

Senior Division – Grades 10-12

Second Place Winner - \$100 Cash Award
2 Methods to Control the Pore Sizes and Shapes

Problem

Advancements in medicine, public health, and medical research start in biomedical and pharmaceutical research labs. Conventionally, novel drugs, treatments, and tests are run on artificial models, such as tissue cultures and plastic based *in vitro* models, or lab animals. However, issues arise while testing on these subjects.

Artificial models

- Unable to accurately represent the complexity of human tissues and organs
- Are subject to delivery mechanism failure in *in vivo* testing
- Established methods require the use of human tissues and organs which are costly, scarce, and limited

Lab animals

- Normal anatomy and physiology, often from human anatomy and physiology
- Costly and ethically controversial

These inconsistencies in current models of testing affect the efficiency and efficacy of current drug testing. These kinds of issues create a growing demand to develop systems that accurately model human organs for safe, efficient, and effective drug testing.

Introduction

Microphysiological systems address the issues with current models of drug testing

These systems model microenvironments and structural components found within human body systems

Cells are grown on the membranes of these systems

The membrane of microphysiological systems was studied in this project

In this study, nanofibers were chosen to serve as the membranes of these systems

Nanofibers were chosen because they have a relatively simple fabrication method

Their unique structure is compatible with the extracellular matrix of cells

Cells can grow in the pores of the nanofibers

The pore size and shape determine how the cell interacts and responds to its environment

Purpose/Hypothesis

The Purpose:

- Discover different fabrication methods for nanofibers
- Control nanofiber fabrication to control cell growth
- Create systems that closely resemble human tissues and organs

The Hypothesis:

The pore sizes and shapes of nanofibers can be altered by...

- Changing the electrode/collector pairing that the fibers are fabricated on
- Changing the amount of time each trial is run for

Methods to Control the Pore Sizes and Shapes of Electrospun Nanofibers for Cell Study

Cindy Liang

Fabrication of the Fibers

1. A syringe with 10% polymer solution is attached to a syringe pump. A needle is also attached to the syringe
2. A collector/electrode pairing sits on an adjustable stand
3. A positive power supply is attached to the syringe needle
4. A negative power supply is attached to the electrode
5. Once the power supplies are turned on, the electrostatic force created by the electric field will break the surface tension of the polymer solution, forcing the solution to jet out of the syringe and land onto the collector due to the conductivity of the electrode



Methods to Test the Hypothesis

Listed below are methods used to test the hypothesis that different electrode/collector pairings or different time periods for fabrication will result in unique pore shapes and sizes.

Method 1	Method 2	Method 3	Method 4
30 minutes for each trial	10 min., 30 min., and 60 min. trials	30 minutes for each trial	10 min., 30 min., and 60 min. trials

Electrode/Collector pairing 1 was used

Pairing 1: electrode collector

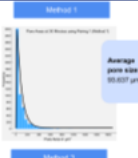
Pairing 2: electrode collector

The electrode is slightly smaller than the collector in this design. This design is chosen to avoid the electrode inadvertently disrupting the electric field. Exposure of the electrode to the electric field will disturb the electric field.

Copper strips attached to the sides of the collector serve as the electrode in the design. Electrodes were aligned perpendicularly in hopes of getting a perpendicular fiber alignment.

Results

Method 1



Average pore size: 85.00 µm

Method 2



Average pore size: 110.00 µm

Method 3



Average pore size: 115.00 µm

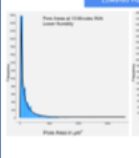
Method 4



Average pore size: 115.00 µm

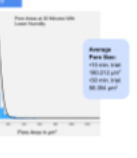
Results cont.

Lowest Humidity



Average pore size: 115.00 µm

Higher Humidity



Average pore size: 115.00 µm

When humidity is low, the average pore size is smaller. As humidity increases, the average pore size increases. This is due to the fact that the electric field is more effective at breaking the surface tension of the polymer solution when the humidity is low. When the humidity is high, the electric field is less effective at breaking the surface tension of the polymer solution, resulting in a larger average pore size.

