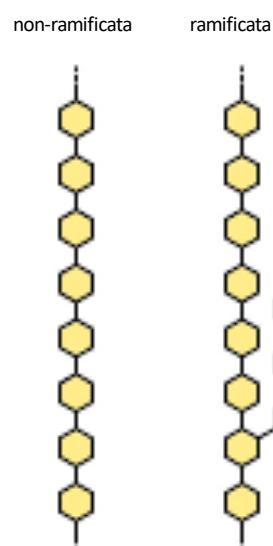
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Polisaccaridi

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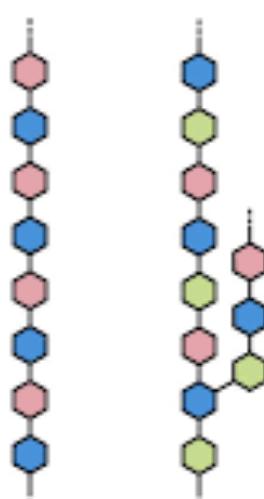
Catene Polisaccaridica

Omopolisaccaridi



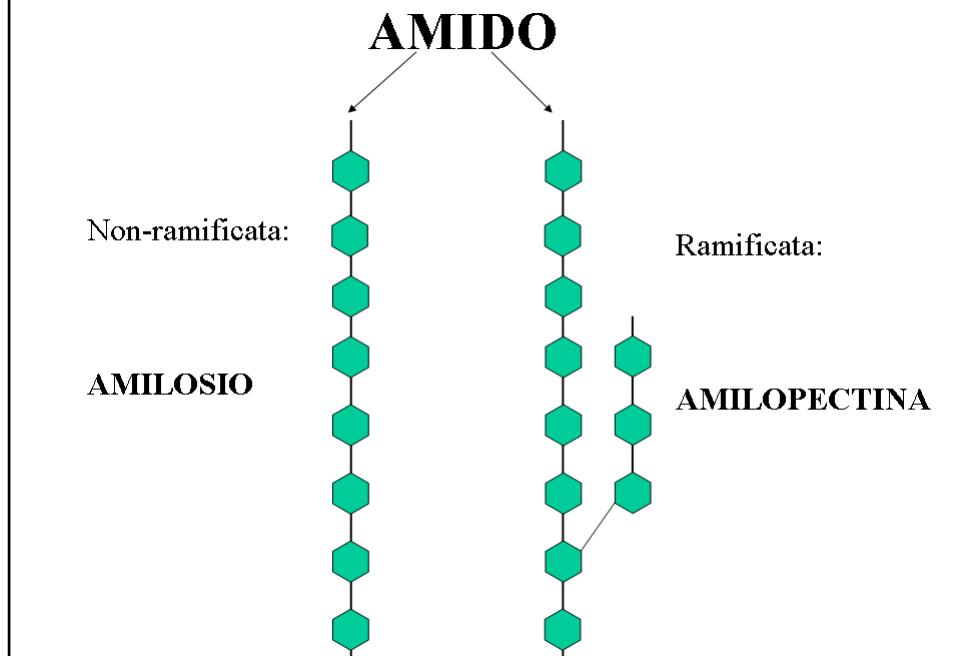
Eteropolisaccaridi

Due tipi di monomeri non-ramificati Diversi tipi di monomeri ramificati

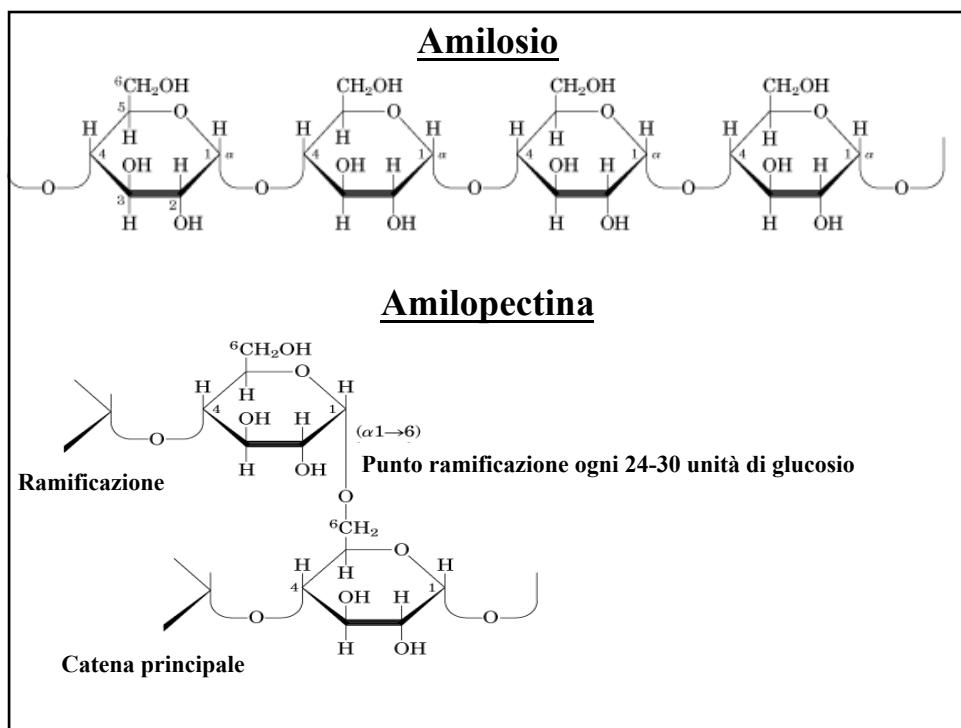


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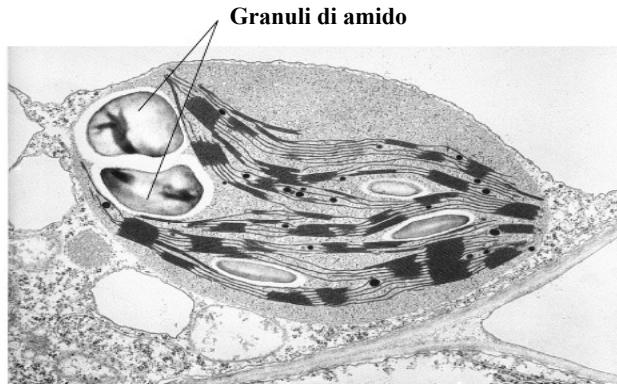
CATENE POLISACCARIDICHE NEL MONDO VEGETALE



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Fotografia al microscopio elettronico di un cloroplasto

L'amido, presente nei semi e tuberi (riso, frumento, patate ...), è il carboidrato di riserva del glucosio nelle piante
L'amido è il principale costituente dell'alimentazione umana.

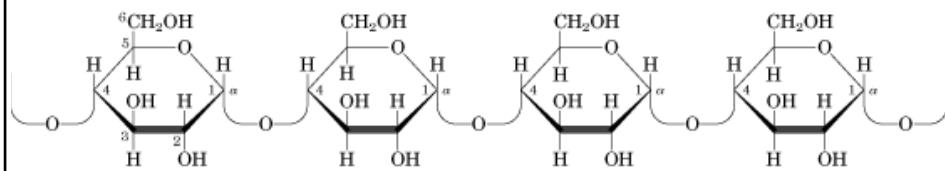
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MALTODESTRINE

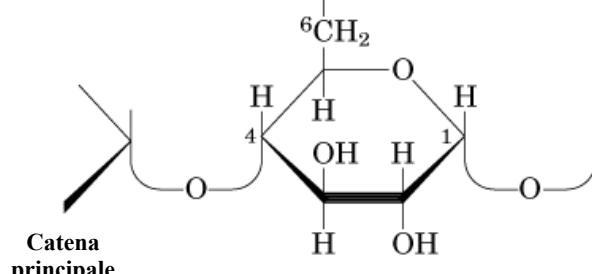
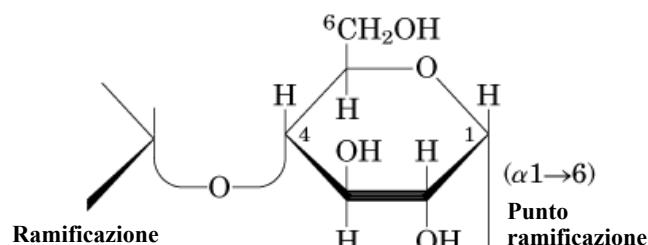
1. Polimeri di glucosio (alcune decine) ottenuti da processi chimici di idrolisi selettiva di amidi (mais o patate).
2. Ideali per sopperire al calo di glucosio che si verifica durante attività fisiche prolungate.
3. Polimeri solubili in acqua facilmente assimilabili sottoforma di bevanda.
4. Pressione osmotica minore rispetto ai carboidrati a basso peso molecolare (1/5 rispetto al glucosio).
5. Utilizzabili a fini energetici (basso indice glicemico rispetto al glucosio)

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Amido

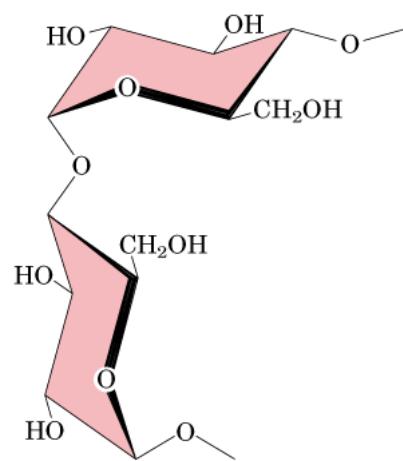


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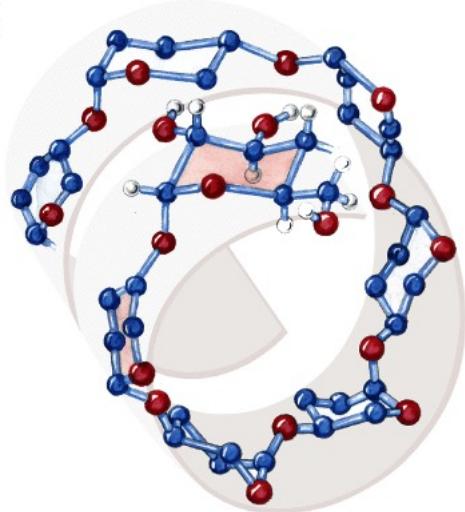
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Unità di α -D-glucosio legati (1-4)

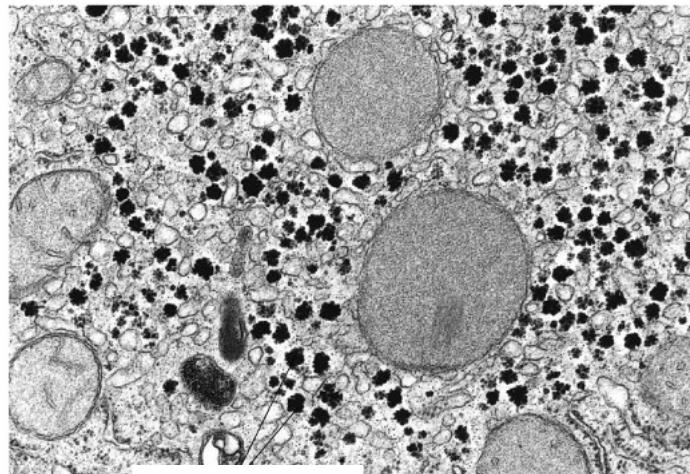
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Amido

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CATENE POLISACCARIDICHE NELL'UOMO: **GLICOGENO**



Granuli di glicogeno

Fotografia al microscopio elettronico di un epatocita

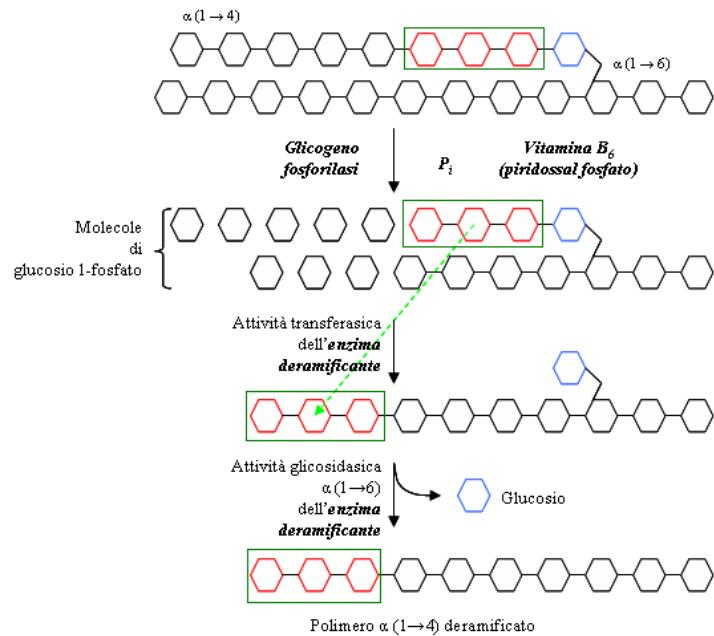
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GLICOGENO

1. Rappresenta il carboidrato di deposito negli animali.
2. E' un polimero di glucosio con legami alfa-1,4. Ogni 8-12 residui vi sono ramificazioni ottenute mediante legami alfa-1,6.
3. Presente nel fegato (circa 100 – 150 grammi) con catene lunghe circa 30000 unità di glucosio e nei muscoli (circa 300 grammi) con catene lunghe circa 6000 unità.

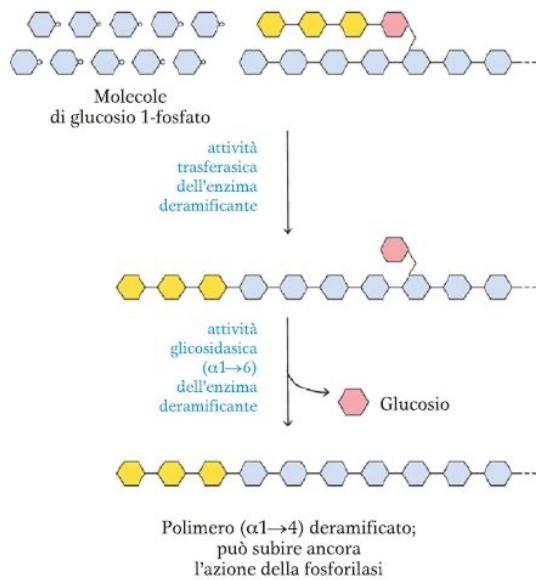
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PRODUZIONE DI GLUCOSIO A PARTIRE DAL GLICOGENO



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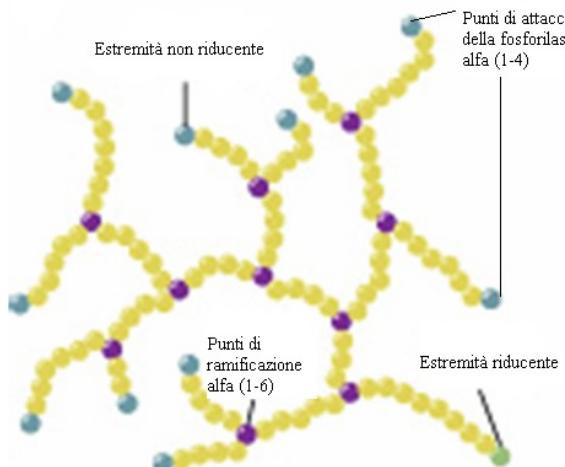
GLICOGENOLISI



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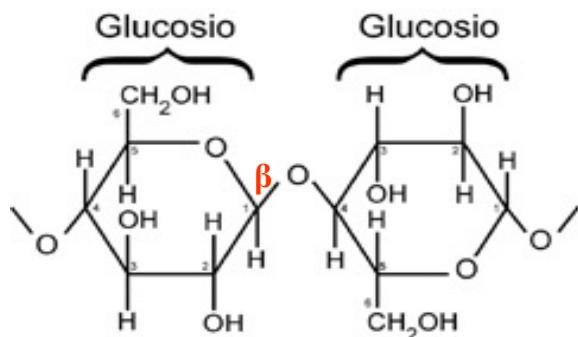
VANTAGGIO DELLA RAMIFICAZIONE DEL GLICOGENO

La ramificazione permette più siti di attacco dell'enzima glicogeno fosforilasi, producendo una velocità di rilascio di glucosio superiore a quanto sarebbe stato possibile con un polimero lineare.



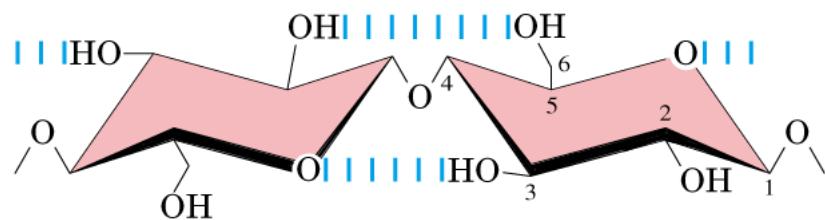
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CELLULOSA

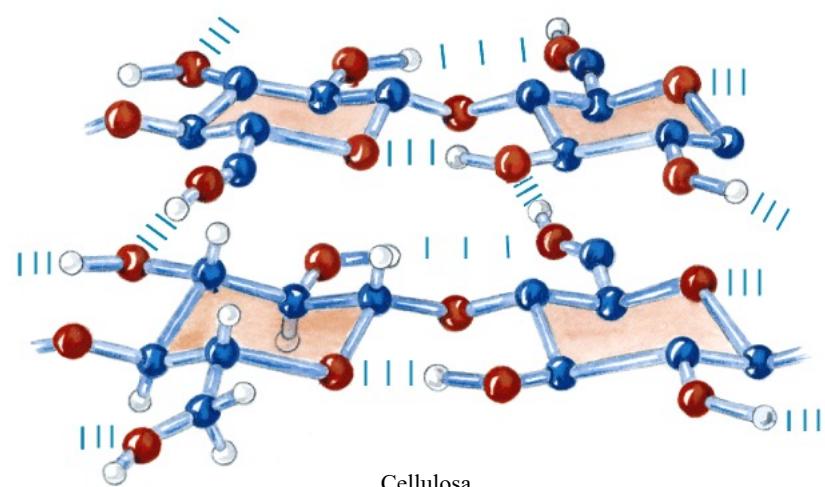


Polimeri lineari di glucosio uniti da legami tipo β (1-4)

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Unità di β -D-glucosio legati (1-4)

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Cellulosa

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1. Costituita da un gran numero di molecole di glucosio (circa da 300 a 3.000 unità) unite tra loro da un legame β -1--->4 glicosidico
2. La catena polimerica non è ramificata. Le catene sono disposte parallelamente le une alle altre e si legano fra loro per mezzo di legami ad idrogeno, formando resistenti fibrille
3. Solido e fibroso presente nelle piante, specialmente nelle loro pareti cellulari
4. L'uomo non è in grado di digerire la cellulosa perché mancano gli enzimi in grado di rompere il legame β -1--->4 glicosidico, che sono invece presenti nello stomaco dei ruminanti.

