Book Review

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Proof: The Science of Booze[3]

By Adam Rogers. 2014. Mariner Books. Houghton Miflin Hartcourt. Boston, Massachussetts, USA. New York, NY, USA. 273 pp.
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Proof: The Science of Booze arrived in the mail at the end of a day we were visiting wineries in preparation for a course one of us (JASB) teaches, entitled *Bacteria, Fungi, and Fermentation*, as well as other professional activities.This book is not about scientific discoveries, instead, it is about "the fun part of doing" science (p. 6), "from yeast to hangovers" (p. 12). As Louis Pasteur, who in 1857 proposed that fermentation was caused by organisms, once said, "chance favours the prepared mind". In contrast, Justus von Leibig considered that fermentation occured in the absence of organisms and, with this, the so-called Liebig–Pasteur dispute – a proxy for the real philosophical battle, namely, vitalism vs. materialism - got started. Many scientific luminaries, from Lavoisier, guillotined in the French Revolution, to the Buchner brothers who lived towards the end of the 19th century, became involved in this research (pp. 15-34). Booze, however, initiated "the single most important event in human history." … "the social and economic revolution that allowed *Homo sapiens* [some 10,000 years ago] to become civilized human beings." (p. 5).

Money is part of the motivation (p. 108). Like "nutritional supplements", in the USA alcoholic (from the Arabic, *al-kohl*) beverages command billions of dollars yearly and market competition is vigorous. "In 2011, Americans consumed more than 465 million gallons of distilled spirits" (p. 9), an average of ca. 1.5 gallon (5.7 liters) per person, if one were to count everyone. Whenever there is money, the tax person often wants a piece of the pie. Regardless of the location of an alcohol-making operation intended to be for profit, one "can't

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[3] Carl Helrich (Allegro Winery, Brogue, PA, USA) provided us with immensely useful information on how wineries operate. Coincidentally, *Proof* arrived in the home of one of us (JASB) the day we returned from Allegro Wineries. Dr. Christian Butzke (Purdue University, West Lafayette Indiana, USA) directed ud to several important sites pertaining to the regulations of the wine industry in the USA.

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afford to loose your presence on the bar" (p. 17). In the case of aged wines and are consumed by more sophisticated drinkers, great care is taken in producing them. The investment, storage in warehouses, and the cost of money, and the long periods the money is tied up is a major concern to wine producers. Furthermore. in the context of the relatively narrow genetic variability of grapes, referred to as "grape racism" (p. 45), where some cultivars become "dominant", the competitive wine market pushes some growers to move to other markets and, for example, be "in the apple game" as new apple cultivars can be released "and if it does well, we can make a killing" (p. 45), or be very successfully economically.

Making alcohol is a multistep process (Figure 1). Numerous genetic (e.g. grape and yeast varieties) and environmental factors (e.g. nature and amount of additives) affect the quality enjoyed by the consumer. Production varies from year to year, from field to field because of weather patterns, but with good quality control in place, producers can put out good products consistently. Reassuring that one bottle, labelled "A", is the same as the next "A", is a concern and it brings the issue of quality control and standardization (p. 81) to the forefront. Standardization in the industry can be difficult to achieve as many alcohol makers have proprietary recipes, including in house batches of yeast. Nevertheless, certain attributes should not vary much. In the quality control protocols, organoleptic evaluation should be used along with chemical analyses. More predictable successes can be achieved by following good quality control protocols.

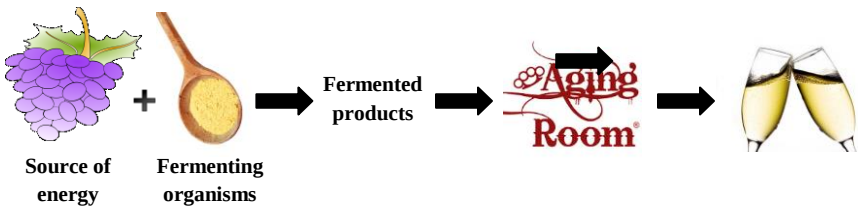

Figure 1. The preparation of an alcoholic beverage is a multistep process, herein greatly simplified. Under the proper environment, a source of energy (e.g. sugars in grapes) and fermenting organism (e.g. yeasts, *Saccharomyces* sp.), yield fermented products (e.g. alcohol + carbon dioxide). Many alcoholic beverages (e.g. brandy, rum) are concentrated through distillation (not shown); others (e.g. wines) are not. Eventually, the products are aged. During aging, more chemical reactions take place. Some alcoholic beverages, like champagne, require a secondary fermentation. The product of these steps (listed above and others not mentioned) may eventually be used for human consumption. All images from Word's Clip Art.

