The effect of caffeine on heart rate

In this experiment, I am going to determine the effect of different concentration of caffeine on the heart rate of Daphnia. Daphnia is assumed as the substitute of human being in this experiment to investigate the effect of chemicals on the heart beat of living organisms. Heart beat is the frequency of heart contraction in one complete cardiac cycle. The average heart rate of human is 72 beats per minute.[1]However, some changes that occur in the body system such as stress, an increase in body temperature or consumption of some chemicals may alter the heart rate. The consumption of caffeine is believed to increase the heart rate as well, and thus this experiment is carried out to test its validity.

Caffeine, 1, 3, 7-trimethylxanthine with its molecular formula of C8H10N4O2 occurs naturally as a white crystalline powder that tastes very bitter. It portrays a unique characteristic in which it is soluble in both water and oil. Generally, caffeine is extracted from beans, leaves and fruits of some plants. The few commonly known sources of caffeine are coffee beans, tea leaves and cocoa beans. In the perspective of science, caffeine is classified as one of the foods or recreational drugs. However, its effects are milder than other drugs such as amphetamines, cocaine and heroin. Therefore, it is made as popular beverages all around the world such as coffee, tea, soft drinks and energy drinks. In addition to those, we can even find caffeine in some chocolate bar and diet pills. Nevertheless, caffeine in its pure form can also be obtained in powders, caplets or tablets. Its popularity is further proven by an estimation of global consumption of caffeine at 120, 000 tonnes per year. The recommended consumption for an average adult is less than 300mg of caffeine per day.

http://upload. wikimedia. org/wikipedia/commons/thumb/d/d8/Caffeine. svg/120px-Caffeine. svg. png http://upload. wikimedia. org/wikipedia/commons/thumb/2/24/Caffeine_3d_structure. png/100px-Caffeine_3d_structure. png

Figure : Structural formula of caffeine, C8H10N4O2

How can caffeine affect us? Through various beverages that contained caffeine, this chemicals can be absorbed into our body through stomach and small intestine. It is metabolised in the liver to produce paraxanthine, theobromine, and theophylline which is then distributed to all tissues of the body. Although caffeine is not stored in the body, the effect of caffeine can be felt for up to 6 hours. Caffeine, as psychological or metabolic stimulant drugs can give impact to our body system particularly to our central nervous system. Recreationally, the main function of caffeine is undeniably its ability to increase alertness and wakefulness which makes it a popular source among students and workers to stay awake. Meanwhile, caffeine provides an increased focus and better general body coordination as well. Besides, caffeine also possesses medicinal use in preparing aspirin (a pain killer). However, caffeine consumption can lead to addiction.

In this context, caffeine can increase the heart beats of many organisms. Caffeine binds to receptors on the surface of heart muscle cells which leads to an increase in the level of cAMP inside the cells which then increases the heart rate. This creates an overall effect to increase the rate of glycolysis and the amount of ATP available for muscle contraction and relaxation. In addition, one of the products from the metabolism of caffeine –

Theophylline acts as a chronotrope and inotrope that increases heart rate and efficiency.

As to body health, caffeine can give positive or negative effect, considering the amount of caffeine taken. Generally acknowledged, caffeine increases anxiety, stress, insomnia and restlessness which are bad for our health. This is believed to be caused by a reduction in serotonin (A neurotransmitter, synthesised from the amino acid tryptophan, that functions in the central nervous system)[2]levels in the blood as a result of caffeine consumption. On the other hand, it can act as a diuretic in which it increases the urine production and thus decrease the blood pressure. Besides, caffeine can minimise the occurrence of some diseases such as diabetes, Parkinson’s disease and colon cancer. By the way, the sensitivity towards caffeine may vary from person to person.

In this experiment, Daphnia or commonly known as water fleas is used to investigate how its heart respond to the chemicals caffeine. It is a small and almost kidney shaped crustacean, having a single compound eye, two doubly-branched antennae, and leaf-like limbs. Furthermore, their exoskeleton is translucent and this characteristic allows its heart beating to be clearly seen under a microscope. Thus, the counting of heart beat possible and can be done more easily. Various aquatic environments ranging from acidic swamps to freshwater lakes, ponds, streams and rivers are suitable habitat for Daphnia to live in. Some Daphnia are widely found in lakes or ponds located in limestone-based areas.

