



Energy Drinks:
Where the Science Meets Main Street

June 30, 2009 | Fashion Institute of Technology | New York, NY



Energy Drink Manufacturers Have Successfully Hooked Our Youth: The Lucrative Scheme of Legally Selling Drugs in a Can

Conrad L. Woolsey, PhD

Bruce A. Goldberger, PhD

June 30, 2009

Supplemental

SUNY YOUTH SPORTS INSTITUTE

P.O. Box 2000 • McNeil Building • Cortland, NY 13045 • (877) 828-881 • www.youthsportsny.org



(Example of a young boy sponsored by Monster – picture from Monster energy website)

Energy Drink Manufacturers Have Successfully Hooked Our Youth:

The Lucrative Scheme of Legally Selling Drugs in a Can

Since the introduction of Red Bull in the U.S. in 1997, the energy drink market has grown exponentially with sales in North America increasing from \$200 million in 2002, to estimates between \$4.7 to \$5.4 billion in 2006. Energy drink (ED) use has increased so rapidly because of the addictive properties of these drinks and aggressive advertising campaigns targeting adolescent, young adult, and athlete populations. An example of this is often seen at sporting events where ED manufacturers give out free samples of their products to get people hooked. Then, once consumers are hooked on the initial positive pharmacological actions (how the substances work) of these drinks, companies charge \$2-4 per can to take full advantage of the addictive properties. What consumers might not know when they start using these drinks is that the initial positive effects do not last with continued use. As witnessed by widespread use and positive athlete testimonial such as 5-hour energy commercials, EDs appear to be perceived as safe and socially acceptable. However, the reality is that EDs and many of the herbal ingredients found within them are unregulated by the Food & Drug Administration (FDA) and have not been recognized as safe. The FDA does regulate the sale of caffeine pills at dosages as low as 100 mg to protect minors and the level of caffeine in soft drinks to 71 mg per 12 ounce container to protect consumers, but because EDs contain herbal ingredients they are considered as “dietary supplements” by the FDA (FDA, 2007). As a result, manufacturers have been able to deceptively include regulated drugs within their drinks, while avoiding regulation because they also contain “dietary supplements” which have allowed them to escape regulation and slip into this highly profitable and scandalous loophole. On the surface this lucrative scheme may seem reasonable, after all, EDs do contain vitamins, amino acids, and herbal ingredients that have been purported to have health benefits when used individually. Furthermore, ED companies pride themselves on the saying, “about as much caffeine as a cup of coffee.” However, EDs are more like a ‘pharmacological Molotov cocktail’ and contain combinations of several stimulant, anti-anxiety (e.g., taurine), and anti-depressant (e.g., inositol) agents that when used in combination go far beyond simply caffeine and have several conflicting biochemical and pharmacological interactions within our bodies. Additionally, EDs do not really supplement anything essential to our diet that we cannot easily and more cost effectively get from foods or in a much cheaper bottle of vitamins (e.g., B-complex). Some of the ingredients in EDs do have positive and supportive functions, but because of the leaching qualities of the stimulant drugs within them they do not supplement or make up for the deficiencies that they cause. The word supplement implies that EDs are good for us and give us things that we need, but in reality EDs work more like an ‘energy parasite’ in our bodies by rapidly releasing and depleting our natural hormones (adrenaline) and chemicals that give us sustained energy. As a result of this negative consequence, people and kids especially, feel like they need another drink to have energy so they keep buying expensive drinks chasing the ‘high’ they felt (knowingly or unknowingly) while on the energy drink. This firmly illustrates the hedonistic (if it feels good do it) and vicious cycle of dependency synonymous with other drugs of abuse. The only difference is that they are legal, but then again so are cigarettes and the marketing for cigarettes started the same way.

