Introduction

Science is one of the oldest and important academic disciplines which covers a wide variety of courses. It is also one of the fundamental parts of the term STEM, used to refer to science, technology, engineering and mathematics. At The Jannali High School we offer Science courses throughout all stages leading to Stage 6 students being able to study Science Extension for their HSC to further their skills and passion for the subject.

Science helps our students' understanding of the world around them. Everything they know about the universe, from how trees reproduce to what an atom is made up of, is the result of scientific research and experiment. Human progress throughout history has largely rested on advances in science. From knowledge of gravity to cutting-edge medicines, students of Science have shaped our modern world.

All of these advances can trace their origin back to individuals learning about Science as students. It is therefore the reason why providing students with the opportunity to study Science Extension at The Jannali High School is seen as so important as these students could be responsible for the next wave of progress in fields that affect our daily lives.

Studying Science provides our students with the opportunity to gain a better knowledge of how and why things function. Science creates curiosity that helps students understand and formulate questions on the information they have accumulated.

This generation of TJHS Science students will be the key to preparing our community for the future. They are to be congratulated for their work presented in this journal.

Mr Rick Coleman,

Principal

Science Extension is a one unit subject students studying senior science courses complete in Year 12. It is an opportunity to learn about the history and philosophy of science, understand the difference between data and evidence and analyse the ways scientists communicate their findings.

Students complete a 'major work' in the writing of a Student Research Report after asking a valid scientific question, planning and conducting an investigation and analysing their results.

Jackson Abbott has a keen interest in Astrophysics and investigated data collected from international organisations on galaxy distribution in the Universe. He collected, sorted and ran mathematical models on the data to create a 3-Dimensional model. His aim was to investigate any patterns in the location of galaxies in the Universe in order to backwards map this to matter distribution in the early Universe.

Grace Caleo was inspired by a claim that promoted hair growth through the application of essential oils. She designed an investigation to test this claim after a thorough literature review, hypothesising Peppermint Oil having the most effect on hair growth. Grace recruited subjects, performed a pilot trial and collected extensive primary data in order to analyse her results. She ran sophisticated statistical tests to make valid conclusions.

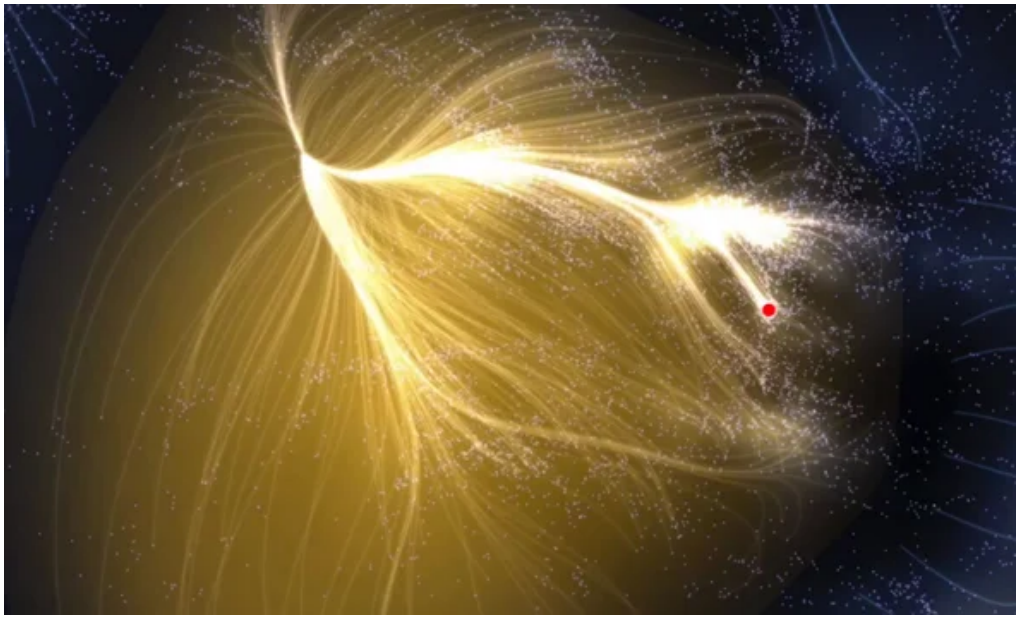
I hope you enjoy reading their Reports and are inspired by their mature approach to the scientific method.

Mrs Amy Homola

Science Extension Teacher, 2022

Contents

Modelling galaxy location in the search for patterns of mass distribution in the early Universe.



Jackson Abbott

Science Extension, The Jannali High School, August 2022

Abstract

This investigation aims to qualitatively analyse the mass dispersion of the universe in the present day to gather a deeper understanding of the uniformity of mass distribution during the early universe. This is done by plotting a variety of galaxies from different data sources into a three dimensional excel graph to then look for clusters and voids to look for patterns. While a cluster was found with some voids no apparent pattern formed. A few possible explanations are proposed including entropy, expansion and dark matter however there seems to be no quantifiable reason for the locations of galaxies in the universe.