Yeasts: The workers. An essential part of an alcohol producing operation are the organisms that make the alcohol, yeasts, through the process of fermentation. The basic chemistry of the reaction of ethanol fermentation is

shown in Figure 2. Yeasts, generally unicellular organisms which are members of the Kingdom Fungi, transform the source of energy (e.g. sugars in grapes) into an alcohol, ethanol, and carbon dioxide in the absence (or low concentrations of oxygen). Additionally, some yeasts spoil food and others are disease-causing organisms.

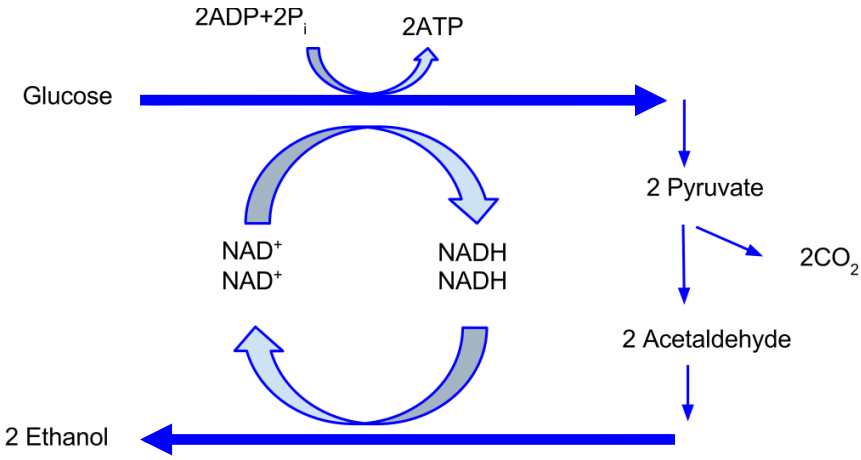

Figure 2. Simplified chemistry of fermentation in yeasts, *Saccharomyces* sp., beginning with glucose. According to Rogers (p. 68), perhaps yeasts evolved some 150 million years ago by feedings on exudates, the usually organic chemicals that many plants ooze, such as gums. As they "fed" on these products, ethanol and many other compounds were produced as a mechanism to get rid of metabolic waste products.Image from https://upload.wikimedia.org/wikipedia/commons/0/08/Ethanol_fermentation-1.svg , slightly modified. Author of original, Davidcarmark.

Although the term "yeast" often refers to members of the genus *Saccharomyces* (e.g. Brewer's yeast, Baker's yeasts), there are other more distantly related fungi which are also called "yeasts" as there are other types of fermenting organisms and types of fermentation (p. 33, https://pbmo.files.wordpress.com/2012/10/fermentation.jpg). Lost yeasts can mean decreased business, thus greater pains are taken to keep stocks of the many variants (or strains) of yeast known (p. 17, The [United Kingdom] National Collection of Yeast Cultures, http://www.ncyc.co.uk/). More yeast variants await discovery in nature (p. 32).

