Cereals and grains
Grain anatomy (APK)

**Bran** -- contains much of the fiber and minerals of the grain.

**Germ** -- the part of the grain that would become the new plant if the seed were planted. High in protein and fat.

**Endosperm** -- approximately 80% starch and 20% protein. Source of flour and starch.
Simplified milling scheme for wheat

Whole wheat kernel

Clean, separate from other grains

Temper
15-19% water (hard wheat)
14-15% water (soft wheat)
Simplified milling scheme for wheat

Break rolls

Middlings
Separate streams
Bran, germ

Reduction rolls
Flour
## Flour grades

<table>
<thead>
<tr>
<th>100 pounds of wheat</th>
<th>28%, feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 % of wheat, straight flour</td>
<td>Poor second clear</td>
</tr>
<tr>
<td>Extra short</td>
<td>40%</td>
</tr>
<tr>
<td>First patent</td>
<td>70%</td>
</tr>
<tr>
<td>Short patent</td>
<td>80%</td>
</tr>
<tr>
<td>Medium patent</td>
<td>90%</td>
</tr>
<tr>
<td>Long patent</td>
<td>95%</td>
</tr>
<tr>
<td>Straight flour</td>
<td>100%</td>
</tr>
</tbody>
</table>
Flour grades (see page 191, Lecture Notes)

- Decreasing protein content
  - Straight flour
  - Long patent flour
  - Medium patent flour
  - Short patent flour
  - First patent flour
  - Fancy patent flour

- The highest protein flour is durum and is used for pasta
Flour grade uses

- It is important to match the flour (and its protein content) to the use to which you are going to put it.
- Some baked goods (cakes, cookies, pie crust) need a low protein flour while others (bread, pizza dough) require a high protein flour.
Flour grades (see page 191, Lecture Notes)

- Fancy clear and poor second clear are sometimes included in pancake mixes.
- Bran and shorts (some flour + bran + germ) goes into animal feed.
Aging of flours

- This can be a natural or chemically accelerated process
- Can use a bleacher, improver, or oxidizer
  - Bleachers - benzoyl peroxide
  - Improvers - bromates, iodates
  - Oxidizers - chlorine dioxide, acetone peroxide
Aging of flours

- The aging process, whether natural or chemically accelerated, works on the flour protein to improve the formation of disulfide (-S-S-) linkages.
- The gluten forming proteins functionality depends strongly on the presence of these disulfide bonds.
Wheat flour (plant) proteins

- Albumins
  - Soluble in water and salt solutions

- Globulins
  - Sparingly soluble in water but soluble in salt solutions
Wheat flour (plant) proteins

- **Prolamines**
  - Soluble in 70-80% ethanol but not in water

- **Glutelins**
  - Insoluble, except in acid or alkali
Gliadin

A prolamine -- molecular weight 32,000-42,000
Single polypeptide chain

Gliadin provides \textit{extensibility and viscosity} to doughs and batters

Intramolecular disulfide bonds
Glutenin

17 subunits -- 3 major fractions

I: 12,000-68,000 MW
II: 68,000-133,000 MW
III: 35,000-45,000 MW

Glutenin provides **elasticity** to doughs and batters
Gluten formation

Flour → Water → Mix → Glutenin → Gliadin → Gluten

No other examples of elastic proteins from plants are known
This is the structure that traps the carbon dioxide leavening gas and causes the bread to rise.

Image courtesy or New Zealand Cyberguide to Milling and Baking (www.crop.cri.nz/foodinfo/millbake/science.htm)
Important amino acids in gluten-forming proteins

L-cysteine, forms S-S bonds

L-glutamine, about 37% of a.a. in gluten-forming proteins. Good H-bond former, promotes cohesiveness.

L-proline, about 14% of the amino acids in the gluten forming proteins. Contributes “tightening” to the gluten-forming proteins.

Images courtesy of Atom World (www.jlc.net/~arettee/atomworld)
Important amino acids in gluten-forming proteins

L-Leucine

- Non-polar side chain promotes hydrophobic bonding which contributes stability to the gluten structure

Glycine, contributes flexibility to the gluten-forming proteins

Images courtesy of Atom World (www.jlc.net/~aretee/atomworld)
Factors modifying gluten formation

- Starch
  - Takes up a lot of water
  - Dehydrates gluten
  - Contributes rigidity due to amylose retrogradation
Factors modifying gluten formation

- Monoglycerides
  - Increases loaf volume
  - Reduces bread staling rate
  - Reduces crumb rigidity
  - Increases moisture content
  - Mechanism of action: prevents amylose exit from starch granules during gelatinization
Factors modifying gluten formation

- Sodium steroyl lactylate (SSL)
  - A dough conditioner
  - Strengthens dough
  - Increases specific loaf volume
  - Provides better texture for bread
  - Mechanism: not well understood
Effects of other ingredients on gluten formation

- **Tenderizers**
  - Sugar -- competes for water
  - Fat -- “waterproofs” the gluten-forming proteins

- **Structure formers**
  - Eggs
  - Flour -- contributes gluten forming proteins
  - Liquid -- involved in gluten formation
  - Stirring/beating -- gluten formation
Other cereals, grains, and seeds

- **Corn**
  - Low gluten forming capacity
  - 50% of its prolamine is a protein called zein
  - Zein -- low in tryptophan and lysine

- **High lysine corn -- Opaque-2**
  - Increased lysine by 75% over normal corn
  - Soft kernels -- storage and milling problems
Other cereals, grains, and seeds

- Rice
  - 80% of rice protein is glutelineline
  - Low in prolamine
  - Relatively high in lysine content
Other cereals, grains, and seeds

- Seeds (soy, cotton, etc.)
  - Proteins are globulins
  - High in lysine but low in S-containing amino acids
  - No viscoelastic properties, little or no starch