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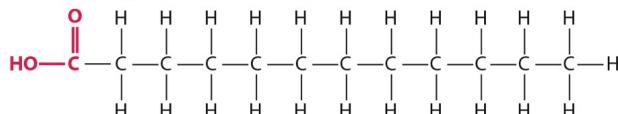
I lipidi

50

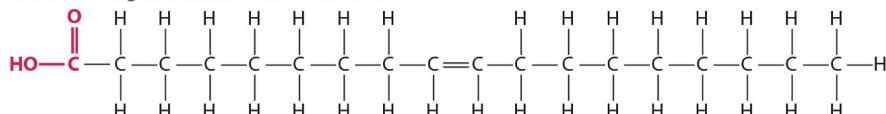
(A) struttura generale di un acido carbossilico



(B) un acido grasso saturo: l'acido laurico



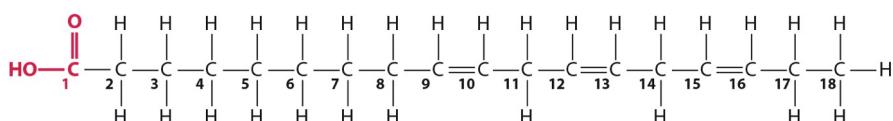
(C) un acido grasso insaturo: l'acido oleico



Numerazione dei carboni degli acidi grassi

La maggior parte degli acidi grassi in natura sono pari a causa della sintesi.

E' raro trovare acidi grassi insaturi con più di 4 doppi legami



Un sistema di numerazione alternativo è detto sistema omega (**ω**): si conta a partire dall'ultimo carbonio

I lipidi

Alcuni ac.grassi naturali

Scheletro carbonioso	Struttura	Nome comune	Punto di Fusione °C	Solubilità a 30 °C (mg/g solvente)	
				Acqua	Benzene
12:0	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$	Laurico	44.2	0.063	2600
14:0	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$	Miristico	53.9	0.024	874
16:0	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	Palmitico	63.1	0.0083	348
18:0	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	Stearico	69.1	0.0034	124

53

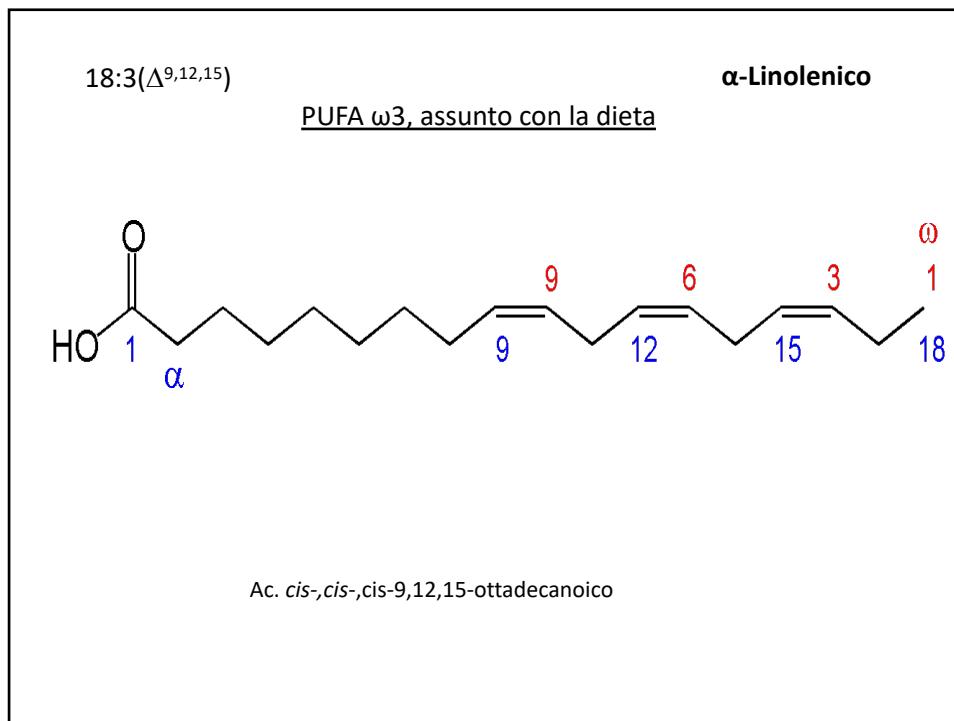
Alcuni ac.grassi saturi ed insaturi

18:0 $\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$ Stearico (pf 69.6°C)
 Ac. *n*-ottadecanoico

18:1(Δ^9) $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ Oleico (pf 13.4°C)
 Ac. *cis*-9-ottadecanoico

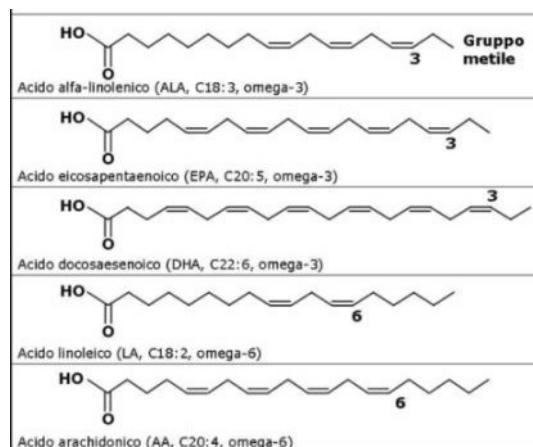
18:2($\Delta^{9,12}$) $\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ Linoleico (pf -5°C)
 Ac. *cis-,cis*-9,12-ottadecanoico

54



55

Acidi Grassi Essenziali AGE o EFA



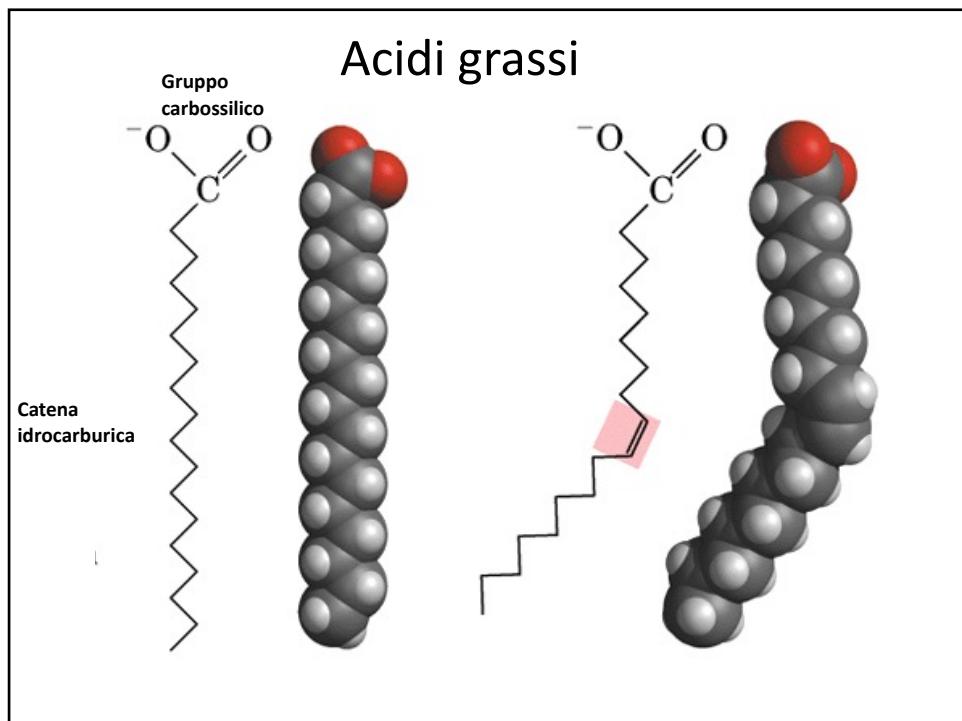
Acidi grassi essenziali

Ac. Linolenico: 18:3,w3,w6,w9

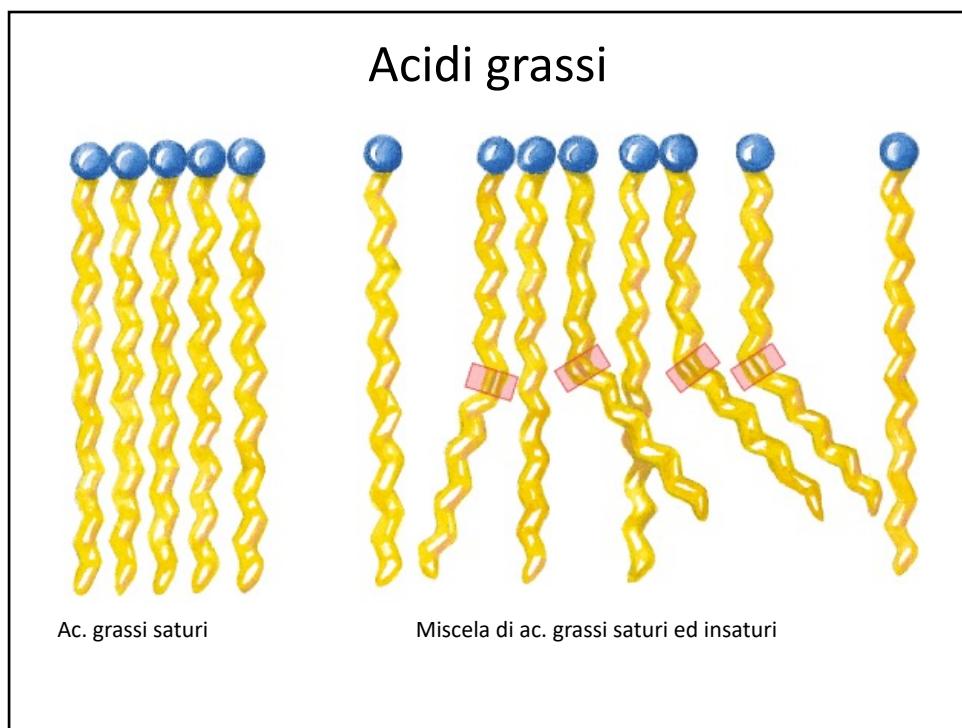
Ac. Linoleico: 18:2,w6,w9.

Sono precursori dell'acido arachidonico e gli ormoni eicosanoidi.

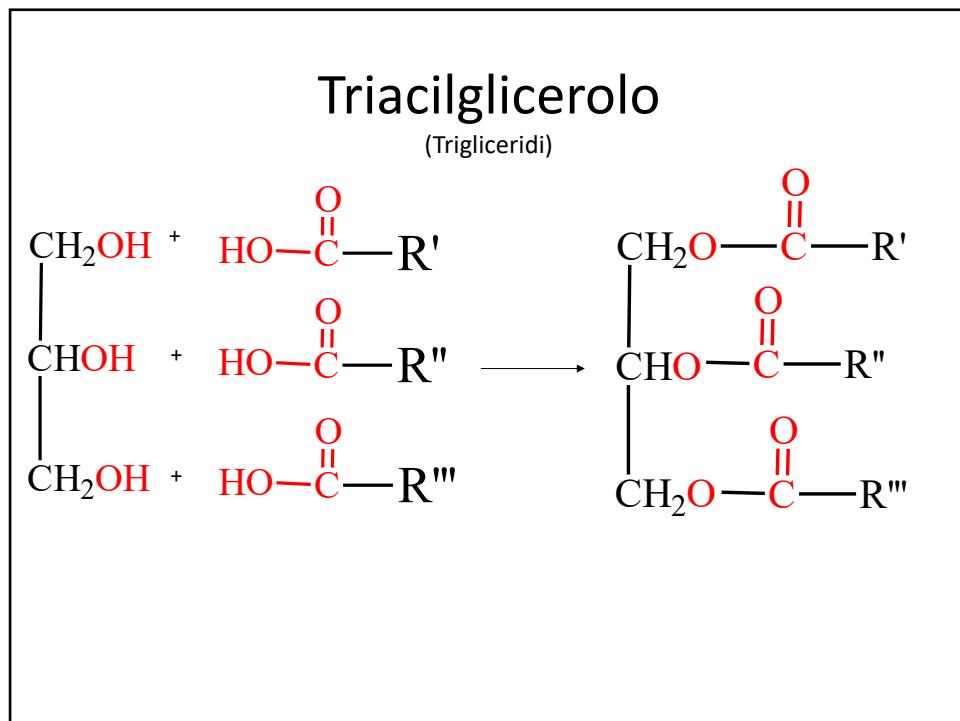
56



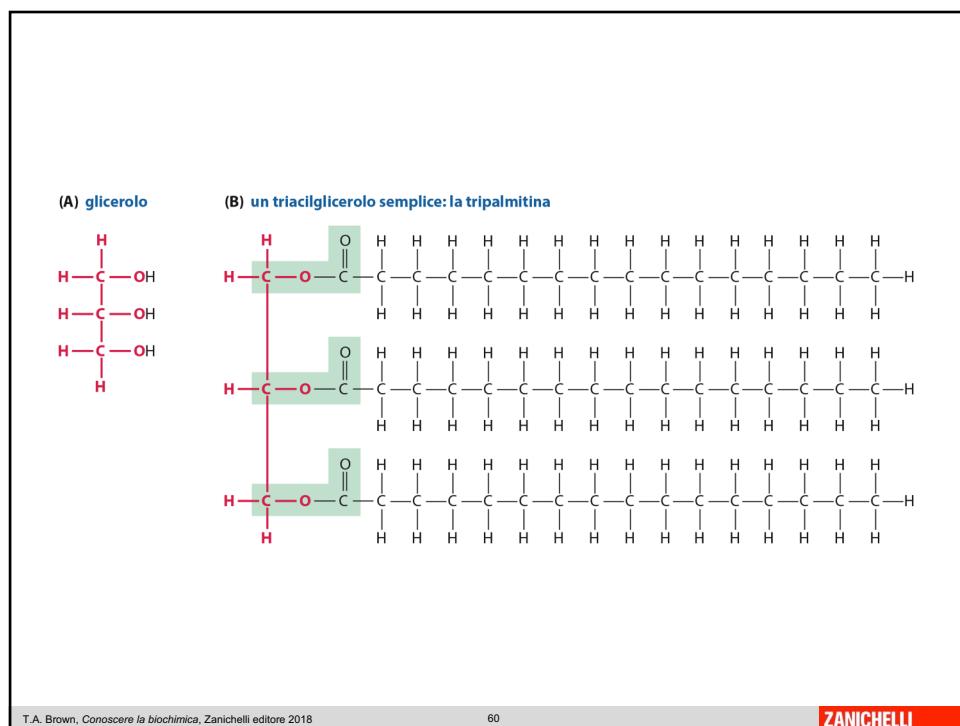
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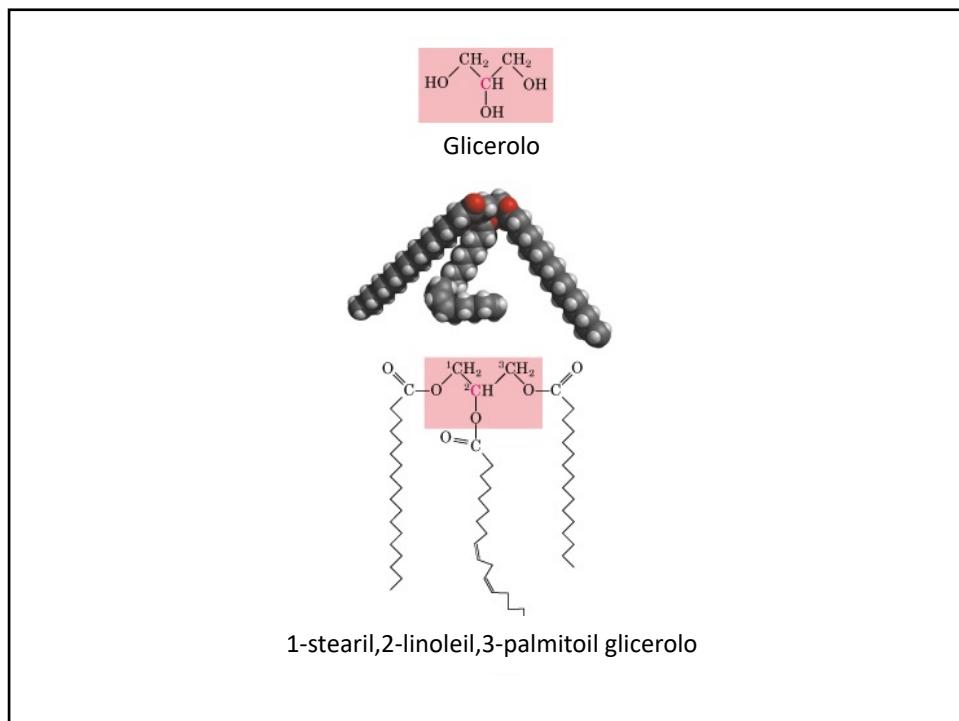
58



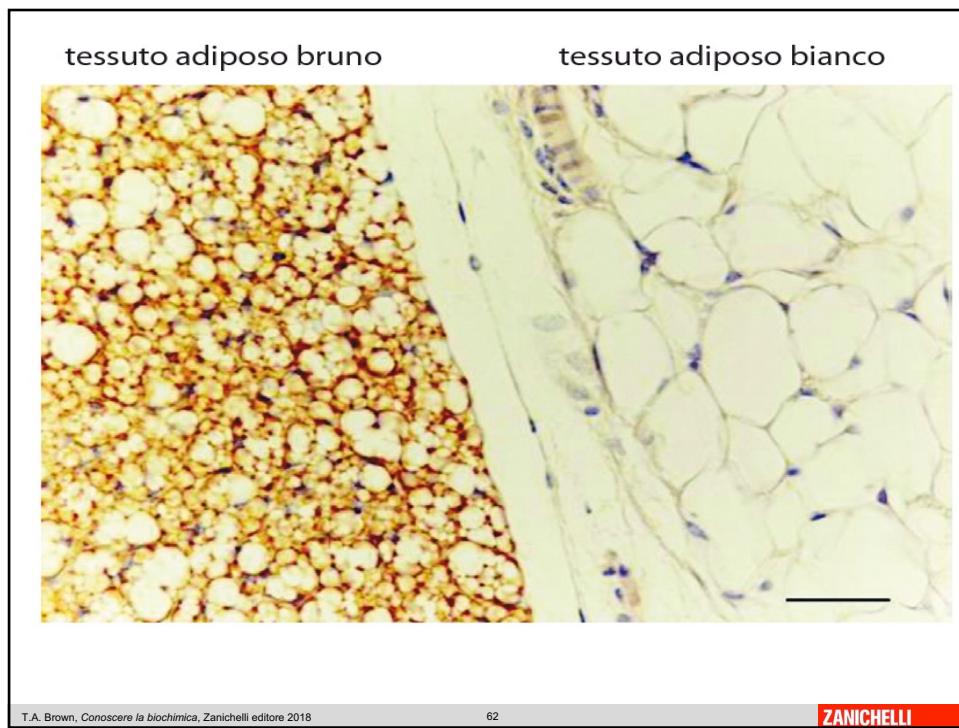
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60



61



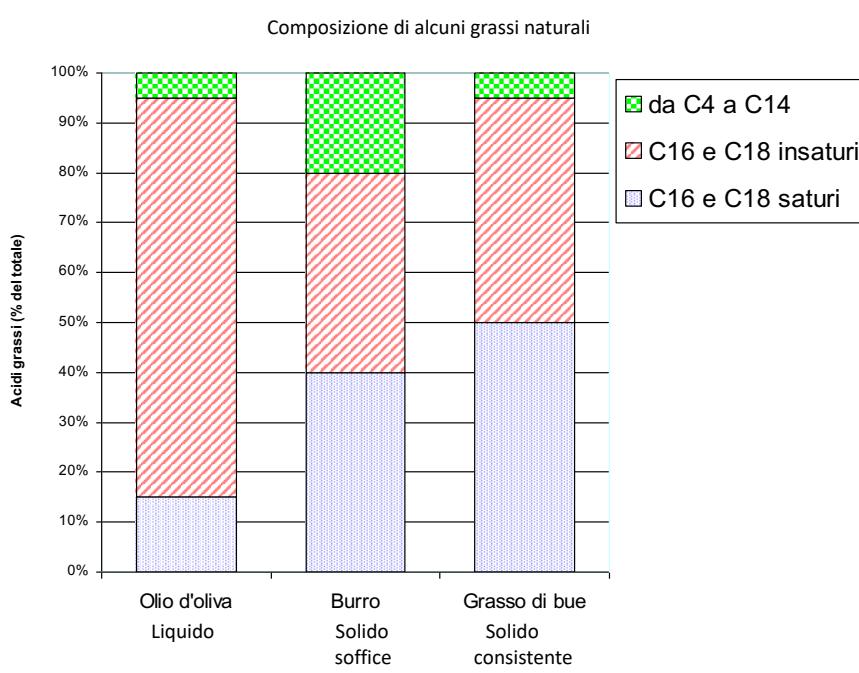
62

Cellule di deposito dei grassi: adipociti

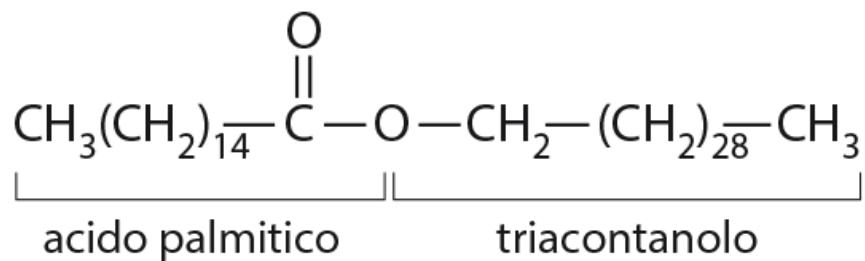
Le cellule adipose bianche contengono una sola goccia di grasso.
Le cellule adipose brune contengono molte goccioline di grasso.