Currently, the manufacturers who are making billions of dollars selling EDs are the ones responsible for protecting the safety of consumers. This is clearly not happening as many are making riches and flourishing by marketing their products as legal alternatives to drugs with names like Cocaine, Dopamine, and Bump. By reading the advertisements and websites for EDs one can easily notice that companies talk about their drinks as drugs. Consumers need to be aware that the potential dangers to using EDs are now greater than when it was simply Red Bull. Many EDs now contain higher levels of caffeine and additional herbal stimulants that were previously not in EDs. For example, Redline and SPIKE Shooter contain caffeine levels approximately 3-4 times higher per ounce (250-350 mg/8 oz) compared to a traditional 8 ounce Red Bull at 80mg. More alarming is the rapid growth of energy shots containing 300+ mg of caffeine, with Redline Power Rush containing 350mg in just 2.5 ounces. Additionally, newer drinks such as Spike and Redline contain stimulants such as yohimbine HCL and evodamine (thermogenic known to cause rapid fat loss and a CNS shivering response), which pose greater dangers to consumers than caffeine because they are more powerful and most do not have a built up tolerance to these herbal-drugs.

The Power of Marketing

Athletes are continually bombarded with messages saying that EDs improve concentration, performance, and mood. In fact, people have heard so much about how EDs improve performance and concentration that many parents are buying them for their children. However, in a recent double-blind placebo controlled study at Oklahoma State University where we tested energy drinks on a dynamic performance skill (undisclosed due to copyright), we only found improvements when examining one-dimensional variables such as reaction time, which does not necessarily translate well into overall performance. Performers actually did worse on the overall skills tested (including concentration) because most performance skills are multi-dimensional and require coordination and sequencing of movements as well as the ability to focus on more than one thing at a time. Performers did perceive they were doing better, but actually made significantly more errors, due to being hyper-focused which is a common side effect of energy drinks. There are several contributing factors to this such as athletes' reduced ability to self-regulate their anxiety and stress levels. As a sport psychology consultant, I have worked with hundreds of clients and it has become a routine question for me to ask athletes' suffering from performance and anxiety related issues if they are using EDs. Most of the time they are regular ED users, and when ED use is removed from the equation, most have shown significant improvements. For parents and those involved with athletics this is an important consideration because people use EDs for the perceived positive benefits and people will continue to use them regardless of the negative consequences if they think that EDs will give them an athletic or academic edge. Once people realize that EDs are actually hurting their performance, it is still difficult, but much easier for them to choose to quit.

Energy Drink Ingredients

Although Red Bull is just one of the more than 500 EDs now available, we will start with it because it is still the most popular (partially due to its powerful monopoly within bar and nightclub scenes). The main ingredients found in Red Bull are sucrose, glucose, sodium citrate, taurine, glucuronolactone (synthesized metabolite of glucose), caffeine, inositol, niacin, D-pantothenol, pyridoxine HCL, Vitamin B12 and B6. Other popular EDs contain N-acetyl-tyrosine and L-carnitine (amino acids that support the synthesis of neurotransmitters), milk thistle, panax ginseng, guarana, yerba mate, yohimbine HCL, evodamine, horny goat weed, bitter orange (thermogenic and appetite suppressant), grape seed extract, and many others. A major concern for consumers is that EDs contain mega doses of vitamins and herbal ingredients which pharmacologically act like drugs in the body and are well above recommended dosages in just one 8 ounce serving. Furthermore, we know that many regularly consume multiple servings and more and more EDs contain 2-4 servings per container. Perhaps because of the looming probability that society will eventually go through a paradigm shift and take further notice of the reckless and highly profitable ED marketing schemes that are taking place at the cost of consumer health, many of the top selling manufacturers have lowered or set their caffeine contents to 80 mg per 8 ounces to match Red Bull, which is still over the FDA regulated limit for canned beverages at 71mg/12 oz. To move up in the market many companies have bumped up their strength, but the top sellers have stepped up to their negligent competition by making 'Monster' sized 16, 24, and 32 ounce cans/containers to keep up with stimulant increases. The bottom line is they are still putting consumers and our youth (especially those at lower bodyweights) at significant risk for immediate and/or future health consequences. Perhaps even at more risk for long-term consequences from overdosing on even more vitamin and herbal compounds in the larger serving sizes. At this point, we (including manufacturers) do not know the long-term effects that these ingredients will have, but we do know that too many vitamins and herbals do put excessive stress on organs such as the kidneys and liver and can build-up to toxic levels within the body. We also know that it is harmful to mix multiple stimulant and depressant type compounds at the same time because they have several contraindicated and aversive effects on the heart and brain.

