White Wine Being Made

Dr. Richard Smart, the flying vine doctor from Australia, opened the “hang time” seminar in St. Helena in 2005 by stating that humans have a lot of nerve calling themselves “winemakers”. Yeasts are the winemakers, we just guide them along.

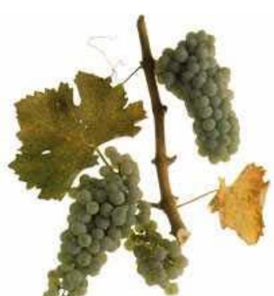
If you went out and picked a few bunches of grapes, crushed the berries with your hands and placed them in a bucket and came back in ten day, poured the liquid from the bottom of the bucket through a spaghetti strainer, the liquid collected is probably a very drinkable wine. Now, how can we humans participate in this process and maybe even improve upon it?

Let’s walk through production of a white wine.

A sauvignon Blanc is desired. Sauvignon Blanc is usually quite distinctive and one of the easier varietal wines to recognize by its often sharp, aggressive smell. The most common smell found in sauvignon blanc-based wines include:

Sauvignon Blanc Smell and/or Flavor Elements	
Varietal Aromas/Flavors:	Processing Bouquets/Flavors:
Herbaceous: grass, weeds, lemon-grass, gooseberry	vanilla, sweet wood
Vegetal: bell pepper, green olive, asparagus, capsicum	butter, cream
Fruity: grapefruit, lime, melon	oak, smoke, toast
Aggressive: mineral, "catbox"	flint

With naturally high acidity, Sauvignon Blanc is always high in acid, and this character pervades even sweet and dessert versions, keeping them from being cloying. Dry-style Sauvignon Blancs are very versatile in accompanying foods. Sauvignon Blanc is probably the best dry white wine to accompany the greatest variety of foods.



Sauvignon Blanc © Tim Ramey

So, let’s examine four possibilities of wine style that can be made.

1. A fairly low-body, high acid, somewhat herbaceous wine,
2. a medium bodied, moderate acid, citrusy and straw like wine, or
3. a full bodied, low acid, fruity, smoky wine,

4. a late harvest Botrytized dessert wine.

If we pick the sauvignon blanc from a cool region vineyard like Anderson Valley or the Carneros, it can come it at 19 °Brix, 1.0 TA and 3.10 pH.

The winemaker may decide that tannins are the least desirable thing in Sauvignon Blanc. Most of the tannin comes from seeds, skin and stems. So, the winemaker sends the uncrushed grapes directly to the press to remove the juice before it can be in contact for any duration with the tannin sources. However, most of the wine flavor is in the skins. So, the tradeoff is “softer”, non-astringent wines with not quite as much varietal character.

The next winemaker wants a bit more varietal character and will tolerate a bit of tannin. This winemaker will crush and destem the grapes and pump the “must” directly to the press.

The third winemaker wants varietal character and knows that skin contact is needed. Any astringency problems can later be confronted with fining or blending. This winemaker sends the crushed, destemmed grapes to a tank for prolonged skin contact. After a period, the juice is drained and the pomace is sent to the press for the final squeezing.

Now, let’s go back to the beginning. Deciding when grapes are mature and ready to pick is a very inexacting task. Even though many different methods of measuring grape maturity have been proposed, none can be said to correlate with wine quality. So, your guess is as good as mine. For the time, we’ll just look at soluble solids, total acidity and pH.

When the grapes are picked, we can crush and remove the stems or keep them as whole berry. If we send the uncrushed bunches of grapes to the press, we will squeeze the whole berries until all the juice is released. That juice will be placed in a tank for the next step.

Crusher-stemmers can be either rollers or perforated cylinders with rapidly spinning paddles. The stems are removed because they may add green flavors, astringency and bitterness to the wine during fermentation – though they are sometimes kept. Crushing breaks up the large cells in the flesh of the grape fruit releasing the grape juice as ‘free run’ juice, but it does not break down the cells within the skin or the seeds which are crucial to red wines in particular. The mixture of pulp, skins and seeds obtained after crushing is called ‘must’.

No matter how we handled the fruit, we still must decide on addition of SO_2. We can decide to add no SO_2 or as much as 125 ppm (rarely higher). Clean, low pH grapes can often be made without SO_2 addition. The yeast will produce SO_2 during fermentation. Making white wines from grapes that have no SO_2 added has been shown to have lighter, greener colors, more delicate fruity noses and the TSO_2 at time of bottling is substantially lower. This is especially true when pH is <3.30. As some people are sulfite allergic, low TSO_2 can be important. Remember, in The U.S., wine labels must state “CONTAINS SULFITES”.

