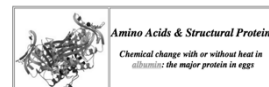


Chem 106: Class/ Lab Week 14

Sign Roster
Pick up papers & Amino Acids Handout
Global Warming
Organic Functions → Proteins & DNA
Cooking an Egg

Chem 106: Class/ Lab Week 14

<http://chemconnections.org/general/chem106/Tech%20Prep/Protein%20Activity%20I-2016.html>



TODAY's Experiment

Amino Acids & Proteins (egg albumin) Course/ Lab
Manual pp. 97-98; (pg. 97 Stamped Today)

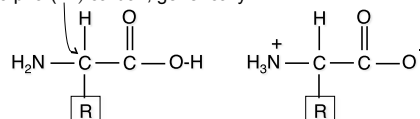
Completed pp. 97-98 Due Next Week

Chem 106: Class/ Lab Week 14

Organic Molecules
Amino Acids (small molecules) –
Proteins (large: “macro” molecules)

A base + an acid in the same molecule? Amino Acids

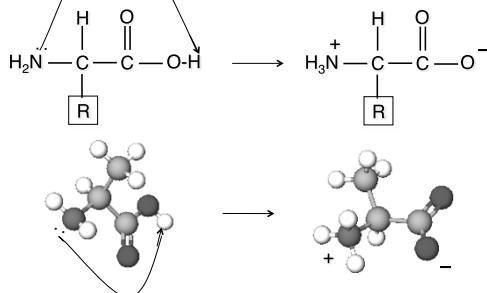
- ▶ More than 700 amino acids occur naturally, but **20** of them are **particularly important**.
- ▶ These 20 amino acids are the **building blocks of proteins** in humans and other organisms
- ▶ They differ in respect to the group attached to the alpha (α -) carbon, generically -R.



- ▶ Why + and – charges in the structure on the right?

A base + an acid in the same molecule? Amino Acids

- ▶ Why + and – charges in the structure on the right?



Amino Acids

https://chem.libretexts.org/LibreTexts/Diablo_Valley_College/DVC_Chem_106%3A_Rusay/Amino_Acids

- Our bodies can synthesize about 10 amino acids.
- “Essential” amino acids are the other 10 amino acids, which have to be ingested in our diet.

20 Amino Acids found in Proteins of Living Organisms

Name	I	D	R	R ⁺	Revised Color	Function & Class
Alanine	Ala	A	Al	CH ₃	dark grey	Aliphatic Hydrophobic
Arginine	Arg	R	Arg	$\text{CH}_2\text{CH}_2\text{CH}_2\text{N}^+(\text{H}_2)\text{CH}_2\text{NH}_2$	blue	Basic Hydrophilic
Asparagine	Asn	N	Asn	CH_2CONH_2	cyan	Acidic Highly Hydrophilic
Aspartate	Asp	D	Asp	CH_2COO^-	bright red	Acidic Hydrophilic
Cysteine	Cys	C	As	CH_2SH	yellow	Sulfur Containing Hydrophobic
Glutamine	Gln	Q	As	$\text{CH}_2\text{CH}_2\text{NH}_2$	cyan	Acidic Highly Hydrophilic
Glutamate	Glu	E	As	$\text{CH}_2\text{CH}_2\text{COO}^-$	bright red	Acidic Hydrophilic

Amino acids: two functions, an acid & a base, in the same mol

Amines $R-NH_2$

Carboxylic Acids $R-C(=O)OH$

$H-N(R_1)-C(=O)-OH$
 $H-N(R_2)-C(=O)-OH$

	Alcohol	$R-OH$
	Ether	$R-O-R'$
X	Amine	$R-NH_2$
	Aldehyde	$R-C(=O)H$
	Ketone	$R-C(=O)-R'$
X	Carboxylic Acid	$R-C(=O)OH$
	Ester	$R-C(=O)OR'$
	Amide	$R-C(=O)NR'$

Amino Acids

"Legos" of Chemical Biology

All amino acids contain C, H, O, and N; two, C & M also have sulfur.

Amino Acid	Three-Letter Code
Glycine	G
Alanine	A
Serine	S
Threonine	T
Cysteine	C
Valine	V
Leucine	L
Isoleucine	I
Methionine	M
Proline	P
Phenylalanine	F
Tyrosine	Y
Tryptophan	W
Aspartic acid	D
Glutamic acid	E
Asparagine	N
Glutamine	Q
Histidine	H
Lysine	K
Arginine	R

20 Amino Acids of Life

chiral: mirror images

General structure of an amino acid:

$$\begin{array}{c} \text{R} \\ | \\ \text{H}-\text{C}-\text{COOH} \\ | \\ \text{NH}_2 \end{array}$$

Chiral: mirror images

Amino Acids:

"Name"	L	H	R	CH ₃	Essential Amino Acids	Essential L-Chain Amino Acids
Alanine	Ala	A	H	CH ₃	pink grey	Basic Hydrophobic
Arginine	Arg	R	H	$\text{CH}_2\text{CH}_2\text{NHC}(\text{NH}_2)_2$	blue	Basic Hydrophilic
Asparagine	Asn	N	H	CH_2CONH_2	cyan	Basic Hydrophilic
Aspartic	Asp	D	H	CH_2COOH	bright red	Acidic Hydrophilic
Cysteine	Cys	C	H	CH_2SH	yellow	Acidic Hydrophilic
Glutamine	Gln	Q	H	$\text{CH}_2\text{CH}_2\text{CONH}_2$	cyan	Basic Hydrophilic
Glutamic	Glu	E	H	$\text{CH}_2\text{CH}_2\text{COOH}$	bright red	Acidic Hydrophilic
Glycine	Gly	G	H	H	light grey	Aliphatic Hydrophobic
Histidine	His	H	H	$\text{CH}_2\text{CH}_2\text{NHC}_3\text{H}_3\text{N}$	pale blue	Basic Hydrophilic
Isoleucine	Ile	I	H	$\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$	green	Aliphatic Hydrophobic

"Name"	L	H	R	CH ₃	Essential Amino Acids	Essential L-Chain Amino Acids
Leucine	Leu	L	H	$\text{CH}_2\text{CH}(\text{CH}_3)_2$	green	Aliphatic Hydrophobic
Lysine	Lys	K	H	$\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NHC}_3\text{H}_3\text{N}$	blue	Basic Hydrophilic
Methionine	Met	M	H	$\text{CH}_2\text{CH}_2\text{SCH}_3$	yellow	Sulphur Containing Hydrophobic
Phenyl- alanine	Phe	F	H	$\text{CH}_2\text{CH}_2\text{C}_6\text{H}_5$	red blue	Aromatic Hydrophobic
Proline	Pro	P	-	$\text{CH}_2\text{CH}_2\text{NHC}_3\text{H}_5$	beach	Aliphatic Hydrophobic
Serine	Ser	S	H	CH_2OH	red	Hydrophilic Hydrophobic
Threonine	Thr	T	H	$\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$	orange	Aliphatic Hydrophobic
Tryptophan	Try	W	H	$\text{CH}_2\text{CH}_2\text{C}_8\text{H}_6\text{N}$	pink	Aromatic Hydrophobic
Tyrosine	Tyr	Y	H	$\text{CH}_2\text{CH}_2\text{C}_6\text{H}_4\text{CH}_2\text{OH}$	red blue	Aromatic Hydrophobic
Valine	Val	V	H	$\text{CH}(\text{CH}_3)_2$	green	Aliphatic Hydrophobic

Reaction of two amino acids to form a peptide bond:

$$\text{H}-\text{N}-\text{C}(\text{R}_1)-\text{COOH} + \text{H}-\text{N}-\text{C}(\text{R}_2)-\text{COOH} \rightarrow \text{H}-\text{N}-\text{C}(\text{R}_1)-\text{CO}-\text{N}(\text{R}_2)-\text{COOH} + \text{H}_2\text{O}$$

The bond formed between the carbonyl carbon of one amino acid and the nitrogen of another is the **Peptide bond**.

(Amide bond)

General structure of a polypeptide chain:

$$\cdots - \text{N}(\text{H}) - \text{C}(\text{R}) - \text{C}(=\text{O}) - \text{N}(\text{H}) - \text{C}(\text{R}) - \text{C}(=\text{O}) - \text{N}(\text{H}) - \text{C}(\text{R}) - \text{C}(=\text{O}) - \cdots$$

The repeating unit is the **amide bond** (peptide bond) connecting the amino acid residues.

Powers of Ten

10^{-18}	ssa
10^{-15}	peta
10^{-12}	tera
10^{-9}	giga
10^{-6}	mega
10^{-3}	kilo
10^0	
10^3	milli
10^6	micro
10^9	nano
10^{12}	pico
10^{15}	femto
10^{18}	atto

Biological Scale Examples:

- Human height: 10^0 m
- Length of some nerve and muscle cells: 10^0 m
- Chicken egg: 10^{-1} m
- Frog egg: 10^{-3} m
- Most plant and animal cells: 10^{-5} m
- Most bacteria: 10^{-6} m
- Smallest bacteria: 10^{-7} m
- Viruses: 10^{-8} m
- Proteins: 10^{-9} m
- Enzymes: 10^{-9} m
- Small viruses: 10^{-10} m
- Atoms: 10^{-10} m

Measurement Ranges:

- Human eye: 10^{-2} m to 10^0 m
- Light microscope: 10^{-7} m to 10^{-4} m
- Electron microscope: 10^{-10} m to 10^{-7} m
- Scanning probe microscope: 10^{-10} m to 10^{-8} m

Biological Statistics:

- You**
 - Bones? 206 bones
 - Organs? 78 organs
- Cells**
 - # of cells? $\sim 5 \times 10^{13}$ cells
 - moles of cells? $\sim 8 \times 10^{-7}$ moles
- Proteins / DNA (Genome)**
 - ~20,000 proteins
 - 3×10^9 bases

Measurements

- 1 centimeter (cm) = 10^{-2} meter (m) = 0.4 inch
- 1 millimeter (mm) = 10^{-3} m
- 1 micrometer (μ m) = 10^{-6} m
- 1 nanometer (nm) = 10^{-9} meter

Organic Molecules

millions

The diagram illustrates the relative sizes of various biological structures on a logarithmic scale from 10^{-18} to 10^0 meters. The scale is divided into sections for different levels of biological organization, with arrows indicating the progression from smaller to larger structures.

Scale and Key Structures:

- Human height:** 10^0 m
- Neanderthal:** 10^0 m
- Bones? Organs?:** 10^{-1} m
- Cells:** 10^{-6} m
- Proteins / DNA (Genome):** 10^{-7} m
- Organic Molecules:** 10^{-9} m

Intermediate Structures and Scale Markers:

- 10⁻¹⁵ m:** Tera, peta
- 10⁻¹² m:** Tera
- 10⁻⁹ m:** Giga
- 10⁻⁶ m:** Mega
- 10⁻³ m:** Kilo
- 10⁻³ m:** Chicken egg
- 10⁻⁴ m:** Frog egg
- 10⁻⁵ m:** Wheat plant and corn cells
- 10⁻⁶ m:** Human bacteria
- 10⁻⁷ m:** Bacteria
- 10⁻⁸ m:** Small bacteria
- 10⁻⁹ m:** Viruses
- 10⁻¹⁰ m:** Lipids
- 10⁻¹¹ m:** Small molecules
- 10⁻¹² m:** Atoms

Measurement Tools:

- Light microscope:** 10^{-6} m to 10^{-4} m
- Electron microscope:** 10^{-10} m to 10^{-4} m
- Radio telescope:** 10^{-10} m to 10^{-18} m

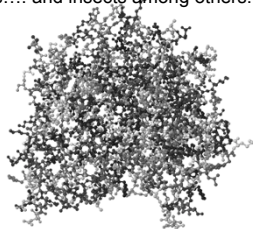
Additional Information:

- 206 bones:** Same as humans... organs?
- # of cells?**
- Measurements:**
 - 1 centimeter (cm) = 10^{-2} meter (m) = 0.1 inch
 - 1 millimeter (mm) = 10^{-3} m
 - 1 micrometer (μ m) = 10^{-6} m = 10^{-4} cm
 - 1 nanometer (nm) = 10^{-9} m = 10^{-6} cm

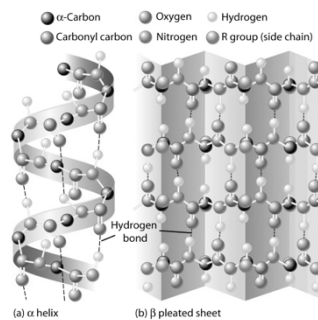
Proteins: Macromolecular Biopolymers

Acetylcholinesterase (ACE)

ACE, an enzyme, which catalyzes a key reaction in a repetitive biochemical cycle that is crucial to neurological and physiological functions in humans.... and insects among others.



4,496
atoms;
4,404 bonds
574 amino
acid
residues



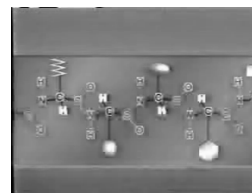
Hydrogen Bonding

<http://chemconnections.org/general/movies/HydrogenBonding.MOV>

Hair: α -Helix

Annenberg World of Chemistry

#23 Proteins : <http://www.learner.org/resources/series61.html>



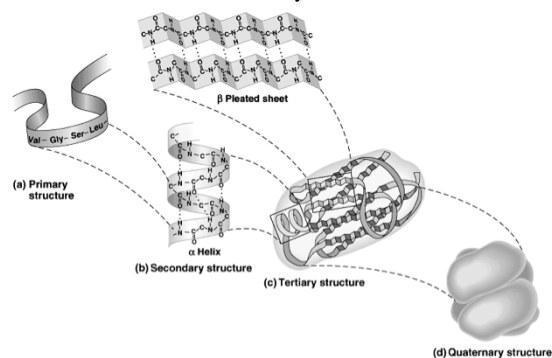
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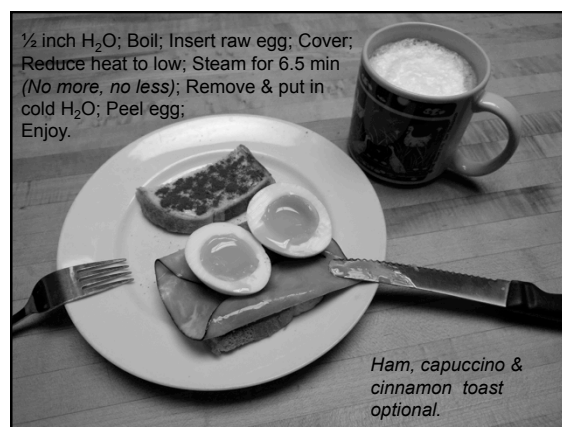
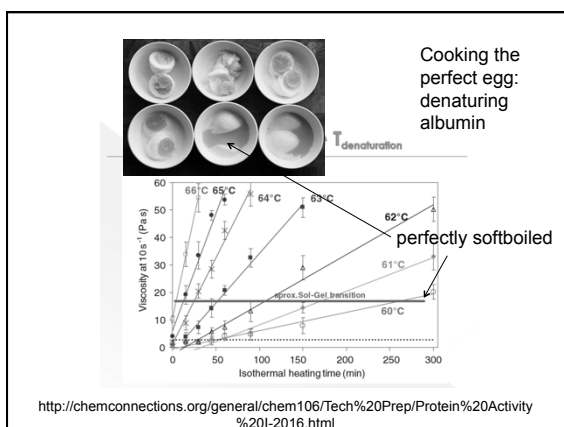
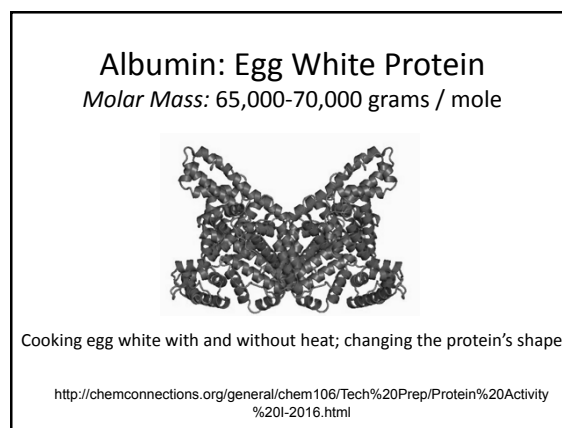
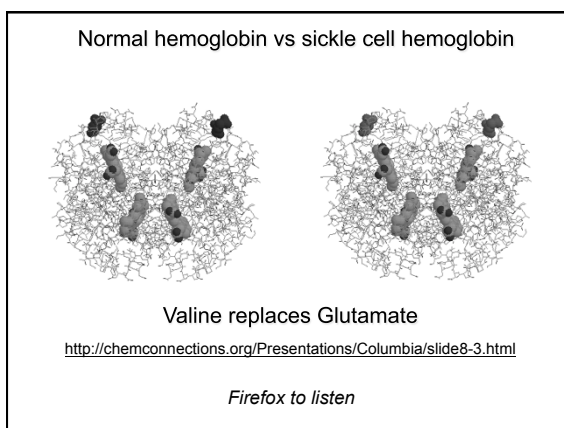
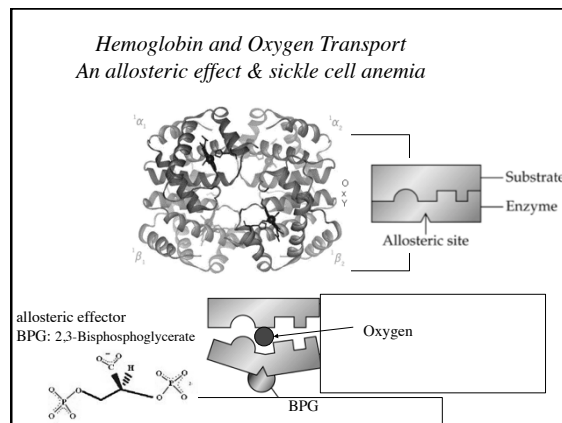
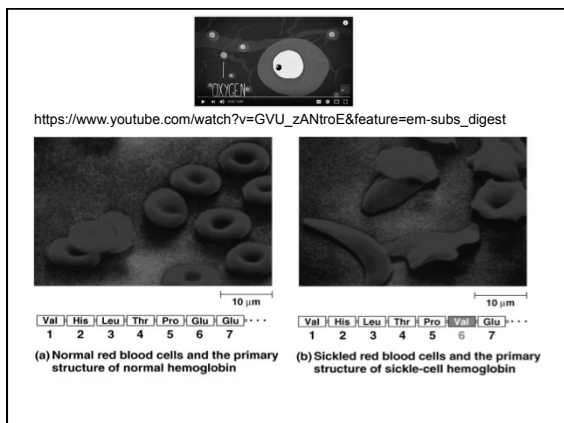
Silk: β -Sheets



<http://chemconnections.org/general/movies/proteins-silk-2.mov>

Summary

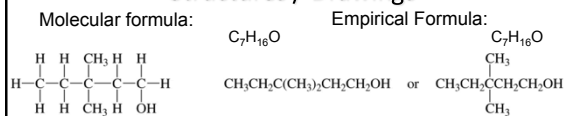




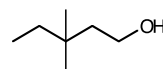
Chem 106: Class/ Lab
Week 14

Organic Molecules
Functional Groups
Amino Acids - Proteins

Organic Formulas:
Kekulé / Condensed / Bond-Line
Structures / Drawings



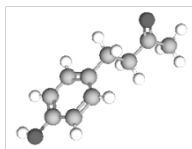
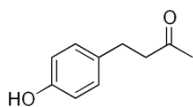
Bond-Line Structure:



QUESTION

A compound that smells like fresh raspberries, the following structure, $C_7H_{16}O$, matches its calculated molar mass which is 164 g/mol.

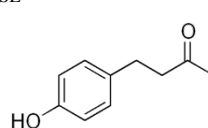
- A) TRUE
B) FALSE



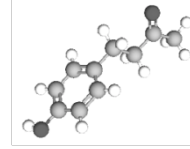
ANSWER

Based on your answers for the compound, which smells like fresh raspberries, in the previous two questions, the following structure matches its molecular formula.

- A) TRUE
B) FALSE

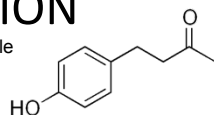


164 g/mol = $C_{10}H_{12}O_2$



QUESTION

Select the function(s) in the molecule

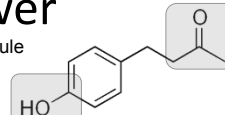


	Alcohol	R-OH
	Ether	R-O-R'
	Amine	R-NH ₂
	Aldehyde	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$
	Ketone	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{R}'$
	Carboxylic Acid	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{OH}$
	Ester	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{OR}'$
	Amide	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{N}^{\text{R}''}_{\text{R}'}$



Answer

Select the function(s) in the molecule

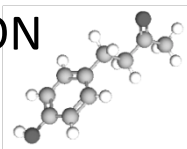


X	Alcohol	R-OH
	Ether	R-O-R'
	Amine	R-NH ₂
	Aldehyde	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$
X	Ketone	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{R}'$
	Carboxylic Acid	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{OH}$
	Ester	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{OR}'$
	Amide	$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{N}^{\text{R}''}_{\text{R}'}$



QUESTION

Select the function(s) in the molecule

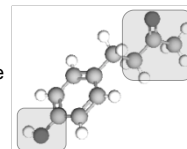


	Alcohol	$R-OH$
	Ether	$R-O-R'$
	Amine	$R-NH_2$
	Aldehyde	$R-\overset{O}{\underset{ }{C}}-H$
	Ketone	$R-\overset{O}{\underset{ }{C}}-R'$
	Carboxylic Acid	$R-\overset{O}{\underset{ }{C}}-OH$
	Ester	$R-\overset{O}{\underset{ }{C}}-OR'$
	Amide	$R-\overset{O}{\underset{ }{C}}-N(R')$



Answer

Select the function(s) in the molecule



X	Alcohol	$R-OH$
	Ether	$R-O-R'$
	Amine	$R-NH_2$
	Aldehyde	$R-\overset{O}{\underset{ }{C}}-H$
X	Ketone	$R-\overset{O}{\underset{ }{C}}-R'$
	Carboxylic Acid	$R-\overset{O}{\underset{ }{C}}-OH$
	Ester	$R-\overset{O}{\underset{ }{C}}-OR'$
	Amide	$R-\overset{O}{\underset{ }{C}}-N(R')$



Chem 106: Class/ Lab

Week 14

Do Today:



Amino Acids & Proteins (egg albumin)
Course/ Lab Manual pp. 97-98; (pg. 97
Stamped Today)

Completed pp. 97-98 Due Next Week

<http://chemconnections.org/general/chem106/Tech%20Prep/Protein%20Activity%20I-2016.html>

DNA / RNA: Proteins

Macromolecular Biopolymers



<https://unlockinglifescode.org/>