Conclusions

Increased Time → Decreased average pore size (seen in data for Method 2 and 4) → Increased fiber density on the collector decreased the average pore size

Different electrode/collector pairings → Resulted in different fiber alignments → Different fiber alignments create different pore shapes

Decreased Humidity → Decreased average pore size (seen in Method 2 and the lower humidity trial)

Previous studies of nanofibers detailed the process of electrospinning; however, extensive study of the pairing of electrodes/collectors and ways to achieve different nanofiber pores and shapes was not approached before. Now, establishing these methods to control pore sizes and shapes will help the construction of microphysiological systems. With more control over nanofiber alignment, researchers will be able to fabricate fibers that generate cellular responses appropriate for research.

Discussion/Future Applications

Human microvascular stem cells (HMSCs) will soon be grown on these nanofiber systems

• Different stem cell responses to these fibers will be observed

• The physical patterns created by these nanofibers could potentially affect the stem cell behavior

• This will ultimately affect the cell differentiation and gene expression

Gene expression for stem cell growth of each of the 4 fibrous vascular patterns will be analyzed to determine which of the stem cells will differentiate into various cell types and which of the fibers that should be utilized to produce these cells into various body cells

• Replicating gene expression in these cells will verify that these fibers can stimulate environments similar to healthy stem niches

Ultimately, new enhanced systems will be constructed using compatible nanofibrous membranes. Medical and pharmaceutical researchers will benefit by conducting trials quickly, efficiently, and safely with these new, enhanced systems.

Project ID: 148725

Senior Division – Grades 10-12

Third Place Winner - \$50 Cash Award

3 Genetic Modification of Medicago

Project ID: 150770

Problem

- Cattle bloat is the buildup of a stable, viscous foam in the rumen of livestock and can cause pressure on the diaphragm of cattle resulting in asphyxiation and even death.
- Cattle bloat kills 20,000 cows in New Zealand annually and costs American farmers \$80 million every year.
- Research has confirmed that cattle bloat is caused by livestock feed lacking proanthocyanidins (PAs).



Background

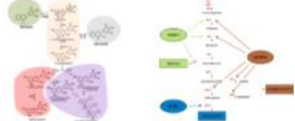
- Proanthocyanidins are polyphenols that are produced from the flavonoid pathway in plants. The presence of PAs in plants is significant as they increase seed sprouting, reduce plant bloating, improve human immune systems, and sequester atmospheric carbon.



- Medicago sativa*, also commonly known as alfalfa, is an excellent source of protein and energy for cattle. In fact, one ton of alfalfa hay contains as much digestible energy as 25 bushels of corn. Because of its dietary advantages, alfalfa is one of the most commonly used livestock feeds globally. However, alfalfa has one major downfall: proanthocyanidins do not accumulate in alfalfa forage.
- Previous research endeavors to increase PA production in alfalfa involved plant breeding and tissue culture strategies; however, both methods were unsuccessful.
- Because of this, genetic modification has gained the spotlight as a novel method to increase PA production in alfalfa.
- Localizing the genetic modification to the epidermal tissues of alfalfa will avoid undesired interactions with important chemical pathways in order to maximize PA production while maintaining stable plant growth.

Purpose and Hypothesis

- The purpose of this research project is to find promoter sequences that would increase the expression of MYB transcription factors that regulate proanthocyanidin production.
- If a highly active epidermal tissue specific promoter was applied to genes affecting proanthocyanidin synthesis in alfalfa, then the alfalfa would have an increased production of proanthocyanidins in the epidermal tissues.



Methodology

Three criteria were used to select optimal promoters. First, the promoter must have epidermal-specific expression. Second, the promoter must be highly active. And thirdly, the promoter's activity must stay consistent when exposed to different seasonal conditions. To analyze these criteria for the promoters, RNA-Sequencing (RNA-seq), quantitative Polymerase Chain Reaction (qPCR), and GUS Reporter assay were performed.