Why add SO_2? The primary yeast that ferments grape sugar to wine is *Saccharomyces cerevisiae*. Non-*Saccharomyces* yeast is much more sensitive to SO_2 than strains of Saccharomyces *cerevisiae*. The addition of 30-50 ppm SO2 to the fresh pressed must or crushed grapes limits the growth of non-*Saccharomyces* yeast. The *Saccharomyces* yeast gain an advantage and grow from less than 1,000 cells per mL to between 10^7 and 10^8 cells per ml to dominate the fermentation.

we can now send the must (crushed grapes) directly to a press. Let the free run drain into the press pan and then press out the remaining juice.

No matter if the juice was pressed as whole berries or crushed and pressed or no some or no SO_2, we have new choices to make.

1. We can chill the juice (to maybe 45 °F) or
2. leave it at cellar temperature.

Chilling will keep it from starting to ferment. It will also allow the grape "solids" to settle to the tanks bottom. We can let the juice sit and settle for a few hours or overnight. Then, the cleaner juice is racked off the juice lees. The juice lees can be cleaned up with a filter or other means and fermented separately. Sometimes these juice lees wines are quite good and are blended back in with the main lot of wines.

3. Or instead of juice settling, we can run the juice through a rotary vacuum filter, a decanter or centrifuge.

In all cases, we're trying to "clean up" the juice and remove solids. The solids can lead to faster fermentation. Sometimes the solids have sulfur left over from dusting for powdery mildew control in the vineyard. This can lead to production of H_2S (rotten eggs) during fermentation. Some winemakers want to ferment in contact with high solids. They'll try to start fermentation directly out of the press. They either control the fermentation with greater tons of refrigeration or like the character of wines fermented more quickly at higher temperature.

4. Since most of the secondary metabolites (flavors) in grapes are in the skins, some winemakers want skin contact. The must is sent to a holding tank for several hour or overnight. The juice then stays in contact with the skin, pulp and seeds. Leaving the juice in a skin contact state is extracting possible flavor compounds and phenols and is inviting fermentation to begin. To prevent this unguided fermentation from commencing, the grapes could have had SO_2 added or the must can be chilled to 45 °F. Once the skin contact has been completed, after, say 24 hours, the "free run" juice is drained away and the pomace left behind is sent to the press to collect the remaining juice. With the present-day tank presses reaching a maximum of 2 atm of pressure, the press juice is of good quality and can be sent to mingle with the free run. Now, as did the direct to press winemaker, you have a tank of juice loaded with solids. The same options exist as to how to handle the juice.

Now, we have to see if our guidance can be beneficial. First, we want to reanalyze the juice for °Brix, TA and pH. All will change because the original measurement was on a smaller sample and dyer sugars will go into solution. Plus, some of the acid will have combined and the TA will generally be lower and pH higher than before.

Sometimes, the winemaker may feel there is not enough acid in the juice. That has to do with experience with a variety and vineyard and the wine style to be made. After crushing, the winemaker has to ensure that the 'must' is ready for fermenting. One very important factor is the pH of the grape juice which should be below about 3.5. This is because the yeast used in fermenting works best at these pH values and also because the sulfur dioxide which is added to the must to prevent it oxidizing in air is most efficient at these low pH values. As well as considering pH the wine maker should consider titratable acidity TA which measures the total concentration of acid including un-dissociated molecules of weak acids. The TA can be raised by adding tartaric acid. This is especially worth studying when picking grapes at higher sugars and lower acids. Prior to fermentation, it is generally important to have a juice with a TA of 0.85 g/100 ml. If the juice is below this, 8 lb of tartaric acid can be added per 1,000 gallons (#/M) of juice to raise the TA 0.10 g/100 ml. This is called acidulation. The tartaric acid is dissolved in water, before adding.