Caffeine

Caffeine comes from in the beans, leaves, and fruit of plants where it acts as a natural pesticide to kill or paralyze insects trying to feed on it. Caffeine is found in a wide variety of beverages and pharmaceuticals, and is known for its thermogenic (increased fat burning) and appetite suppression qualities. Because of its effects on how we think and feel caffeine has been called the most commonly used psychoactive drug in the world. Tolerance levels to caffeine vary widely among individuals and are dependent on multiple factors including liver functioning and other substances that are present in the body. The half-life or how long it takes for half of the drug caffeine to break down in the body is

4-6 hours with an average half-life among users of 4.9 hours. For women taking oral contraceptives, caffeine's half-life increases to as high as 5-10 hours. Furthermore, when higher doses are consumed (250-500 mg), caffeine's elimination from the body is slowed even more. Therefore, assuming that one is not on birth control and they have an average caffeine half-life elimination time of 4.9 hours, if an energy drink with 200 mg of caffeine is consumed at 5 pm, then by 10 pm we would expect the level of caffeine to be about 100 mg, by 3 am approximately 50 mg, and by 8 am 25 mg. In users, noticeable differences have been measured at dosages as low as 25 mg. Thus, the subtle effects of caffeine such as reduced sleep quality and hormone/neurochemical productions go far beyond the noticeable effects within the first few hours. Several people perceive that caffeine helps them concentrate and to be more productive; however, with regular use in as little as 4-6 weeks, caffeine has actually been shown to reduce concentration and learning ability as a result of neurotransmitter deficiencies, reduced sleep quality, and its effects on the hippocampus of the brain (area responsible for forming new memories). Of even more concern for youth and regular caffeine users is the link between caffeine use and the development of psychological disorders such as anxiety and depression. Insomnia often precedes depression and other mental disorders because quality sleep is needed for the body to restore neurotransmitters and other hormones. It doesn't take months for this to happen either. Symptoms of depression can be caused in as little as 5 days when people are deprived of just two hours of sleep from what they report normally needing to feel good (Wehr, 1990). By examining several sleep research studies, one can plausibly conclude that increased stimulant use (Caffeine, Adderall, etc.) over the past 10 years has exacerbated the current epidemics of clinical depression and behavior disorders among today's youth.

An acute overdose of caffeine, known as caffeine intoxication, can occur at dosages in excess of about 250-300 milligrams depending on the persons' tolerance and body weight. The effects of caffeine intoxication may include restlessness, nervousness, excitement, euphoria, insomnia, flushing of the face, increased urination, gastrointestinal disturbance, muscle twitching, loss of muscle mass, a rambling flow of thought and speech, irritability, rapid or irregular heartbeat, and others. In cases of large doses, mania, depression, lapses in judgment, disorientation, disinhibition, delusions, hallucinations, and psychosis may occur (See Figure 1).

Herbal Caffeine

When examining caffeine content calculations found on energy drink labels, consumers need to be aware that EDs generally do not include herbal forms of caffeine such as guarana and yerba mate into their listed caffeine content calculations. As a caffeine source, guarana contains approximately twice the amount of caffeine found in coffee beans (2-4.5%) and has longer lasting effects than standardized caffeine. Herbal forms of caffeine are unstandardized which means that the strength of these substances varies and is different depending on how it was cultivated. More so than traditional caffeine, guarana has been acknowledged for its ability to suppress appetite. Yerba mate is a caffeine source that comes from the leaves and stems of a South American plant and/or small tree and its caffeine content varies between 0.7% and 1.7% by dry weight, compared to 0.3-0.9% for tea leaves and 2.5-7.5% for guarana. Consumers need to be aware that the qualities of many ED ingredients, even within the same company, are not of equal potency or regulated. Even the manufacturers themselves are not exactly sure how strong one batch of their drink is compared to another, which is probably why they do not include herbal caffeine sources in their listed caffeine calculations, even though they can significantly contribute to the strength of the drink.