Negli obesi le cellule adipose bianche aumentano di volume e numero.

Nelle piante i grassi sono immagazzinati nei semi e forniscono l'energia alla piantina dopo la germinazione.



Cera d'api



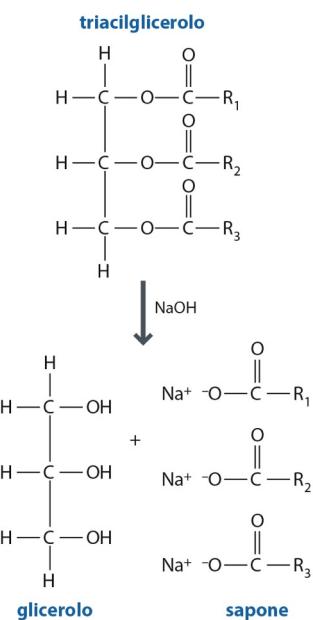
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SAPONI



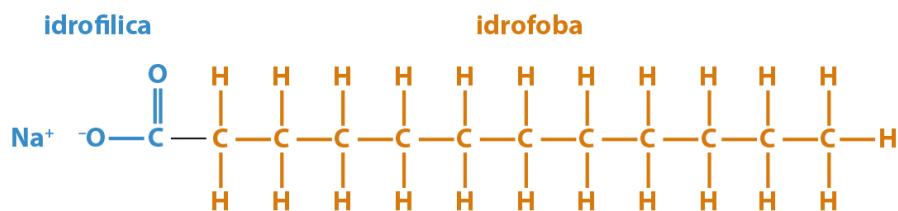
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Una molecola di sapone è anfipatica e forma micelle



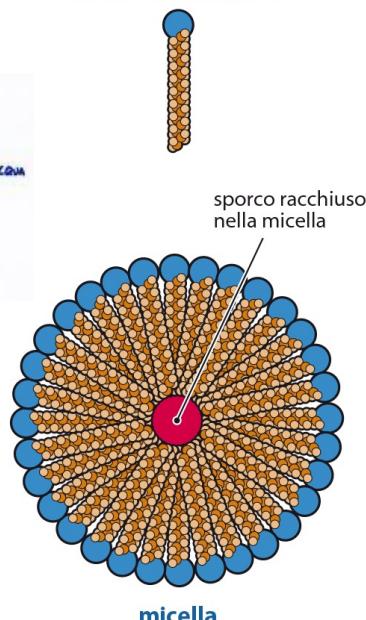
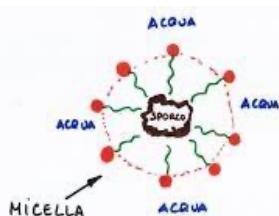
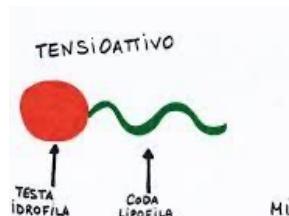
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molecola di sapone

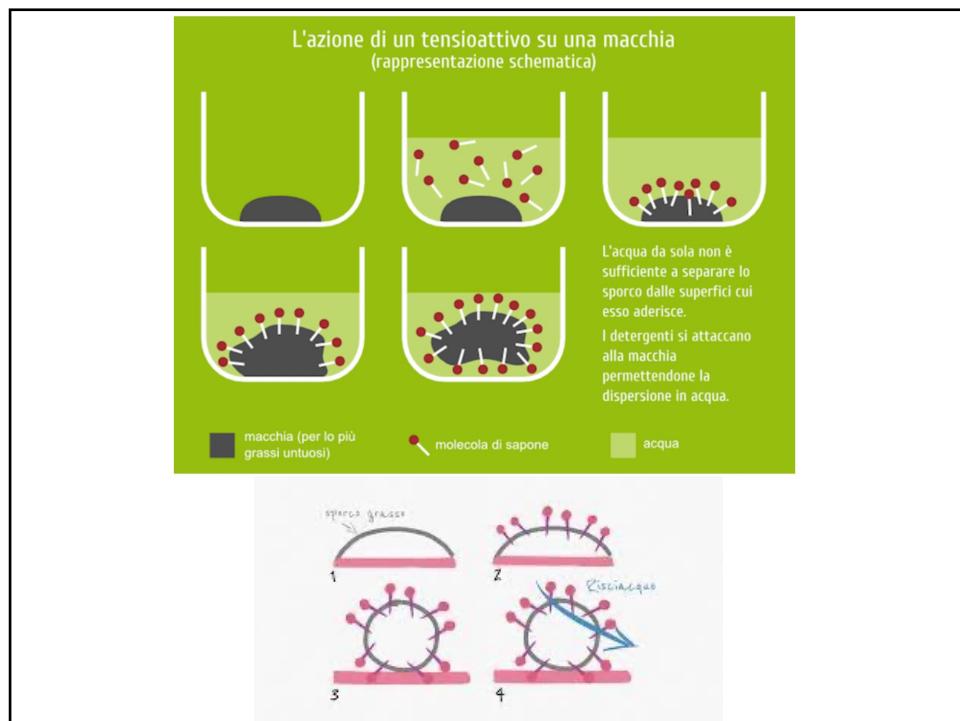


T.A. Brown, Conoscere la biochimica, Zanichelli editore 2018

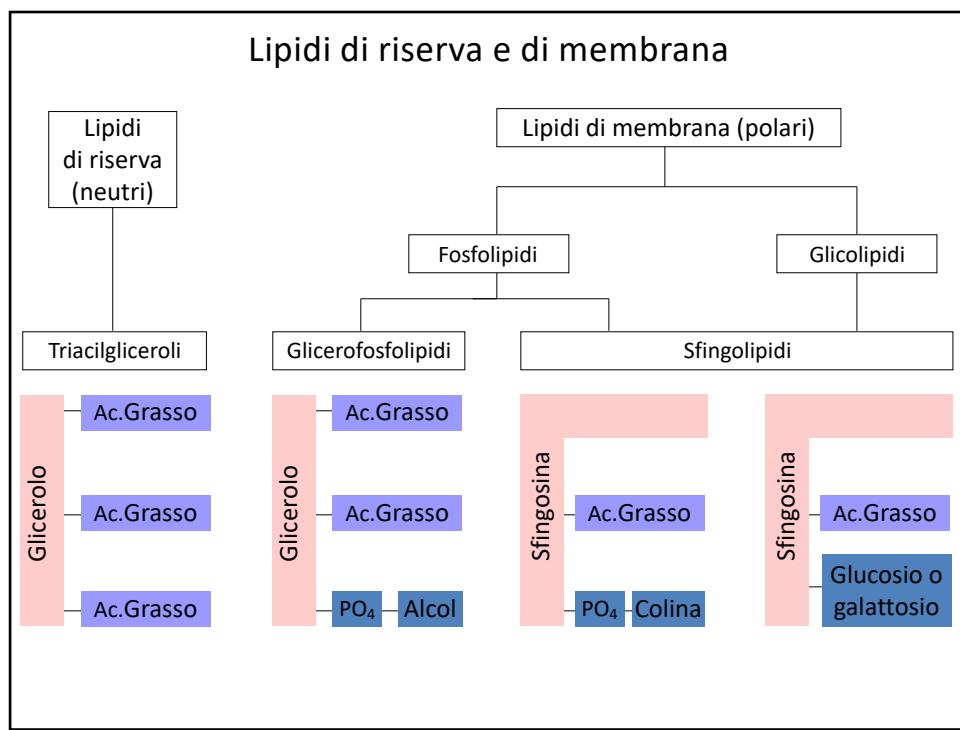
68

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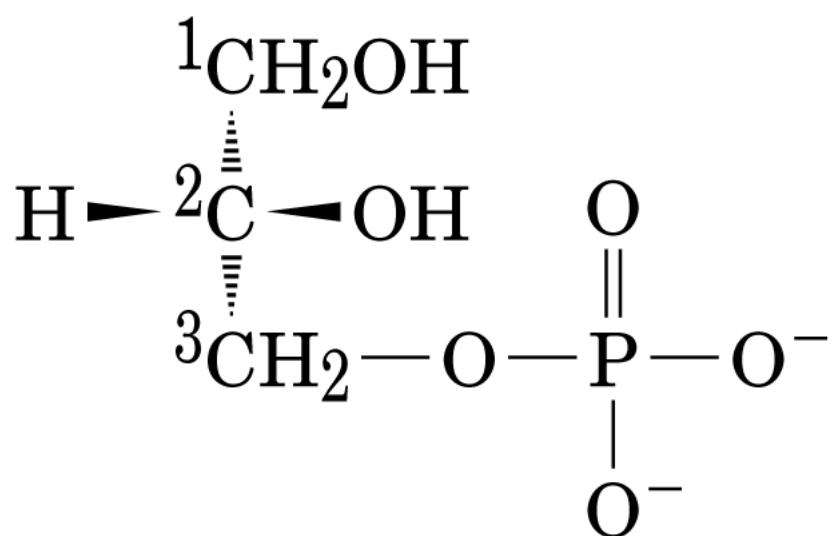


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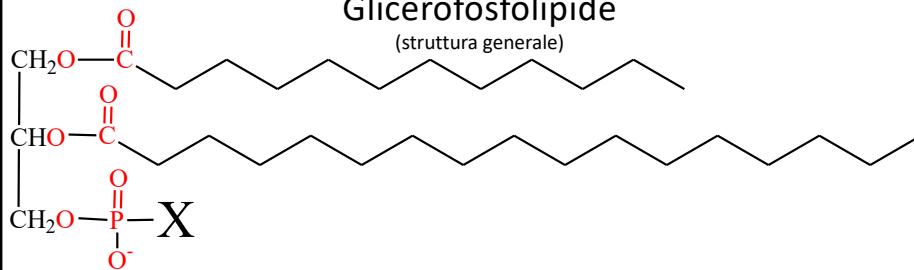
70

Glicerolo -3-fosfato

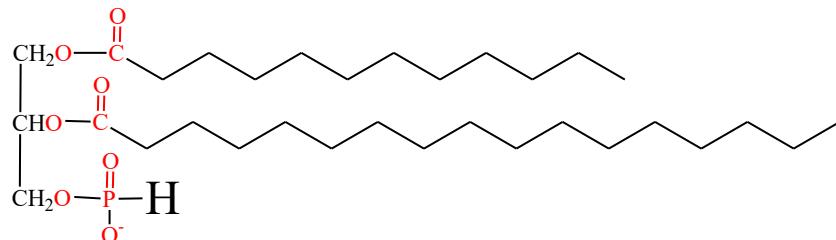


71

Glicerofosfolipide (struttura generale)



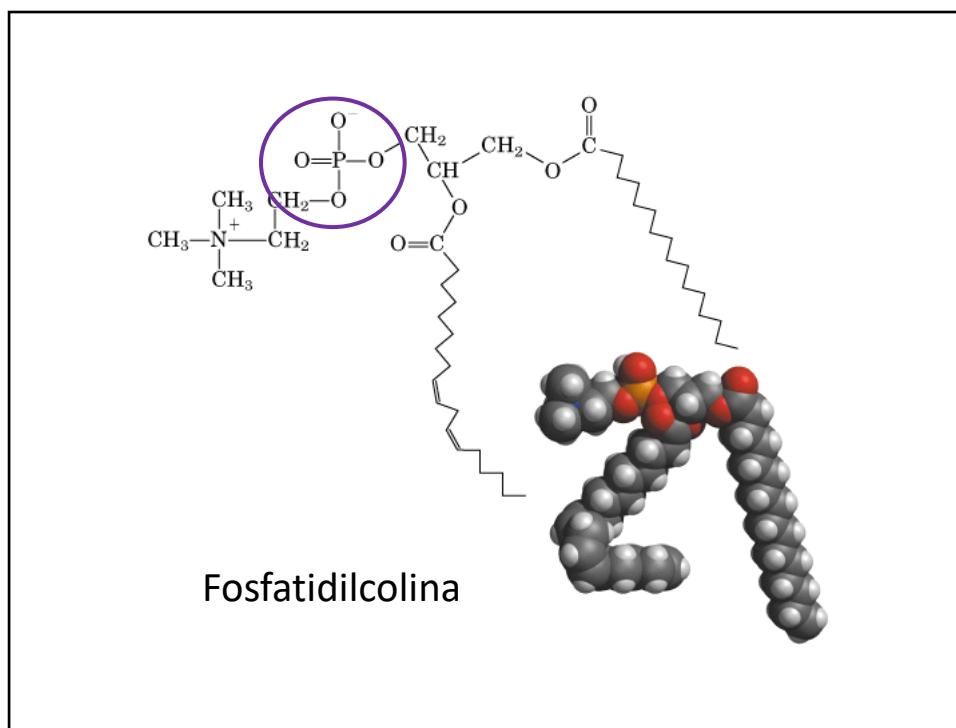
Acido fosfatidico



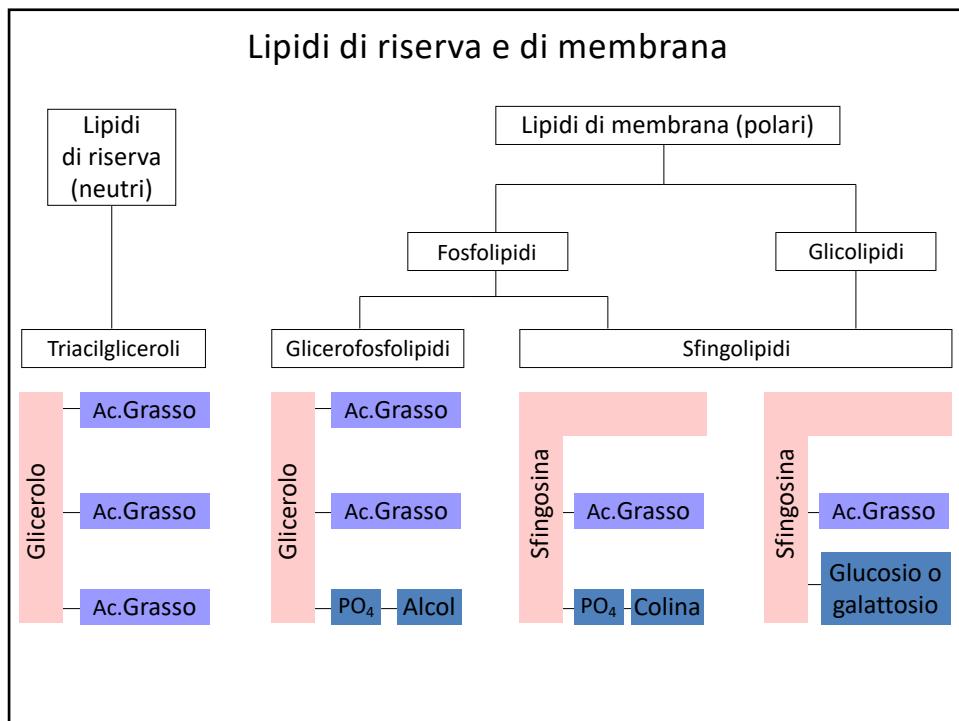
72

<u>Alcoli dei fosfolipidi</u>		
Nome di X	Formula di X	Nome del glicerofosfolipide
etanolammina	$\text{HO}-\text{CH}_2-\text{CH}_2-\overset{\oplus}{\text{NH}_3}$	fosfatidiletanolammina
colina	$\text{HO}-\text{CH}_2-\text{CH}_2-\overset{\oplus}{\text{N}(\text{CH}_3)_3}$	fosfatidilcolina
serina	$\text{HO}-\text{CH}_2-\underset{\text{COOH}}{\text{CH}}-\overset{\oplus}{\text{NH}_3}$	fosfatidilserina
glicerolo	$\text{HO}-\text{CH}_2-\underset{\text{OH}}{\text{CH}}-\text{CH}_2-\text{OH}$	fosfatidiglicerolo
inositolo		fosfatidilinositolo