Many other items can be analyzed, but an important one is the nitrogen. Nitrogen is needed for healthy fermentation. Yeasts need nitrogen during their growth phase and throughout fermentation. The best way to calculate how much nitrogen should be added to a juice is to test ammonia nitrogen and alpha-amino nitrogen (NOPA). The sum of these measurements is called "Yeast-Available Nitrogen" (YAN). If the juice is deficient in nitrogen and nitrogen should be added, It is very important to break supplements into portions instead of adding them all at once. The most popular N-supplement used is diammonium phosphate (DAP). The addition scheme follows:

1. Add 1/3 of the needed DAP at yeast inoculation.

2. Add 1/3 when fermentation is fully active and Brix has dropped at least 2 degrees. At this point the yeasts have taken up most of the nitrogen present in the juice, especially ammonia N.
3. Add 1/3 at or just before midfermentation, before 10 Brix. When yeast growth has stopped, but the alcohol level is low enough that yeasts can still take up nitrogen.

YAN Guidelines (juice YAN plus added YAN):
21 Brix or less 200-250 ppm YAN
23 Brix 250-300 ppm YAN
25 Brix 300-350 ppm YAN

So, you now know if your grapes had enough nitrogen. Besides nitrogen, many winemakers add other nutrients and "superfoods" to boost their yeast performance. Many yeast foods are available.

Next, should the winemaker use wild yeast or should the juice be inoculated with selected yeast.
Wild yeast comes from many sources, but mainly it comes from the winery walls and equipment. The vast majority of European wineries use wild yeast. Plus, American wineries, like Ridge vineyards in Cupertino, have been using wild yeast since 1962. Wild yeast may produce more complex wines or introduce off characters. The wineries using wild fermentations successfully have developed a specific group of yeasts in their winery. Once the yeast population is in place, the risk is not so great.

It has been shown that in any winery, there is a local, resident *S. cerevisiae* population consisting of strains optimized for wine making and adapted to produce a set of compounds possibly involved in the formation of the local, individual bouquet. The logical and enological consequence of this observation is that, by means of a simple and inexpensive isolation from internal walls, any winery may obtain its own superselected starter with personalized bouquet characters. The scope of the evidence is to make winemakers aware of a new, easily accomplished, inexpensive, and certainly beneficial advance in the biotechnology of wine making.

It appears that the cultures of *S. cerevisiae* that initiated in the grape-must fermentation, when the particular winery first came into activity, underwent radical modifications of their characters over time. Furthermore, a genetic selection occurs in each winery, leading, vintage after vintage, to a progressive adaptation of resident *S. cerevisiae* populations to the nutritionally extreme conditions of grape must. A selective pressure may have been operating that limited environmental factors such as ethanol level in favor of vigorously fermenting strains; or sugar concentration in favor of strains capable of fermenting in adverse osmotic conditions; or high concentrations of SO_2 in favor of strains resistant to its action. A winery-restricted annual cycle of *S. cerevisiae*, implying a recurring flow of cells from surfaces to freshly pressed musts and a return at vintage to winery surfaces after a series of about ten generations (multiplied by the number of vats and the total volume of must fermented), may actually have provided enough variability for a selective optimization of resident strains.

Another noteworthy observation derives from comparison of the chemical analyses of wines obtained with the best performing cultures isolated from each of several regions. Small lot fermentations were carried out on the same sterile grape must (Pinot gris) using 18 different starters. Data, derived from 14 different bouquet-affecting compounds analyzed in the 18 obtained wines, were studied by principal components analysis. The first and second principal components were identified, and these accounted for 54% of the variance. Different strains of yeast should be used for different conditions. For example, specialist yeasts are chosen for conditions in which the must is very acid (pH less than 3.0) the must contains a lot of sugar - in this case, a high concentration of alcohol could be produced and an alcohol tolerating yeast should be used the must has limited amounts of nutrients which are important for the growth of some yeasts. Beyond encouraging varietal expression, yeasts are increasingly cultivated to meet new functional demands in the winery as well: to improve color stability, enhance mouthfeel, tolerate a broader range of fermentation temperatures and accomplish two or three things at once. Yeasts tend to become less active as the alcohol concentration increases, and special yeasts must be used in making high alcohol wines. In general, the strongest wine that can be produced during fermentation has an alcohol content of about 14% - above this level, yeasts become inactive.

With the obsession to make "fruit forward" wines, many winemakers are demanding their grapes hang and concentrate prior to harvest. Loads of flavor, but lots of alcohol results. Wine tends to taste "hot". Many wineries must resort to reverse osmosis or spinning cones to remove alcohol. Surprisingly, in a recent informal survey of winemakers and researchers, No. 1 on the current list of yeasty preoccupations is the challenge posed by rising alcohol levels. Work is being done to find yeast strains producing lower amounts of alcohol at given sugar levels.