Keywords: Galaxy, mass dispersion, excel modeling, patterns

Literature review

Mass is a property of matter. Larger objects tend to have a higher mass. Galaxies are a prominent example of this as they are some of the largest celestial bodies we know of. The way that they are distributed across the universe can tell us how the early universe behaved.

The different types of masses that are distributed across the universe are known to a certain extent. We know that the majority of the universe's matter is hydrogen followed by helium, together making up approximately 98% of the regular, baryonic matter (baryonic matter being matter made of the physical particles that make up the standard model). The way that this is distributed around the universe is more of a mystery, we can see the results of the movement but why it moves in that certain way is another question. We can look at galaxy clusters such as virgo or the laniakea supercluster to gather an understanding of certain patterns that can present themselves throughout the universe. Entropy also plays a role in how the universe is distributed. It is a universal constant and is a measure of the “chaos” of the universe. This “chaos” alters the momentum of particles on a small scale and galaxies on a larger scale so it can have an effect on where galaxies are located in relation to each other thereby giving some areas clusters that are unrelated to gravity and vice versa with voids.

Aside from Entropy and Expansion, there is one more, albeit heavily theoretical factor. Dark Matter. Dark Matter is a type of matter that was first inferred by Fritz Zwicky in 1933, it is impossible to directly observe with the current tools and instruments that humanity has access to as it does not directly interact with regular baryonic matter (what we know to make up everything in the universe). Despite this, there is a lot of evidence to point towards its existence, and galaxies are one of them. It is often credited to dark matter that galaxies can stay as a single entity in the way they do today. Galaxies are extremely large celestial bodies, often spanning in the hundreds of thousands of lightyears in radius. No single body has enough gravity to hold an entire galaxy together. The most massive object in the universe is currently known to be TON-618, a hyper-massive black hole estimated to be 66 billion solar masses. This body, while extremely massive, still is unable to hold something like a galaxy together on its own. The remaining gravitational assistance is explained by dark matter. One issue with dark matter is that it’s akin to imaginary numbers, they work in theory and as a helpful explanation, but are only useful in theoreticals meaning it’s difficult to attribute the cause to dark matter.

Many articles have been published and studies have been conducted into galactic masses and entropy but none were found that looked to determine if there was a specific correlation or consistent pattern between galaxies and how they’re distributed across the universe. These

other studies, while not following the exact same path as this, still had some useful information in how they conducted their investigations. Many relevant studies were conducted by the Pennsylvania State University. This institution has delved deep into astronomical and astrophysical studies which gives some excellent data on all sorts of astronomical phenomena including galaxy locations. After locating a data set consisting of over 4000 galaxies each with coordinates, magnitude, velocity and a velocity error, a decision was made to use their datasets as a basis for this investigation.

Research Question

How does the mass dispersion of the universe in the present day inform about the uniformity of mass distribution during the early universe?

Hypothesis

H_1 = There is a pattern between celestial masses within the universe and where they are located

H_0= There is no pattern or correlation between celestial masses within the universe and its where they are located

Methodology

1. *Collate secondary data sources available from publicly available data sets, eg. https://astrostatistics.psu.edu/datasets/Shapley_galaxy.dat and http://www.sao.ru/lv/lvgdb/*

2. *Organise data into approximately 40 data points based on the galaxies location using R.A and Declination Coordinates that have been converted into x, y and z values using trigonometric ratios and processes.*

3. *Place x, y and z data into an excel spreadsheet with a macro script by Gabor Doka.*

4. Create a three dimensional graph within excel.

5. Analyse the graph for clusters in a qualitative analysis.

6. Run a Pearson correlation test for correlation within axis variations.

Results

A 3-D model showing the location of each galaxy in the data-set. Galaxies are represented by blue dots. A label is added to locate the Milky Way as a reference point. Andromeda is the closest galaxy that is also labelled. Right Ascension and Declination 0,0 are used as a reference point.

Table 1. Right Ascension & Declination of each galaxy converted to x, y and z values using trigonometry.

Labels	x-value	y-value	z-value
Milky Way	0	0.15	0.45
Andromeda	-0.6454	0.6786	0.7654
R.A and Dec	-0.9	0.15	0.45
	0.9035	0.3294	0.1802
	-0.7231	-0.4925	0.8109
	-0.9039	-0.3942	0.4033
	0.6330	-0.0906	0.9001
	0.7365	0.3746	0.7000
	0.4354	-0.5180	0.0139
	-0.7584	0.7843	0.6474
	0.4587	0.7698	0.2925
	0.7523	0.2930	0.5812
	-0.8020	0.5985	0.8420
	-0.7842	0.8576	0.6753
	-0.5875	0.4903	0.8754
	-0.4510	0.4650	0.7294
	0.7409	-0.2386	0.0576
	-0.5423	-0.6875	0.1952
	0.3672	0.4687	0.1349
	0.7452	0.2487	0.5073
	-0.5982	0.6269	0.8023
	0.1824	0.4976	0.9012
	0.5642	-0.3705	0.7269
	0.1246	-0.4891	0.4816
	0.7615	0.6183	0.3462
	-0.6745	0.8971	0.7129
	-0.6489	-0.6239	0.7491
	-0.2703	0.4501	0.6814
	0.5643	-0.7241	0.5792
	-0.4548	0.2438	0.4682
	-0.5618	-0.2482	0.8237
	-0.5649	0.5904	0.5874
	-0.6867	0.6019	0.8949
	-0.6482	0.7293	0.9078
	-0.4583	-0.6103	0.4935
	-0.7824	0.8452	0.8693
	-0.5946	0.6982	0.8791
	-0.6821	0.8856	0.7923
	-0.4856	0.5876	0.9012
	0.4354	-0.5180	0.0139

Figure 1. Isometric View of Data Plot showing x, y and z planes.