Phase 1: RNA Sequencing

- RNA-Seq was performed on five different leaf structures of *Medicago truncatula* (a genetically similar species to alfalfa):

- A. Upper Epidermis
- B. Rest of Upper Epidermis
- C. Bottom Epidermis
- D. Rest of Bottom Epidermis
- E. Entire Leaf



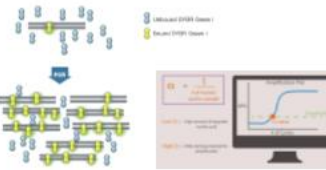
- Genes with high FPKM values only in A, C, or both had epidermal tissue specific expression and were considered as candidate genes.
- RNA-seq revealed that there were 11 upper epidermis specific promoters. The FPKM values for tissue A for these promoters is significantly higher than the FPKM values for the other tissues.
- RNA-seq revealed that there were 12 bottom epidermis specific promoters. The FPKM values for tissue C for these promoters is significantly higher than the FPKM values for the other tissues.
- RNA-seq revealed that there were 16 upper and bottom epidermis specific promoters. The FPKM values for tissue A and C for these promoters is significantly higher than the FPKM values for the other tissues.

RNA-seq Results

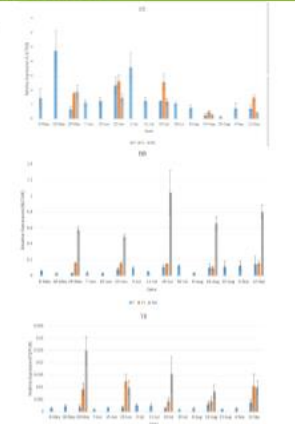
	UPPER_FPKM	UPPER_FPKM	UPPER_FPKM	UPPER_FPKM	UPPER_FPKM
U1	100.0	100.0	100.0	100.0	100.0
U2	100.0	100.0	100.0	100.0	100.0
U3	100.0	100.0	100.0	100.0	100.0
U4	100.0	100.0	100.0	100.0	100.0
U5	100.0	100.0	100.0	100.0	100.0
U6	100.0	100.0	100.0	100.0	100.0
U7	100.0	100.0	100.0	100.0	100.0
U8	100.0	100.0	100.0	100.0	100.0
U9	100.0	100.0	100.0	100.0	100.0
U10	100.0	100.0	100.0	100.0	100.0
U11	100.0	100.0	100.0	100.0	100.0
U12	100.0	100.0	100.0	100.0	100.0
U13	100.0	100.0	100.0	100.0	100.0
U14	100.0	100.0	100.0	100.0	100.0
U15	100.0	100.0	100.0	100.0	100.0
U16	100.0	100.0	100.0	100.0	100.0
U17	100.0	100.0	100.0	100.0	100.0
U18	100.0	100.0	100.0	100.0	100.0
U19	100.0	100.0	100.0	100.0	100.0
U20	100.0	100.0	100.0	100.0	100.0
U21	100.0	100.0	100.0	100.0	100.0
U22	100.0	100.0	100.0	100.0	100.0
U23	100.0	100.0	100.0	100.0	100.0
U24	100.0	100.0	100.0	100.0	100.0
U25	100.0	100.0	100.0	100.0	100.0
U26	100.0	100.0	100.0	100.0	100.0
U27	100.0	100.0	100.0	100.0	100.0
U28	100.0	100.0	100.0	100.0	100.0
U29	100.0	100.0	100.0	100.0	100.0
U30	100.0	100.0	100.0	100.0	100.0
U31	100.0	100.0	100.0	100.0	100.0
U32	100.0	100.0	100.0	100.0	100.0
U33	100.0	100.0	100.0	100.0	100.0