There are dozens of commercial yeast strains available, each with different attributes. Most yeast used for fermentations in the U.S., are in a dried form and need to be rehydrated prior to use. The juice needs to be inoculated with a yeast starter. The starters can be made with the directions given.

So, a yeast source is chosen. The juice is inoculated with yeast starter in a non-temperature shock method.

Where will the white wine be fermented?
1. Should it be fermented at 45 °F in jacketed stainless steel tanks for 30+ days to produce very fruity wines?
2. Should it be fermented in 60-gallon (225-liter) oak barrels or 120 gallon (500-liter) oak puncheons? To control the fermentation temperature the barrels and puncheons must be placed in air conditioned rooms.
3. Or, maybe the winemaker wants to ferment in 1,000 to 3,000 gallon oak tanks and control fermentation temperature with shell-and-tube heat exchangers.
Other choices are also available.

The use of wooden containers for fermenting, or later aging, should be studied. Fermenting and aging wine in wood containers does two things. First, a wood flavor can be extracted from the wood by the juice or wine. Second, the wooden container helps age and softens the wine more quickly than tightly sealed containers like stainless steel.

The putting of wood flavor into the wine has many possibilities. The type of wood from which the container is constructed is one of the primary choices. The size of the container must be decided. The age of the container is important. The use of wood alternatives to give wood flavor is very popular. Let's look at three possibilities.

1. The winemaker wants wines with toasty, vanilla bouquet in the wine. The container of choice would be 60-gallon, oak barrels, with wood from the center of France. Maybe 20% Hungarian oak.
2. The winemaker wants a wine with oak as a spice and not to be obvious. Two possibilities exist. The container of choice would be 120-gallon puncheons, with wood from the center of France or Hungary. Or, use 60-gallon barrels that are two years old.
3. The winemaker wants wood character in their mid-priced white wine. Barrel or puncheon fermenting and aging would be too labor and capital intensive. So, the container of choice is a large jacketed, stainless-steel tank. Once the fermentation is completed and the wine filtered, the winemaker would place oak alternatives in the wine. They could be in the form of barrel inserts, chains of oak or oak chips. There are other practices, like micro-oxidation, that can help age the wine in conjunction with the oak addition.

Comparative approximation of cost of using barrels versus oak alternatives (excluding labor)-2006

Oak Addition	French Oak Barrel	American Oak Barrel	Barrel Insert (FO)	Chain of Oak (FO)	Chips (FO) (0.6 lbs)
Cost	$700	$300	$150	$100	$6
Cost per	$2.33	$1.00	$.50	$.33	$.02

bottle (one fill)					
Cost per bottle (4 years usage)	$.63	$.25	$.25 (2 years)	$.16 (2 years)	No reuse

The rate of aging wine in wood containers depends on the container dimensions. The ratio of the volume of wine stored in the container and the surface area of the wood in contact with the wine will determine the rate of oak flavoring and aging.

Cooperage: Volume to Surface Area

<u>Container</u>	Volume <u>(gal)</u>	Height <u>(in)</u>	Diameter <u>(in)</u>	Surface Area <u>(in^2)</u>	In^2 per <u>gallon</u>
barrel	60	36	27	2,915	48.58
puncheon	120	43	36	4,804	40.03
Upright	950	90	56	20,749	21.84
Upright	1,840	130	64	32,226	17.51

Enzymes are basically reaction catalysts. They facilitate and increase rates of natural chemical reactions. They exist naturally. It is felt by some winemakers that they also promote fruity characters and reduce off-characters in the resulting wines. Enzymes called 'pectinases' can be added to break down the large peptide molecules in the grape solids, producing a greater yield of juice. They are added at the time of crushing. Certain enzymes are targeted for white, pink and red wines. They are generally granular pectinases and betaglucaneses. Manufacturers provide a lot of technical data and recipes for using enzymes.

Another additive to white juice is bentonite. Bentonite is clay used in removing unstable proteins from finished white wines. The argument is to use it on the juice. In doing so, it leads to less handling of the wine later on, the bentonite settles with the juice lees, it improves juice clarification, it partly fixes oxidation compounds and gives cleaner tasting wines. The problem is that the amount of bentonite needed could easily change as the pH changes and it would need to be added again.