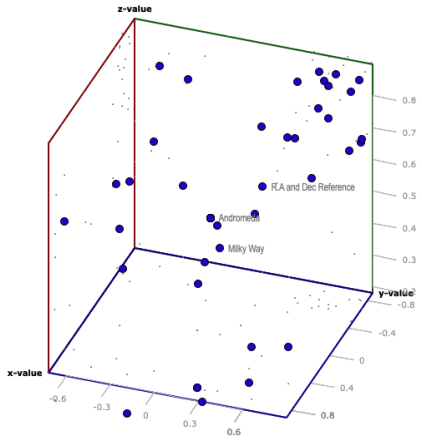


Figure 2. Plan of Data Model.

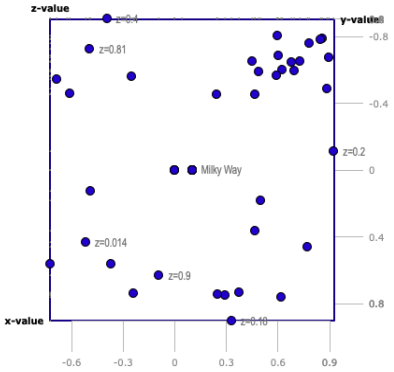


Figure 3. Elevation of Data Model. Note that some galaxies are far away from the reference point that they are off the axis of the model.

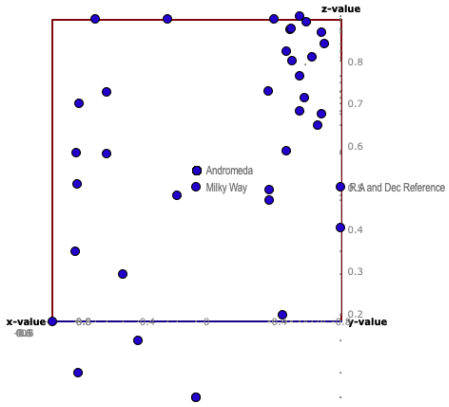


Figure 4. End Elevation of Data Model.

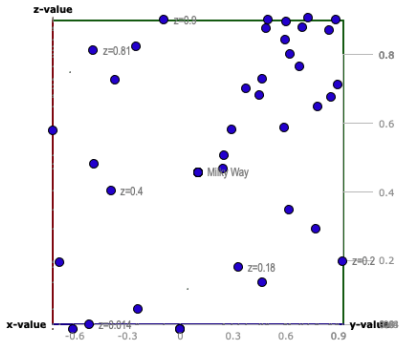


Table 2. Correlation Matrix of x, y, z coordinates showing Pearson Correlation values 'r'.

	x	*y*	*z*
x	1		
y	-0.2572772	1	
z	-0.5213309	0.40700755	1

Discussion

The data shows many different things, while it shows what it needs to, being the galaxy's positions and coordinates. It also shows aspects such as any small clusters or voids that occur in deep space as well as a general shape of the somewhat local galactic group. Using the Milky Way as a reference frame is possible by giving it a central placement in the data plot which has been done as well as a reference point for R.A and Dec = 0. The main noticeable thing shown by the data is a large cluster of approximately 15 galaxies is shown in the top right corner of the isometric view, this cluster is still within the laniakea supercluster and also the virgo cluster as looking further requires much more powerful tools then were available to the first hand data collectors. Outside of the obvious cluster of data, the galaxies are quite evenly spread with 6 in both the top right and bottom right quadrants when looking at the Elevation view.

An issue that arose from using that specific macro in excel was that the axes could only stretch so far despite the fact that some galaxies are extremely far away from our own. This contradiction leads to some of the data points ending up off the axes of the plot. However due to the three dimensional nature of the plot, qualitative analysis can still take place.

The data was taken from two different major galactic studies. These studies both collected thousands of data points respectively and were conducted by large academic and scientific institutions one of which being the Pennsylvania State University and the other being a more vague Russian study. They were looking at different areas of the sky with the Pennsylvania University being a much more narrow set in terms of the night sky when compared to the Russian set. This could have led to the clustering seen in the data plot, The narrow view of the original study may have been too narrow for this investigation. With the assistance of the other Russian dataset, more of a spread could form however the cluster was still noticeable in the final data plots. With a bigger axis scale and more data sources or an easier and more accessible method of collecting first hand data may have led to a more even spread or perhaps the possibility of the main cluster being more pronounced.