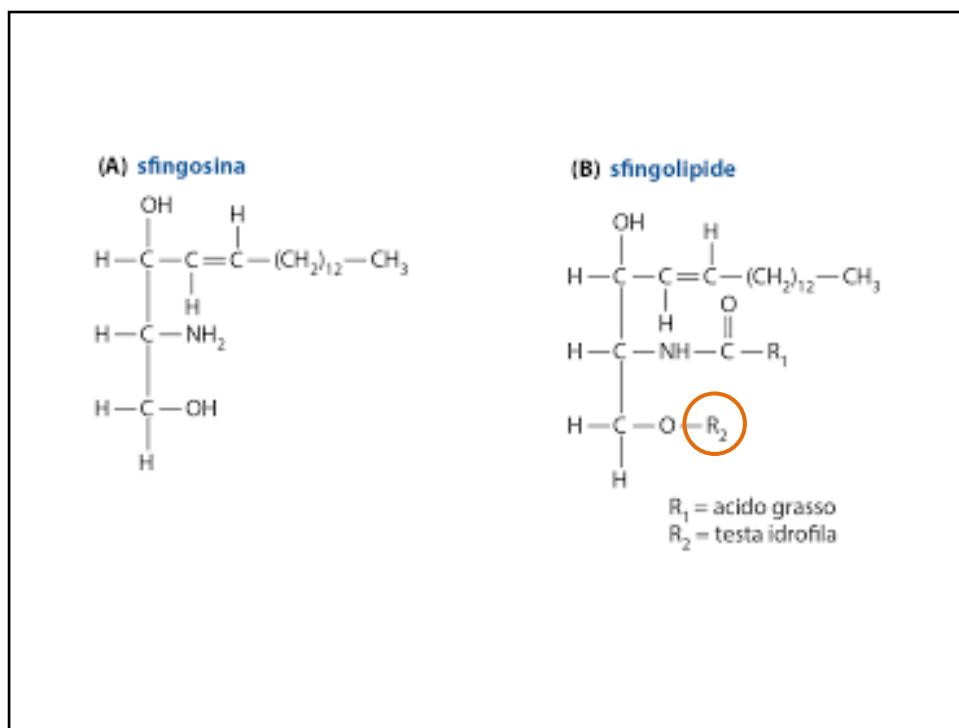
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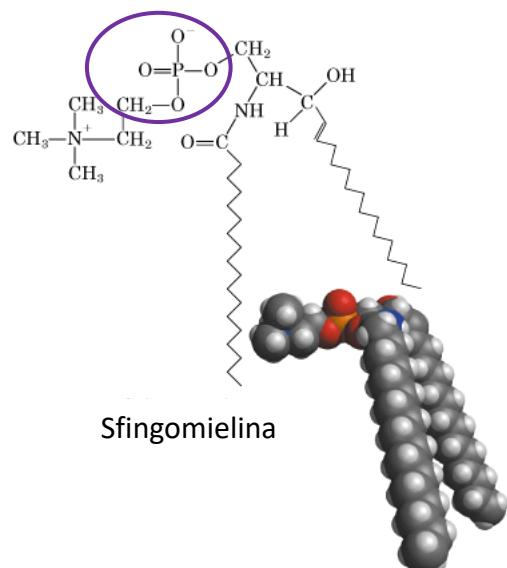
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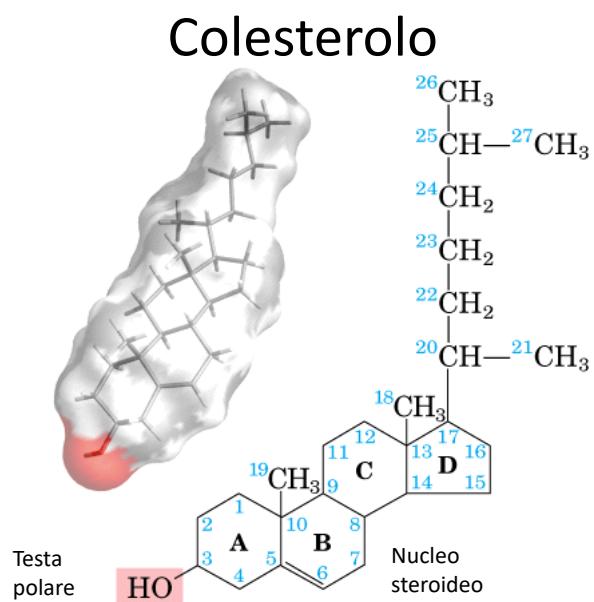
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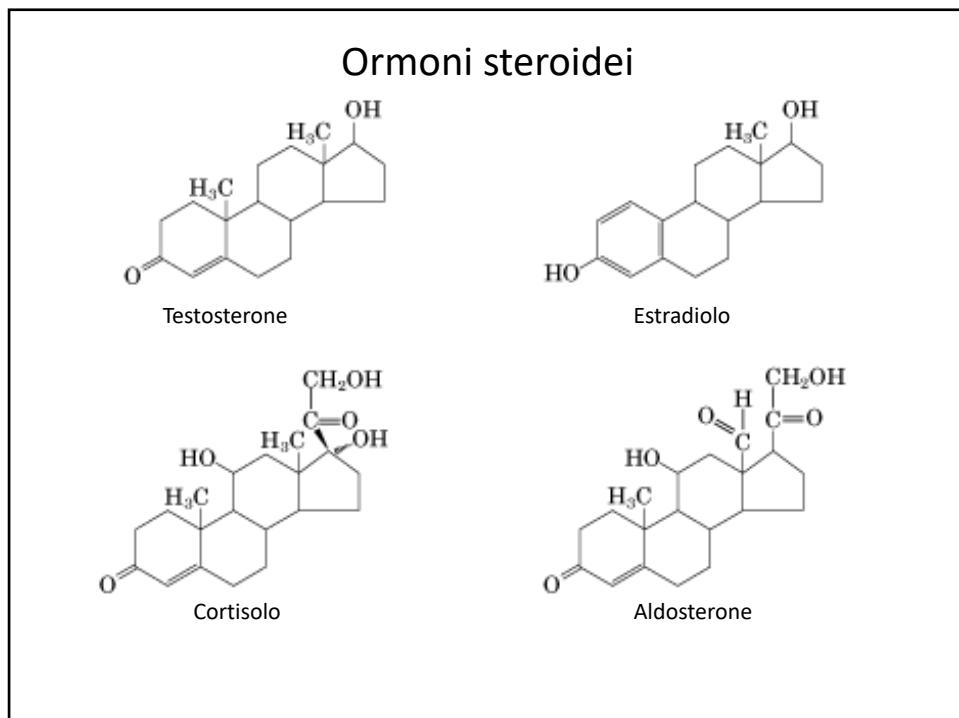
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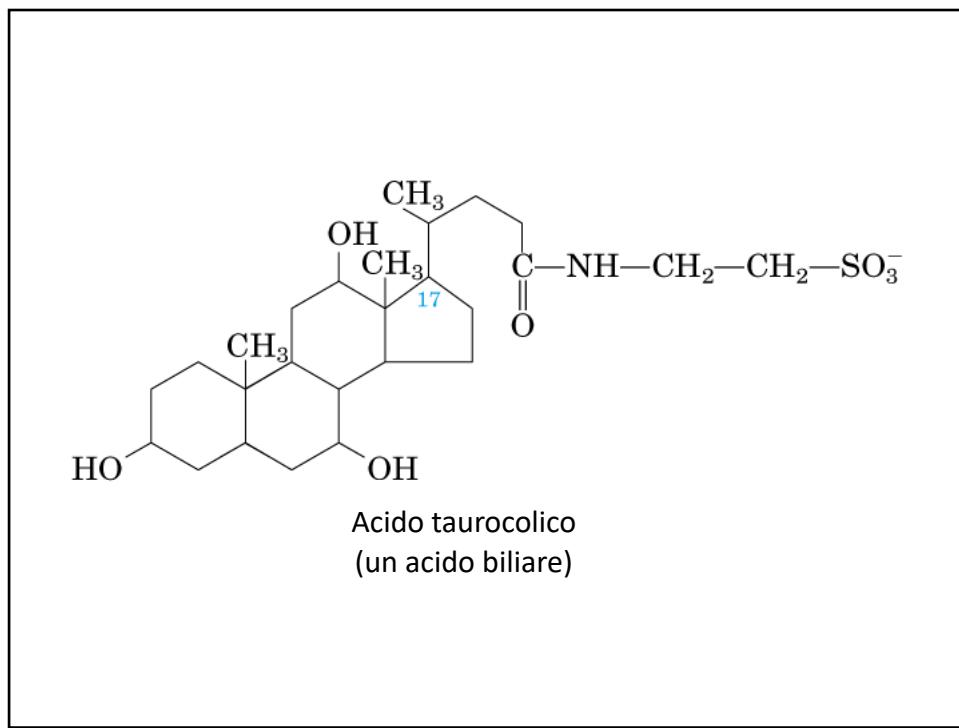
77



78



79



80

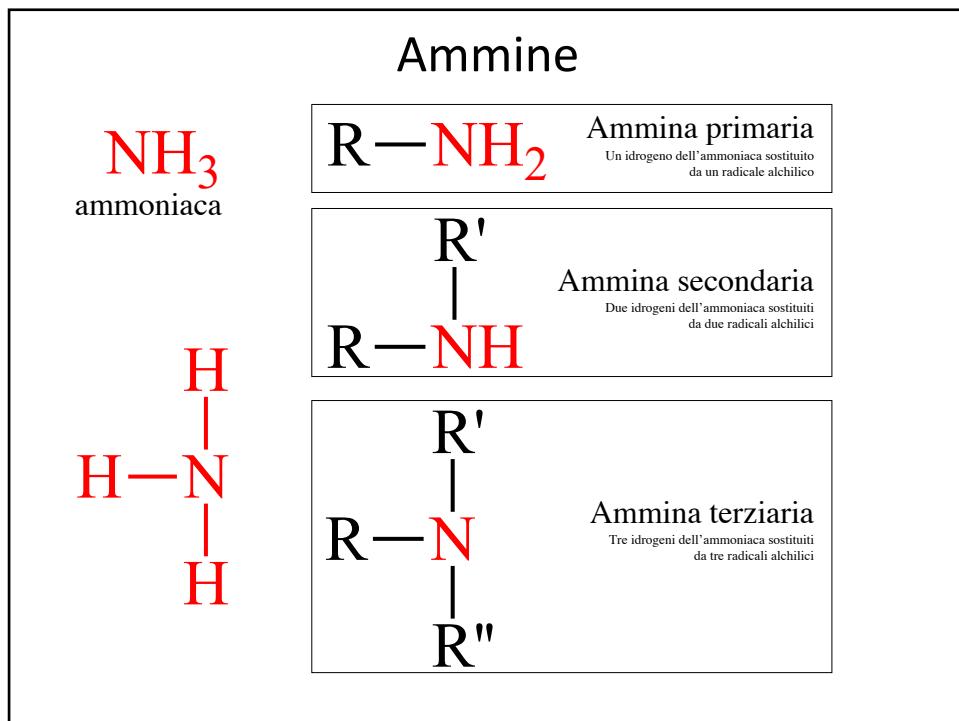
Eicosanoidi

- Prostaglandine
- Trombossani
- Leucotrieni

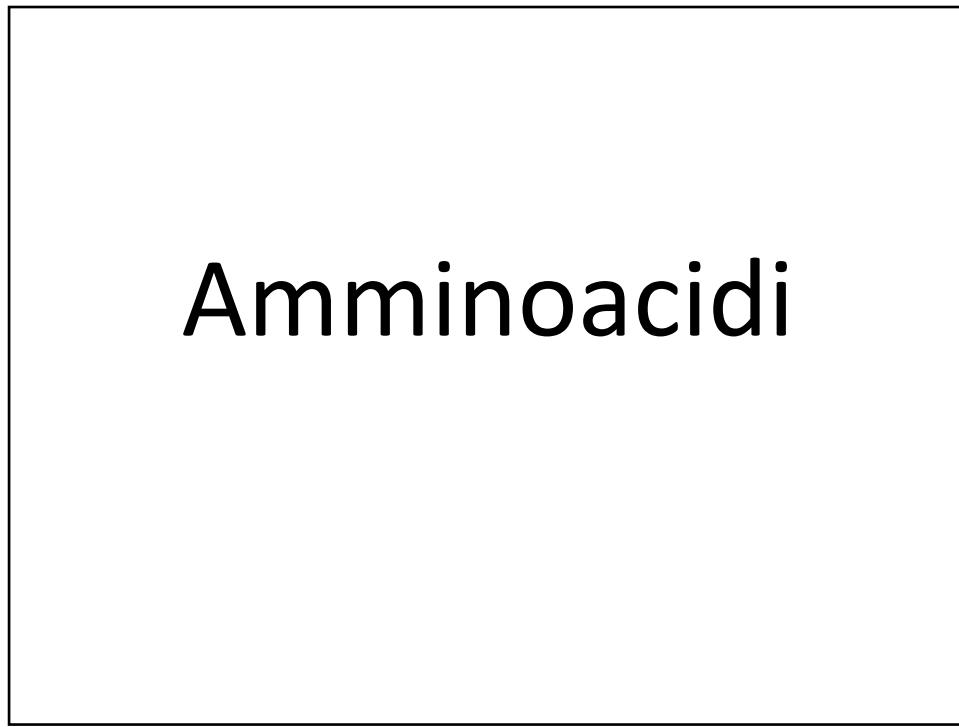
81

I Protidi

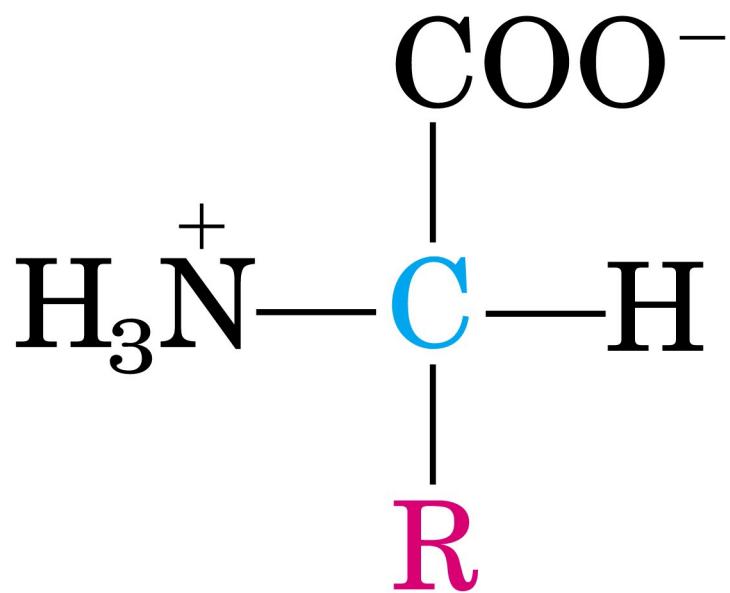
82



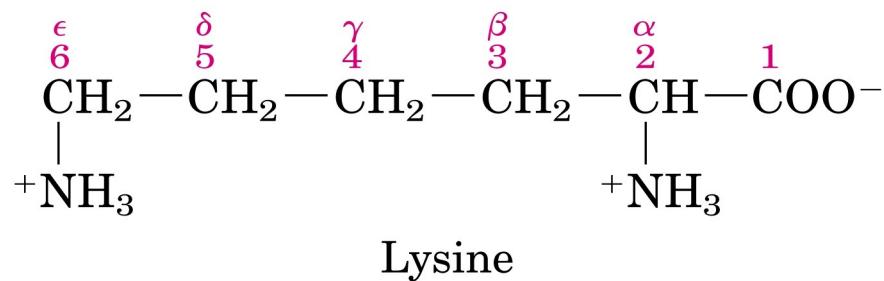
83



84

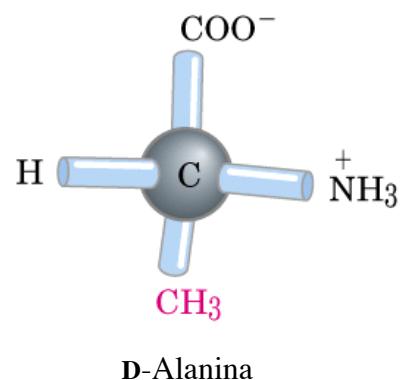
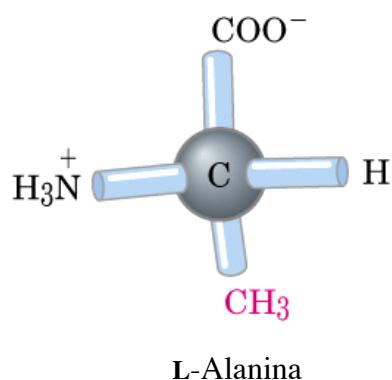


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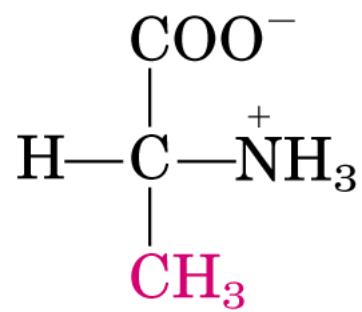
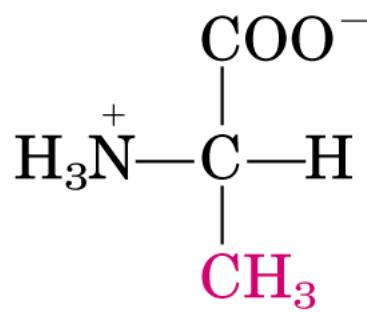
86

