Introduction to Amino Acids and Proteins

Jianhan Chen
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Section Overview

- "Nitrogen Metabolism"
- Feb 26 – April 7 (spring break: March 17-21)
- Textbook "Fundamentals of Biochemistry" by Voet, Voet and Pratt, 4th Edition (3rd Edition works fine too).
- Metabolisms of Amino acids (Chapter 21) & nucleotides (Chapter 23)
- Redacted versions of the PowerPoint slides will be available on KSOL under: \Couse Content\Modules\Module II – Nitrogen Metabolism\Lecture Notes
  - Be prepared to take good notes during lectures
- Office hours: MF 1:30 – 2:30 PM, Chalmers 034
  - Or by appointment

Quizzes and Exam

- Quizzes: 10 point each
  - Three quizzes: Fridays of March 7, March 14, and March 28
  - Up to 10 minutes at the beginning of lectures
  - Cover materials since the first lecture (first quiz) or the previous quiz
  - Will reflect the emphasis of Section exam (below)
- Section final exam (70 points):
  - Monday of April 7: one hour
  - All materials of Section II
  - One A4 cheat sheet allowed
- No make-up: please plan your schedule accordingly

- Grading: overall course grade will be determined by adding the scores from the three sections and grading on a curve

BIOCH 765: Biochemistry II Spring 2014

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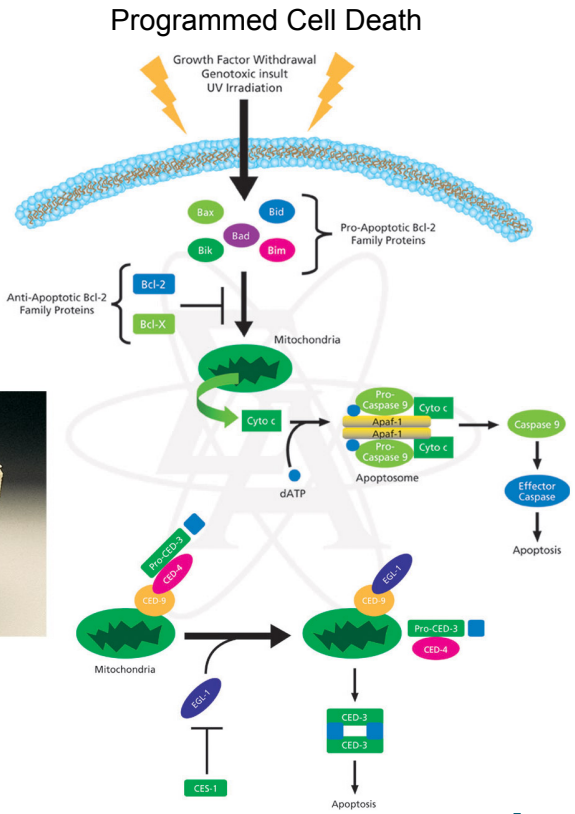
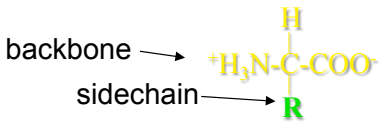
Proteins and Protein Functions