While my process was accurate and valid, the reliability could be improved, while a sample size of 38 was used, in the world of astronomy 38 is quite a low number. If larger datasets

were available as well as more time then that could be increased tenfold. This restriction on accessibility and time is something that could be remedied in future research into the topic. This extra, untapped data, could have also shown a different perspective into the field which may have changed the outcome or outlook of the investigation which is something to think about if one were to tackle this in a future investigation.

The galaxies that were analysed showed a low correlation between the coordinates. This means that if a galaxy was at a certain x coordinate, you could not reliably predict where it would be on the y and z planes. This was to be expected as galaxies all have unique positioning within the Universe

A plausible reason for the lack of a pattern or formula as to how the galaxies are placed is a combination of factors, the universe's expansion explained via Hubble's constant and its entropy, a concept often explored in thermodynamics to determine the random nature of a system, being the two most prominent. These two factors make the universe a very diverse and quite a random environment by definition. This small factor of randomness is enough to make things very unpredictable in terms of thermodynamics and the movement of smaller particles which when scaled to the galactic level has enough of an effect to make galactic movement somewhat unpredictable.

There is one more possible solution to the galaxy's clustering habits, albeit it is quite theoretical. Dark Matter. As discussed earlier it is something that is, currently, a fabricated and convenient solution. So while it is the last remaining solution. Until it is directly observed it is simply a theoretical solution rather than a practical and quantifiable one.

Conclusion

The distributions that were observed and analysed show that there is no real formula or pattern on the mass distribution of the universe. Figures 1-4 shows that while there are clusters and voids, there is no apparent reason for this cluster outside of random chance explained via the entropy of the universe. If we were to look on a larger scale, there would be things such as the Laniakea Supercluster and the Bootes Void as extreme examples of clusters and voids respectively and even still there is no apparent reason for the clusters outside of possibly a small gravitational force However this gravitational force should be outclassed by the expansion of the universe shown through Hubble's constant. On the small scale that was accessible, there seems to be no reasoning for the groupings of galaxies.

This lack of a uniformity and a currently observable explanation for it tells us that the early universe followed the same random rules that we observe today and that things have not changed despite the immense time difference between now and then.

Acknowledgements

Faulkes Telescope Project,
Mrs A. Homola, Science Teacher
Mr K. Hannon, Science Teacher

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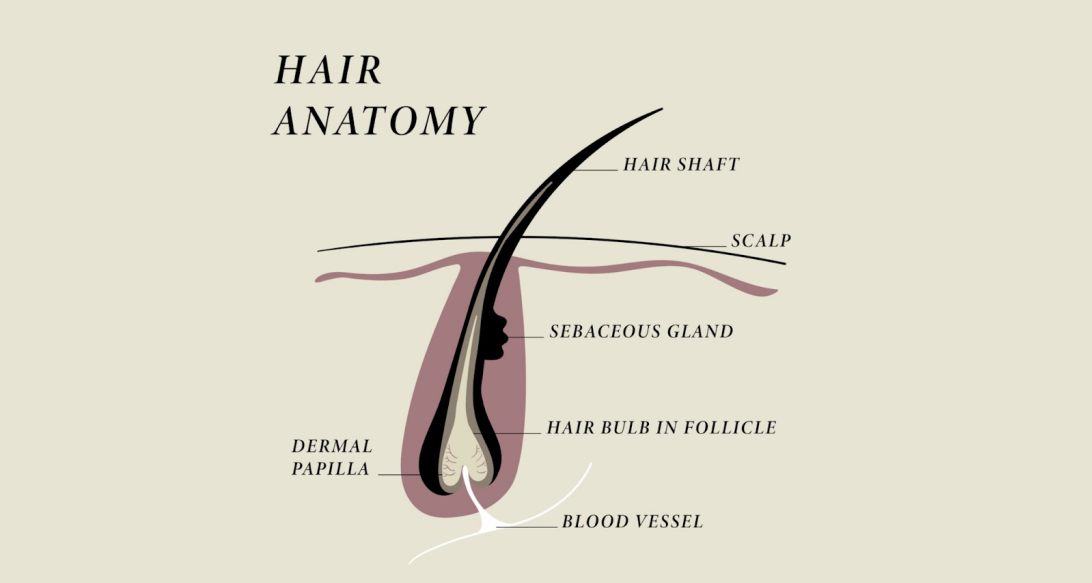
Appendix

Link to Excel Macro:
https://doka.ch/Excel3Dscatterplot.htm

The effect of essential oils as an agent on the promotion of hair growth.



Grace Caleo

Science Extension, The Jannali High School, August 2022

Abstract

Throughout history long, thick, and luscious hair has defined beauty within many cultures and has ultimately created insecurities for both men and women who suffer from hair loss conditions such as alopecia. In recent years, many health and beauty companies have claimed essential oils promote hair growth. These claims have been supported through similar conclusions found in the literature review which revealed that essential oils such as peppermint oil did promote hair growth. This study hypothesised that Peppermint oil would have the greatest effect on the promotion of hair growth and investigated the effect of essential oils as an agent on the promotion of hair growth on six participants aged between 17-18 years. The essential oil solutions were prepared in fixed proportionate solutions using coconut oil as a base. An irritation test was performed on each participant before continuing the trial and the essential solutions were applied topically everyday over a 19-day period. Results were assessed through photographic observation and suggests that tea tree oil may induce an increase in hair growth rate, however, due to there being no statistically significant difference between the essential oil solutions, the results are inconclusive.