The temperature the barrel fermentation room will also define the wine style. Very cold, slower fermentation, gives fruitier wines. As temperature increases vinous character increase and fruity characters decrease. The same is true for the temperature control in tank fermentations.

Fermentation releases a lot of heat energy which could raise the temperature of the must to levels which would kill the yeast, so good cooling must be provided. The large amounts of carbon dioxide gas produced are also potentially dangerous to people working in cellars which must be well ventilated.

Yeasts catalyze the fermentation of sugars in must to ethanol and other by-products (which may contribute satisfying bouquets to the wine). When air is present (as it may be at the beginning of fermentation) *respiration* takes place while *fermentation* can start once all oxygen is used up.
The relevant equations are:

In the absence of air $C_6H_{12}O_{6\,(aq)} \rightarrow 2C_2H_5OH_{(aq)} + 2CO2_{(g)}$ $\Delta H = -98.5\ kJmol^{-1}$
In the presence of air $C_6H_{12}O_{6\,(aq)} + 6O_{2\,(g)} \rightarrow 6H_2O_{(l)} + 6CO_{2\,(g)}$ $\Delta H = -2825\ kJmol^{-1}$

It is important to keep oxygen away from the wine during the main fermentation, but the carbon dioxide produced forms a barrier between the must and surrounding air.

The optimum temperature for yeasts is about 25°C (77° F), and above 30°C (86 °F) the growth of yeast is seriously restricted and fermentation may stop. However, fermentations at different temperatures result in different amounts of other useful products, and fermentation at low temperatures (7°C (45 °F) or even less) may cease before all the sugars have been consumed.

Fermentation produces a lot of carbon dioxide gas – about 40 times the volume of grape juice. In large fermenting vats this forms a blanket over the top of the vat preventing oxygen in the air attacking the must. However, it can build up to levels which are dangerous for humans in closed cellars and these must be well ventilated. Smaller fermentation vessels (such as those used by research teams) need to be provided with a fermentation bung which allows carbon dioxide to escape while preventing air from entering.

So, the fermentation is going. Let's assume we will let the fermentation be completed and all the fermentable sugar will be used. The wine is dry. Once dry, action must be immediately taken to retain the wines freshness. First, the wine must be tasted (actually, smelled) to make sure it is clean and has no off characters. At the end of fermentation the yeasts (which have multiplied during the fermentation) deposit as lees. The biggest fear is the presence of H_2S. Rotten eggs. If it has off characters the wines must be immediately racked off the yeast lees. Analysis must be done on the wine and a solution found immediately. Delay can lead to catastrophe.

Even if not stinky, the winemaker has other choices not predicated on overcoming a problem.

Now, we can rack the wine off the lees to full tanks, barrels, puncheons, etc. This will allow the wine to become clear as a result of having the solids in the wine to settle with the aid of gravity. This can take a few months, or so. It can settle more quickly if the rooms in which the wines are stored are cooler.

Another choice is to pump the dry wine to a filter and make the wine immediately brilliant. After filtration, the wine must be stored in full containers.

A further choice is to simply top up the fermentation tank, barrel or puncheon with the same wine and leave the wines *sur lie*. What is *sur lie*? In French that's "on the lees". Before fermentation begins, a yeast population must go through a lag and growth phase. Once it builds the needed population, fermentation happens. During fermentation, the yeast populations are 80 to 120 million cells per ml. Or, in one drop of fermenting grape juice, there may be 5 million yeast cells. After fermentation is completed, the yeast dies and settles to the bottom of the fermenting tank. Normally when this occurs, the wine is racked of the yeast lees.

Sur lie is most widely known in sparkling wine. Adequate aging of wine, *sur lie*, is needed to develop roundness in the body, increase complexity and retain the wine freshness. During the secondary fermentation in the *Méthode Champenoise* process of sparkling wine production, there is an accumulation of amino acids from the *cuvée* into the yeast cells. When the sugar is depleted, the fermentation ends. The yeast will then restore the amino acids back to the wine. This is a free exchange and not autolysis. After this excretion of amino acids at the end of the secondary fermentation, the amino acid concentration in the wine remains unchanged for several months. Yeast autolysis (cell breakdown) then begins and the amino acid concentration in the wine slowly rises. The amino acid concentration during yeast contact does not vary significantly between the 3rd and 12th month of contact. The amino acid concentration does increase between the 12th and 43rd month *sur lie*. After 6 months, the sparkling wine contains 12% greater amino acid content than the *cuvée*; 24.5% greater after 12 months and

25% greater in 4 years the wine contained amino acid content than the *cuvée* base wine. The greatest activity took place between 9 and 12 months. Autolysis is dependent upon such parameters as pH, alcohol content and temperature. Elevated pH significantly increases the rate of autolysis. This gives advantage to wines completing Malolactic fermentation before starting *sur lie* aging. It is known that aging wine at elevated temperature accelerates the autolysis, but can reduce bubble retention and sensory attributes in sparkling wine.

