BJCP PRESENTATION: Malting, the whys and wherefores

I: Introduction:

Beer: **Noun**

1. A general name for alcoholic beverages made by fermenting a cereal (or mixture of cereals), flavored with hops usually or very occasionally nowadays, other bittering substances. Cereal grains include rice, wheat, barley, corn, oats, sorghum, rye and others (millets, triticale, buckwheat, and fonio). Sake, often mistakenly referred to as rice wine is more properly described as a beer, and the only one to my knowledge that does not use any bittering to provide balance.

Modern beer is made predominantly from barley. Other important grains used in the production of beers include wheat (important styles include weiss, weizens, & american wheat beers), and especially in the production of North American commercial beers, rice and corn which are used to lighten the flavor (and reduce the cost) of the brew. Other instances of using adjunct grains include the use of oatmeal in stouts and more rarely, porters; rye in the production of an increasingly popular American craft beer style, and sorghum in the production of gluten free beers. Other brewing adjuncts include unmalted barley, sugar, syrups, honey, and spices.

II: Why barley?

a) Can be made into bread with or without wheat flour, and barley was grown and used for bread in many places and cultures since ancient times, including Greece and Rome, Egypt, Scandinavia, the British Isles, Mesopotamia, and East Asia. Bread made with it was usually coarse and dark and as a consequence not very appreciated, although more affordable than bread made with wheat. One reason that the original German Purity Law (Reinheitsgebot) did not allow for the use of wheat was for fear that all the bakers supplies would be used by brewers and the resulting scarcity of wheat would make bread unaffordable!
http://en.wikipedia.org/wiki/Reinheitsgebot

b) Has a number of characteristics that make it ideal for brewing:

- A light but nutty flavor.
- The presence of a husk which helps in forming a filtration bed (wheat has none).
- Low amount of oils and gums which might interfere with extraction or foam retention.
- Grows everywhere.
- Has both a large amount and good balance of protein and starch dissolving enzymes which ensure a good yield of extract during mashing.
- It also contains a large number of yeast nutrients which makes for a healthy and vigorous fermentation, e.g. most of the B vitamins and other trace nutrients.

III: What is malting and why is it necessary? Malting is the process whereby cereal grains (usually barley and wheat) are germinated, allowed to grow to a carefully controlled extent, and then halted by heating the growing grain. The extent of internal growth correlates with the process referred to modification during which the following occurs (see picture):

- Complex insoluble starches and fibers are broken down to simple sugars and soluble starches
- Large proteins are broken down to small fragments and their building blocks, amino acids
- B-glucan which is a primary structural component of cell walls is broken down—this is the process bottleneck as the endosperm cell walls where the nutrients are warehoused is 70% B-glucan.
- Large amounts of the enzymes responsible for these and other processes are synthesized, setting the stage for the mash where these processes are carried out to completion.

The seed is typically allowed to grow between 75 and 100 percent of the length of the kernel, during which times rootlets will develop, but the developing grass itself is usually stopped short of actual sprouting. The degree of modification varies among malt houses and the grains used, but all modern malted barley if fully “modified.” The point of doing this is to convert the raw storage nutrients found in the un-germinated seed into a form that can be used by yeast, and which will provide flavor and other desirable characteristics such as head retention in the final product. So called undermodified malts require considerably more complex mashing methods to make suitable wort, and reached a high art in the hands of German brewers in a process known as decoction mashing.

Primarily the two major nutrient types of concern in brewing are carbohydrates and proteins. A quick review of some very basic biochemistry may be of help to those without any past exposure to the subject.

a) Carbohydrates chemistry: Carbohydrates are defined by the chemical composition of $C_x(H_2O)_x$ In the case of a simple single sugar unit x will be 5 or 6, e.g. fructose (fruit sugar), glucose (blood sugar). Many other common sugars consist of two (disaccharides) sugar units combined, e.g. sucrose (table sugar), maltose (malt sugar), and lactose (milk sugar). See table.