Keywords: Essential oil, hair growth, Peppermint oil, Alopecia.

Literature review

Long, thick and luscious hair is a very desired trait and a beauty standard in many cultures around the world. Creating insecurities for both men and women who lack this desired trait which consequently feeds into the problem of companies' false advertising to make a profit. Many companies with a substantial social media following and influence in the health and beauty industry have been involved in several controversies over the years for advertising incorrect information in order to boost viewership and increase profit. According to the NYU Langone Health ``Androgenetic alopecia is the most common type of hair loss, affecting more than 50 million men and 30 million women in the United States." Androgenetic alopecia is caused by a genetically determined sensitivity to the effects of dihydrotestosterone (DHT). The anagen phase of the hair cycle lasts from three to six years and is thought to be shortened by DHT to just a few weeks or months. Which results in these follicles gradually becoming smaller as a result, producing progressively fewer and finer hairs.

Human hair growth does not follow a seasonal pattern. A random sample of hairs will be in one of the three growth and shedding stages: Anagen, catagen, or telogen, at any given time. The active phase of the hair cycle is anagen. This is where the cells in the hair's root are dividing rapidly, as a new hair grows, and pushes the previous hair up the follicle and out the other side. Catagen is the transitional state and takes 2-3 weeks to complete. During this phase the outer root sheath contracts and attaches to the hair root as growth ends, which is called the development of a club hair. The final stage is the telogen phase which is the resting stage. For scalp hair, this phase lasts for roughly 100 days. The hair follicle is completely at rest and the club hair is fully developed during this stage. A solid, hard, dry, white substance will be visible at the root of a hair when it is pulled out during this stage.

A study by Oh, Park and Kim (2014) investigated the effect of peppermint oil on hair growth with the aim to "address the therapeutic potential of peppermint oil (PEO) for hair loss via the comparative analysis between PEO and minoxidil (MXD)," and found that in terms of hair promotion "from week 2, PEO grew hair more rapidly than saline (SA) and jojoba oil (JO). At week 3, PEO remarkably promoted hair growth than SA and JO, even greater than MXD. At week 4, PEO showed hair growth about 92%, whereas MXD about 55%" with this the results clearly demonstrated that the topical application of "PEO induced very thick and long hair after 4-week topical application and promoted the elongation of hair follicles from the epidermis down to the subcutis in a vertical section (Fig. 3), showing in the stage of anagen III." This is significant because it indicates that there is a correlation with hair growth and the application of oils in addition to demonstrating

the potential use of peppermint oil as an assisting agent to promote hair growth. This study influenced my hypothesis and methodology which included the use of coconut oil as a base for my essential oil solutions. As the data was collected through photographic observation after each week this method of hair growth assessment was also implemented in my experiment twice a week. However a limitation of this study was that it was not done on humans but mice, and that the mice were all males, this is impactful because while this could potentially be used as a therapeutic or preventive alternative medicine for hair loss in humans, humans and mice are still different species and could potentially have different reactions to the application of peppermint oil, the factor of gender also needs to be further considered when assessing the effectiveness of peppermint oil as males are prone to grow hair faster than females due to the potency of testosterone in their system. Hence, further research into this should be done on humans of both genders with a wide age range and in my study will be done on male and female participants aged between 17-18 years old.

A study published through the International Journal of PharmTech Research by Jain, Das and Jain (2016), aimed to “to develop a formulation containing Ethanolic extracts of these drugs in the form of herbal hair oils in varying ratios & concentrations and evaluating the formulated oils for their hair growth initiating and hair growth promoting activity” as it made note in their introduction that “the traditional system of medicine in India acclaims a number of herbal drugs for hair growth promotion.” Although this article does not go over commonly known essential oils in the western beauty industry and is considered traditional Indian herbal medicine, the same theme of using essential oils as an agent to promote hair growth is still applied. Through their trial, the results demonstrated that “among the various formulation HF2 showed good and satisfactory result for hair initiation and hair growth activity, it also shows the remarkable improvement in the length of hair and its diameter as compared to control, standard and other test formulations HF1 & HF3 . Hence it can be concluded that HF2 shows excellent hair growth promoting activity.” This is significant because like the study above it further proves the correlation of essential oils and hair growth, as well as now kickstart further research on the production of hair oils to test on humans. The use of an irritation test and the use of a coconut oil base as a controlled group were implemented in my investigation. The article provided little details in their discussion and explanation of results which contributed to being a limitation for future researchers wanting to further this study as they would have to make some potentially inaccurate assumptions on the trial.