Carbonio alfa

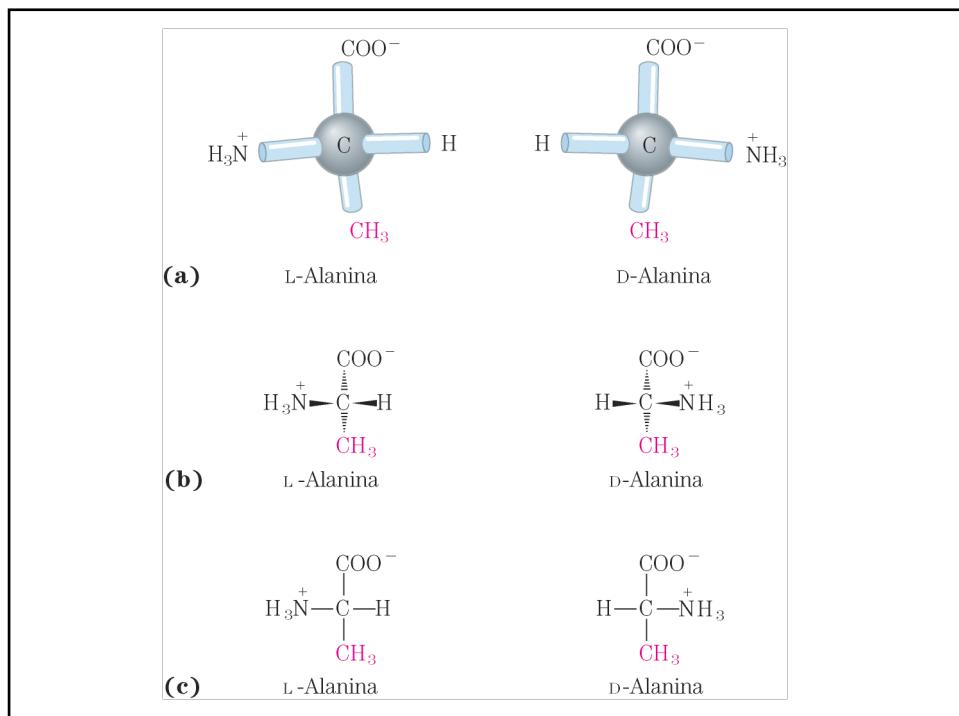


87

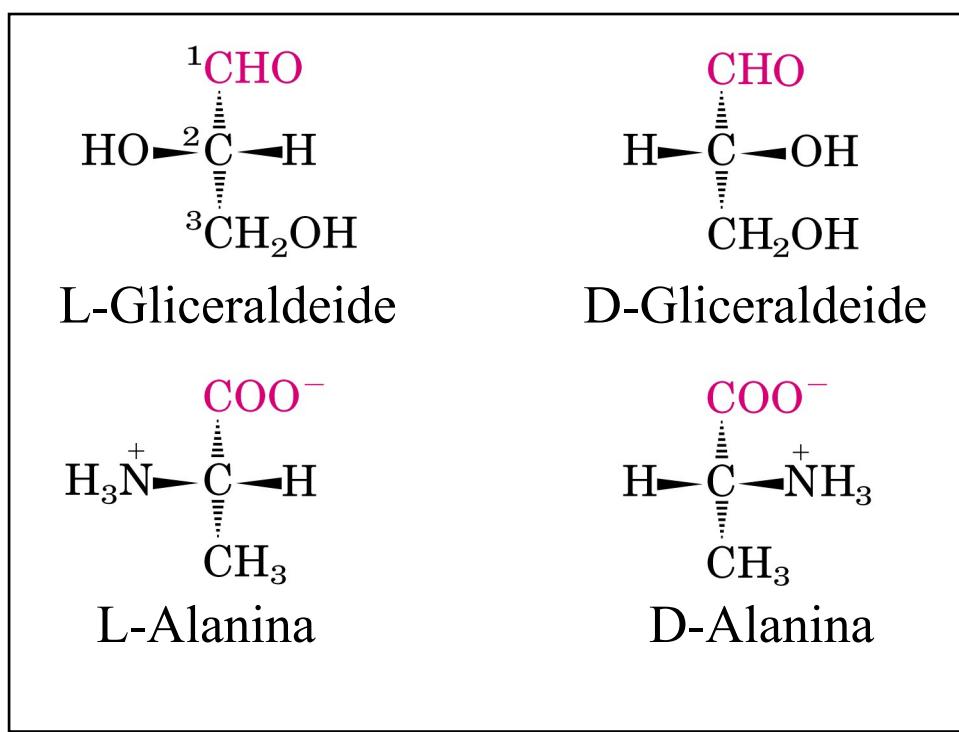
Stereoisomeri dell'alanina



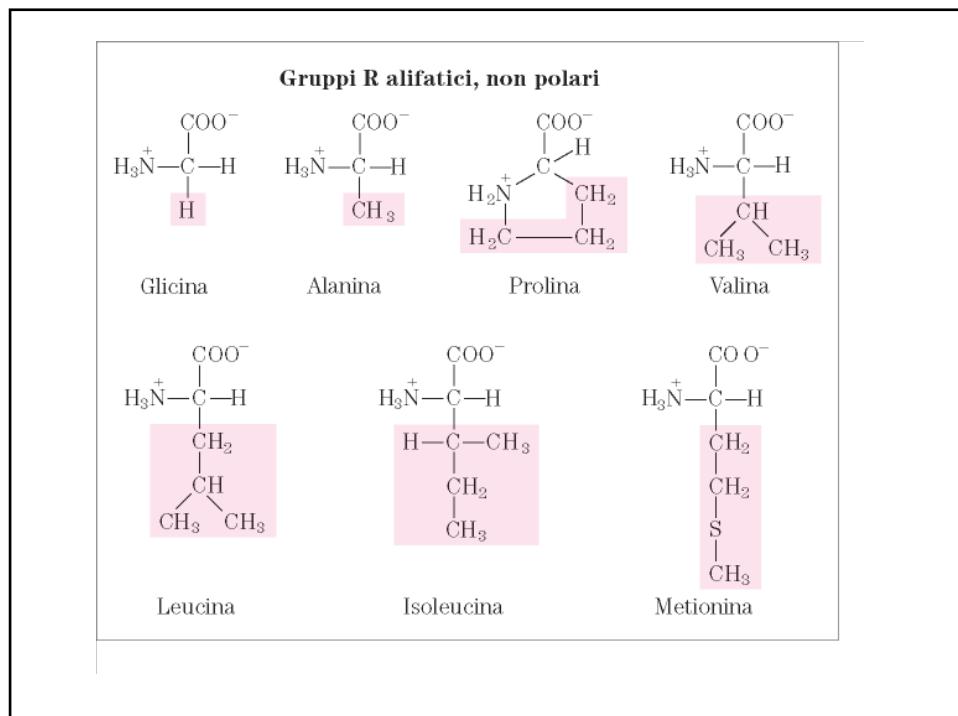
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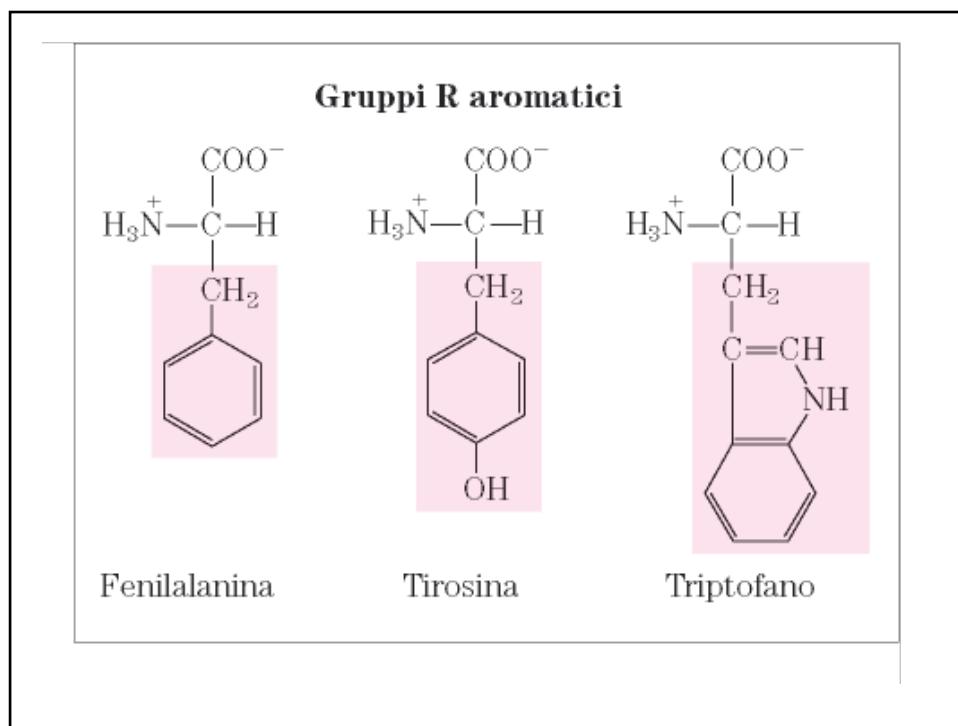
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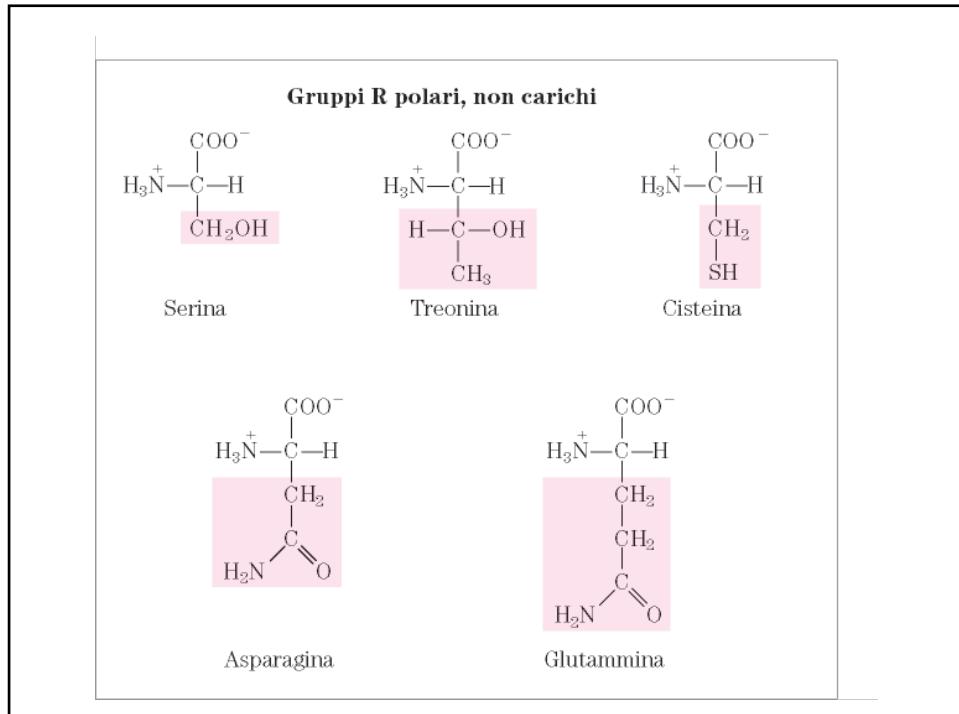
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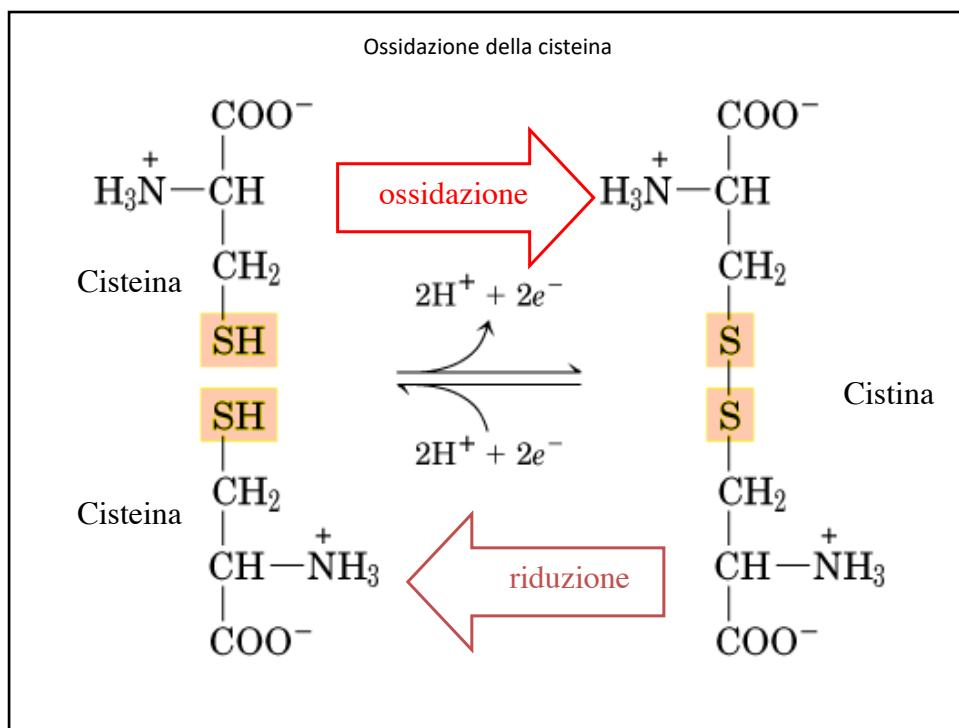
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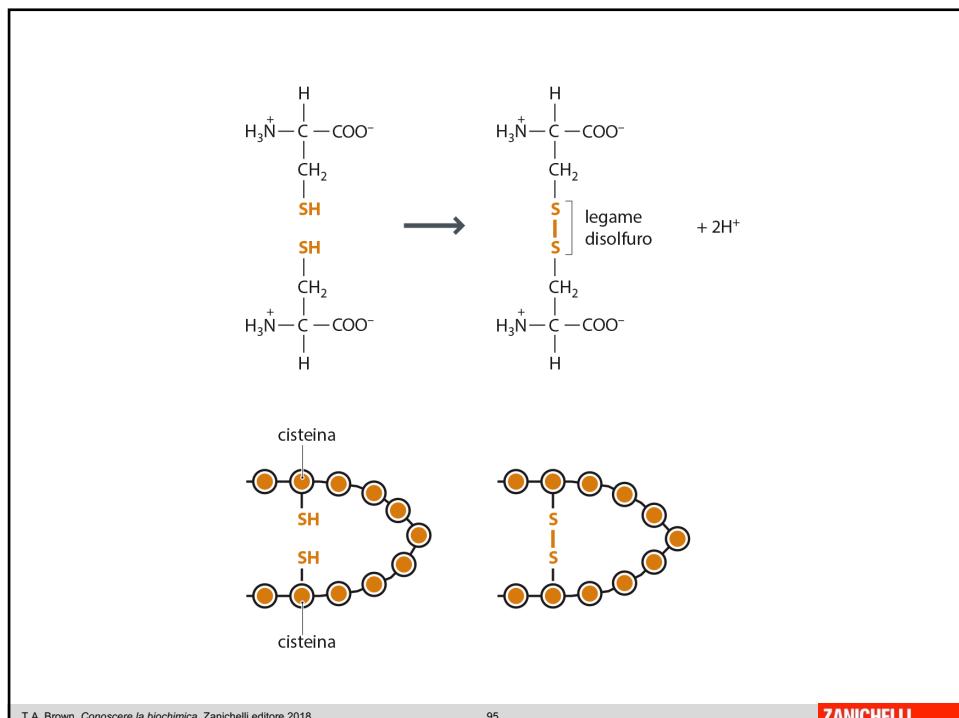
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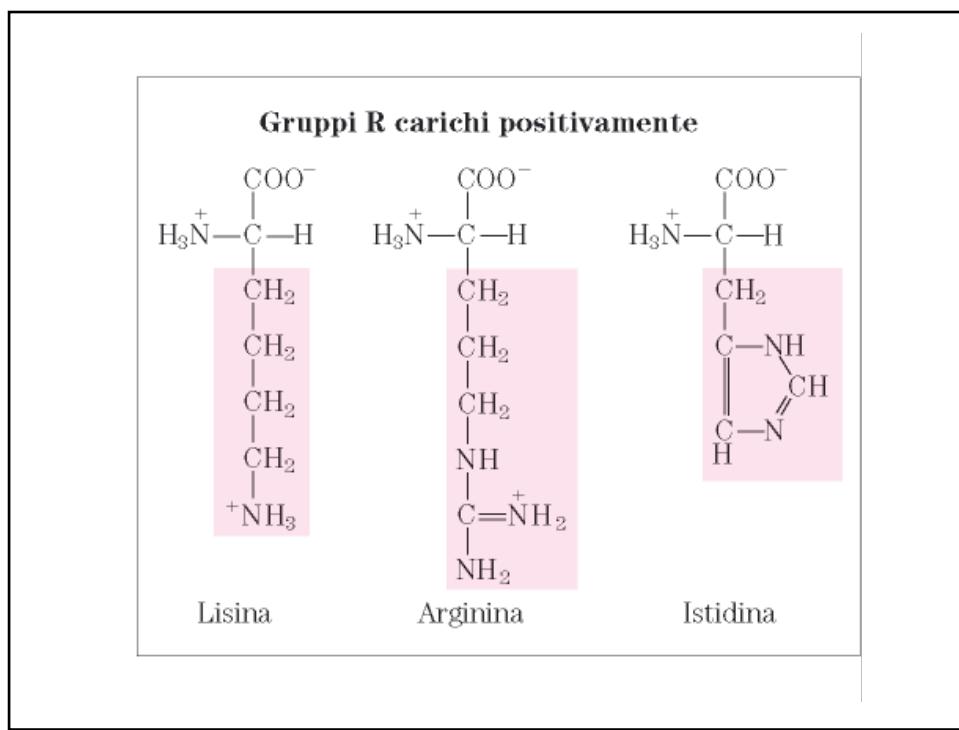
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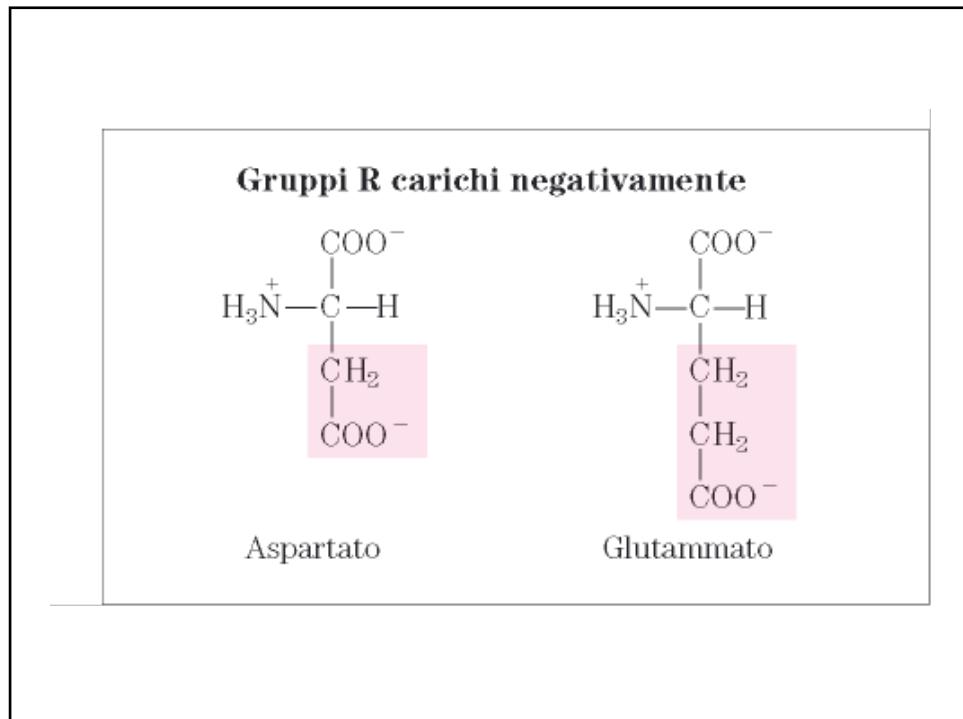
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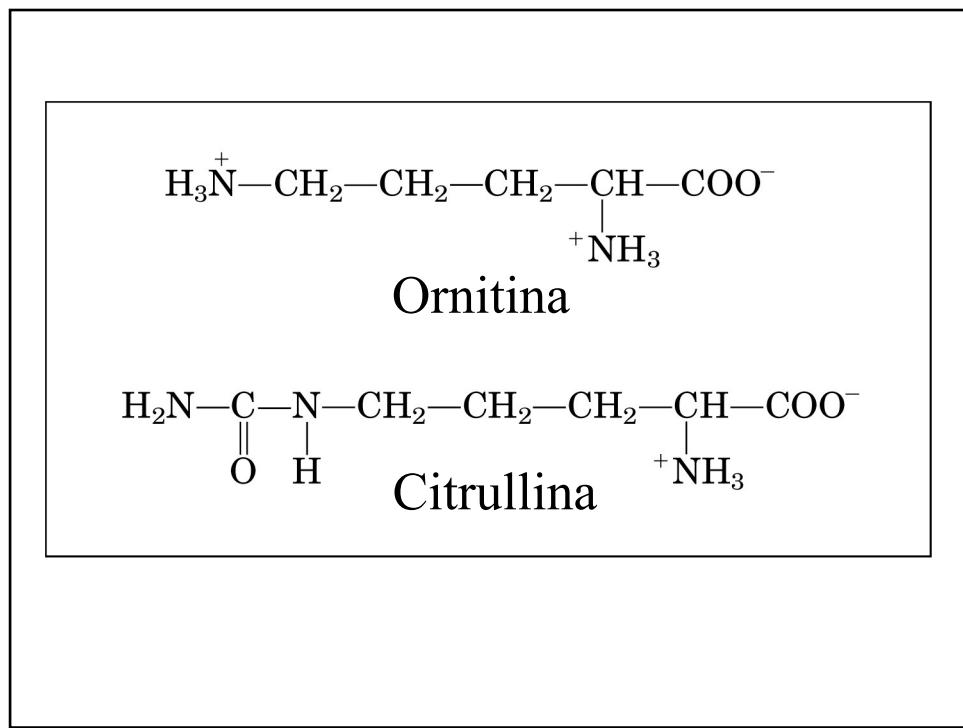
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96