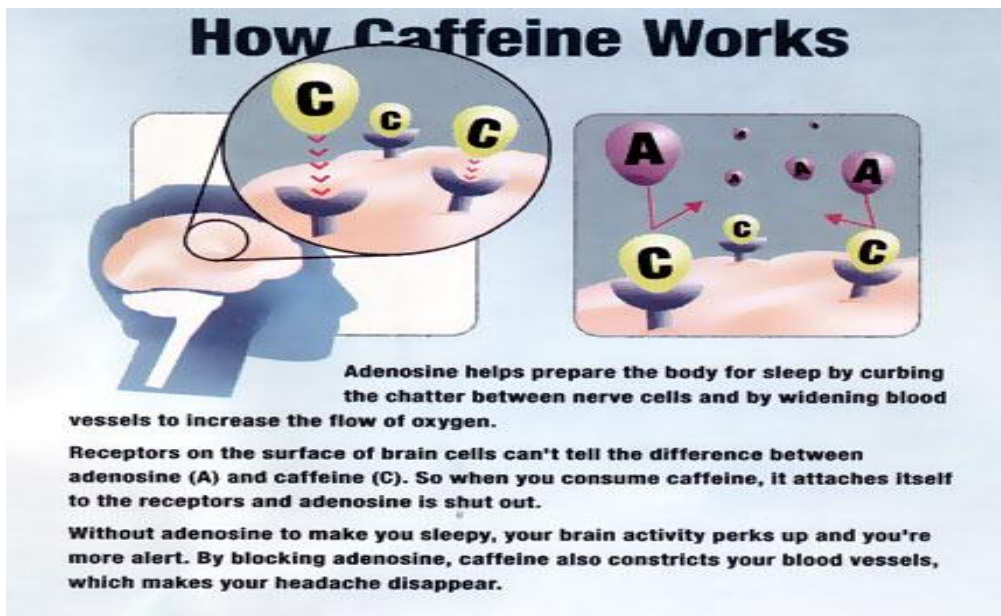


Figure 1. Symptoms of Caffeine Overdose

How does caffeine work in the brain?

Caffeine works in the brain by binding to adenosine receptors as a nonselective adenosine antagonist (competitor) and is molecularly similar to adenosine, which allows it to occupy adenosine receptor sites in the brain (Fisone, Borgkvist, & Usiello, 2004; See Figure 2). Adenosine receptors have important roles including regulating the release of pleasure reward (e.g., [dopamine](#)) and energy producing neurotransmitters such as nor-epinephrine. Like what occurs with other stimulant drugs of abuse, with regular caffeine use people become low in neurotransmitters and hormones such as epinephrine (i.e., adrenaline) and thus have to use caffeine in order to avoid feeling tired and other withdrawal effects such as headaches. Because of this mechanism of action, high doses of caffeine alone can cause an increase in a persons' tolerance to alcohol and other drugs. Some people may perceive this as a good thing, but having a tolerance simply means one has become deficient in neurotransmitters within the body which influence how we think, feel, and perform (See Figure 3).

Figure 2. How Caffeine Works in the Brain



Yohimbine Hydrochloride

Yohimbine HCL is a powerful herbal stimulant and aphrodisiac which is available in the U.S. as a prescription medicine that has been used to treat male erectile dysfunction. Yohimbine has also been used for the treatment of sexual side effects caused by anti-depressant medications. In bodybuilding circles, yohimbine HCL is used during crash diets during contest preparation for energy and its ability to accelerate fat loss. Yohimbine has significant side effects and can be dangerous when used in high amounts or with other stimulants. Side effects of yohimbine are anxiety, rapid heart rate, high blood pressure, overstimulation, insomnia/sleep disturbance, panic attacks, hallucinations, headaches, dizziness, and skin flushing. Yohimbine has also caused seizures and renal failure and should not be used by anyone with liver, kidney or heart problems, or a psychological disorder.