The Grand Cru chateau of the Côte d' Or all use *sur lie* aging of their Chardonnay, e.g. two of the greatest chateau, Domaine Coche-Dury gives 10 months and Domaine Étienne Sauzet 12 months of *sur lie*. At Louis Latour's Chateau Corton Grancey in Aloxe-Corton, their Pinot noir is drained and pressed from the fermenting tank while still not dry. The wine is placed in barrels and the fermentation proceeds. Upon dryness, the barrels are topped and the wine remains *sur lie* until removal for bottling in 18 to 24 months. After *sur lie*, the wines are found to retain their freshness longer, have increased middle body, have silky textures on the palate and develop more complex noses. The risk is the possibility of picking up off characters from the lees.

To increase the benefit of *sur lie* aging, the wines should be gently stirred every couple weeks to distribute the amino acids better.

In all cases, as soon as the dry wine is in a full tank, it must have the FSO_2 raised to 25 ppm, or so. This prevents oxidation and aids in microbiological stability.

The winemaker may decide that the wine should undergo malolactic fermentation (MLF). However, the bacteria which promote MLF are more sensitive to sulfur dioxide and if this is required during fermentation the presence of sulfur dioxide from the must can be an issue. Generally, lower levels of SO_2 will be sought. Some winemakers add no SO_2 if MLF will be started. The wines must be watched carefully. The ideal wines to undergo MLF are between 68° and 77° F, have alcohol less than 13% (v/v), pH above 3.4, TSO_2 below 25 ppm, and low levels of short and medium chained fatty acids, low levels of organic acids and low levels of polyphenols. Only a few of these things will be measured by wineries and in most cases, the winemaker just wants the MLF to take place.

Grapes contain small quantities of 'malo-lactic' bacteria which convert malic acid into lactic acid producing carbon dioxide as well. Sometimes this MLF can be unwanted. However, it is often promoted by the winemaker because the process reduces the overall acidity of the wine. The bacteria may or may not start, so if MLF is desired, selected bacteria can be used to inoculate the wine. The primary ML bacteria are stains of *Oenococcus oeni*. They also can be purchased in freeze dried form and have good preparation instructions.

Malo-lactic fermentation is catalyzed by enzymes in the bacteria. The equation for the reaction is

$$COOH\text{-}CH(OH)\text{-}CH_2\text{-}COOH_{(aq)} \rightarrow COOH\text{-}CH(OH)\text{-}CH_{2\,(aq)} + CO_{2\,(g)}$$

Now, we have completed the primary (alcohol production) and secondary (MLF) fermentations. We spoke earlier about alcohol yield and yeast. *S. cerevisiae* generally produced a wide range of alcohol levels. If you take the °Brix and multiply by 54% to 61%, you'll get the expected alcohol (% by volume) range. If the 22° Brix juice is fermented very slowly at 45 °F, it will probably produce a wine of 13.4% alcohol. The same juice fermented rapidly at 80° F, may produce a wine of 11.9% alcohol. The lower temperature, slower fermentation retains more volatile compounds, including EtOH.

Before processing is complete, wines are often cloudy due to the presence of suspended solid materials such as yeast cells, particles of skin and so on. Removal of the suspended material is called 'clarification' and involves a number of different techniques.

Racking is the process of allowing the lees to settle and then decanting the wine from the lees.

Fining can be quite an art, and it can take a lot of experience to know just what fining agent to add and how much to add in order to precipitate out the cloudiness from the wine without leaving behind new impurities. Fining is the addition of a material such as bentonite (a type of clay) or gelatins which adsorb the particles and precipitate them out.

Bentonite is a type of clay which absorbs proteins and other impurities.

White wines normally do not require fining agents, except for bentonite. It they have an unwanted astringency or bitterness, fining may be in order.