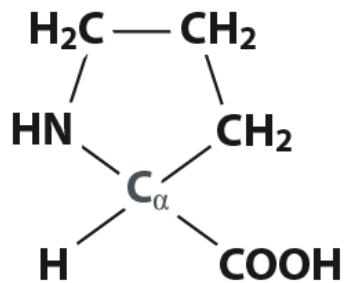


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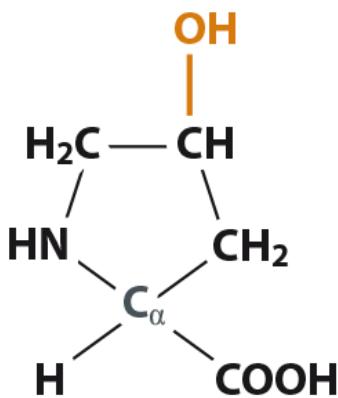


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Modifiche posttraduzionali



prolina



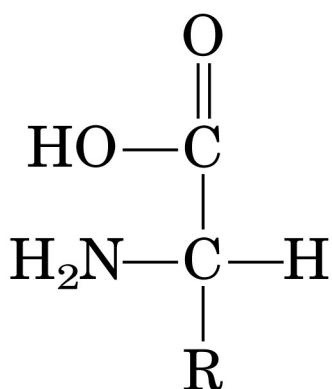
4-idrossiprolina

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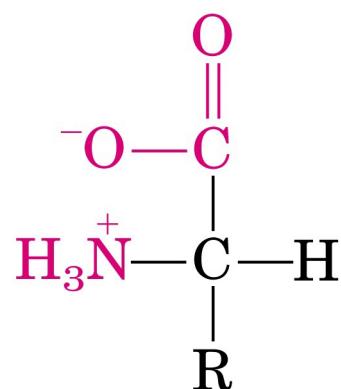
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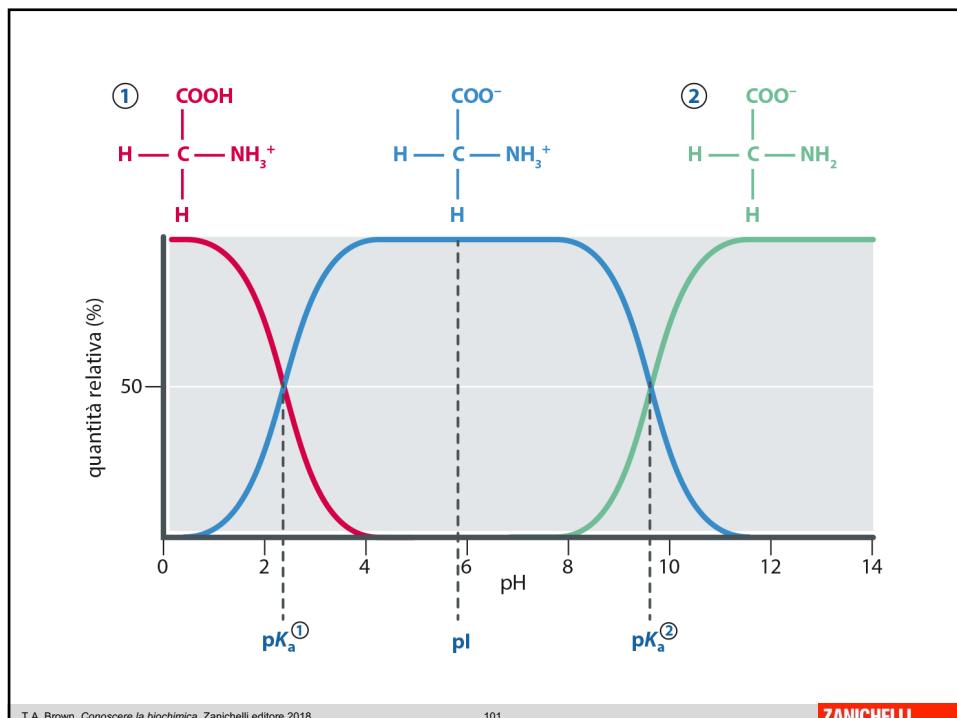


Nonionic form

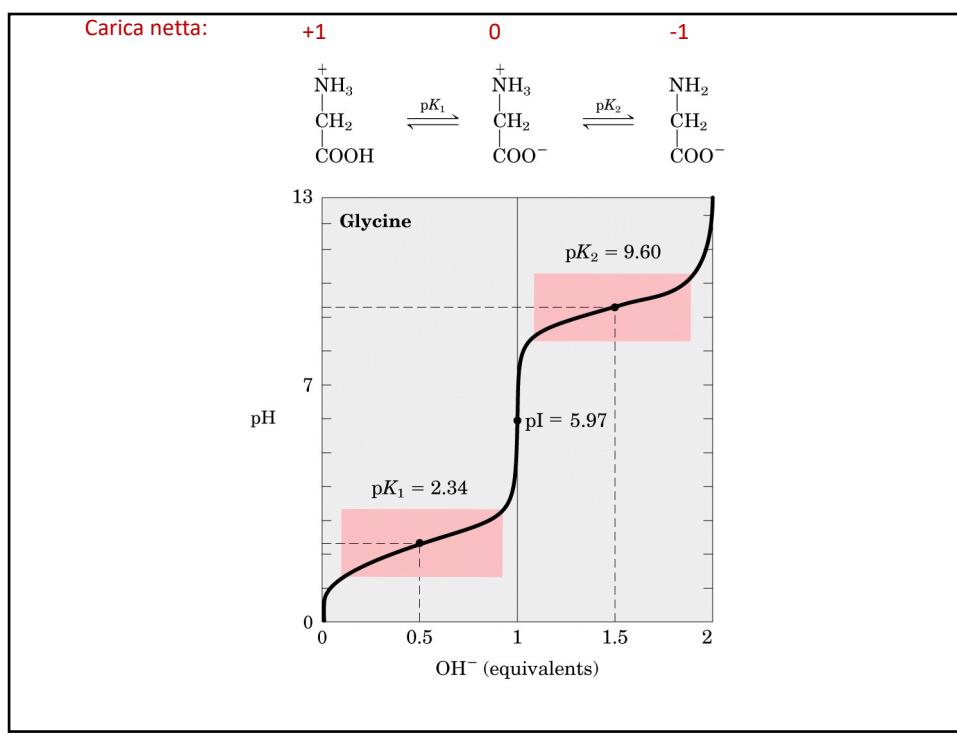


Zwitterionic form

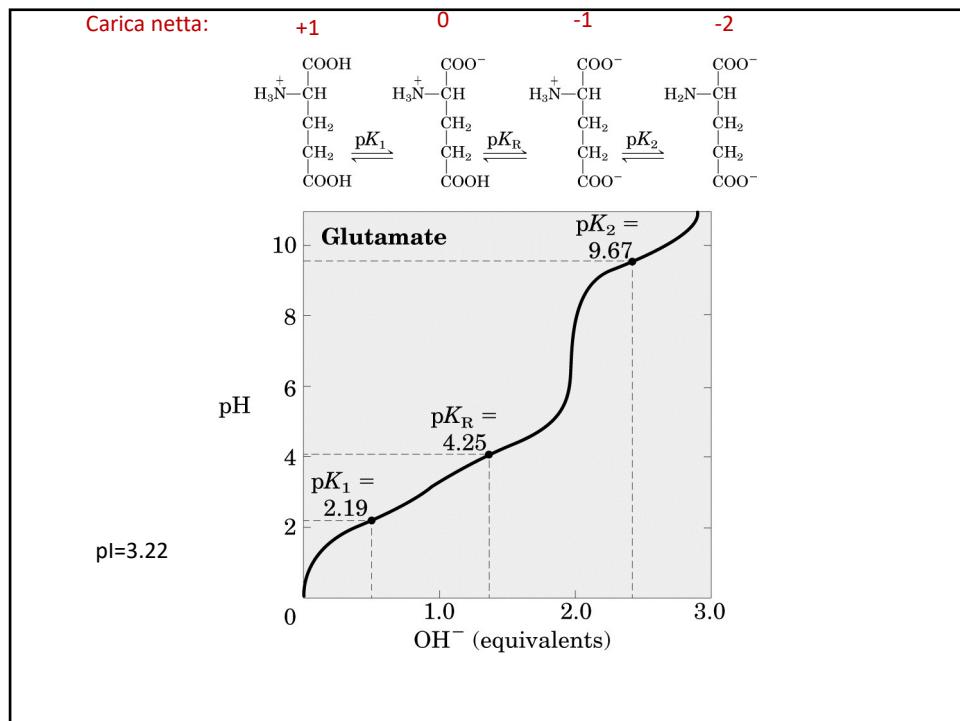
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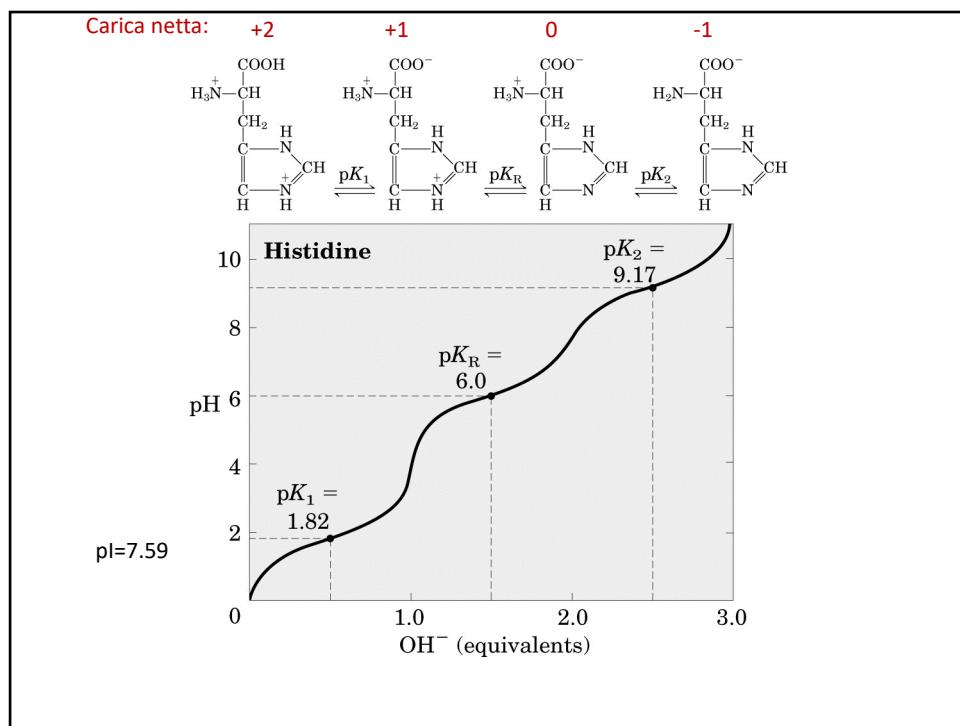
101



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table 5–1

Properties and Conventions Associated with the Standard Amino Acids

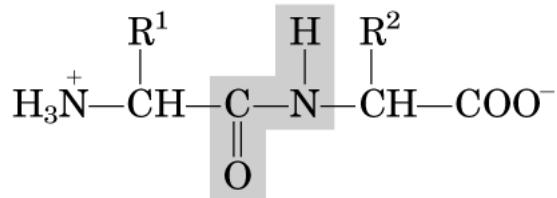
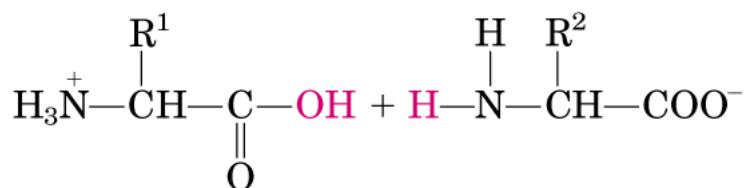
Amino acid	Abbreviated names	M_r	pK_a values			pl	Hydropathy index*	Occurrence in proteins (%)
			pK_1 ($-COOH$)	pK_2 ($-NH_3^+$)	pK_3 (R group)			
Nonpolar, aliphatic R groups								
Glycine	Gly G	75	2.34	9.60	5.97	−0.4	7.2	
Alanine	Ala A	89	2.34	9.69	6.01	1.8	7.8	
Valine	Val V	117	2.32	9.62	5.97	4.2	6.6	
Leucine	Leu L	131	2.36	9.60	5.98	3.8	9.1	
Isoleucine	Ile I	131	2.36	9.68	6.02	4.5	5.3	
Methionine	Met M	149	2.28	9.21	5.74	1.9	2.3	
Aromatic R groups								
Phenylalanine	Phe F	165	1.83	9.13	5.48	2.8	3.9	
Tyrosine	Tyr Y	181	2.20	9.11	10.07	5.66	−1.3	3.2
Tryptophan	Trp W	204	2.38	9.39	5.89	−0.9	1.4	
Polar, uncharged R groups								
Serine	Ser S	105	2.21	9.15	5.68	−0.8	6.8	
Proline	Pro P	115	1.99	10.96	6.48	1.6	5.2	
Threonine	Thr T	119	2.11	9.62	5.87	−0.7	5.9	
Cysteine	Cys C	121	1.96	10.28	8.18	5.07	2.5	1.9
Asparagine	Asn N	132	2.02	8.80	5.41	−3.5	4.3	
Glutamine	Gln Q	146	2.17	9.13	5.65	−3.5	4.2	
Positively charged R groups								
Lysine	Lys K	146	2.18	8.95	10.53	9.74	−3.9	5.9
Histidine	His H	155	1.82	9.17	6.00	7.59	−3.2	2.3
Arginine	Arg R	174	2.17	9.04	12.48	10.76	−4.5	5.1
Negatively charged R groups								
Aspartate	Asp D	133	1.88	9.60	3.65	2.77	−3.5	5.3
Glutamate	Glu E	147	2.19	9.67	4.25	3.22	−3.5	6.3

*A scale combining hydrophobicity and hydrophilicity of R groups; it can be used to measure the tendency of an amino acid to seek an aqueous environment (− values) or a hydrophobic environment (+ values). See Chapter 12. From Kyte, J. & Doolittle, R.F. (1982) *J. Mol. Biol.* **157**, 105–132.

[†]Average occurrence in over 1150 proteins. From Doolittle, R.F. (1989) Redundancies in protein sequences. In *Prediction of Protein Structure and the Principles of Protein Conformation* (Fasman, G.D., ed) Plenum Press, NY, pp. 599–623.

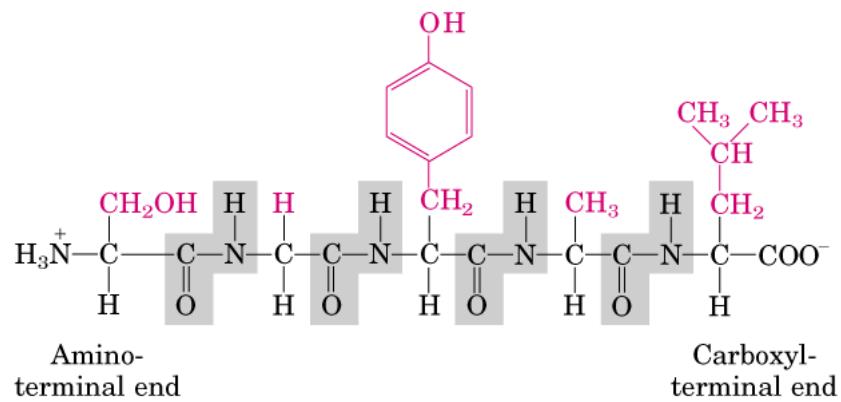
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Legame peptídico



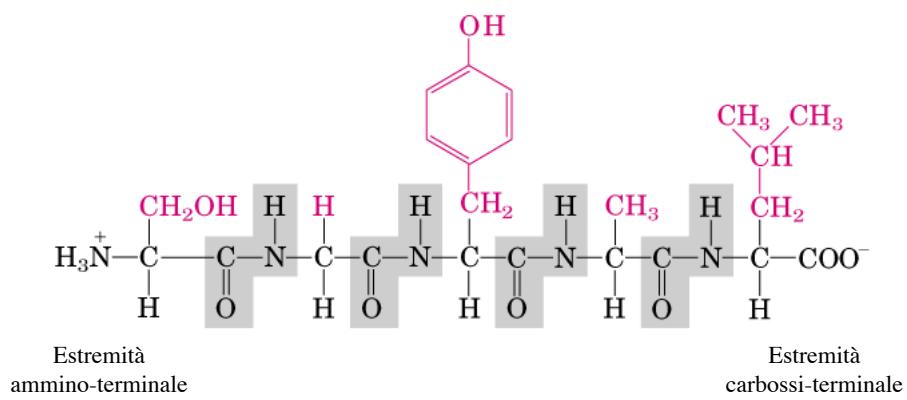
106

Legame peptidico

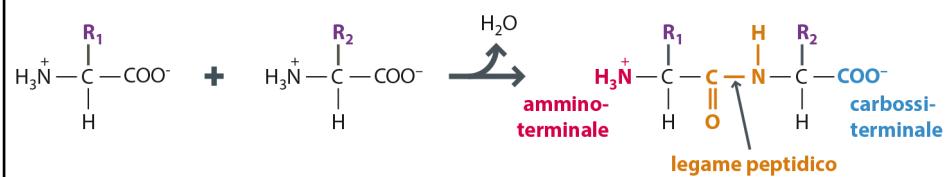


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Polipeptide



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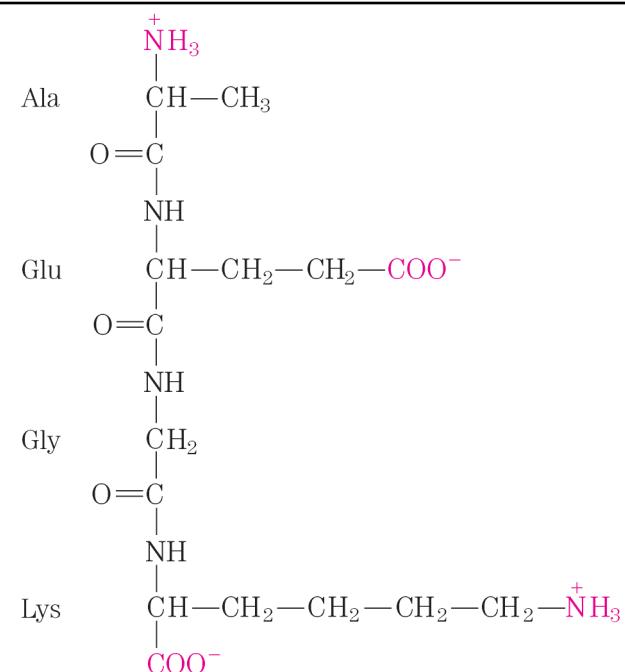