Ginseng

The root panax ginseng is a stimulant ergogenic herb that has been used for centuries to improve energy, enhance memory, and as an adaptogen (to increase the body's resistance to stress). Ginseng is also used as an aphrodisiac and has been found to effectively enhance libido (Hong et al., 2002). Ginseng is widely used in Chinese and Korean medicine but its' pharmacological properties are not fully understood. Side-effects reported from ginseng have included insomnia, nausea, diarrhea, headaches, nose bleeds, high blood pressure, low blood pressure, and breast pain. Ginseng may also lead to mild serotonin syndrome (serotonin toxicity) and mania when mixed with anti-depressants, exacerbation of extrapyramidal effects (inability to regulate movements) caused by neuroleptic (i.e., anti-psychotic) drugs (Fugh-Berman, 2000). Several other interactions have been reported so people should be cautious of mixing herbs like ginseng with pharmaceutical drugs.

Taurine

Taurine is an amino acid naturally found in the body at levels between 40 to 400 mg, whereas most EDs contain 1000 mg per 8 ounce serving. Studies have found that taurine increases dopamine production, improves locomotor activity, reduces symptoms of alcohol induced amnesia, and reduces the toxic effects that alcohol has on the liver. Taurine has also been shown to act as an anti-anxiety agent by effecting GABA, which is the major inhibitory (i.e., depressant) neurotransmitter in the brain. Alcohol works similarly on GABA receptors, which is another reason why EDs can be considered as gateway drugs - besides that fact that they have been linked to the increased use of alcohol, amphetamines, and other drugs.

Inositol

Inositol was once considered as a member of the B-complex vitamin family, but because it is produced by the body as a by-product of glucose metabolism, it is not an essential nutrient. Other vitamins such as niacin can also be synthesized in the body but generally not in abundant amounts. The ingestion of caffeine is known for diminished levels of inositol as well as several other key nutrients in the body. Of importance to our readers in this article, inositol facilitates neuron communication and has been shown to be a serotonin modulator (regulates activity) and has successfully been used in clinical trials as an anti-depressant medication (Nick, 2004; Fux, Levine, Aviv, & Belmaker, 1996).

Glucose and Glucuronolactone

In the human body, all of the foods that we eat (proteins, carbohydrates, and fats) are eventually converted into glucose so they can be used for fuel through our body's normal energy conversion process known as gluconeogenesis. Unlike regular soft drinks which only contain sucrose or table sugar, EDs also contain straight glucose and glucuronolactone as well as fructose (fruit sugar), sucralose, maltodextrine, and other artificial sweeteners. Glucuronolactone is a substance naturally produced in humans during the metabolism of glucose in the liver. However, EDs contain synthetic glucuronolactone at levels that far exceed what would normally be found in the human body. Glucose may not seem like a stimulant, but the direct administration of glucose significantly accelerates heart rate. Glucose is also used like a medication among diabetics when they get low blood sugar. Whenever alcohol is consumed the natural conversion of foods into glucose and glucuronolactone is inhibited which often leads to alcohol-induced hypoglycemia. Because the combined-use of alcohol and energy drinks is clearly a negative health behavior, some may not want to acknowledge the potential positives of using EDs with alcohol; however, it is important to address why glucose, glucuronolactone, taurine, high doses of B-vitamins, and many of the other ingredients such as milk-thistle (herbal liver protectant prescribed to recovering alcoholics), horny goat weed (known to raise testosterone; whereas alcohol is known to lowering testosterone) have been included in EDs by manufacturers. High doses of B-vitamins have been shown to help remove alcohol from the body and intravenous B-vitamins are given to people with alcohol poisoning. Previously, it has been posited that a contributing factor to these ingredients being included really has more to do with EDs being made by manufacturers to be combined with alcohol (Woolsey, 2007; Woolsey, in press). In fact, before the production of EDs, many ingredients such as caffeine, B-vitamins, ginseng, taurine, and others had previously been studied and clinically tested for their effects on alcohol metabolism and although it is a topic of much controversy, each has shown significant interactions with alcohol at high dosages. If manufacturers did not intend for energy drinks to be mixed with alcohol or used to reduce alcohols' negative effects, then why would they throw promotional parties and give establishments free Red Bull fridges or other dispensing machines?

