**Introduction:**

My family drinks coffee every morning, because it gives them energy and “wakes them up”. I drink coffee at least once a day, and I am really amazed how much energy this wonderful drink gives me. Of course, I understand that if I will take too much, it will have negative effect on me. But until then…I enjoy a cup of coffee, so I can go to school cheerful and full of energy.

“*Caffeine was discovered in 1820. It is an alkaloid and belongs to the methylxanthines group. Caffeine is found in guarana, kola nuts, coffee, tea, cocoa beans, mate and other plants. Caffeine is the most popular drug on the globe. It is a power and energy accelerant for human body. It is a powerful stimulant to the Central Nervous System”[[1]](#footnote-0)1.*

If you think about it, caffeine affects different people in many different ways. For example – many people think that it is not good for kids. Maybe because they are growing organisms and they need healthy diet? And caffeine doesn’t carry a supply of certain vitamins. People start drinking coffee from one cup a day in the morning and then in a few months they are already addicted to it, and can’t function properly without taking it. The described above things are very common points of view of most of the people. Why do we know so little about the effect of coffee on other living organisms? Scientists are doing experiments, discover things, publish them – but if to ask an average person about the effect of caffeine on animals and plants – not many of them would be able to answer this question. Animals, plants, fish, mushrooms, plankton and so on? Isn’t it interesting to know what affect can caffeine cause on different creatures, if have an effect at all. Let’s take for example plants. Caffeine is not an essential nutrient, so we would think that it wouldn’t influence plants at all. But caffeine is not an essential nutrient for humans either, but still, it has huge effect on human metabolism system. So, why not to make an experiment and know for sure if caffeine is influencing plants or not. Let’s say that we’ve decided to make an experiment. The first step than will be to make a good search on “caffeine” and “plants” topics, as well as “caffeine and plants” together. All the information that could be found may be interesting and useful for the experiment that I am going to make.

“*The caffeine is not just a stimulant, but it reaches deep into the muscle cell to provide lasting power and delaying the onset of muscle fatigue. Caffeine affects CNS (Central Nervous System) causing more alertness and allowing for more intense focus. The chemical structure of caffeine is very similar to that of adenine (a component of ATP, DNA, and cyclic AMP). Only the substituents are different. This helps explain caffeine’s stimulating effects. Because of the structural similarities, caffeine can slip right into adenosine receptors, keeping cyclic AMP active rather than it being broken down. When cyclic AMP breaks down, the body’s energy supply decreases. Because caffeine fools the body into using enzymes to break it down, the cyclic AMP supply remains higher for longer. Nobody really needs caffeine, but if all of America were stop drinking coffee or caffeine-containing soft drinks/beverages, productivity would fall by 70%. So, for more alertness and mental/physical boost a little caffeine can be used safely. Also – deficiency is not an associated problem with caffeine because it is not an essential nutrient”*[[2]](#footnote-1)2.

If a molecule of caffeine is similar to the one of adenine, then it is a very important factor for us to know because if caffeine will help plants to grow (which will be my hypothesis) then we will know that one of the factors that helps it to grow is that caffeine will provide enough adenine-similar molecules in the plant that can be used by the plant so the plant wouldn’t have to look for adenine if it needs some, it will just use the given caffeine molecules to take a good care of its DNA and ATP.

“*Caffeine increases the level of circulating fatty acids. This has been shown to increase the oxidation of these fuels, hence enhancing fat oxidation. Caffeine has been used for years by runners and endurance people to enhance fatty acid metabolism. It's particularly effective in those who are not habitual users”*.[[3]](#footnote-2)3

Certainly plants are not use to take caffeine solution instead of regular water that can be found in the soil (for example - grasses, trees, bushes – all take water from the soil, unless it is a specially grown plant that is being watered with some special solution). Caffeine would be something new if to introduce it to plants. The webpage that is above quotation is taken from says that caffeine is particularly effective in those who are not habitual users. Plants are not “habitual users”. Would it be right to assume that the caffeine solution is going to effect plants stronger if they would be watered with tap water and then suddenly with caffeine solution? That would be an appropriate thing because if I was to start watering the seeds, that I have just planted, with a caffeine solution, then if they won’t grow, I will not know if it’s the caffeine solution that I am watering them with or something else. Therefore, it is better to water them with tap water first, and then when they will grow I can water them with caffeine solutions and by collecting data every week, I will see what comes out of the experiment – whether plants will grow and have obvious variations from concentration to concentration, or they will not vary at all. The controlled plants will be kept being watered with a regular water, so the collected results can be compared with one another : no-caffeine solution with different %-ages of caffeine concentrations.