U34	100.0	100.0	100.0	100.0	100.0
U35	100.0	100.0	100.0	100.0	100.0
U36	100.0	100.0	100.0	100.0	100.0
U37	100.0	100.0	100.0	100.0	100.0
U38	100.0	100.0	100.0	100.0	100.0
U39	100.0	100.0	100.0	100.0	100.0
U40	100.0	100.0	100.0	100.0	100.0
U41	100.0	100.0	100.0	100.0	100.0
U42	100.0	100.0	100.0	100.0	100.0
U43	100.0	100.0	100.0	100.0	100.0
U44	100.0	100.0	100.0	100.0	100.0
U45	100.0	100.0	100.0	100.0	100.0
U46	100.0	100.0	100.0	100.0	100.0
U47	100.0	100.0	100.0	100.0	100.0
U48	100.0	100.0	100.0	100.0	100.0
U49	100.0	100.0	100.0	100.0	100.0
U50	100.0	100.0	100.0	100.0	100.0
U51	100.0	100.0	100.0	100.0	100.0
U52	100.0	100.0	100.0	100.0	100.0
U53	100.0	100.0	100.0	100.0	100.0
U54	100.0	100.0	100.0	100.0	100.0
U55	100.0	100.0	100.0	100.0	100.0
U56	100.0	100.0	100.0	100.0	100.0
U57	100.0	100.0	100.0	100.0	100.0
U58	100.0	100.0	100.0	100.0	100.0
U59	100.0	100.0	100.0	100.0	100.0
U60	100.0	100.0	100.0	100.0	100.0
U61	100.0	100.0	100.0	100.0	100.0
U62	100.0	100.0	100.0	100.0	100.0
U63	100.0	100.0	100.0	100.0	100.0
U64	100.0	100.0	100.0	100.0	100.0
U65	100.0	100.0	100.0	100.0	100.0
U66	100.0	100.0	100.0	100.0	100.0
U67	100.0	100.0	100.0	100.0	100.0
U68	100.0	100.0	100.0	100.0	100.0
U69	100.0	100.0	100.0	100.0	100.0
U70	100.0	100.0	100.0	100.0	100.0
U71	100.0	100.0	100.0	100.0	100.0
U72	100.0	100.0	100.0	100.0	100.0
U73	100.0	100.0	100.0	100.0	100.0
U74	100.0	100.0	100.0	100.0	100.0
U75	100.0	100.0	100.0	100.0	100.0
U76	100.0	100.0	100.0	100.0	100.0
U77	100.0	100.0	100.0	100.0	100.0
U78	100.0	100.0	100.0	100.0	100.0
U79	100.0	100.0	100.0	100.0	100.0
U80	100.0	100.0	100.0	100.0	100.0
U81	100.0	100.0	100.0	100.0	100.0
U82	100.0	100.0	100.0	100.0	100.0
U83	100.0	100.0	100.0	100.0	100.0
U84	100.0	100.0	100.0	100.0	100.0
U85	100.0	100.0	100.0	100.0	100.0
U86	100.0	100.0	100.0	100.0	100.0
U87	100.0	100.0	100.0	100.0	100.0
U88	100.0	100.0	100.0	100.0	100.0
U89	100.0	100.0	100.0	100.0	100.0
U90	100.0	100.0	100.0	100.0	100.0
U91	100.0	100.0	100.0	100.0	100.0
U92	100.0	100.0	100.0	100.0	100.0
U93	100.0	100.0	100.0	100.0	100.0
U94	100.0	100.0	100.0	100.0	100.0
U95	100.0	100.0	100.0	100.0	100.0
U96	100.0	100.0	100.0	100.0	100.0
U97	100.0	100.0	100.0	100.0	100.0
U98	100.0	100.0	100.0	100.0	100.0
U99	100.0	100.0	100.0	100.0	100.0
U100	100.0	100.0	100.0	100.0	100.0