Pharmacology of energy drinks explained

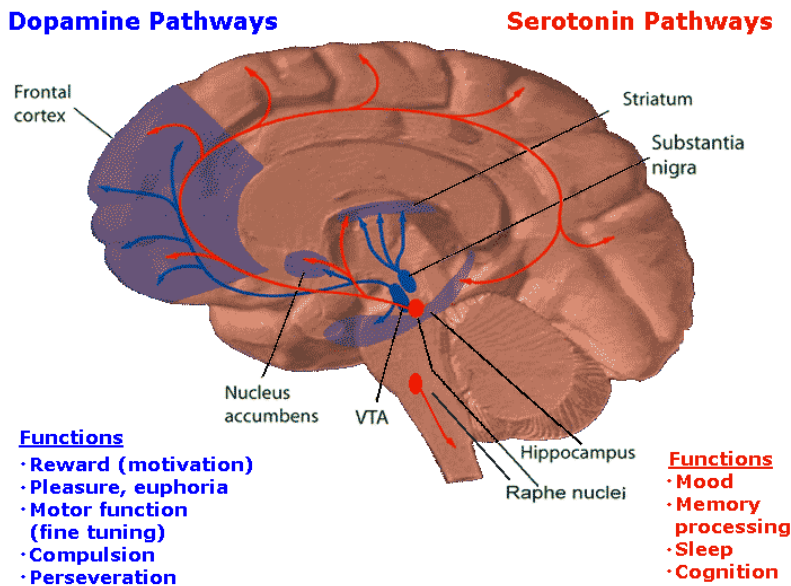
Like drugs of abuse, EDs work by causing a large release and/or prolonged action of pleasure-reward neurotransmitters (dopamine/serotonin) and stress hormones (nor-adrenaline/adrenaline), which in turn provides a short term high followed by a low or crash. Yes, even 5-hour energy, the shot that has been vivaciously marketed as the drink without a crash, works this way. The difference is that 5-hour energy does not contain large amounts of sugar like many other energy drinks. Users still swear that they don't feel a crash with it, but this just further exemplifies how our perceptions of how a drug will work has a large influence on the effects they have. After all, energy drinks work by causing the release/prolonged action of natural substances already within our bodies and it has been proven that people can cause the release of these same substances naturally (e.g., an adrenaline rush). There are ingredients in energy drinks such as the amino acid L-tyrosine, which are precursors to producing more dopamine and other neurotransmitters; however, these will not replenish neurotransmitter stores fast enough or balance out the negative neurological and nervous system effects.

Why we need FDA regulation besides the obvious health risks

An abundance of medical research indicates that adolescents and young adults (those under age 25) are vulnerable to developing long-term addictive personality traits and habits with substance use. Furthermore, adolescents are particularly vulnerable because of the incomplete development of their memory, addiction, and impulse control

centers of their brains (Lubman, Yücel, & Hall, 2007; Miller & Carroll, 2006). The younger one starts using EDs the more vulnerable their brains are to developing a dependency to them. Adolescents and young adults have a harder time seeing future consequences when enticed with the immediate pleasures/rewards of energy drinks. Parents, coaches, teachers, and practitioners need to be well aware that ED use predisposes youth to developmental brain changes that put them at-risk to experiencing increased future health problems. These problems included a higher risk for dependency/addiction to other substances and increased thrill seeking/risk-taking behaviors such as drinking and driving. Energy drinks work like drugs pharmacologically. As a result, regular ED use causes brain chemical deficiencies and increased pleasure-reward neurotransmitter and receptor site thresholds, meaning that the person will spend more time in unpleasant physical and psychological states after EDs are used. This is very important to remember because the brain chemicals that EDs effect control how we think, feel, and perform and it takes time for these to return to normal levels after drugs are used - sometimes they never do with drugs like amphetamines (See Figure 3).