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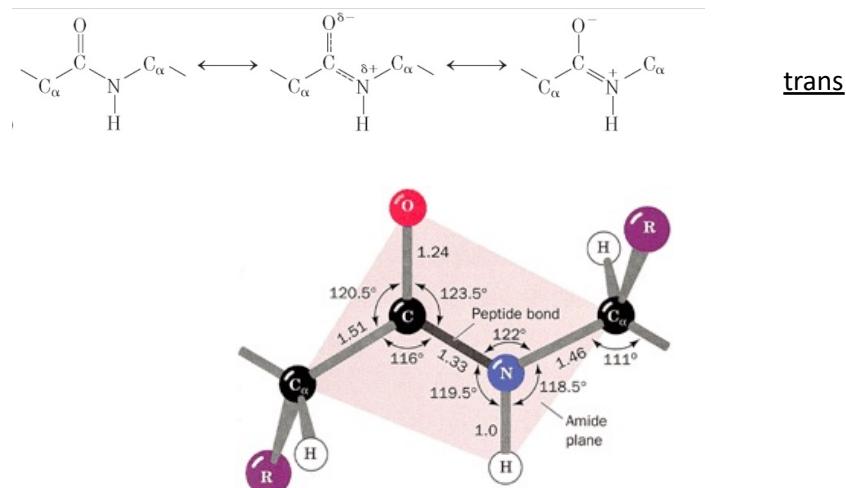
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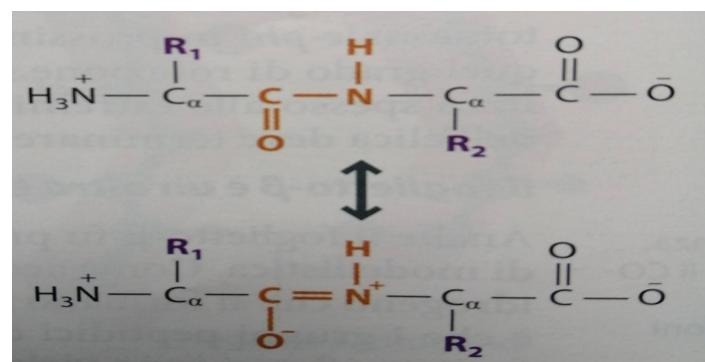


110

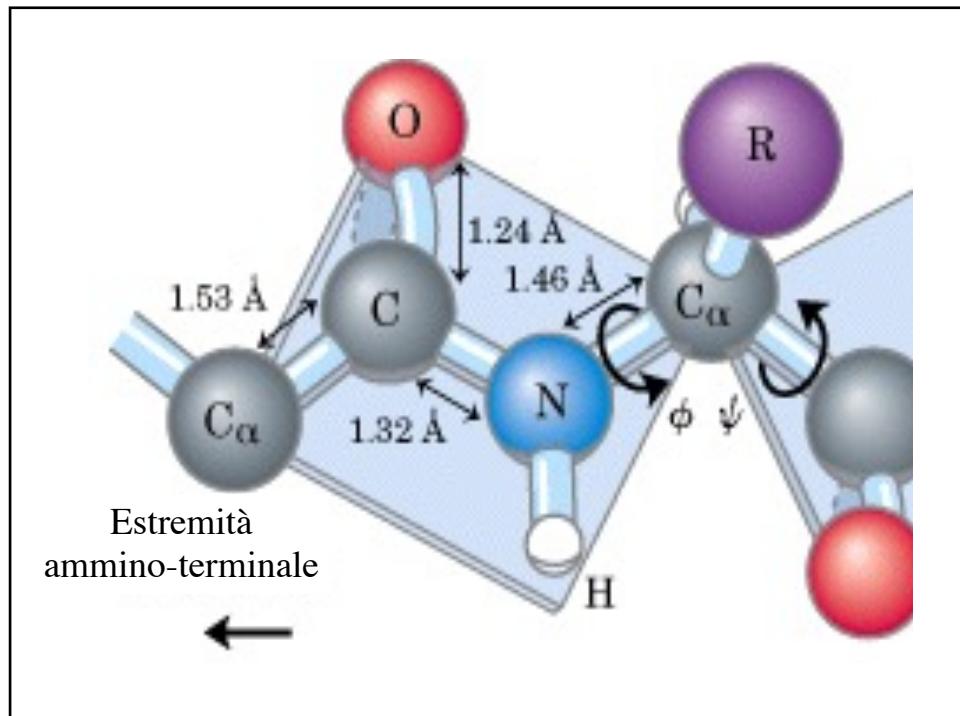
Struttura delle Proteine: Legame peptidico



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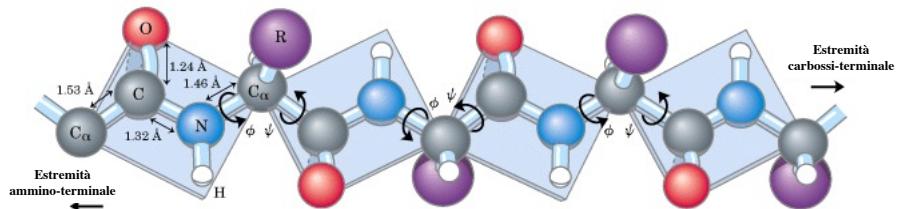


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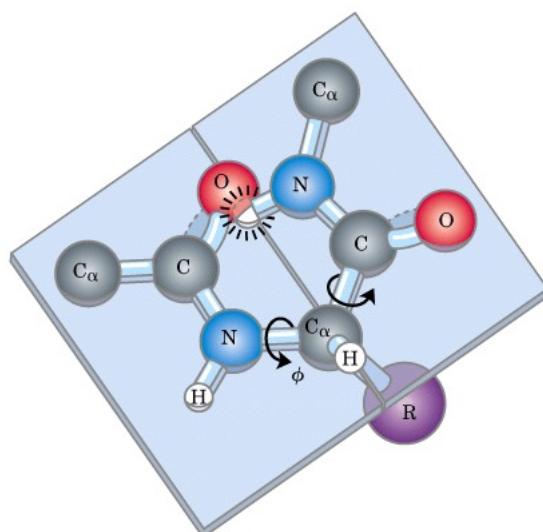
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Conformazione spaziale del legame peptidico