Phase 2: qPCR

- Quantitative Polymerase Chain Reaction, or qPCR, was used to discover which candidate promoters were most active and consistent with seasonal changes.
- In qPCR, a primer mixture containing the DNA from the gene of the candidate promoter, water, and the Power SYBR PCR Master Mix, containing fluorescent dye and a thermostable DNA polymerase is mixed with the cDNA of 99 alfalfa samples planted at different times of the year.
- During elongation, the fluorescent dye will bind to the cDNA at sites of the target candidate gene.
- During the denaturation process, the fluorescence is released indicating genetic expression.
- qPCR produces cycle threshold scores. Cycle Threshold (CT) scores are inversely proportional to expression level of the genes.
- The relative expression of each candidate gene was calculated in comparison to the expression of the housekeeper gene, tubulin.
- Three promoters were selected as being most optimal: U1, B8, and T8.



qPCR Results



Phase 3: GUS Reporter Assay

- GUS staining was performed with the B8 and T8 promoters to confirm high promoter activity.
- Model organism *Arabidopsis thaliana* was used for the staining procedure.
- Expression vectors containing the promoters and the GUS gene were inserted in *Agrobacterium tumefaciens*, which infected *Arabidopsis thaliana*, which then showed blue staining to indicate high expression.

GUS Reporter Assay Results



Conclusion and Future Plans

- The U1 promoter showed the greatest gene expression but was more volatile than B8 and T8. The B8 and T8 promoters showed the most consistent results across different seasons, and had significant gene expression for mature leaf samples. GUS staining confirmed the high promoter activity of B8 and T8.
- Future plans include inducing PA synthesis as secondary metabolites to environmental stresses and applying the promoters on specific flavonoid pathway enzymes rather than MYB Transcription Factors. Both B8 and T8 have shown positive results in increasing PA production in transgenic alfalfa lines so far but further testing is needed.
- Mass-producing PA-rich alfalfa will have important applications in agriculture, medicine, and climate science.

Senior Division – Grades 10-12

Special Award - \$50 Cash Award – Business Application

Background

Deep learning systems:

- Successful at a wide variety of high-level tasks on short documents
- Limited success on complex and lengthy documents

Text graph based systems:

- Successful at a wide variety of basic tasks on short documents and lengthy documents alike
- Limited success on high level information extraction and knowledge representation tasks

Those deficiencies greatly limit the applications of natural language processing (NLP).

Engineering Goals

To make NLP more practical and accessible, a model that combines the strength of different approaches is constructed. The model is available at [1].

The engineering goals of the symbiotic approach include:

- Comparable performance to solely machine learning based approaches on short texts
- Superior performance than machine learning based approached on medium to long text length
- Higher resilience to increasing text length than machine learning based approaches
- Wide range of applications and flexibility

Description of Design

- Text graph expansion
- Prioritization of entities
- Scaling against distance in text graph
- Statistical representation of entity importance
- Scaling against sentence length
- Question words expansion
- Synergy between text graph based NLP and machine learning based NLP

Methodology

1. Create a text graph of the text using extracted relations
2. Identify sentences that are likely answers to questions (algorithmically), using either Talker or Ripple
3. Feed the identified sentences into BERT, a deep learning model that can only handle very small text documents
4. BERT [2] returns a short answer

Symbiotic Neural and Graph-based Question Answering

Yifan Guo

Creating TextGraph

Procedure

Designing TextGraph

Entity-oriented Text Graph Representation:

- SVO edge and has instance edge
- Prioritization of nouns

Text Graph Expansion using Syntactic Relations:

- Syntactic Relations Edges

Question Answering

Procedure

Talker

For each sentence, ranking value = $\frac{\text{shared} \times \text{important}}{\text{unusual}}$

- shared = the amount of original question words and expanded question words in the sentence
- important = the ranking value of the sentence
$$IV = \text{sentence length} - \text{average sentence length} \times \text{sentence length}$$
- unusual = $\frac{\text{degree}(Q)}{\text{the harmonic mean of the number of occurrences of each question word}} \times \text{the number of sentences in the article}$

Ripple

Scaling against distance

Ripple Example

Q: Who wanted to paint the roses red?

Original key words: paint, rose, red

Testing

Stanford Question Answering Dataset (SQuAD)

Usually, an article from the SQuAD dataset [3] is broken into about 10 paragraphs and each paragraph is processed individually.

Such ideal tests are unrealistic in a real-world situation, where the texts analyzed are seldom pre-processed and usually much longer.

Therefore, two tests are conducted to simulate real-world situations:

1. Full Articles Processing: multiple full articles are combined and fed to the models at once.
2. Paragraph Processing: multiple paragraphs are combined and fed to the models at once.

In each text, the F1 score and word count are recorded.

Full Articles Processing (SQuAD)

Word Count Range	Talker	Ripple	BERT
2000-3000	68.08	70.22	61.66
3000-10000	67.20	66.13	58.66
10000-30000	64.59	61.23	51.37

Paragraphs Processing(SQuAD)

Word Count Range	Talker F1	Ripple F1	BERT F1
0-399	61.41	67.66	58.15
400-599	70.70	74.23	70.61
600-999	70.58	71.24	66.59
1000-1499	69.4	71.21	63.34
1500-1999	67.04	67.08	61.47
2000-2499	61.65	62.69	61.48
2500-2999	64.97	64.15	61.99
3000-3499	65.2	66.58	62.82
3500-4000	64.39	66.41	61.16

NewsQA

NewsQA dataset [4] contains short documents that are CNN articles.