Sugar: A source of energy. Chemoanthropological evidence suggests that humans have been involved in the art and science of fermentation at least for the last 10,000 years (p. 61). Alcohol-producing yeasts do their deed beginning from relatively simple sugars. Wines come from *Vitis vinifera* L. (Vitaceae) grapes, it colors from the anthocyanins, mostly on the skin; the aromas and flavors from a host of other chemicals, including terpenes, in the grapes

(https://en.wikipedia.org/wiki/Winemaking). Yet, we could not help but wonder whether there may be other fruits that could beat *V. vinifera* grapes. Numerous other fruits generate other alcoholic beverages, through fermentation, such as cider from apples. Non fruity items are also used as base for alcoholic beverages. For example, *sake*, the national beverage of Japan, made from fermented "food", rice, begins its journey through the action of another fungus, a species of *Aspergillus*, that breaks down the starch in the rice. The species, *A. oryzae* (Ahlburg) E. Cohn (Ascomycota), produces smaller sugars that yeast can then then convert into ethanol. Amidst trying to improve the efficiency of *sake* production, the Japanese entrepenour working in the USA, Jokichi Takamine became rich and paid for the cherry trees that now ornate the Tidal Basin of Washington, District of Columbia, USA (p. 57).

Getting the booze. Fermentation is like painting with tastes and smells. An example close to home is the "Planta Piloto de Ron, built in R[í]o Piedras, … outside [Old] San Juan. This small pilot distillery was used to analyze all aspects of the rum making process from fermentation through distillation. Heading the research was Cuban born, Rafael Arroyo, who had begun rum-making research before the war and became known as the father of Puerto Rican rum." (http://www.ministryofrum.com/countrydetails.php?c=66, see also p. 72 of *Proof*). Often, makers of alcoholic beverages use different additives during fermentation and aging.

Distillation: Separating the alcohol from everythting else to further concentrate the booze. Maria, The Hebrew, a woman from one of the first three centuries of the common era, whose historicity is not clear, pressumably from Alexandria (Egypt), is credited for having invested the distillation technology (boil fermented product, make it rise through a column, and condense the evaporating product). Archeological evidence is not as old, dating only to the middle age. By the time of the Plague (also known as Black Death, circa 1350 CE), alcohol was well known. Different raw materials added to the fermenting mix will generate different amounts of ethyl alcohol and other chemicals, including alcohols with more than two carbon atoms (propyl-, isoamyl-, butyl- and pentyl-alcohol). Because fermentation by yeast produces many unwanted compounds, copper alembiques (from Arabic, *al-anbiq*) were introduced to chemically remove some of them from the distillate. In modern distillation, this can be achieved by double or even triple distillation, like in the case of vodka. That process produces almost neutral alcohol devoid of other unwanted chemicals. However, a number of alcoholic beverages are not distilled.

Aging. Tradiationally, the aging was carried out in barrels, although some alcohol producers use vats/tanks and add other materials. The barrels are either from French or American white oak (*Quercus* sp., Fagaceae). Other woods from other trees are favored in other circumstances (p. 121). As time goes by, the ethanol reacts with other compounds that may have codistilled with it, with the wood of the container, if such has been used, and a number of additives that

the alcohol beverage maker may choosen to add. In the case of wine, tannins from both grapes and from wooden barrels degrade to form new compounds as the wine ages in the bottle. Wine is normally aged (7 to 24 months in the barrel); liquors, on the other hand, can be aged up to 20 years. For wines, maturation also takes place in the bottle. Because the maturation of alcohol can last long (1-20 years for red wines), there is a lot of interest in accelerating the process without sacrificing quality (p. 128). What can be added to alcoholic beverages in the USA? In the case of wines, a tax collecting unit in the USA, the Alcohol and Tobacco Trade Bureau (ATTB) of the Department of the Treasury regulates what can be legally added to wines, http://www.ttb.gov/wine/wine_treating_materials.shtml and what must, at the minimum, be declared on the label, http://www.ttb.gov/labeling/index.shtml, http://www.ttb.gov/ssd/labeling_methods.shtml , http://www.ttb.gov/pdf/wine-labeling-guide.pdf , file:///C:/Users/jas1074/Downloads/p51901%20(2).pdf. Alcohol producers, however, are required to document well beyond the label what they do to the ATTB. Consumers rely mainly on trust when it comes to product health and safety as the government does not have the resources to test everything. As we were visiting wineries, the similarity between the chemical complexity of alcoholic beverages and that of plant exudates, of which amber is a fossilized resinous example, became evident. Yet, chemistry is not everything in an alcoholic product.