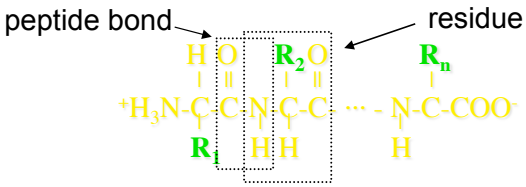


Hierarchical Organization of Proteins

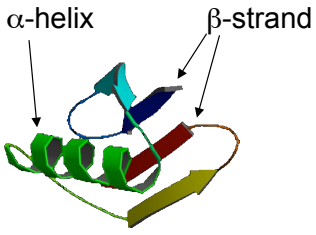
Amino Acids



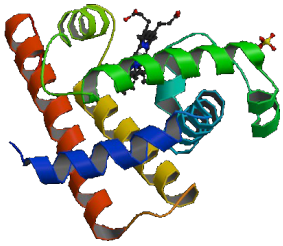
Peptides



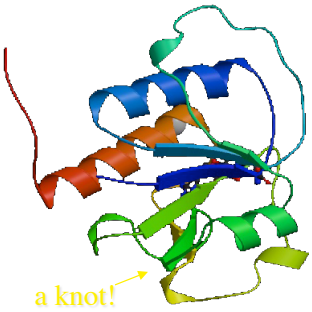
Primary Sequence: MTYKLILNGK TLKGETTTEA VDAATAEKVF KQYANDNGVD GEWTYDDATK TFTVTE



Protein G B1 (3gb1)



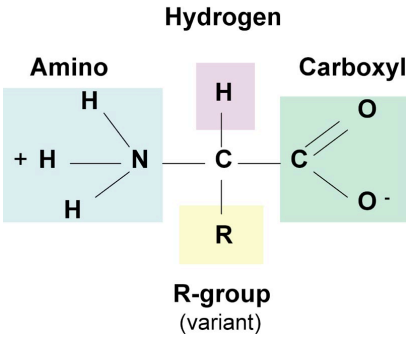
Myoglobin (1mbc)

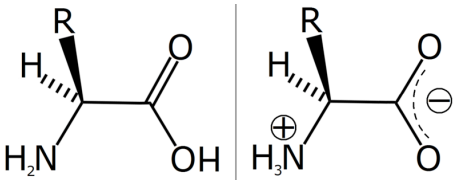


tRNA transferase (1mxi)

Natural Amino Acids

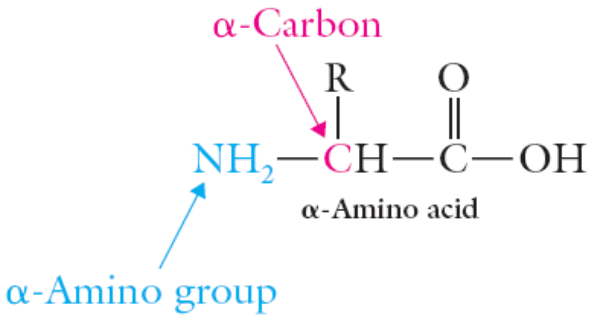
- Nearly all polypeptides from animals and plants are constructed from the 20 standard α-amino acids
- All α-amino acids in L-configuration (except gly)
- Side chains vary
- Essential (10) vs non-essential ones
- Co-exist in two forms
  - Ionic (zwitterionic form) and unionized