Type	F1	Exact Match
Talker	38.3	28.09
Ripple	36.15	26.62
Bert	35.1	25.44

Project ID: 147115

Data Analysis

The Symbiotic approach achieves:

- More resilience to increase in text length compared to BERT
- Better performance than BERT on all tested texts over 100 words
- Decent performance on news article dataset
- High accuracy

Error Analysis

- Version 1.4 of the symbiotic system did not filter noise words and sentences
- Version 2.1 of the symbiotic system did not incorporate BERT correctly
- Version 1.3 of the Ripple algorithm put too much weight on expanded question words

Conclusion

The symbiotic approach achieves:

- High resilience to lengthy text
- A wider variety of applications compared to solely deep learning based models

The symbiotic approach would be suitable for:

- Question answering on all types of document
- Daily Usage (ex: answering questions regarding lengthy product instructions, legal documents, and books)

The symbiotic approach has implications for:

- Natural Language Understanding
- Artificial General Intelligence

Applications

- Chat-bot for books
- Automatic summarizer (combined with a scanner)
- Improving the performance of machine learning based NLP systems
- Social media monitoring
- Survey-income analysis
- More flexible and intelligent search engines

References

- [1] <https://github.com/Yifan-Guo/symbiotic>
- [2] Jacob Devlin, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. 2019. BERT: Pre-training of deep bidirectional transformers for language understanding. In Proceedings of NAAACL.
- [3] Pranav Rajpurkar, Jian Zhang, Konstantin Lopyrev, and Percy Liang. Squad: 100,000+ questions for machine comprehension of text. arXiv preprint arXiv:1606.05250, 2016.
- [4] Adam Fischler, Tong Wang, Xingdi Yuan, Justin Martin, Alessandro Sordani, Philip Bachman, and Zaher Sultan. NewsQA: A machine comprehension dataset. arXiv preprint arXiv:1611.09430, 2016.

Special Award - \$50 Cash Award – Learn from Mistakes, Not a Failure

Project ID:139225

- Enabling the input to be a 1000bp DNA Sequence to predict the effect of the mutation in conjugation with the functional conservation score
- Reducing the Biological noise within the Cross-Species Training Data
- Determining why the functional conservation score and the phyloP/phastCons scores did not have as a high of a correlation as intended
- Try training the model through a LSTM approach rather than an 8-layer CNN

Does fabric content (i.e., 100% cotton vs. Cotton/Poly blend) in similar items of clothing, like t-shirts, impact UV reduction?

Junior Division – Grades 7-9

Third Place Winner - \$25 Cash Award

HOW TO HEAT UP YOUR GOLF GAME:
Effects of temperature on the speed and distance of your golf ball
Jimmy Mackley

PROJECT ID #153096

Rationale

One of golf is pure physics with a golf swing being the transfer of energy from the club to the ball. For the golfer, control and consistency is key. All golfers want to maximize their long drive which is dependent on many different factors.

A known fact is that a golf ball will travel less distance in colder temperatures. When a golf ball and golf club are colder, the transfer of energy is not as efficient, so the ball speed will be lower. Also, cold air is more dense than warm air, resulting in more drag.

A general belief is that golfers lose two yards on their drives for every 10 degree drop in temperature and that golfers will hit out two yards on their drives for every 10 degree rise in temperature. It is a common practice to switch to a lower compression ball in colder weather because the compression of the ball decreases in cold temperatures.

With heat, ball compression goes up which is the basis of this experiment. I want to see if the actual ball temperature impacts a golfer's performance by affecting the distance the ball travels through the air.

Introduction

It is the actual distance the ball travels through the air. Spinners to the speed that it spins on its axis while in flight. It is measured in revolutions per minute (rpm). The spin on your ball generates lift which affects how high the golf ball flies and also affects the distance. Applying the right amount of spin will also stop the ball. The ideal ball is the one that carries the longest distance and also stops according to the player's technique. The spin rate is dependent on different things such as golf club velocity, the golf club face, weather conditions and of course the golfer's technique. Club speed is the speed the club head is moving immediately prior to impact. Club speed also affects a golfer's potential distance.

It has been known to change the type of golf ball based on compressibility depending on the weather. A low compression ball allows the golfer to hit farther while a high compression ball is for accuracy and precision.

A modern day golf ball has a solid inner core made of rubber or plastic materials which have different densities and compressibilities. The tighter the core, the higher the compression. Golf balls have a thin outer covering made of resin. Balls are designed with different compression rates which affect the golfer can affect distance and control. A ball with low compression is wound less tight and is considered to be soft and can go farther but with less control. A ball with a high compression is wound tighter and is referred to as being hard.