Smell and Taste and the rest of *Proof*. In spite of all the technology available to describe alcoholic beverages with great precision, at the end, "Our taste in drinks may have litle or nothing to do with how we taste drinks." (p. 159; see also Figure 3, herein). This makes me remember an article I once read "The perceptual ambiguity of wine helps explain why contextual influences—say, the look of a label, or the price tag on the bottle—can profoundly influence expert judgment. This was nicely demonstrated in a mischievous 2001 experiment led by Frédéric Brochet at the University of Bordeaux. In one test, Brochet included fifty-four4 wine experts and asked them to give their impressions of what looked like two glasses of red and white wine. The wines were actually the same white wine, one of which had been tinted red with food coloring. But that didn't stop the experts from describing the "red" wine in language typically used to describe red wines. One expert said that it was "jammy,"5 while another enjoyed its "crushed red fruit." Another test that Brochet conducted was even more damning. He took a middling Bordeaux and served it in two different bottles. One bottle bore the label of a fancy grand cru, the other of an ordinary vin de table. Although they were being served the exact same wine, the experts gave the bottles nearly opposite descriptions. The grand cru was summarized as being "agreeable," "woody," "complex," "balanced," and "rounded," while the most popular adjectives for the vin de table included "weak," "short," "light," "flat," and "faulty." " http://www.newyorker.com/tech/frontal-cortex/does-all-wine-taste-the-same.

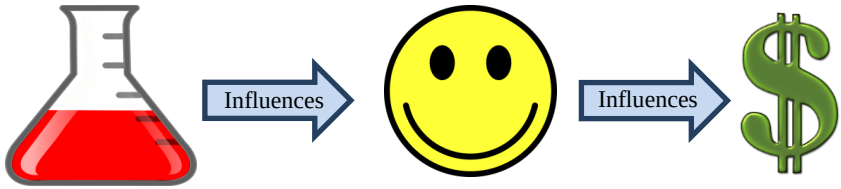

Figure 3. While chemistry influences the characteristics of alcohol and its likeability, many other factors, including psychological, are also important, and, ultimately, help determine how economically-successful the alcohol production operation operation is. For instance, most wine drinkers (consumers) pick a bottle of wine because they have drunk the same wine before and they liked it or, they pick a wine that has been recommended by another consumer. More sophisticated drinkers and collectors tend to look for nuances as they compare different wines. Although small, that segment of the consumer market is important because they purchase the more expensive, aged wines. A good wine should keep well and not degrade easily upon storage or transportation through regions with varying temperatures. Compounds that produce, puckering astringent, bitter astringent, velvety astringent, sweet and mouthful, salty, and sour sensations were recently identified. Monitoring those compounds in beverages could improve the quality and consistency of wines. Efforts to reconstitute wine from scratch have been carried out. However, regardless of a having all the necessary chemicals, if the wine does not taste well, it will not sell. Good wines should be easy to drink and the alcohol content should be about 13.5%. However, there are compounds whose quantities make a wine be classified differently. These compounds include total phenols, titratable acid-which contributes to the sweetness, sulfur dioxide, total solids (tannins and metals). Knowledge of how compounds that give alcoholic beverages good(or bad) flavor and how those compounds are produced can be useful in designing the beverage. For example, pyrazines, specifically 3-isobutyl-2-methoxypyrazine, are found in grapes. At high concentrations, this volatile compound, which has a vegetal, bell peppery odor, tends to be displeasing to consumers. It was determined that grapes exposed to direct sunlight accumulate less of the odorant than grapes in the shade. The production of 3-isobutyl-2-methoxypyrazine can be solved by simply pruning leaves from vines to expose grape clusters to more direct sunlight instead of filtering the troublesome compound with charcoal- which might also remove beneficial compounds. All images from Word's Clip Art.

Proof will be useful, interesting, and delightfully entertaining to anyone interested in alcohol fermentation of various botanical products, such as fruits, and grains to produce alcohol. Its numerous historical remarks and at times hilarious anecdotes will make readers dig in the booze beyond just drinking it. From now on, every sip you take will have the added meaning of knowing more how much it takes to get it from the source to your lips.