Under normal conditions, the average heart rate of Daphnia is approximately 180 beats per minute (bpm). Daphnia is very sensitive to the change of chemicals composition in its living surroundings. In this case, its heart beat is also easily affected by a wide range of chemicals such as caffeine solution used in this experiment. It will also show an immediate effect after the addition of the chemicals. Daphnia is poikilothermic, whereby its body temperature and metabolic rate is highly dependent on the surrounding temperature. Averagely, Daphnia has a comparatively short lifespan in which it can only survive for less than one year.

Problem Statement:

Does different concentration of caffeine affect the heart rate of Daphnia?

Objectives:

To investigate the effect of caffeine on the heart rate of Daphnia(water fleas)

To develop the technique of utilising microscope and other effective experimental skills throughout the experiment

Aim:

To determine the effect of different concentrations of caffeine on the heart rate of Daphnia.

Hypothesis:

The higher the concentration of caffeine, the higher the heart rate of Daphnia.

Techniques :

Observe and calculate the heart rate of Daphnia under a light microscope

By setting a control to the experiment by examining the heart rate of Daphnia under normal condition.

Record the rapid heart beats of Daphnia by using a calculator

Materials :

Culture of Daphnia, pond water, distilled water, 0. 3 % caffeine solution, filter paper or paper towel, muslin cloth

Apparatus :

Microscope, cavity slides, dropper, measuring cylinder, 50ml beaker, stopwatch, calculator

Variables :

Variable

How the variable is determined

1. Manipulated

Presence and concentration of caffeine solution

By using two different dilutions of caffeine solution, 0. 15% and 0. 30% and a control set without caffeine solution

2. Responding

The heart beat rate of Daphnia

By observing and calculating the beating of heart of Daphnia under light microscope for 20 seconds and the values are multiplied by 3 to obtain the heart rate of Daphnia (number of beats/minute)

3. Constant

The surrounding temperature

The light intensity

By conducting the entire experiment under the room temperature

By carrying out the experiment under a controlled amount of light intensity of the microscope

Procedure :

0. 15 % Caffeine dilution is prepared from the stock solution of 0. 30 % Caffeine solution using the following method :

Concentration of Caffeine

0. 30 %

1 cm3 of 0. 3% stock solution

0. 15 %

1cm3 of stock solution + 0. 1 cm3 distilled water

A microscope is set up and its brightness is adjusted to prepare for the observation of Daphnia.

A large Daphnia is transferred from the culture to a cavity microscope slide using a dropper.

The excess fluid is removed with a filter paper, so as to cause the animal toile on its slide.

Gauze or muslin cloth is placed over the cavity as to slow down the movement of Daphnia.

Diagram : Placement of muslin cloth on cavity slide

The slide is placed on the stage of microscope. The Daphnia is located and examined using low-power objective. The heart rate can be seen beating extremely fast.

The slide is left on the stage for 5 minutes to equilibrate Daphnia so that it can adapt to the environment.

By working in pairs, a basic calculator is set up to add one digit respectively for 20 second periods to practise counting heart beats. A stop watch is used by the other student to time.

The results of two consecutive counting periods are recorded. The mean value is calculated. It is expressed in beats per minute.

About 5 minutes is allowed to lapse.

A drop 0. 15 % caffeine solution is added to the cavity of the slide using a dropper. Excess of the solution is removed using a filter paper. Counting of the heart beats is started for 20 seconds.

A fresh Daphnia is used and the procedure 4-7 and step 11 is repeated by using 0. 30 % caffeine solution.

At the end of each experiment, the Daphnia is returned to the culture solution.

All the results are recorded. Each of the results is multiplied by 3 to obtain heart beat rate per minute. The results are tabulated and a bar chart is drawn to show the distribution.

Results :

Condition of the solution

No. of Heart beats of Daphnia in 20 s / Times

Trial 1

Trial 2

Mean

Normal

36

40

38

Concentration of Caffeine Solution

0. 15

41

51

46

0. 30

50

52

51

Table 1: The heart rate per minute of Daphnia under different conditions of solution

Calculation:

Formula 1 : The mean value of the date obtained

=

Formula 2 : Heart rate per minute of Daphnia / times

=

Analysis of Data – Bar Chart :

Discussion:

Based on the above experiment, the effect of different concentrations of caffeine is successfully determined. A bar chart is drawn based on the results obtained in the experiment to show the data in a clearer way and provides a better mean for analysing. The results show the heart rate of Daphnia is

positively affected by the presence of caffeine, and it is increased when the concentration of caffeine solution is raised. The average heart rate of Daphnia under normal condition which acts as a control experiment is 114 heart beats per minute. When 0. 15% caffeine solution is added, its heart rate increases to 138 heart beats per minute. The heart beats rise to 153 in solution containing 0. 30% caffeine solution. However, theoretically, the increase of the heart rate should reach a maximum point where a further increase in the concentration of caffeine has no further effect on the heart rate of Daphnia. In this experiment, the saturated or maximum amount of caffeine that affects the heart rate of Daphnia cannot be obtained due to the lower concentration of caffeine used in the experiment.

In this experiment which includes the use of Daphnia as a living organism, some ethical issues arise. Even though Daphnia is so small to be seen unless by using a microscope, it remains a fact that each every Daphnia is a life and we have no right to harm or kill them even though by the name of science. In this case, we should be very careful when carrying out any experiment involving the use of organisms so as not to harm them. Therefore, after carried out every experiment, the Daphnia which is still alive should be returned to its culture solution to sustain its survival. The light intensity of microscope should be controlled so that it will not kill the Daphnia involved. In addition, the experiment is carried out as quickly as possible because the Daphnia may not survive for long in a new environment. The concentration of caffeine should be lower than 1% to prevent the dying of Daphnia. Furthermore, the process to remove excess water using a filter paper is

carried out cautiously as to prevent the absorption of Daphnia accidentally which will kill it.

However, throughout the experiment some errors might occur in which the real values may not be obtained. Firstly, as this experiment is done based on the observation on the specimen, some counting of heart beats might be missed due to human limited abilities. This is probably due to the rapid and inconsistent beating of Daphnia's heart. In this case, a calculator is set up to ensure a more accurate reading. Parallax error may occur as well when the dilution of caffeine is measured using a measuring cylinder. To minimise the errors, the experiment is repeated twice and the mean reading is obtained. To further increase the accuracy of the results, a camera can be used to record the entire process and is then played repeatedly. A ' blind' study is preferable in which the observer is unknown of the condition of solution being added to Daphnia as to avoid bias. There is also assumption made in this experiment. In the experiment, the heart rate of every Daphnia is assumed to be the same when a fresh Daphnia is used for different concentration of caffeine.

Consequently, there are a few precautions that ought to be taken to increase the accuracy of the results obtained. Before a new drop of caffeine solution is added to the Daphnia, approximately 5 minutes is allowed to equilibrate the Daphnia. This is done to adapt it to the surroundings so that other factors would not interfere with the manipulated variable. Next, as the rapid movement of Daphnia can affect the results taken, it is better to place muslin cloth or cotton wool to keep it in place to make the counting process easier. Besides, during the experiment, the light intensity of microscope

should be adjusted to a point where it would not be too bright to affect the sight of the observer. During the transition of each test, the light intensity should be controlled as well to prevent dying of Daphnia. Moreover, we should not spill any water used onto the microscope particularly the electrical compartment as this will damage the microscope. The Daphnia should be handled carefully to prevent injuries as this will alter its heart beats.

Along the process of the experiment carried out, some problems occur. For instance, the Daphnia is difficult to be captivated using a pipette as it is too active. Besides, the sample of water provided contain other microorganisms such as tadpole, euglena and amoeba that are being thought as Daphnia to be tested in the experiment. Throughout the experiment, some safety measures should be abided by. A lab coat should be put on. The glass wares and the microscope used should be handled carefully as they are fragile.

Conclusion:

The hypothesis is accepted. The presence of caffeine increases the heart rate of Daphnia. When the concentration of caffeine solution used increases, the heart rate of Daphnia also increases.

Limitation:

The age of the Daphnia

An old Daphnia may have a lower heart rate as compared to a young and active Daphnia

The size of Daphnia

A larger Daphnia may have a lower heart rate than a smaller one

The species of Daphnia

Different species of Daphnia may show different heart rate and may differ in the way it response to the different concentration of caffeine

Further Work:

The effect of temperature on the heart rate of Daphnia

The effect of different light intensity of microscope on the heart rate of Daphnia

The effect of different chemicals such as ethanol or aspirin on the heart rate of Daphnia

The effect of different concentrations of caffeine on other microorganism beside Daphnia such as paramecium