Methods and Materials

MATERIALS

- Titleist NTX tour practice golf balls (60)
- TrackMan golf radar
- Taylor Made Sim Driver golf club (standard flex / Mitsubishi Diamana S Limited 60 shaft)

I conducted my experiment at one setting using the TrackMan golf simulator to record my data which included:

Carry	Ball speed
Spin rate	Height
Total distance	Trajectory
Club speed	Dispersion

The ambient temperature was 59 degrees Fahrenheit. I hit 60 range balls (Titleist) using my driver at full swing. 20 balls were at ambient temperature. 20 balls were cooled in ice water (32 degrees Fahrenheit). 20 balls were heated in hot water (159 degrees Fahrenheit).

Summary/Discussion

I did not prove that heated balls increase drive distance but did confirm that cold balls do not travel as far. I tried to do all my experiments at one session since it would be hard to recreate the exact outside temperature conditions on different days. A limitation of my experiment is the fact that hitting 60 golf balls at full swing consecutively can result in golfer fatigue. I did note that my club speed was consistent for all three study groups indicating that my effort was consistent and would not skew the data. While the total distance was not my main focus, the heated balls were not longer than the ambient balls. However the cooled balls traveled a shorter distance than both groups.

Results

AMBIENT TEMP
table 1

Carry	Ball speed	Spin rate	Total distance	Club speed	Height	Trajectory	Dispersion
180.9	118.1	2577	2577	83.1	66.0	118.1	2577
176.3	114.7	2803	2803	83.2	72.0	114.7	2803
173.6	113.8	2331	2331	83.2	67.0	113.8	2331

DISPERSION
graph 1

TRAJECTORY
graph 2

CONCLUSIONS

For the ambient temperature balls (control) the average carry was 180.9 yards, spin rate 2577 rpm, club speed of 83.1mph ball speed 118.1mph and height of 66ft. (table 1)

For the heated balls the average carry was 176.3, spin rate 2803 rpm, club speed 83.2mph, ball speed 114.7mph and height 72ft. (table 2)

For the cold balls the average carry was 173.6 yards, spin rate 2331 rpm, club speed 83.2mph, ball speed 113.8mph and height 67ft. (table 3)

The Dispersion graph showed consistency of drives in the target region. (graph 1)

The Trajectory graph shows the consistency of the drives and the flight paths of the balls as they launch through the air. (graph 2)

The average club speed for the three groups ambient 83.1 mph/ heated 83.2mph / cooled 83.2mph.