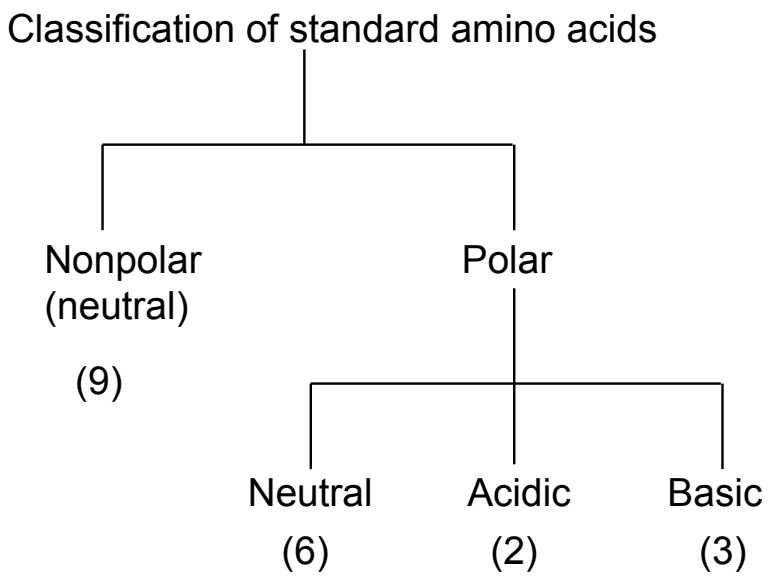


α-Amino Acids

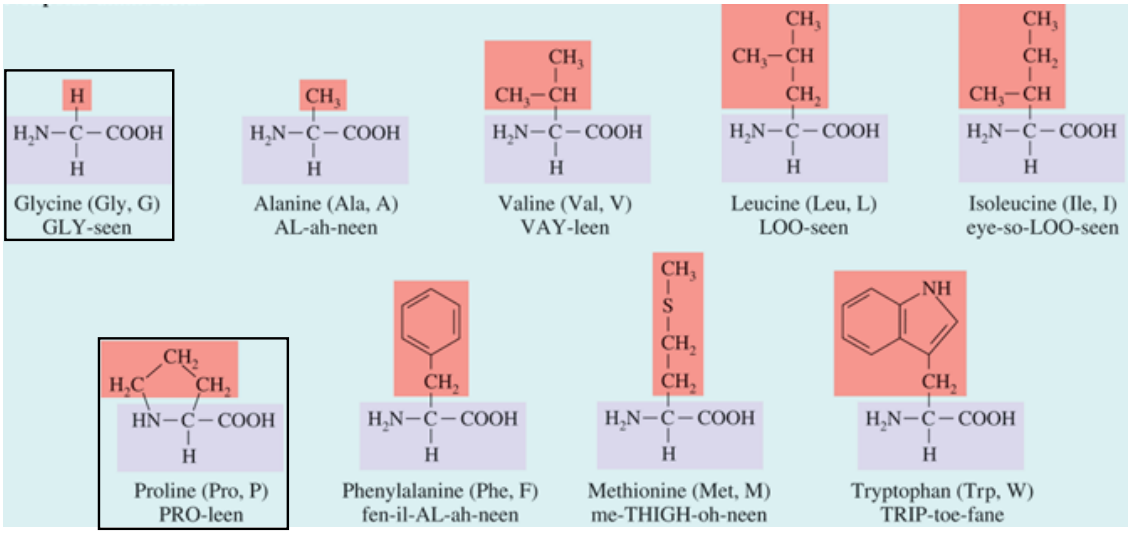
- An *amino acid* is an organic compound that contains both an *amino* ($—NH_2$) group and a carboxyl (—COOH) group bound to the same carbon (α carbon).