Figure 3. Functions of Dopamine and Serotonin



This image is a work of the [National Institutes of Health](#), part of the [United States Department of Health and Human Services](#). As a [work](#) of the [U.S. federal government](#), the image is in the [public domain](#).



Recommendations

To develop more effective prevention programs positive motivations for ED use should be explored further. By better understanding why people choose to use energy drinks we can better predict their future drinking choices. Rather than focusing on the negatives of energy drink use and using scare tactics, parents, coaches, teachers, and practitioners need to focus on the positive reasons that people choose to use energy drinks in a non-judgemental and understanding way. After all, many people have already been hooked on these drinks before they fully understood that they were using drinks containing drugs and mind altering substances. Prevention programs need to focus on how to achieve desired positive outcomes through alternative methods such as getting better sleep, exercise, eating a balanced diet, and the utilization of excitation and cognitive control strategies to improve alertness and concentration. While it generally takes time to recover, those who are currently dependent on EDs need to know that there is hope for recovery and there are natural ways to have more energy and to feel much better than they currently do while on EDs. When working with clients, practitioners should assess what clients already know about EDs and selectively share information when given

permission or when people indicate they are ready to change (Rollnick, Miller, & Butler, 2008). With this and other health behaviors, people respond better and more importantly have better chances to successfully make lasting long-term changes when a positive communication style and collaborative approach is used. Clinicians should acknowledge that there are positives of using EDs, which is why people continue to use them despite knowing many adverse consequences.

Selected References for Readers

- Hong, B., Ji, Y. H., Hong, J. H., Nam, K. Y., Ahn, T. Y. (2002). A double-blind crossover study evaluating the efficacy of korean red ginseng in patients with erectile dysfunction: a preliminary report. *The Journal of Urology*, 168(5), 2070-3. PMID: 12394711
- Fisone, G., Borgkvist, A., & Usiello, A. (2004). Caffeine as a psychomotor stimulant: mechanism of action. *Cellular and Molecular Life Sciences*, 61(7-8), 857-872. doi:10.1007/s00018-003-3269-3
- Fugh-Berman, A. (2000). Herb-drug interactions. *The Lancet*, 355(9198), 134-138. doi:10.1016/S0140-6736(99)06457-0
- Fuxe, K., Ferré, S., Genedani, S., Franco, R., & Agnati, L. F. (2007). Adenosine receptor-dopamine receptor interactions in the basal ganglia and their relevance for brain function. *Physiology & Behavior*, 92(1-2), 210-217. doi:10.1016/j.physbeh.2007.05.034
- Lubman, D. I., Yücel, M. & Hall, W. D. (2007) Substances and the adolescent brain: A toxic combination? *Journal of Psychopharmacology*, 21, 792-794.
- Miller, W. R., & Carroll, K. M. (2006). *Rethinking substance abuse: What the science shows, and what we should do about it*. New York: Guilford Press.
- Nick, Gina L. (October, 2004). Inositol as a treatment for psychiatric disorders. *Townsend Letter; the Examiner of Alternative Medicine*. <http://www.townsendletter.com/Oct2004/Oct2004.htm>
- Rollnick, S., Miller, W. R., & Butler, C. C. (2008). *Motivational interviewing in health care: Helping patients change behavior*. New York, NY. The Guilford Press.
- Wehr, T. (1990). Manipulations of sleep and phototherapy: Nonpharmacological alternatives in the treatment of depression. *Clinical Neuropharmacology*, 13(1), 54-65.
- Woolsey, C. (in press). Energy drink cocktails: A dangerous combination for athletes and beyond. *Journal of Alcohol and Drug Education*, 54(3), December 2010.
- Woolsey, C. (2007). *A study of NCAA Division I athletes on the use and effects of combining alcohol & energy drinks*. Doctoral dissertation, University of Missouri, Columbia. <http://edt.missouri.edu/Summer2007/Dissertation/WoolseyC-071207-D7933/research.pdf>

Authors Note:

If readers would like further information on this article they can contact Dr. Conrad Woolsey at conrad.woolsey@okstate.edu