Isinglass is made from the swim bladders of certain fish. It is also a protein which removes phenolics and other proteins from wine and from beer. It can produce very clear wines, particularly white wines.

Milk products including casein are often used to remove unpleasant flavours from white wines.

Filtration is one of the important ways of clarifying wines and many different filters are available to winemakers. Filtration can also remove solids, yeast cells and bacteria.
Filtration is carried out after racking has removed the gross lees, and often after centrifugation has removed most of the remaining solid particles. In order of usage filtration techniques include

1. Diatomaceous earth filters: the earth is added to the young wine, trapping solid impurities.
2. Cellulose (“Pad”) filters made from fine fibers: these can be made fine enough to remove yeasts and bacteria. They work both by trapping particles in the small spaces between the fibers and by adsorbing particles onto their surfaces through electrostatic attraction.
3. Membranes: these are best used for final clarification before bottling. They can remove microorganisms left over in pad filtering.

Once bottled, wines can still undergo chemical reactions which produce precipitates or cloudiness. These include bottle crust in red wines, potassium bitartrate crystals in all wines and heat haze resulting from unstable proteins. Stabilization is the process of removing the chemicals which cause these precipitates before bottling. It must be done carefully, because over stabilizing can actually remove interesting tastes from the wines and so reduce their quality.

Heat haze generally occurs only in white and pink wines. Amino acids are a range of organic compounds containing the amine $–NH_2$ and acid –COOH functional groups which are attached to a side chain R. They take part in two acid/base equilibria:

(*Remainder of amino acid molecule*)$–NH_2 + H^+ \Leftrightarrow$ (*remainder of amino acid molecule*)$–NH_3^+$
(*Remainder of amino acid molecule*)–COOH $\Leftrightarrow$ (*remainder of amino acid molecule*)$–COO^- + H^+$

Because of this, amino acids form ions which have both a positive and a negative charge. Such ions are called ‘zwitterions’. The *isoelectric point* for an amino acid is the pH at which the number of positive amino acid ions is equal to the number of negative amino acid ions. At pH *less* than the isoelectric point, the amino acid ions are mostly positive while they are mostly negative at higher pH values.

Proteins are essentially long chains of amino acids, and also form zwitterions. Bentonite binds to the positive protein zwitterions, precipitating them out from solution. Hence bentonite is more effective at low pH levels. As an example, one quarter as much bentonite is required to remove protein at a pH of 3.0 as at pH 3.6.

The main acid found in wine is tartaric acid. This forms salts with potassium and calcium ions, and these salts can precipitate out if the wine is cooled or if it becomes less acid. While the crystals formed do not affect the quality of the wine, they are unsightly. Winemakers generally try to prevent this happening by *cold stabilizing* the wine before bottling.

At the pH levels found in wine, tartrate ions participate in two main equilibria:

❶ $KHT_{(s)} \leftrightarrow K^{+}_{(aq)} + HT^{-}_{(aq)}$ (endothermic)

❷ $H_2T_{(aq)} \leftrightarrow H^{+}_{(aq)} + HT^{-}_{(aq)}$

Traditional cold stabilization involves cooling the wine to near freezing point, driving equilibrium ❶ to the left and (over a few weeks) precipitating out excess KHT. A number of modern techniques such as the 'contact process' and 'ion-exchange' have made the removal of tartrates much more efficient than before.

While most wine is drunk very soon after purchase, many wine lovers will keep a 'cellar' in which wines – particularly red wines – may be stored for many years. Winemakers keep this in mind when making their wines: some wines are made to 'drink now', while others are made for long term storage. The chemical reactions which take place in the bottle are complex. 'Drink now' wines will often have a very fruity taste, with the dominant flavours being due to fruity esters. Over time these degrade and the wine becomes less pleasant. Keeping wines tend to have a high proportion of tannins which soften over the years producing interesting flavours.

Since white wines do not contain significant anthocyanins and have much less tannin than red wines, the aging process in white wines is not well understood. There is often some color development, possibly due to flavones (a yellowish pigment) and there is a development in flavor. Some white wines will keep for many years, but it is generally thought that white wines do not keep for as long as red wines.

All of the above decisions must be made for making a medium bodied, moderate acid, citrusy and straw like wine, or a full bodied, low acid, fruity, buttery wine. The harvest dates will be later, sugars higher and acids lower. The resulting alcohol can depend on yeast strain and fermentation temperature and rate.