Future Directions

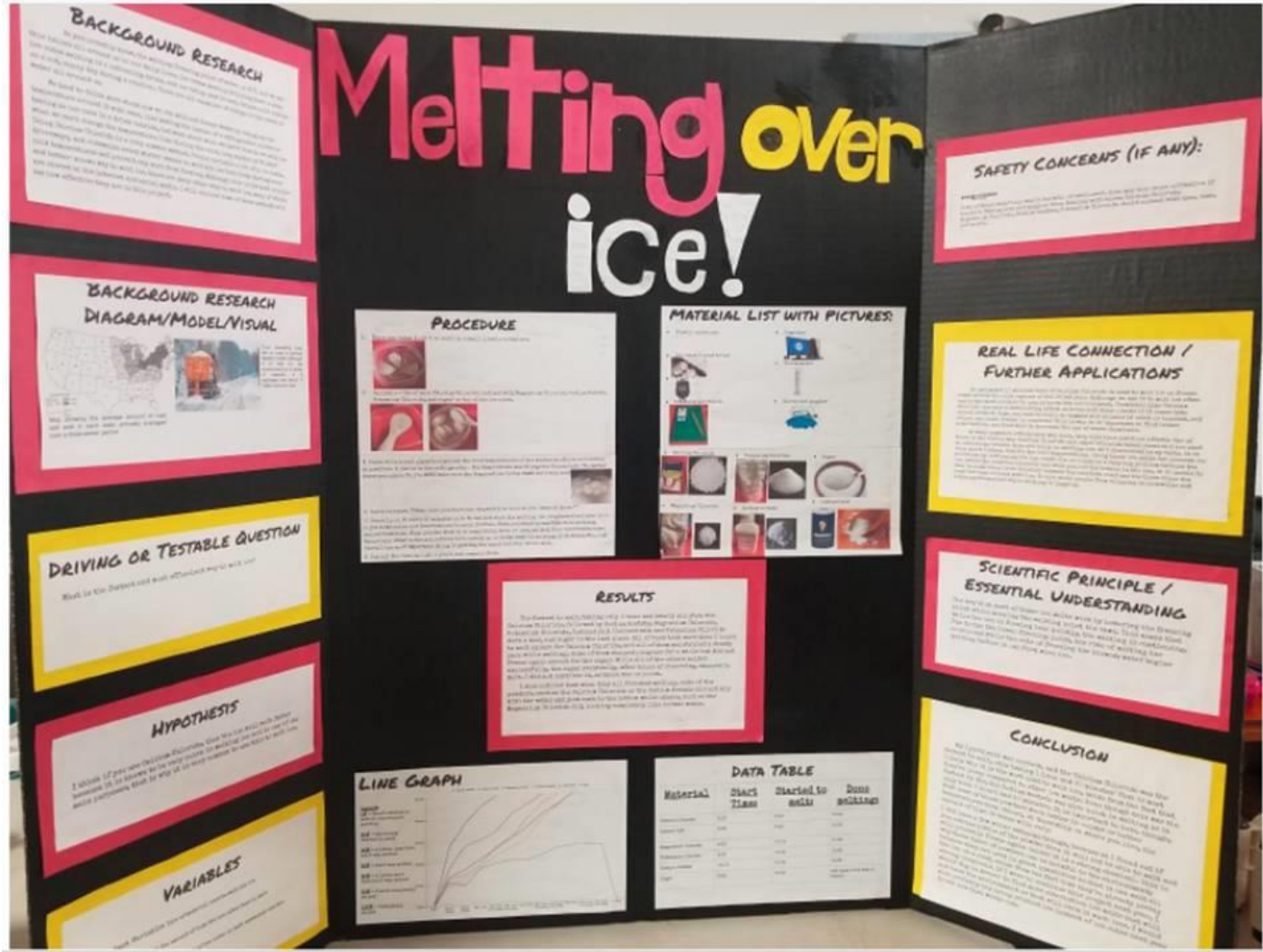
Future experiments could look at different club heads under the 3 conditions. Also, measuring the actual compression of the golf ball and perhaps even different brands of golf balls would be a great study.

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Junior Division – Grades 7-9

Special Award - \$25 Cash Award – Practical Application



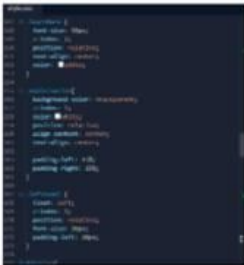
Junior Division – Grades 7-9

Special Award - \$25 Cash Award – Computer Simulation Programming

What Resources do we Have Left: An interactive 3D modeled globe.

Abstract

This project was made to better reinforce viewers about climate change. Through visual reinforcement, the viewer is often better off than reading some article. Research has show that people better understand something when they are shown images or models. This project was created in order to fix the way that people are informed about climate change. It is innovating the industry in order to convince more people. I did some research about climate change and how our world has been changing. I funneled all of this research into the website so it was informative. In conclusion, my website combines standard learning with an interactive website allowing the user to fully understand climate change.



Conclusion

According to a survey of multiple family and friends, 90% of them said that they had a better understanding of the world's changing climate due to the website.

Rationale

Over the years, there has been many attempts to try and get the point across that climate change is a big deal. They get people to understand how its important, but don't explain ways to help. My website does and has a page that talks about ways anyone can help.



Materials

Laptop, Coding Software, Blender, free website hosting using GitHub developer pack.

Engineering Goal

Does a more interactive website better promote people to be more aware about climate and take action themselves.

Procedure

First I designed my website with a drawing and decided which features I was going to add. Then I started coding each part, bit by bit. That's how I did it!

Data and Observations

Data collected from family and friends shows that 90% of them benefited from the website and said that they understood the state of the earth better than before.

Future

Next year I plan on adding many new features, such as a more in depth simulation and more iterations of the earth.

Special Award - \$50 Cash Award – Water Purification