“*The biochemical effect of caffeine on plants (and animals) is well known, so much so that caffeine is often used as a tool to investigate processes affecting a variety of cell functions. Caffeine is a calcium release inducer. That means that adding caffeine to cells causes internal calcium to be released. This can result in a wide array of effects as calcium is used in plant cells for a number of purposes. The well-defined action of caffeine makes it useful, because basically, if you see an effect when caffeine is added, the effect is presumed to involve calcium release and/or membrane permeability. For example, recent literature investigating haptonema coiling and cellular differentiation used caffeine to identify calcium efflux and permeability changes as playing a role in these plant processes. Another apparent affect of caffeine on plants may be a role in UV protection. This effect may be mediated through calcium as well. All plants have a requirement for calcium which affects the permeability and organization of membranes. Calcium is also required by alpha-amylase, an enzyme involved in the hydrolysis of starch. Calcium can be used for detoxifying oxalic acid, which becomes insoluble and non-toxic to the plant protoplasm when calcium is bonded onto the acid. Some algae deposit calcium externally, as a by-product of obtaining carbon dioxide for photosynthesis, and are responsible for a large proportion of reef-building. Adding caffeine in appropriate doses would lead to symptoms similar to calcium deficiency including stunted growth. (Not mentioning that adding caffeine, or anything else, in high doses could result in more immediate toxic effects. For example, caffeine solutions may be overly acidic, so that the result seen is a pH effect, rather than a direct effect of caffeine. These potential problems must all be taken into consideration in designing the experiment.) Calcium deficiency is seen in plants as a general disorganization of cells and tissue, which is consistent with its role in membrane organization. Growing tips may be* *particularly affected resulting in stunted growth of leaves and roots because calcium is poorly transported from older to younger shoots. Both effects are reflected in the general health of the plant which may succumb to a variety of diseases as secondary infections take hold. For example, blossom-end rot in tomato fruit is often attributed to calcium insufficiency. Caffeine application is likely to mimic these effects.”*[[4]](#footnote-3)4

Here we can see a scientific explanation of results that caffeine causes in plants. If plants wold need calcium, they can use caffeine molecules if we were to water them with caffeine solution. Caffeine molecules might react with the molecules in plants in the same way as calcium would do. In this way the plant will not need to use calcium, because it will have enough supply of caffeine molecules.

“*There was a paper published some time ago which suggests caffeine inhibits the process of* ***cytokinesis*** *in plant cells - the last part of mitosis where the two daughter cells split their cytoplasm and organells before a cell wall forms to fully separate them.”*[[5]](#footnote-4)5

Putting caffeine in the soil might make it difficult for cells to divide, and it may require more energy for the cells to divide. And if it will slow down the rate of cell division, maybe the roots will be not very long. The good side of it is that if the roots will not be very long that we can grow plants in small pots and their roots will have enough space for them to grow and not form a huge bundle. On the other hand – the leaves may not grow large enough and the plant will be doing poor. Also – the roots will not have enough surface area for the plant to absorb the nutrients it needs. But let’s not forget the structure of caffeine molecule – it is close to the one of adenine, and it might give the plant a lot of energy – for the process of making ATP and for DNA structure – 2 main things in the life of plant.

“*Regarding* ***methylxanthines*** *- a family of chemicals of which caffeine is a member. Many plant-dervied methylxanthines function as antimicrobial factors and naturally-occuring insecticides.”*[[6]](#footnote-5)6

That is a good thing because we all want our plants to be protected from all the diseases and insects that may cause the plant’s development to slow down. We don’t want the plant to waste energy on putting forces on recovering from the damage caused by the insects or recovering from diseases – especially the fruits and vegetables – we don’t want our food to have any diseases in it. The best way would be if the plants would not have any damages at all. So if we will put the caffeine solution in the soil – it might protect plants from certain things that we don’t want it to have.

“*Caffeine increases growth of Rye Grass – plant growth increases with the use of coffee as the hydrating element vs. the use of ordinary tap water.*”[[7]](#footnote-6)7

The quote above shows that someone have already done a research on the growth of Rye grass and the results showed that it grows better with caffeine. If I will make an experiment by myself, I will know for sure if watering plants with caffeine will help them to grow or will not have a great impact on their growth.

“*Studies show that plants watered with caffeinated coffee grow better than control plants watered with water.”*[[8]](#footnote-7)8

This statement just supports the one made before – it shows that someone made an experiment on watering plants with caffeine solution and the results appeared to be so that caffeine really does influence the growth of plants in a positive way.

“*There are two thoughts on the idea, but no one really knows for sure. One study (Frischknect et.al. 1985) believes that caffeine protects plants from insect or fungal attacks. Another study (Friedman & Waller 1983) believes that caffeine excreted by the plant into the soil surrounding it reduced growth of competing plants and bacteria.”*[[9]](#footnote-8)9

Here is another opinion about protection of plants from insects by putting caffeine in the soil. It is already second time I meet this kind of statement during my search on “caffeine and plants” topic. But my area will cover the influence of caffeine on metabolism of plants – exactly how tall they grow and how large their leaves will grow, to see if caffeine makes plants grow larger. After completing my experiment I can investigate other branches in this area, for example – to see if adding caffeine to the soil changes the amount of insects that live on the given plant. But then I will have to choose some plant that is being damaged by insects a lot – like potato or tomato, so my experiment will show if plants that are grown in caffeine solution will be damaged less than the ones being watered with a regular water.