Classification of α-Amino Acids

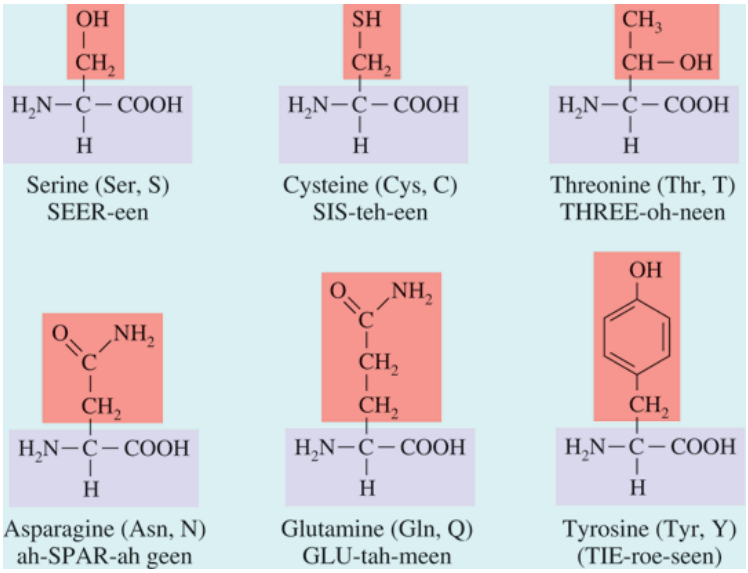


Nonpolar α-Amino Acids



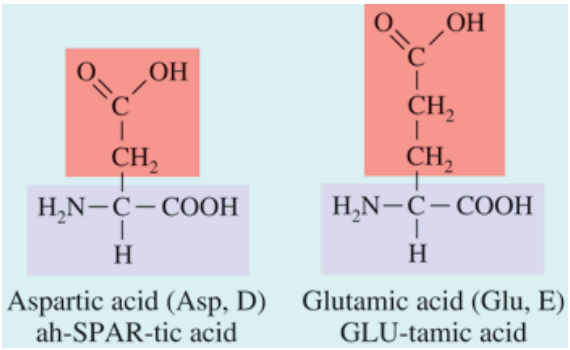
A *nonpolar amino acid* is an amino acid that contains one amino group, one carboxyl group, and a *nonpolar hydrophobic* side chain.

Polar Neutral α-Amino Acids



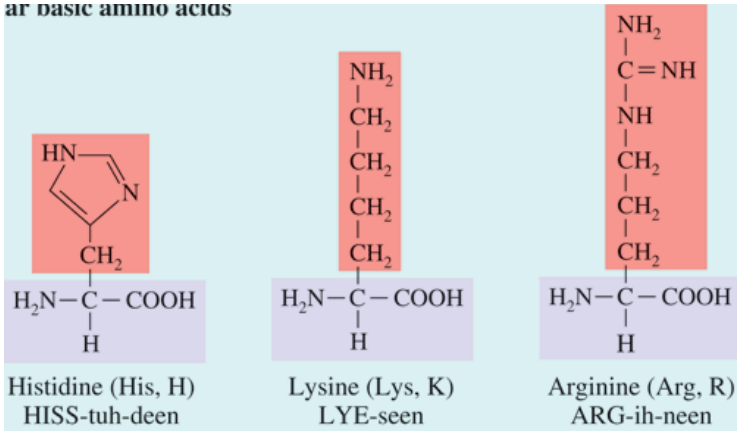
A *polar neutral amino acid* contains a side chain that is polar but neutral at physiological pH (side chain can form H-bonds).

Polar Acidic α-Amino Acids



A *polar acidic amino acid* is an amino acid that contains one amino group and 2 carboxyl groups, the second carboxyl group being part of the side chain.

Polar Basic α-Amino Acids



A *polar basic amino acid* is an amino acid that contains ≥ 2 amino groups and one carboxyl group, the second amino group being part of the side chain.

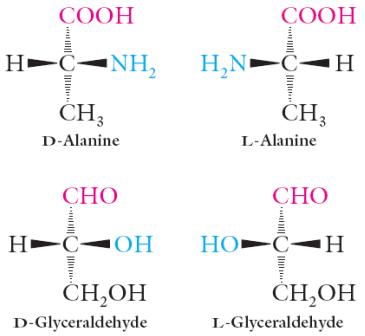
Three-Letter and Single-Letter Codes

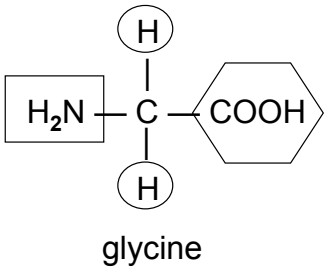
Amino Acid	3-Letter	1-Letter
Alanine	Ala	A
Arginine	Arg	R
Asparagine	Asn	N
Aspartate	Asp	D
Cysteine	Cys	C
Histidine	His	H
Isoleucine	Ile	I
Glutamine	Gln	Q
Glutamate	Glu	E
Glycine	Gly	G

Amino Acid	3-Letter	1-Letter
Leucine	Leu	L
Lysine	Lys	K
Methionine	Met	M
Phenylalanine	Phe	F
Proline	Pro	P
Serine	Ser	S
Threonine	Thr	T
Tryptophan	Trp	W
Tyrosine	Tyr	Y
Valine	Val	V

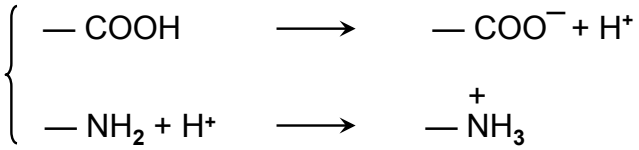
Chirality of α-Amino Acids

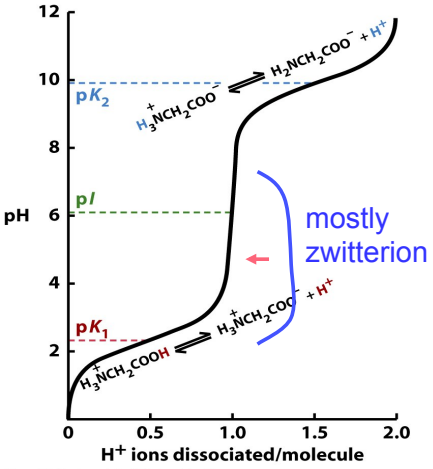
- α-carbon is a tetrahedral stereocenter (except glycine)
  - Pair of enantiomers
- Only L-α-amino acids exist in the proteins of animals and plants (with very few exceptions)
  - Amino acids refer to L-α-enantiomers

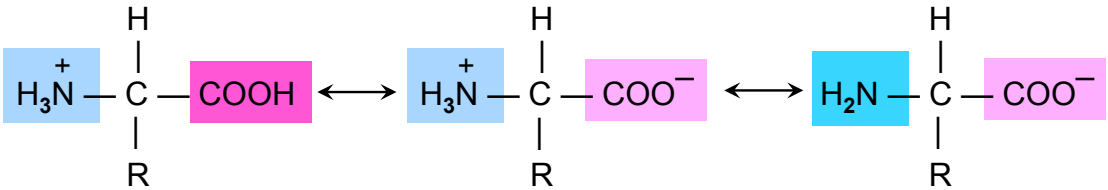




Acid-Base Properties





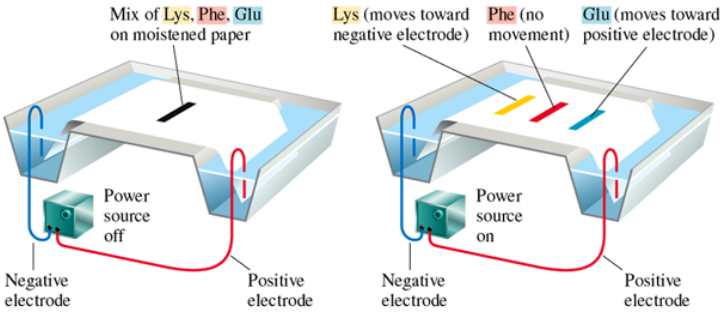


Low pH | neutral pH = PI | high pH

Isoelectric point (pI): *zwitterion*

Electrophoresis

- Analyze a mixture of α-amino acids
- Identify substances in an electrical field by separation
  - Cations (1+) move to the negative electrode
  - Anions (1-) move to the positive electrode
  - Neutral α-amino acids does not migrate



Lys: positively charged

Glu: negatively charged

Phe: neutral

α-Amino Acids

TABLE 20.1 α-Amino Acids

Name	Abbreviations		Side group (R)	Isoelectric point (pI)
NONPOLAR NEUTRAL				
glycine	Gly	G	H—	5.97
alanine	Ala	A	CH_3—	6.01
valine*	Val	V	$(CH_3)_2CH$—	5.96
leucine*	Leu	L	CH_3CHCH_2—	5.98
isoleucine*	Ile	I	CH_3CH_2CH—	6.02
phenylalanine*	Phe	F	$C_6H_5CH_2$—	5.48
methionine*	Met	M	$CH_3SCH_2CH_2$—	5.74
proline†	Pro	P		6.30
tryptophan*	Trp	W		5.88

(Continued at the top of the following page.)

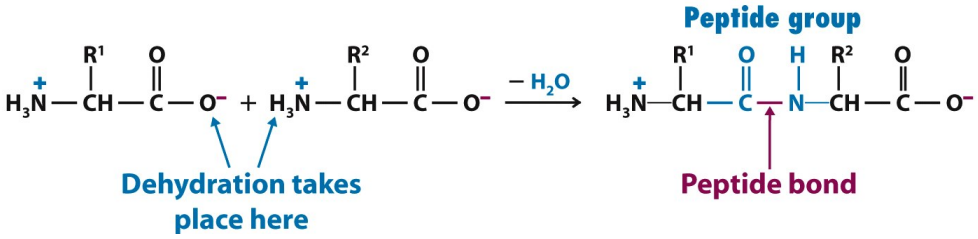
α-Amino Acids

TABLE 20.1 (*continued*)

Name	Abbreviations		Side group (R)	Isoelectric point (pI)
POLAR NEUTRAL				
cysteine	Cys	C	$HSCH_2-$	5.05
serine	Ser	S	$HOCH_2-$	5.68
threonine*	Thr	T	$CH_3CH(OH)-$	5.60
asparagine	Asn	N	$H_2NC(=O)CH_2-$	5.41
glutamine	Gln	Q	$H_2NC(=O)CH_2CH_2-$	5.65
tyrosine	Tyr	Y	HO-C$_6$H$_4$-CH_2-	5.66
POLAR ACIDIC				
aspartic acid	Asp	D	$HOC(=O)CH_2-$	2.77
glutamic acid	Glu	E	$HOC(=O)CH_2CH_2-$	3.22
POLAR BASIC				
lysine*	Lys	K	$H_2NCH_2CH_2CH_2CH_2-$	9.74
arginine*	Arg	R	$H_2NC(=NH)NHCH_2CH_2CH_2-$	10.76
histidine*	His	H	imidazole-CH_2-	7.59

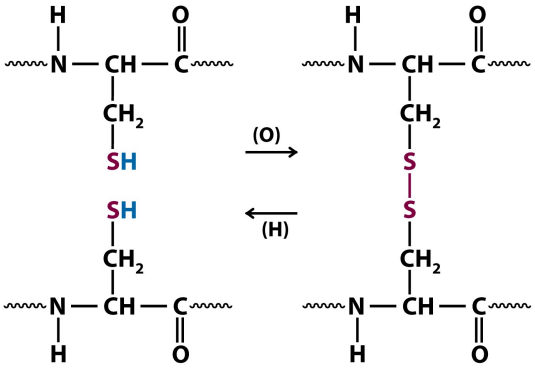
Basic Chemical Reactions

- Backbone: common to all amino acids
  - Amines and carboxylic acids undergo dehydration to form amides
  - Peptides are polyamides formed by α-amino acids

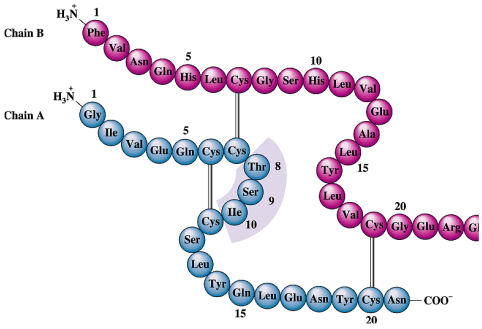


- Side chains: amino acid specific
  - Often occurred as "post-translational" modifications (signaling, natural modification, oxidation/damage etc)
  - Disulfide bond formation: between cysteines, an important structural feature

Disulfide Bonds



The small protein insulin has two polypeptide chains connected by two interchain disulfide bonds. There is also one intrachain disulfide.



- The amino acid cysteine contains a **thiol** group, -SH. Pairs of cysteine residues often link two peptide chains or two parts of one peptide chain through **disulfide bridges**.
- Formation of disulfide is an oxidation reaction and the reverse involves disulfide reduction.

Summary

- Proteins: overview
- Amino acids
  - Chemical composition: backbone and side chain
  - Classification: side chain properties
  - Physical and chemical properties
    - zwitterionic form;
    - peptide bond formation
- Peptides and proteins: polyamides (heteropolymers of amino acids)
- Next two+ weeks: amino acid metabolism (Chapter 21)