Elements of Molecular Biology

Stephen Altschul

National Center for Biotechnology Information
National Library of Medicine
National Institutes of Health
The Structure of DNA


The Structure of DNA in the Abstract

Replication

Information
Watson-Crick Base Pairs

**Purines**
- Guanine (G)
- Adenine (A)

**Pyrimidines**
- Cytosine (C)
- Thymine (T)
DNA Informs Cells How to Make Proteins: The “Central Dogma”
The Three-Dimensional Structure of Sperm Whale Myoglobin

A Variety of Protein Three-Dimensional Structures

http://www.lbl.gov/Publications/Currents/Archive/Apr-01-2005.html
The Structure of an Amino Acid

Amino + H \(\text{H} \quad \text{H} \quad \text{N} \quad \text{C} \quad \text{R} \) Carboxyl

Hydrogen

R-group (variant)
Chemical Structures of the Twenty Common Amino Acids

**Small**

- Glycine (Gly, G)  
  - MW: 57.05

- Alanine (Ala, A)  
  - MW: 71.09

- Serine (Ser, S)  
  - MW: 87.08, $pK_a = 16$

- Threonine (Thr, T)  
  - MW: 101.11, $pK_a = 16$

- Cysteine (Cys, C)  
  - MW: 103.15, $pK_a = 8.35$

**Hydrophobic**

- Valine (Val, V)  
  - MW: 99.14

- Leucine (Leu, L)  
  - MW: 113.16

- Isoleucine (Ile, I)  
  - MW: 113.16

- Methionine (Met, M)  
  - MW: 131.19

- Proline (Pro, P)  
  - MW: 97.12

**Aromatic**

- Phenylalanine (Phe, F)  
  - MW: 147.18

- Tyrosine (Tyr, Y)  
  - MW: 163.19

- Tryptophan (Trp, W)  
  - MW: 186.21

**Acidic**

- Aspartic Acid (Asp, D)  
  - MW: 115.09, $pK_a = 3.9$

- Glutamic Acid (Glu, E)  
  - MW: 129.12, $pK_a = 4.07$

**Amide**

- Asparagine (Asn, N)  
  - MW: 114.11

- Glutamine (Gln, Q)  
  - MW: 128.14

**Basic**

- Histidine (His, H)  
  - MW: 137.14, $pK_a = 6.04$

- Lysine (Lys, K)  
  - MW: 128.17, $pK_a = 10.79$

- Arginine (Arg, F)  
  - MW: 156.19, $pK_a = 12.48
# The Twenty Common Amino Acids

<table>
<thead>
<tr>
<th>One-letter code</th>
<th>Name</th>
<th>One-letter code</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Alanine</td>
<td>M</td>
<td>Methionine</td>
</tr>
<tr>
<td>C</td>
<td>Cysteine</td>
<td>N</td>
<td>Asparagine</td>
</tr>
<tr>
<td>D</td>
<td>Aspartic acid</td>
<td>P</td>
<td>Proline</td>
</tr>
<tr>
<td>E</td>
<td>Glutamic acid</td>
<td>Q</td>
<td>Glutamine</td>
</tr>
<tr>
<td>F</td>
<td>Phenylalanine</td>
<td>R</td>
<td>Arginine</td>
</tr>
<tr>
<td>G</td>
<td>Glycine</td>
<td>S</td>
<td>Serine</td>
</tr>
<tr>
<td>H</td>
<td>Histidine</td>
<td>T</td>
<td>Threonine</td>
</tr>
<tr>
<td>I</td>
<td>Isoleucine</td>
<td>V</td>
<td>Valine</td>
</tr>
<tr>
<td>K</td>
<td>Lysine</td>
<td>W</td>
<td>Tryptophan</td>
</tr>
<tr>
<td>L</td>
<td>Leucine</td>
<td>Y</td>
<td>Tyrosine</td>
</tr>
</tbody>
</table>
# The Genetic Code

<table>
<thead>
<tr>
<th>2nd→</th>
<th>U</th>
<th>C</th>
<th>A</th>
<th>G</th>
<th>3rd→</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st↓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>Phe</td>
<td>Ser</td>
<td>Tyr</td>
<td>Cys</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Phe</td>
<td>Ser</td>
<td>Tyr</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td>Ser</td>
<td>Stop</td>
<td>Cys</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td>Ser</td>
<td>Stop</td>
<td>Stop</td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>Leu</td>
<td>Pro</td>
<td>His</td>
<td>Arg</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td>Pro</td>
<td>His</td>
<td>Arg</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td>Pro</td>
<td>Gln</td>
<td>Arg</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td>Pro</td>
<td>Gln</td>
<td>Arg</td>
<td>G</td>
</tr>
<tr>
<td>A</td>
<td>Ile</td>
<td>Thr</td>
<td>Asn</td>
<td>Ser</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Ile</td>
<td>Thr</td>
<td>Asn</td>
<td>Ser</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Ile</td>
<td>Thr</td>
<td>Lys</td>
<td>Arg</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Met</td>
<td>Thr</td>
<td>Lys</td>
<td>Arg</td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>Val</td>
<td>Ala</td>
<td>Asp</td>
<td>Gly</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Val</td>
<td>Ala</td>
<td>Asp</td>
<td>Gly</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Val</td>
<td>Ala</td>
<td>Glu</td>
<td>Gly</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Val</td>
<td>Ala</td>
<td>Glu</td>
<td>Gly</td>
<td>G</td>
</tr>
</tbody>
</table>

Marshall Nirenberg 1927-2010