Regupathi, Chitra, Ruckmani and Kumaar (2016) in an effort to “formulate and evaluate hair growth promoting activity of various herbal hair gel formulations" include various concentrations of Eclipta alba L. Hassk. and Lippia nodiflora Linn. They make note that it

is “very important to develop new therapeutic materials to stop hair loss and to enhance hair growth,” as alternative medicine gains traction because it “has not yet been incorporated into the mainstream of medical care because of limited scientific evidence and lack of mechanistic understanding, alternative medicine is becoming an increasingly attractive approach all over the world.” The experiment prepared five different herbal hair gel formulations and topically applied them into seven groups of six mice, with one of these groups being a controlled group over a 30,-day time period. “Throughout the 30 days study period, all the seven groups of animals were observed closely to determine the hair growth initiation and completion time. This was achieved using a magnifying lens that enabled observation of minute changes in the hair growth pattern. The point at which a tiny prickle of hair growth was observed and it was noted as the initiation time.” They found “the effect of EEEA and EELN gel formulation on the qualitative hair growth and length was found to be more significant as compared to standard and control group treated animals. The quantitative effect of HG5 gel formulation definitely promotes hair growth by inducing hair follicles in the anagen phase.” For that reason, whilst it does not include the effects these formulations can have on humans, it is significant because it assists in future research as this gel formulation can be tested on human volunteers for its hair growth activity. Through this study, I was able to gain further inspiration in the conduction of my methodology and a greater understanding on the undertaking of the promotion of hair growth through the different biological stages of hair growth.

These studies share the recurring theme of using essential oil as an agent to assist the promotion of hair growth and address the issue of hair loss for both men and women in society. Yet also the limitation on the lack of results on human hair and the effectiveness of this being applied to humans. The purpose of my study is to learn more about what promotes hair growth and to see if the essential oils that many companies claim to have a beneficial effect on hair growth are indeed effective. Thus, the research question is, can essential oils be used as an agent to assist the promotion of hair growth?

Research Question

Can essential oils be used as an agent to assist the promotion of hair growth?

Research Hypothesis:

The essential oil Peppermint oil will have the greatest effect on the promotion of hair growth.

Null Hypothesis:

No greater effect in the promotion of hair growth will be seen in Peppermint oil compared to the selected range of essential oils.

Methodology

A pilot study was conducted on the author using the three oils in a base of Coconut oil and control of Coconut oil for a duration of two weeks to test the time for measurable hair growth and viability of the study and ability to measure hair growth from photographs.

Participants:

Six participants in total were recruited for this experiment, 3 of the participants were female and the other 3 participants were male aged between 17 and 18 years old. Participants completed a consent form and undertook an irritation test prior to commencing the trial.

The irritation test was conducted on the arm that would not be tested on. The essential oil solutions were applied to the skin and observed for 20 minutes. Those with the following symptoms could not participate in the experiment: hives, rashes, swelling, or irritation (itchy, burning sensations).

Preparation of solutions:

Three identical labelled ('L', 'P', 'T') 10ml solution bottles were prepared according to the ratio in Table 1 below. The fourth bottle was a control bottle of 10ml Coconut oil (labelled 'C').

Image 1: Labeled Identical Sample Bottles For Participants

Table 1: Ratio of solutions for topical application.

Solution 1	Solution 2	Solution 3
1ml Lavender, 9ml Coconut oil	1ml Peppermint, 9ml Coconut oil	1ml Tea Tree, 9ml Coconut oil

Application and Measurement:

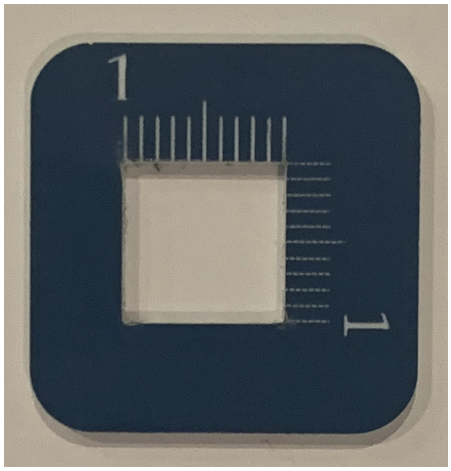
1. The upper side of the arm was shaved hairless into 4 even sections using a derma planing razor. These sections should run from the base of the hand to the elbow and be approximately 4cmx4cm squares. Photos were taken to record the beginning of the experiment.
2. Participants were allocated sections for the solutions. For example, Participant 1 was allocated T, P, C, L in order from elbow to wrist. The order was randomised for each participant.
3. The arm was prepared, by rinsing with water then patting dry with a paper towel before applying solutions. This was prior to original application and may not have been followed by participants upon daily application.
4. Participants were taught how to and advised to continue to apply the same amount of each solution to its allocated section and massage in a circular motion with two fingers until the solution has been absorbed by the skin.

Participants were instructed to repeat this process everyday for 3 weeks.

5. Participant arms were photographed in a purpose-built photography box with a laser cut measurement scale placed over each skin section, two times each week.
6. Photographic images were recorded and analysed to measure the progression and symptoms of the hair growth for the duration of the study.