A very important part of winemaking must also be addressed. Blending.

If one had to find two grape varieties that define blending it would be Sauvignon blanc and Semillon.

The ripe Semillon berry is a rich yellow color at maturity, although increasing sun exposure may turn it amber-pink. If processed as a dry or semidry table wine, the thin skins and tender, juicy pulp require speedy but gentle handling.

Semillon Smell and/or Flavor Elements	
Varietal Aromas/Flavors:	Processing Bouquets/Flavors:
Fruity: fig, lemon, pear	Botrytis: apricot, quince, peach, honey, pineapple, vanilla, candy
Spice: saffron	Malolactic: butter, cream
Herbal: grass, weeds	Oak (light): vanilla, sweet wood

Vegetal: bell pepper, asparagus	Oak (heavy): oak, smoke, toast

Wines made with Semillon have fairly full body and tend to be low in acidity, even "fat" at times. This is the flavor profile of a supporting role grape, rather than a star, and most Semillon is blended. Semillon is the soft, subtle, rich Yin to balance the Yang of Sauvignon Blanc, which can be aromatically aggressive and acidic.

Semillon can be produced in the same manner as Sauvignon blanc. Blends can range from 20% to 80% Semillon. Different wine styles ensue.

BOTRYTIS cinerea is a fungal disease that can blight many species of plants, including flowers, fruits, and vegetables. Depending upon weather conditions, Botrytis can take one of two forms in grapes, one as destroyer, and the other as enhancer.

As "grey rot" it appears and grows during lengthy periods of humidity early in the season. Settling in on immature grapes, it multiplies rapidly. The grape bunches seem covered with a grey powder and the berries eventually darken and drop. Yields are greatly reduced and wine made from this fruit will taste moldy and oxidize easily. In some climates, grey rot is a severe problem with most all grape varieties.

In certain white grape varieties, such as Semillon, Sauvignon Blanc, Riesling, and Furmint, an infection of Botrytis can be so beneficial, even critical, to the production of dessert wines like Sauternes in France, Tröckenbeerenauslese in Germany, or Tokaj in Hungary, that the mold is called "Noble Rot" in these locales (*La Pourriture Noble* in French, *Edelfaule* in German).

Dessert wines made with botrytised grapes are prized and somewhat rare, because weather conditions must be just right for "Noble Rot" to occur. Ideally, a short period of humidity or rain in mid to late season, when the grapes are more ripe than green, will be followed by a sustained period of cool, dry weather, where daytime temperature hovers near 60° F.

Under these somewhat rare conditions, the Botrytis fungi penetrate the grape skins with mycelia to feed and take water from the grapes, which shrivel. Overall acidity decreases. Gums form, along with glutinic and citric acids, and the grape sugars become very concentrated.

This intense sweetness partially inhibits yeast and fermentation can be very slow, lasting for months. High concentrations of glycerol develop during these extended fermentations and the resulting wines can be fragrantly enticing, exceptionally smooth, and extremely long-lived, cellaring well for decades.

A production example…
2002 began as a mostly mild season. Frost in April and unexpected rain in May caused some uneven bloom and set during flowering. Summer brought long, mild days with a couple of heat spikes in mid-Summer creating some fast-ripening days. The result was highly concentrated and complex fruit flavors with modest per acre tonnage in a highly compressed harvest period.
The grapes for this wine were selected from a vineyard in southeast Napa Valley, where morning fogs linger and development of Botrytis cinerea is encouraged. The micro-climate provides ideal conditions for flavor and sugar concentration.
Vineyards were hand-picked at the peak of maturity. Following harvest, the grapes were gently crushed and fermented. The wines were then aged in three small, new French oak barrels with extended lees contact for twenty-six months.
This rich, complex Late Harvest Semillon delivers ripe tropical fruit accented by vanilla, orange rind and citrus notes. The generous fruit is balanced by firm acidity that complements the wine s sweet finish.
Technical Data:

- Varietal Composition 100% Semillon
- Alcohol 14.1%
- TA 0.82g/100ml
- pH 3.31
- Oak Aging 26 months
- Oak Cooperage French oak, new
- Appellation Napa Valley
- Production 163 cases
- Bottling Date February 15, 2005
- Harvest Brix 35º
- Brix at Bottling 9.5º