As you can see, there are many interesting things about caffeine influencing plants. Then, why not to investigate it? Indeed, if I will have a successful experiment ant it will appear that plants grow better when I water them with caffeine solutions rather than with regular water, then we can be watering plants with caffeine, and get much higher harvests on our fields, expand our economy in some way, and moreover – expand our knowledge in the field of metabolism of plants. Further we can investigate why caffeine causes similar effects on metabolism of plants as it does on metabolism of humans, and what do humans and plants have in common that caffeine is so much attracted to? On the other hand – if my experiment will show that caffeine doesn’t make plants grow better, but makes them die, we will know for sure that there in no use of watering plants with caffeine, because it will just kill them.

Summarizing all the information discovered during the search, we can see the clear outline:

* molecule of caffeine is similar to the one of adenine, which is found in DNA and ATP – two very important components of the plant life
* molecule of caffeine replaces the molecule of calcium and could be used instead of calcium to cause similar effect on plants as calcium does
* protection of plants from insects and diseases by adding caffeine to the soil

Therefore, we can use caffeine as a part of a fertilizer. It could be an expensive

fertilizer, but there is always a way to work things out. For example – used coffee still has some caffeine in it and if it can be added to the fertilizer, it will be not that expensive. If my experiment will support my hypothesis, then we could get a lot more from our harvests. Of course then we would have to study all the side effects, because each plant is individually unique, and it doesn’t mean that if it has a good effect on one plant, then it will have a good effect on any plant.

After some analysis I have started an experiment. I chose to use *brewed coffee* because the caffeine content in it is not very large *(80-135)* in compare with *espresso (100) and drip (115-175)* . In brewed coffee the 25% solution of it will be relatively small and not as large as if I would of chosen the coffee that has huge caffeine content in it and 25%, 50%, 75% and 100% caffeine solutions of it would be still very strong for plants – making it too much. But 25% of brewed coffee will be different from the 50% and so on. I don’t really know which concentration will be effective, so I chose four different concentrations: 25%, 50%, 75% and 100%. Noting that the coffee I chose – “*Columbia Supreme” has 1.37% caffeine in its beans and blends.”*[[10]](#footnote-9)10

I took 50 mg of coffee and 500ml of water and made brewed coffee, and counted the proportion 50mg/500ml as 100%. Then by adding water I was able to get other concentrations, like – 25%, 50%, and 75%. The controlled plants should be grown without caffeine in it, so I will have data to compare it with. The only changing variable is that plants are being watered with different caffeine concentration solutions, and the controlled ones are taking water. The rest of them are the same unchangeable conditions. Each sample size contains 10 pots with plants that all get the same amount of hydrating solution. The 25% ones have 16 pots and each one of them gets the equal share of watering solution. The radish was chosen to be the object of an experiment because it is a fast growing plant and it is a vegetable – so the experiment can be of use – fertilization of the soil. The seeds are 2-3 mm long, were planted, and within a certain amount of time when the plants reached a certain height, I started to water them with caffeine solutions. The coffee was kept closed in a dry place, to prevent it from spoiling, and fresh coffee was made every week so it is always fresh for plants and it was kept in plastic bottles. The project itself will take 5 weeks - 5 times of data collection, and the results will be carefully examined, recorded, analyzed and discussed in class with the students and the teacher.

In my project I want to see if caffeine really does influence the growth rate of plants, and if it does, then how does it influence it. Also – all the other noticed changes in plants will be recorded, so they can be investigated further in other experiments.

1. 1 Research made on [www.musclesurf.com](http://www.musclesurf.com) [↑](#footnote-ref-0)
2. 2 Research made on [www.musclesuf.com](http://www.musclesuf.com) [↑](#footnote-ref-1)
3. 3 Research made on <http://coffeefaq.com/caffaq.html#Chemistry> [↑](#footnote-ref-2)
4. 4 Karen Culver-Rymsza, Grad student oceanography. Research made on <http://www.madsci.org/posts/archives/mar98/891046117.Bt.r.html> [↑](#footnote-ref-3)
5. 5 Lopez-Saez JF. Mingo R.Gonzalea-Fernandez A.

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   Published by Nick Bourbaki, Collective Enigma Elucidator [↑](#footnote-ref-4)
6. 6 Nathanson JA.

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   Research made on <http://www.madsci.org/posts/archives/dec96/844959492.Ag.r.html>

   Published by Nick Bourbaki, Collective Enigma Elucidator [↑](#footnote-ref-5)
7. 7 Research made on <http://river.clarion.edu/stratgrassexps/kukich.html> [↑](#footnote-ref-6)
8. 8 Research made on <http://www.omsi.edu/explore/whatzit/life.cfm> [↑](#footnote-ref-7)
9. 9 Frischknecht, P.M., et al. 1985. Purine alkaloid formation in buds and developing leaflets of Coffee arabica: expressionof an optimal defense strategy?? Phytochemistry. 3:613-616.

   Friedman, J. and Waller, G.R. 1983. Seeds as allelopathic agents. Jour. of Chem. Ecol. 9:1107-1115.

   Research made on <http://www.omsi.edu/explore/whatzit/life.cfm> [↑](#footnote-ref-8)
10. 10 Research on <http://coffeefaq.com/caffaq.html#Chemistry> all the cursive words in this paragraph that have information about caffeine contents are from the given web-page [↑](#footnote-ref-9)