Image 2: Photography Box

Image 3: Laser Cut Measurement Chip



Results

Table 2. Descriptive Statistics, Final Total Hair Growth.

	Control	Lavender	Peppermint	Tea Tree
Mean	2.12	2.22	2.55	2.63
St. Error	0.21	0.25	0.21	0.22
Median	2.00	2.00	2.45	2.00
Mode	1.00	2.00	3.00	2.00
Standard Deviation	1.14	1.23	1.13	1.32
Sample Variance	1.31	1.51	1.27	1.73
Range	4.70	4.60	4.50	5.50
Minimum	0.30	0.40	0.50	0.50
Maximum	5.00	5.00	5.00	6.00
Sum	65.80	55.50	76.50	94.50
Count	31.00	25.00	30.00	36.00

Table 3: ANOVA: Data Statistical Test, Final total hair growth.

Source Of Variation	Between Groups	Within Groups
df	3	118
F	1.2982	
P-value	0.2784	
F critical	2.6815	

Graph 1: Box and Whisker Plot of the Total Final Length in Hair Growth

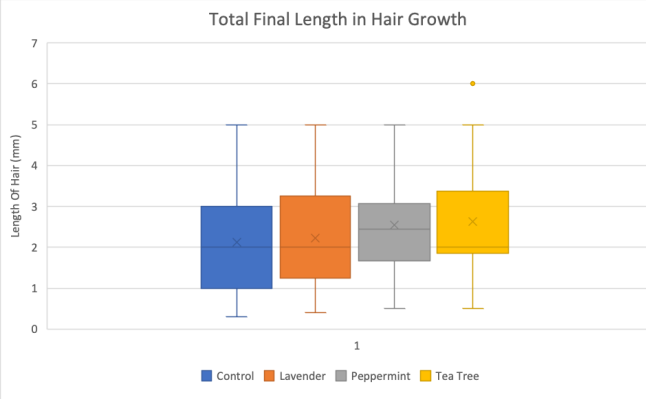


Table 4: Descriptive Statistics, Average Hair Quantity

	Control	Lavender	Peppermint	Tea Tree
Mean	**5.25**	**4.75**	**4.92**	**4.42**
St. Error	**0.77**	**0.72**	**0.56**	**1.02**
Median	**4.42**	**4.58**	**5.08**	**5.17**
Standard Deviation	**1.88**	**1.77**	**1.38**	**2.50**
Sample Variance	**3.52**	**3.12**	**1.90**	**6.24**
Range	**4.83**	**3.83**	**3.83**	**6.5**
Minimum	**3.67**	**3**	**3**	**0.5**
Maximum	**8.5**	**6.83**	**6.83**	**7**
Sum	**31.5**	**28.5**	**29.5**	**26.5**
Count	**6**	**6**	**6**	**6**

Table 5: ANOVA: Data Statistical Test, Average Hair Quantity

Source Of Variation	Between Groups	Within Groups
df	3	20
F	1.5481	
P-value	0.2331	
F critical	3.0984	

Graph 2: Box and Whisker Plot of the Total Average Hair Quantity Length in Hair Growth

Discussion

The experiment monitored the hair growth of 6 participants aged 17-18 years old, 3 female and 3 male, who applied 3 essential oil solutions (as shown in table 1) and a controlled solution every day over a period of 19 days. This was done to determine if the use of essential oils as an agent on the promotion of hair growth is effective. The essential oils chosen were Lavender, Peppermint and Tea tree oil and were chosen based on the healthline website advocating its effects in promoting hair

growth, along with their accessibility and affordability to buy them. For future trials, a larger range of essential oils could be tested, as well as in different concentrations. The progress of the participants hair growth was recorded through taking photos twice a week, the results were divided into two categories: Total final length in hair growth and Average hair quantity, and are as followed;

For total final length in hair growth, this measurement was chosen because it could demonstrate a distinct difference between the essential oils and the controlled solution on the progression of hair growth. The results demonstrated (in table 2) that all three essential oils had a greater mean compared to the controlled variable, with Tea tree oil having the greatest, followed by Peppermint, then Lavender oil. To make note, Peppermint oil along with the Controlled solution did have the highest and closest to the mean, median values, which indicates that data had the most consistent results due to it being the closest to an even distribution. The data in graph 1 illustrates that all four solutions had a similar range, but when examining the interquartile range, the solutions could be divided into two groups: the controlled and lavender solutions, which are most similar to one another and have the largest interquartile ranges, display that the data had a larger dispersion; while the peppermint and tea tree solutions, which are also most similar to one another, have the smallest interquartile ranges, depicting a smaller dispersion.

The measurement of Average hair quantity was chosen because it provides a recognisable indicator of the difference between the essential oil solutions and the controlled. The results exhibited (in table 4) that the controlled solution had the largest mean and sum compared to the essential oil solutions, with peppermint oil following after, then lavender and tea tree oil. Even so, the controlled solution also had the largest difference between its median and mean, indicating that when compared to essential oil solutions, they had more consistent results. In graph 2, the box and whisker plots again present that the controlled solution had the greater average hair quantity compared to the essential oil solutions but displayed the data as more positively skewed, while the lavender and peppermint oil solutions had the closest to a normal distribution along with range and interquartile ranges suggesting that there means were a better representation of the data sets than the other solution. The tea tree oil solution was negatively skewed and showed the largest range and interquartile range.