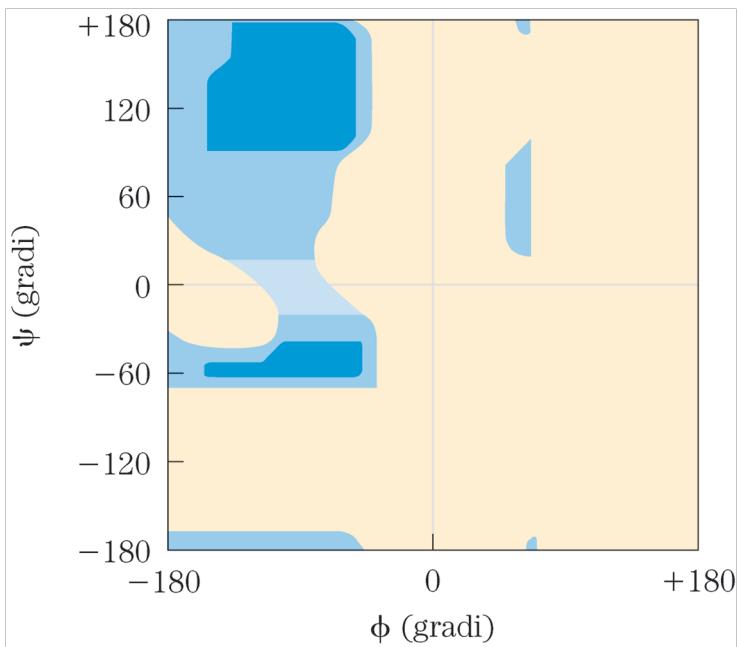
114

Conformazione stericamente proibita

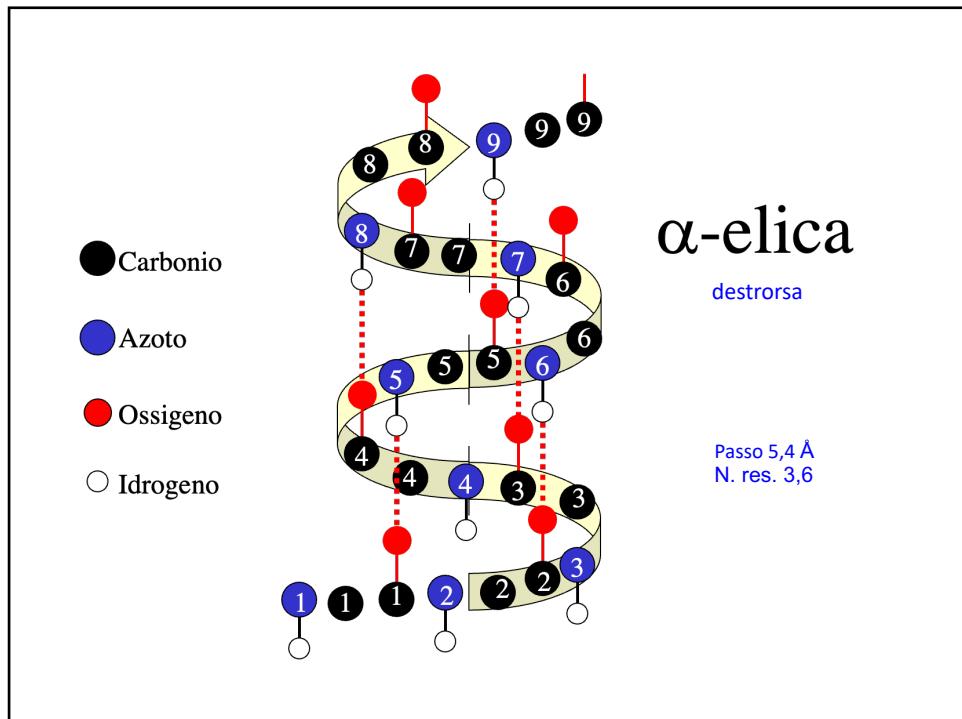


115

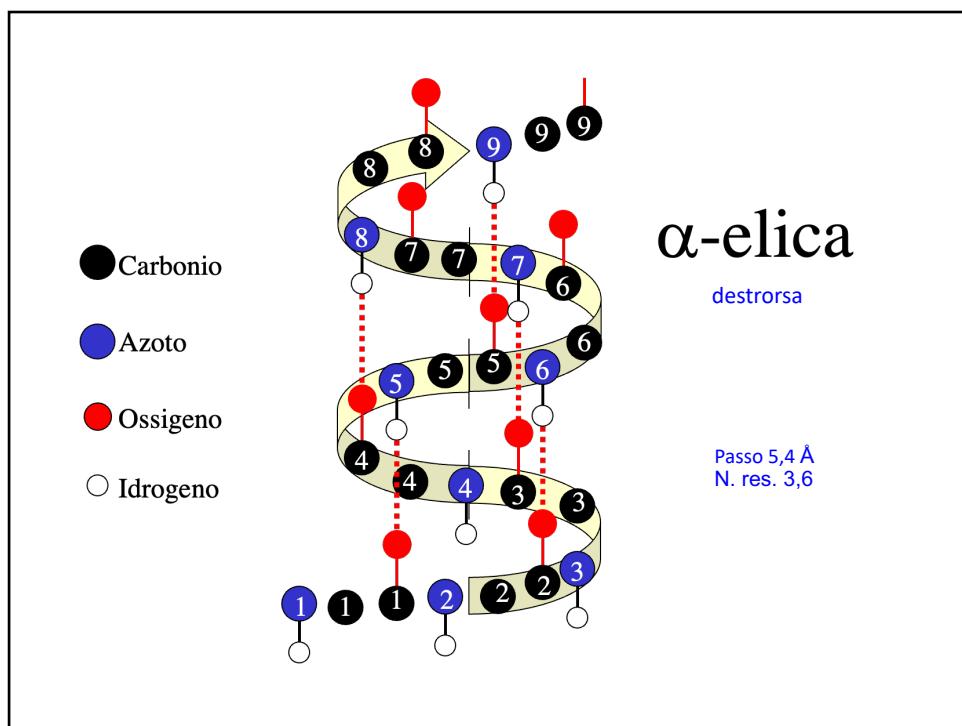
Grafico di Ramachandran



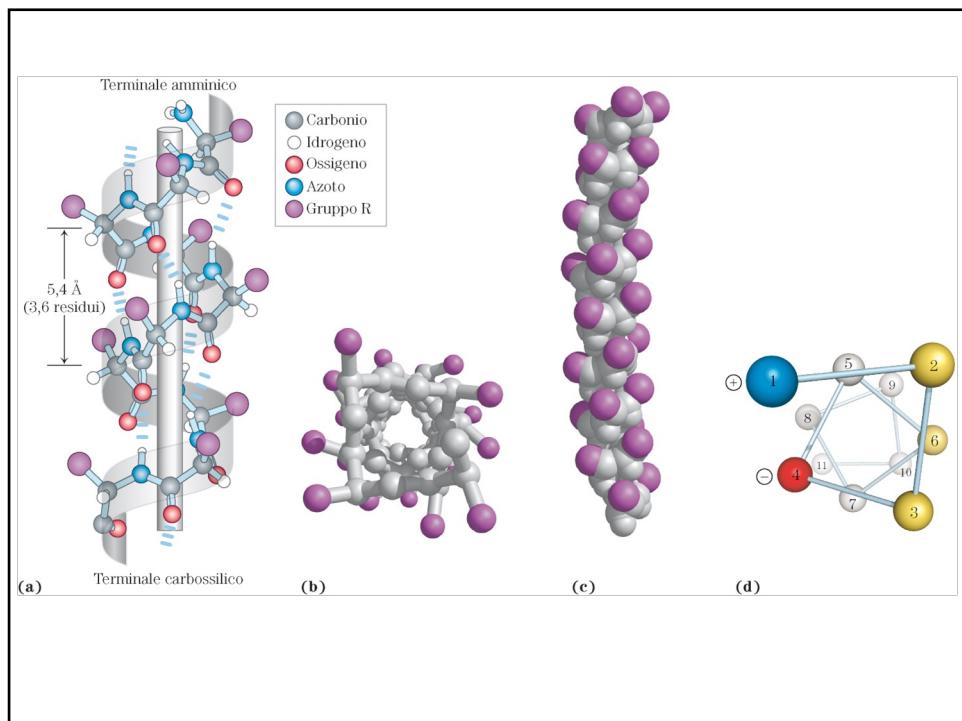
116



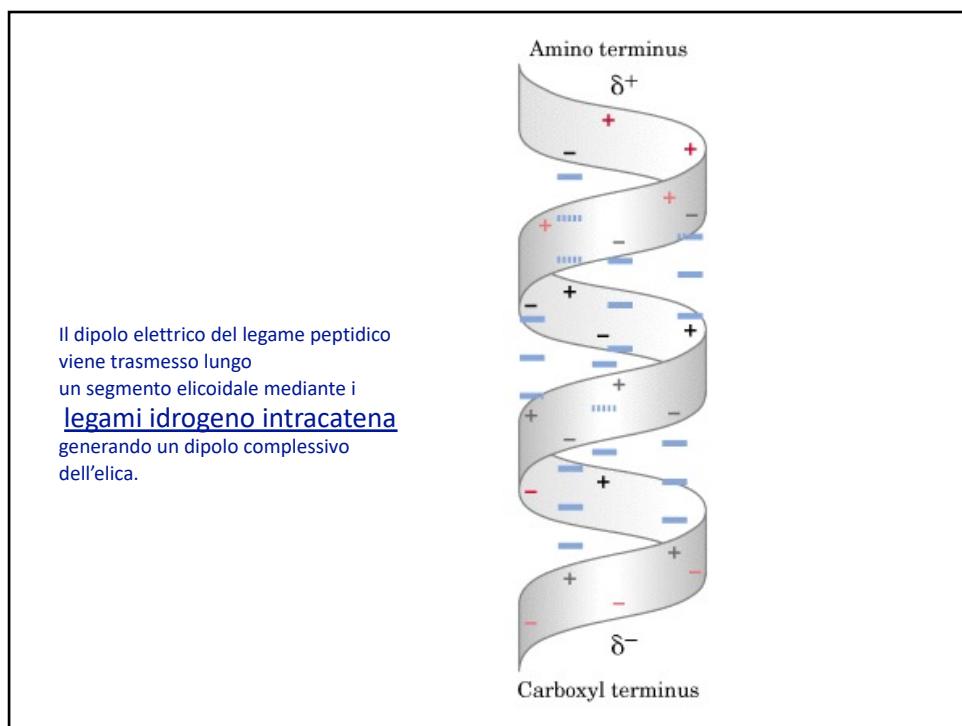
117



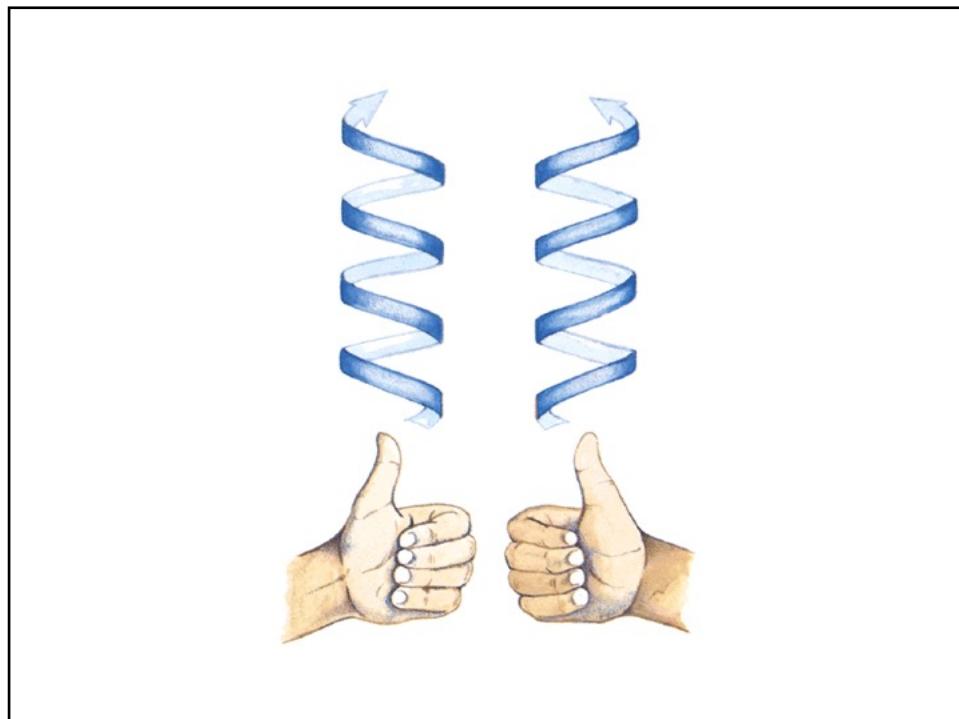
118



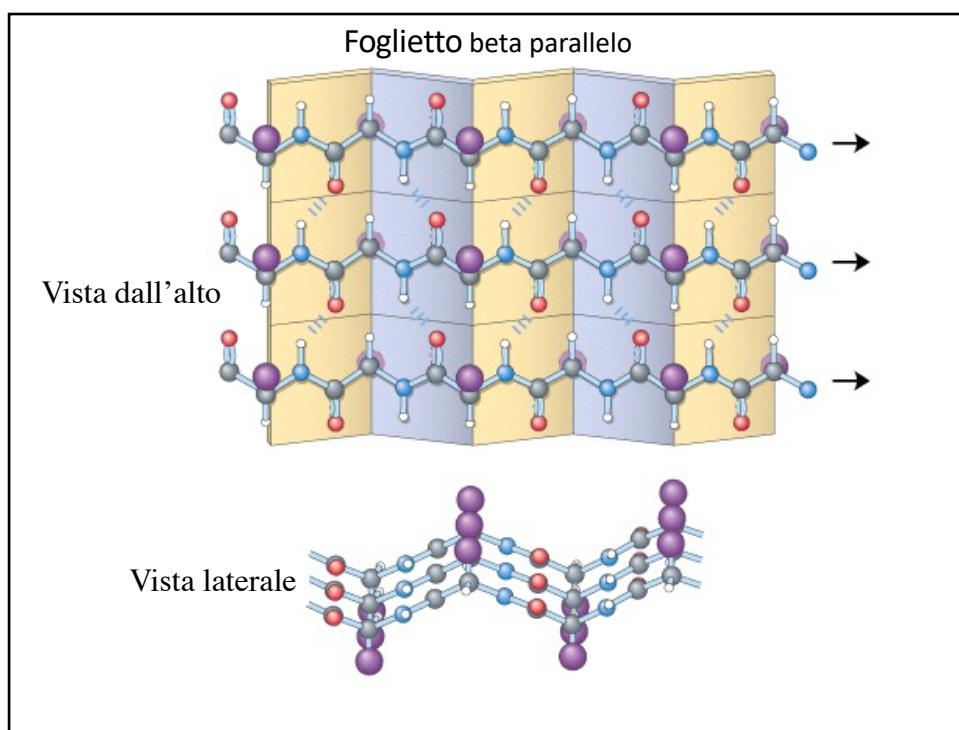
119



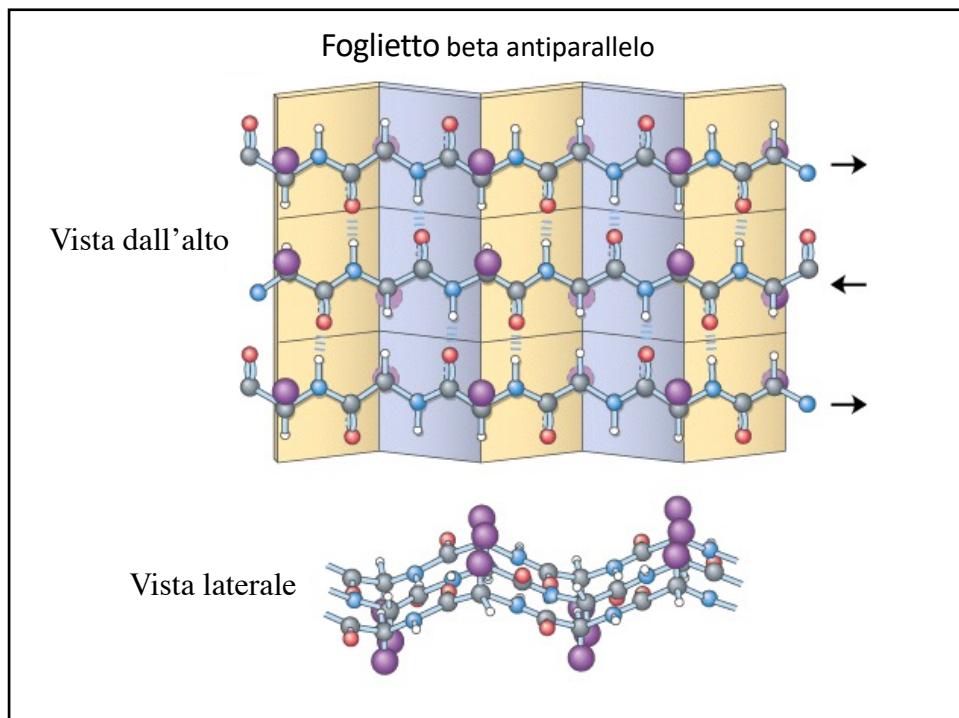
120



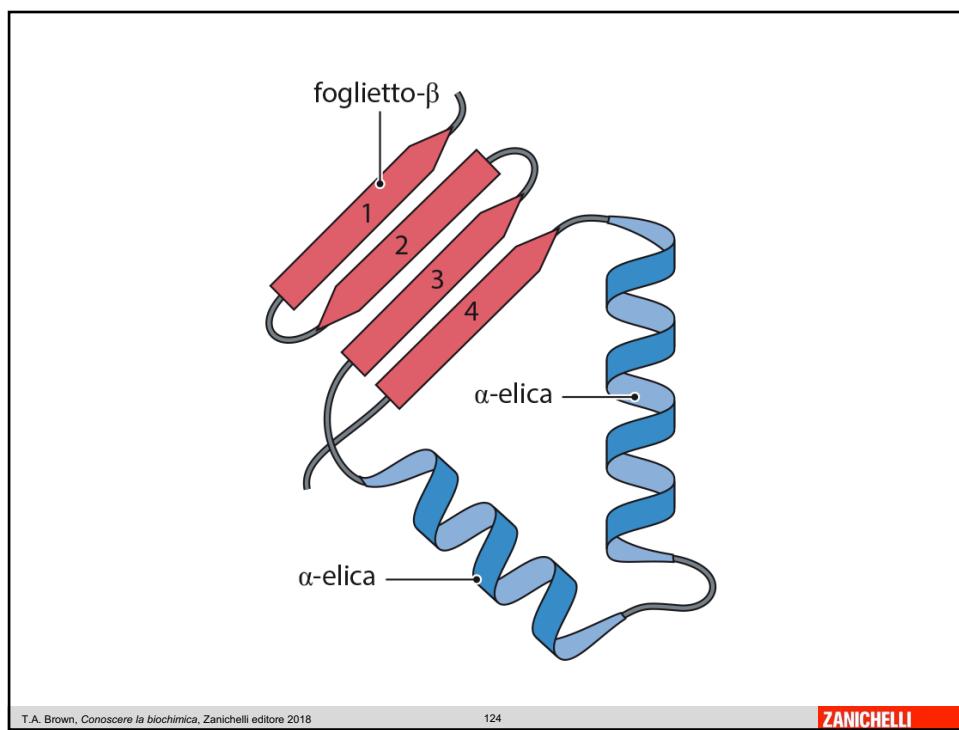
121



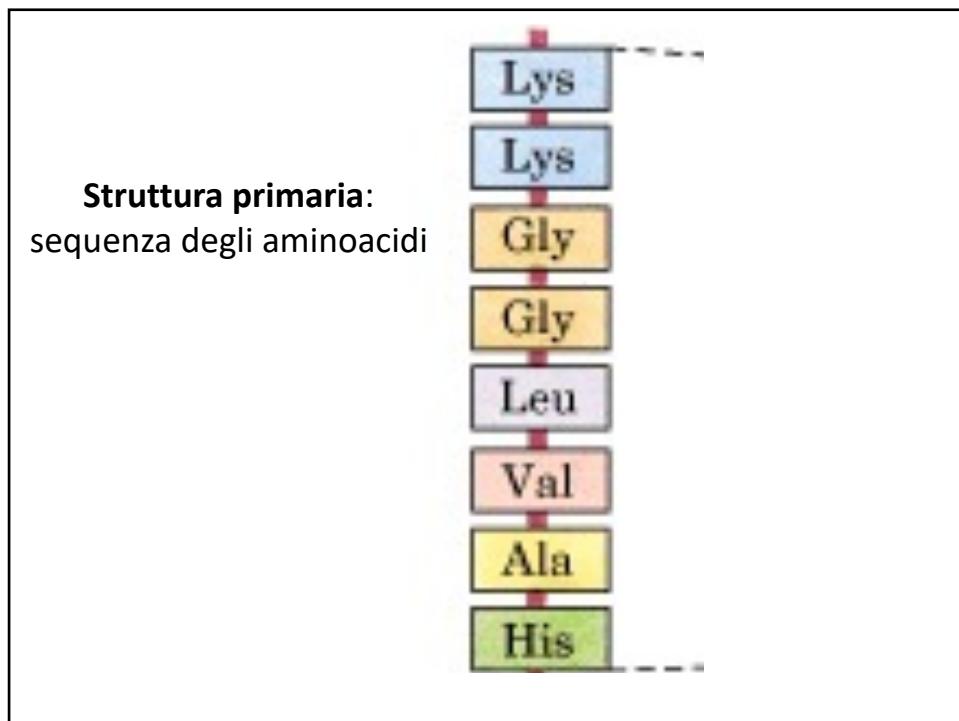
122



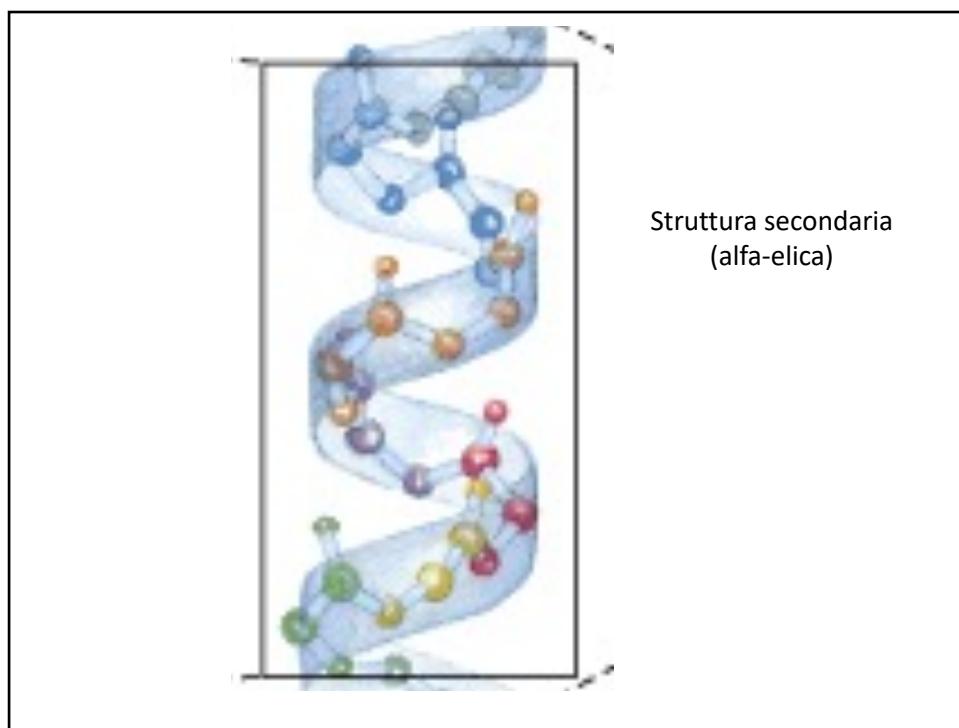
123



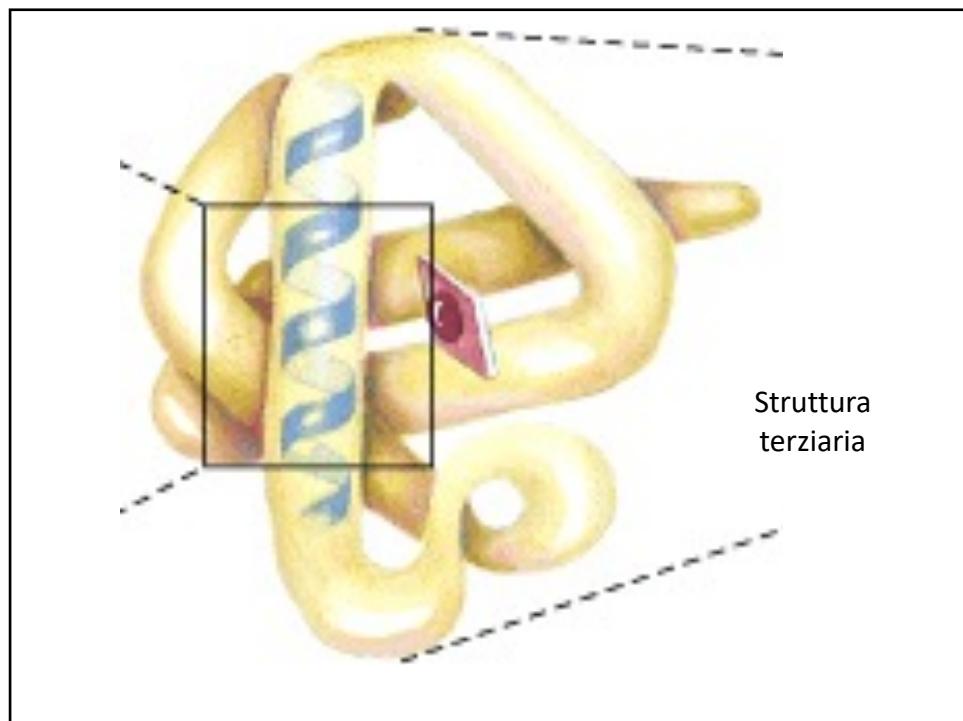
124



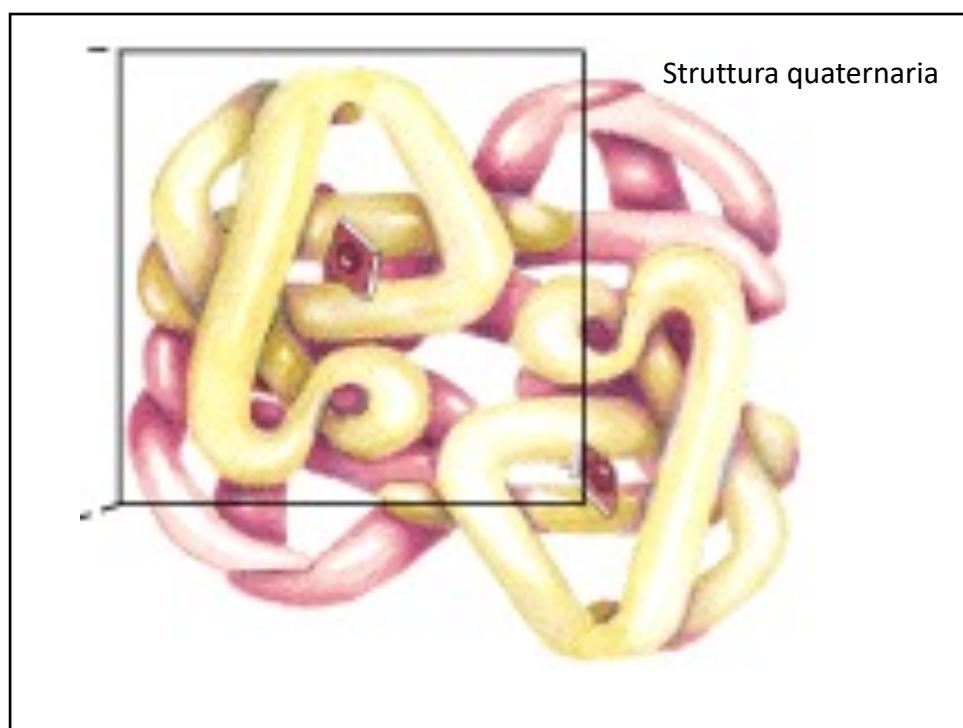
125



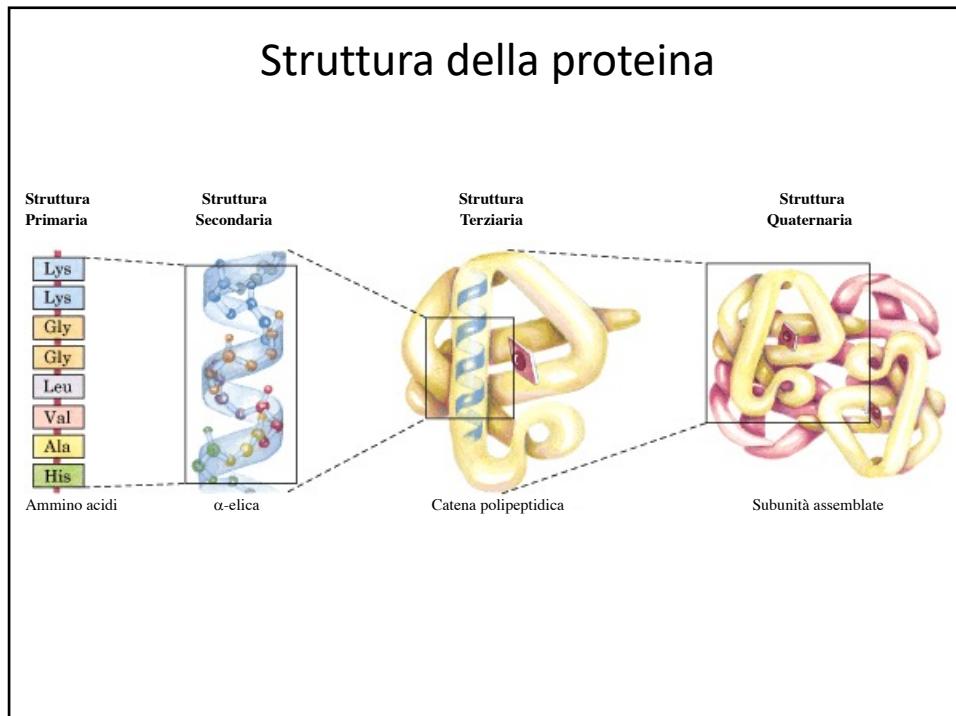
126



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Banca dati sequenze

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

La struttura primaria è un codice stereochimico (in gran parte sconosciuto) che contiene tutte le informazioni strutturali e funzionali della proteina.

Banca dati strutture

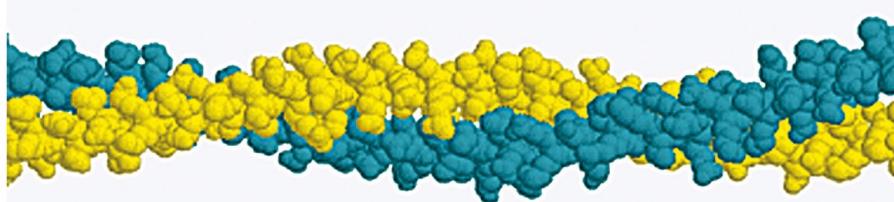
<http://www.pdb.org/>

Difrazione a raggi x e NMR

130

CHERATINA: capelli, unghie ecc

Due eliche destorse formano una super-elica sinistrorsa
Sono legate da ponti disolfuro (cisteine) e van der Waals



T.A. Brown, Conoscere la biochimica, Zanichelli editore 2018

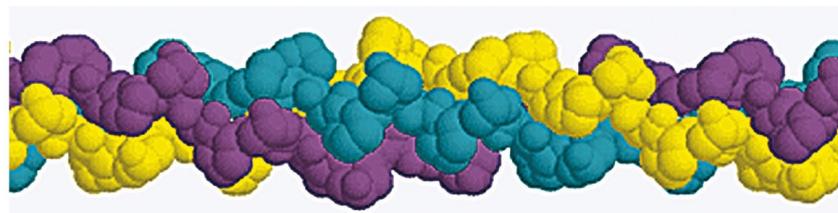
131

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Collagene: la proteina più abbondante (tendini)

Struttura a tripla elica allungata
Glicina-prolina-idrossiprolina



T.A. Brown, Conoscere la biochimica, Zanichelli editore 2018

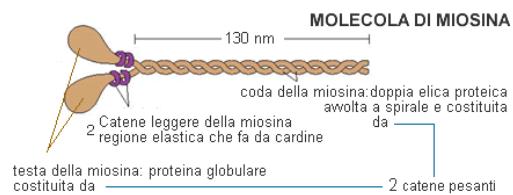
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Miosina e Actina: componenti proteiche più rappresentate nel muscolo striato

Miosina: nei filamenti spessi, è una molecola proteica formata da 6 catene polipeptidiche, due dette *catene pesanti*, le altre quattro, a due a due uguali, dette *catene leggere*. Proteina che possiede sia le proprietà tipiche delle proteine globulari che di quelle fibrose.



Actina: nei filamenti sottili, rappresenta circa il 20% di tutte le proteine del tessuto muscolare.