Sugar	Carbohydrate	Monosaccharide or disaccharide	Additional information
Beet sugar (cane sugar)	Sucrose	Disaccharide (fructose and glucose)	Similar to white and powdered sugar, but varied degree of purification
Brown sugar	Sucrose	Disaccharide (fructose and glucose)	Similar to white and powdered sugar, but varied degree of purification
Corn syrup	Glucose	Monosaccharide	
Fruit sugar	Fructose	Monosaccharide	Very sweet
High-fructose corn syrup	Fructose	Monosaccharide	Very sweet and inexpensive Added to soft drinks and canned or frozen fruits
Honey	Fructose and glucose	Monosaccharides	Primarily sucrose with small amts of other sugars
Malt sugar	Maltose	Disaccharide (glucose and glucose)	Formed by the hydrolysis of starch, but sweeter than starch
Maple syrup	Sucrose	Disaccharide (fructose and glucose)	
Milk sugar	Lactose	Disaccharide (glucose and galactose)	Made in mammary glands of most lactating animals

SOURCE: Mahan and Escott-Stump, 2000; Northwestern University; Sizer and Whitney, 1997; and Wardlaw and Kessel, 2002

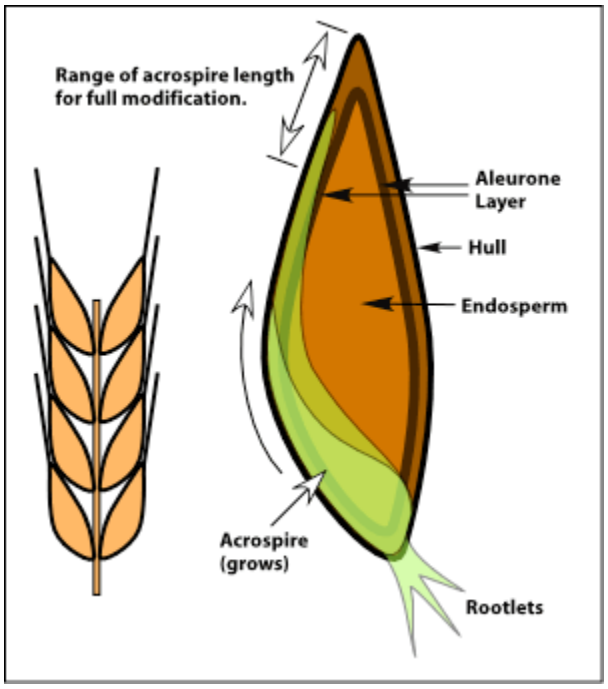
An interesting note: brewers yeast is incapable of digesting lactose, and therefore this sugar can be used to sweeten beers, e.g. milk/cream stouts.

Carbohydrate chemistry (continued): The other major forms of carbohydrates include starches and dietary fibers. Starches and fibers are the primary form of energy storage in seeds, consisting of long polymeric molecules made up of simple sugars in a repeating array. These are digestible through the action of enzymes found in saliva and the digestive tract. Similar enzymes are also found in barley which are produced within the aleurone during the malting process which begin to convert the hard, insoluble carbohydrates found in the raw seed into a form that can be used by the developing plant embryo (acrospire).

These same enzymes are harnessed during the mashing process to complete the conversion of the starch into a blend of sugars, primarily maltose, and partially degraded starches that contribute residual sweetness and mouth feel to the beer.

b) Protein chemistry. Like starch which is made of a large number of simple sugars bound together by one or two types of chemical bonds, proteins consist of large numbers of simpler molecules known as amino acids bound together into a much larger super-molecule. Proteins can be categorized into structural and functional members: the functional proteins are mostly enzymes which greatly accelerate needed chemical reactions, and along with DNA/RNA is the basis of life itself. Other related terms one may run across in the brewing literature are oligopeptides and polypeptides which are smaller than proteins and consist of between several and hundreds of chained amino acids.

Amino acids are essential to yeast metabolism as well as the flavor profile of the beer, and one of the most important events during malting is the breakdown of complex proteins into the building blocks (amino acids). These are used to make all the new proteins of the developing plant including the enzymes used to breakdown the protein/starch matrix which makes up the endosperm. AA's participate in a very important chemical reaction during malting known as Maillard reactions which involve sugars and produce a wide spectrum of flavors: for more info see: http://en.wikipedia.org/wiki/Maillard_reaction



The aleurone plays a critical support role to the developing grass shoot (acrospire). Among other functions, this is the site of enzyme synthesis. These enzymes are responsible for the changes during modification. The first step is breaking down the call walls of the endosperm tissue, so that the starch granules which are embedded in a protein matrix can be freed to nourish the developing plant. During the entire process of germination, the seed is breathing and so large amounts of fresh air must be blown through the grain piles. Large fans do this in modern malt houses in a process known as pneumatic malting.

The process of malting can be subdivided into three primary processes: (The terms used by maltsters are a bit different than those used botanically)

- Steeping: the aged (1 to 12 months) and sorted malt is steeped in water (between 60 and 80 degrees) to soften the grains and prepare it for germination. Process requires one to three days during which the moisture content will increase from several percent to nearly one-half. At the end, the barley or other grain is referred to as *chit malt,* referring to the emergence of rootlets. The seeds need to breathe during this and subsequent phases, so it is not so simple as merely dunking the grain in water. The food reserves for this early stage are pre-stored in the aleurone (outer later of endosperm) and embryo.

- Germination: In maltster terms, germination refers to the actual growth process of the seed embryo, and it is during which the major biochemical processes of modification are accomplished. The process requires between 3 and 6 days and like steeping requires precise control of temperature and humidity. The embryo continues to take in oxygen and release carbon dioxide, and large amounts of humidified air must be continuously cycled through the barley to prevent suffocation and/or overheating. In the past this was accomplished by so called floor malting which is extremely energy intensive and has been made virtually obsolete by pneumatic malting methods. See here for a comparison: http://www.ukmalt.com/howmaltismade/oldnew.html At the end of germination phase, the malt is referred to green malt.

- Kilning: Once the grain has reached the desired level of modification, the process is halted by the use of high temperature air. In addition to bringing an end to the process of modification, the maltster uses variable temperature, humidification and time to produce the desired malt characteristics. In addition the malt is dried out in the process, leaving it much less susceptible to spoilage. As will be seen in the next section, manipulation of these variables enables the maltster to produce an almost bewildering array of different malt types which are then used by the brewer to produce the entire spectrum of beers: everything from the lightest most delicate blonde pilsner to the blackest, roastiest of Russian Imperial Stouts.

IV: The malts themselves:

Barley is a beautiful thing!

In discussing different malts, some general biochemical principles help to make sense of these malty matters. The first of these is the process of caramelization: sugars when heated above boiling, burn (oxidize) at a slow rate producing an altogether different flavor profile that depending on time and temperature, and the sugars themselves, range from nutty to scorched earth. Caramel candy is a familiar example, which while still sweet like the sugar from which it is made, takes on an altogether different nature. Higher temperatures/longer kilning times lead to more roast/charcoal flavor. Shorter and

lower temperatures leave less of an impact obviously. (In actuality, lower temp but moister air is used for many of the caramelized malts, the idea being that this enables the seeds contents to literally stew in their own juices, while hot dry air quickly dries the pale malts.)

The second principle involves enzymes. One of the primary goals of malting is to produce a kernel of grain that is chock full of the enzymes needed to render the seed materials into a form usable by the yeast. These enzymes are harnessed during mashing when the remaining seed starches are converted into simple sugars. But the enzymes made by the seed are destroyed by the same heat that caramelizes sugars.

This leaves the maltster with a trade-off: The hotter and wetter the malt gets during kilning, the greater the extent of caramelization, but the less active the remaining enzymes to carry the next step in the process of converting barley into beer during the mash. Lightly kilned malts have all the enzymatic power needed to convert their own weight (and then some) into fermentable wort, while the more roasted grains are rendered water soluble.

The latter, like teas thus only need to be steeped in hot water to extract their flavor. This is especially useful to homebrewers who may not want the hassle associated with all grain brewing, but want to expand the variety of beers they make beyond the extracts available to them. The table below is a fairly complete list of the malts now available.

One very useful way of categorizing these is according to the enzymatic (diastatic) power: Those with sufficient enzymes to convert themselves during a mash are called base malts while those without are usually referred to as specialty malts. Generally the specialty malts can be steeped w/o mashing to extract their sugars and assorted compounds. There are a couple of exceptions, however, which I will note.

The other dimension used to sort malts is the color they impart to beer. There are a couple of standards in use: the Lovibond scale is used primarily in the US and UK, while the SRM (standard research method) is favored in continental Europe. I will use the Lovibond scale. As might be expected, the darker the color (higher the Lovibond number), the further along the spectrum of grainy-malty-nutty-caramelized-roasted. There are a few exceptions to this rule of thumb, as barley itself can have distinct flavor depending on the cultivar, region where it is grown, climate, and other variables. Most malt we buy is blended to even out local variation; some of the more renowned cultivars of barley I will mention later. There are only two different types of barley used in brewing: 2 row and 6 row. Only North America uses 6 row to an appreciable extent for brewing. It has slightly higher diastatic power, and possesses a stronger, grainy flavor, which is one of the reasons believed that US Pilsners evolved towards the heavy use of adjuncts such as rice and corn to lighten the flavor. A detailed discussion of the differences between the two can be found here:
http://brewingtechniques.com/bmg/schwarz.html#spike

An excellent general barley info resource can be found here:

http://oregonstate.edu/instruct/css/330/five/BarleyOverview.htm#BarleyMaltingQuality

The Base(or Brewer's) Malts:

Name	Color Range	Flavor Notes	Beer styles
Pilsner/lager malt	1-2	Light	All
Pale malt (US) (2 & 6R)	1.4-2.5	Light	All, 6R usu higher L
Pale malt (UK)	1.5-4.5 (Maris Otter highest)	Many employ slightly higher kilning than US	All ales, esp English
Vienna Malt	2.4-4	Dry toasty lightly malty	Vienna lagers Marzen/Octoberfest
Mild Malt	4L-6L		Brown Ales
Munich malt	8-15L (sometimes denoted by I and II)	Very malty	Dark German Lagers: dunkels and bocks
Wheat Malt (red&white)	White 2-2.5 Red:3-3.5	Smooth, grainy,bready	Wheat beers

Specialty Malts:

Carapils/Dextrin Malt	1-2L	None: adds head retention & mouthfeel	All, especially useful in darker beers
Cara-vienne	15-20	Malty-caramel	
Cara-munich	30-50	More malty-caramel	
Caramel/crystal	10-160	Sweet, nutty, caramel,toffee (see below)	Many, higher L's used in scottish,red, and some dark ales
Amber malt			
Victory malt (toasted)	25 (must be mashed)	Similar to Buicuit, nuttier	
Biscuit malt (toasted)	25 (must be mashed)	Bready, biscuit flavor, toast crust	
Brown malt	100-200	Dark roasted, coffee notes at times	Brown ales, porters, cream stouts
Special B	150-220	Roasted, toffee, raisiny	Many Belgian styles, esp Trappist
Chocolate (barley usu but wheat and rye available)	300-400	Chocolate(?), nutty,roasty	
Black patent	450-500	Intense roast/charcoal	
Roasted Barley	500-600		Signature ingredient in stouts
Peat malt		peaty	"Inappropriately" used in scotch ales
Smoked malt		Smokey, meaty	Rauchbiers
Honey/brumalt/melanoidin	25-40	Intense malty flavor	Many styles
Debittered black malts: carafa dehusked I-III	300-500	Much milder via dehusking, used to color	Black lagers, others
Aromatic malt	16-24	Strong malt aroma	Can be used as base malt

The crystal/caramel malts encompass a very wide range of kilning methods and accompanying flavor profiles that they are impossible to characterize as a whole. For tasting purposes, I brought a variety of crystal malts to help gain an appreciation for their flavor characteristics. The table above is not complete by any stretch as maltsters are always concocting different specialty malts. The terminology is a bit confusing: generally the term crystal is used in the US/UK and caramel (often hyphenated by cara-XXXX) is favored on the continent.

In today tasting session, we will experiment with some of these specialty malts by adding them to light American pilsner style beer. Because the teas have not been fermented, they will add more sweetness than would be typical were they mashed or steeped and then added to the brew kettle. At any rate it is hoped this will provide some appreciation for the flavor and aroma characteristics these can impart to a brew.

In practice, specialty malts comprise a small portion of the overall grain bill: usually between 5 and 30 percent. Sierra Nevada Pale Ale for example is made from roughly 90 percent pale ale malt and 10 percent 60L crystal malt. Stouts which use roasted unmalted barley do so in very small amounts—a five gallon batch may use 10 to 15 pounds of grain, and only a few ounces of this will be roasted barley. In general, the lower the Lovibond number, the larger the portion that a specialty grain malt can be before completely overwhelming the beer.

Adjunct Grains

Oats, should be instant oats or rolled		Silky mouthfeel, body, may interfere with head retenention due to oils	Oatmeal stout, porter
Rye		Spicy, intense flavor, used in small amts (<15%)	Roggenbeir, American Rye beer
Rice		Little flavor	US and Japanese pilsners
Corn		Little flavor	US Pilsners, British bitters
Unmalted Barley, often flaked		Grainy, increased head retention	Typically darker styles like porters and stouts

Tasting Notes:

Base malts beers were created by mini-mashing 1.5# of grain of varying proportion into wort of 1.048-1.052 starting gravity that was hopped using Hallertaur as a boiling hop. The same amounts of hops were used for each beer; if there is a noticeable difference in hopping rates, this is unintentional. Specialty and sweeter base malts will require on average a greater amount of hops to provide a good balance to the finished product, and may be one reason why the hopping rate may seem to vary between the different brews.

Beer 1: 1.5# of 2 row pale malt

Beer 2: 1# of mild malt (Breiss/Ashburne), 0.5# of pale ale

Beer 3: 1# of malted wheat (red) and 0.5 # of pale ale

Beer 4: 1# of Munich II malt, 0.5# of pale ale

Any of the base malts can be used in amounts up to 100 percent; this is not entirely practical, however, as the huskless wheat malt is very difficult to mash/sparge without some means of forming a filter bed (rice hulls can be used). Another example is the Munich malt: 100 percent here tends to be a very cloying beer according to friends who have tried this.

As to styles, I think it is important to remember that there are at least a few ways to skin a cat, and so too with beer: for instance, one could make a perfectly acceptable Brown ale by using almost all mild malt or by using crystal and judicious amounts of darker malts such as brown or chocolate. Malts might be the backbone and even the entire skeleton of the beer, but just as important in fleshing out the final product are the yeast (and other critters in the case of Belgium brews), fermentation temperatures, and hops used. The only exception is to this rule of thumb that comes to mind is color: the malts determine the color: nothing short of dilution with water can lighten the product once made, and even long boil times will only darken the beer somewhat.

Finally, a few words about cultivars. Some cultivars have become sufficiently renowned that they have become almost synonymous with certain beer styles: the practice is most prevalent in the UK where Maris Otter (English), Fawcett Optic(English), and Golden Promise (Scottish) are preferred in certain styles. Elsewhere Moravian malt originally grown in Czechoslovakia is prized for its full malty character in Pilsners. Here in the states it is used in Coors. Generally when trying to produce a beer from a specific region, it is helpful, but by no means necessary, to obtain grains from the same area.