However, when both these results were put through a student's t-test (shown in table 3 and 5) it showed that there was no significant difference between groups because the p value was above the alpha value 0.05, also the F value was not larger than the f critical value, therefore the null hypothesis cannot be rejected. This result may be due to the size of the data set, as it was quite small. Future studies should include a larger data set, to

obtain a larger range and further improve the experiment's reliability and validity.

The reasons that could have led to the data having no difference in statistical significance come from potential areas of uncertainty such as lack of honesty from participants on whether or not they remembered to apply the essential oil solutions everyday or applied them properly. Including possible random errors, were a scar or freckle that looked like a hair was counted and measured or systematic errors such as irregularities in solution concentrations due to faulty equipment. These factors of reliability could be better established by finding a system that creates greater accountability for participants throughout the trial, doing photographic observations with a better camera and double checking the calibration of equipment.

Studies in the literature review did find a correlation between the application of essential oils and hair growth, when testing herbal essential oil solutions to male mice. Although no statistical hypothesis test was displayed, their results concluded that the essential oil formulations used did induce the promotion of hair growth. When comparing this experiment's results to the literature review, it reveals that while the experiment did indicate that tea tree oil had a possible effect on the promotion of hair growth in terms of hair rate as seen in table 2, nonetheless due to the limited time frame, small number of participants and the results of the student's t-test it can not be considered conclusive.

Future research improvements that could be made are increasing the sample size of participants, the time period of hair growth assessment from 19 days to potentially 30 days, as well as the age range of participants. This trial could also test different sections of the body with hair such as the legs or scalp, include a larger range of oils, or change the base oil. This study should also look into further considerations such as a person’s sex as males are proven to have a faster rate in hair growth and larger quantities of androgenic hair. Moreover, different ethnicities, as some ethnicities have proven to have faster hair growth rates compared to others due to factors such as varying diameters in follicles.

Conclusion

Can essential oils be used as an agent to assist the promotion of hair growth? The hypothesis tested, was that the essential oil Peppermint oil will have the greatest effect on the promotion of hair growth. The progress of the participants' results was recorded over a 19 day period and the results were divided into two categories: Total final length in hair growth and Average hair quantity. Total final length in hair showed that tea tree oil had the greatest final length, while Average hair quantity showed that the controlled solution produced the greatest average hair quantity. However, when a student's t-test was done these results ended up not being statistically significant and thus inconclusive. Therefore, while the null hypothesis, no greater effect in the promotion

of hair growth will be seen in Peppermint oil compared to the selected range of essential oils, cannot be rejected, this study did indicate that tea tree oil has a possible effect on the promotion of hair growth in terms of hair rate and with further improvements in regard to the data set this study could reveal further insight into the effect of essential oils on the promotion of hair growth and demonstrate a significant statistical difference.

Acknowledgements

Industrial Arts Staff from The Jannali High School, printing of measurement scale
Mrs A. Homola, Science Teacher
J. Miller and T. Clay, assistants
Ms P. Casaceli, Research Librarian

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Appendix

Image of Consent Form

Evaluating The Hair Growth Of Essential Oils
Consent Form

The purpose of this study is to learn more about what promotes hair growth and to see if the essential oils that many influential companies in the health and beauty industry claim to have a beneficial effect on hair growth are indeed effective.

The aim of this research project is to test the effectiveness of the following essential oils on increasing hair growth:

- Peppermint oil
- Lavender oil
- Tea tree oil

Method Overview:
For the experiment the participants' arms will be shaved using a derma planing razor into 4 sections, 3 of these sections will have peppermint, tea tree and lavender oil applied to the skin everyday for a 3 week period. The results will be recorded every 3 days.

Safety Precautions:

Risk	Incidence	Prevention
Itching, Tingling, Swelling, Hives, Rash or Eczema.	Allergic reaction to oils	Irritation test
Rash, Redness, Itchiness, Swelling, Tenderness or Burning sensation.	Cut from razor or razor burn	Using a derma planing razor
Watery eyes, Redness and Swelling of the eyelids, Gritty, Burning sensation in the eyes or Itchy eyelids.	Oil in eyes	Each participant will be taught proper procedure before the experiment begins

[Irritation Test] Each participant will take part in an irritation test and their reactions will be monitored for the first hours, before further participation.

If the following symptoms occur within a 24 hour irritation test further participation will not go ahead:
- Hives
- Rashes
- Swelling
- Irritation

Confidentiality:
The participant's names will remain confidential and be labelled as Participant 1, 2, 3, … etc
Information that will be recorded into data are as follows:
- Progression of hair growth
- Symptoms of hair growth
- Age
- Sex

I …… agree to participate in the research project Evaluating The Hair Growth Of Essential Oils conducted by Grace Caleo who has discussed the research project with me.

Name:

Signature:

Date: