Protein & amino acid
Proteins play key roles in a living system

• Three examples of protein functions

  – Catalysis:  
    Almost all chemical reactions in a living cell are catalyzed by protein enzymes.

  – Transport:  
    Some proteins transports various substances, such as oxygen, ions, and so on.

  – Information transfer: 
    For example, hormones.
Amino acid: Basic unit of protein

An amino acid

Different side chains, $R$, determine the properties of 20 amino acids.
# 20 Amino acids

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycine (G)</td>
<td><img src="image" alt="Glycine" /></td>
</tr>
<tr>
<td>Alanine (A)</td>
<td><img src="image" alt="Alanine" /></td>
</tr>
<tr>
<td>Valine (V)</td>
<td><img src="image" alt="Valine" /></td>
</tr>
<tr>
<td>Isoleucine (I)</td>
<td><img src="image" alt="Isoleucine" /></td>
</tr>
<tr>
<td>Leucine (L)</td>
<td><img src="image" alt="Leucine" /></td>
</tr>
<tr>
<td>Proline (P)</td>
<td><img src="image" alt="Proline" /></td>
</tr>
<tr>
<td>Methionine (M)</td>
<td><img src="image" alt="Methionine" /></td>
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<tr>
<td>Phenylalanine (F)</td>
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<tr>
<td>Tryptophan (W)</td>
<td><img src="image" alt="Tryptophan" /></td>
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<tr>
<td>Asparagine (N)</td>
<td><img src="image" alt="Asparagine" /></td>
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<tr>
<td>Glutamine (Q)</td>
<td><img src="image" alt="Glutamine" /></td>
</tr>
<tr>
<td>Serine (S)</td>
<td><img src="image" alt="Serine" /></td>
</tr>
<tr>
<td>Threonine (T)</td>
<td><img src="image" alt="Threonine" /></td>
</tr>
<tr>
<td>Tyrosine (Y)</td>
<td><img src="image" alt="Tyrosine" /></td>
</tr>
<tr>
<td>Cysteine (C)</td>
<td><img src="image" alt="Cysteine" /></td>
</tr>
<tr>
<td>Asparatic acid (D)</td>
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<tr>
<td>Glutamic acid (E)</td>
<td><img src="image" alt="Glutamic acid" /></td>
</tr>
<tr>
<td>Lysine (K)</td>
<td><img src="image" alt="Lysine" /></td>
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<tr>
<td>Arginine (R)</td>
<td><img src="image" alt="Arginine" /></td>
</tr>
<tr>
<td>Histidine (H)</td>
<td><img src="image" alt="Histidine" /></td>
</tr>
</tbody>
</table>

White: Hydrophobic, Green: Hydrophilic, Red: Acidic, Blue: Basic
Proteins are linear polymers of amino acids.

The amino acid sequence is called as primary structure.

A carboxylic acid condenses with an amino group with the release of a water.
Peptide bond

- Joins amino acids
- 40% double bond character
  - Caused by resonance
  - Results in shorter bond length
  - Double bond disallows rotation
Amino acid sequence is encoded by DNA base sequence in a gene

DNA molecule = DNA base sequence

G ≡ C
C ≡ G
G ≡ C
C ≡ G
T ≡ A
T ≡ A
A ≡ T
A ≡ T
G ≡ C
C ≡ G
C ≡ G
Amino acid sequence is encoded by DNA base sequence in a gene

<table>
<thead>
<tr>
<th>First letter</th>
<th>Second letter</th>
<th>Third letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>TTT</td>
<td>Phe</td>
</tr>
<tr>
<td></td>
<td>TTA</td>
<td>Leu</td>
</tr>
<tr>
<td></td>
<td>TTA</td>
<td>Leu</td>
</tr>
<tr>
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<td>CTT</td>
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<td></td>
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<td>Val</td>
</tr>
<tr>
<td></td>
<td>GTG</td>
<td>Val</td>
</tr>
</tbody>
</table>

| Amino Acid | TTT (Phe) | TCT (Ser) | TAT (Tyr) | TGT (Cys) | TTT (Phe) | TCT (Ser) | TAT (Tyr) | TGT (Cys) | TTT (Phe) | TCT (Ser) | TAT (Tyr) | TGT (Cys) | TTT (Phe) | TCT (Ser) | TAT (Tyr) | TGT (Cys) | TTT (Phe) | TCT (Ser) | TAT (Tyr) | TGT (Cys) | TTT (Phe) | TCT (Ser) | TAT (Tyr) | TGT (Cys) |