

**Briarcliff Science Research**  
**Junior and Senior Summer Assignments**  
**2026**

**Table of Contents**

|                                                                      |    |
|----------------------------------------------------------------------|----|
| Summer Assignment Instructions by Student Grade and Designation..... | 2  |
| Appendix A: Lab Notebook Formatting.....                             | 6  |
| Appendix B: Statistics Information.....                              | 7  |
| Appendix C: Writing a Research Plan.....                             | 9  |
| Appendix D: Review of Literature Outline.....                        | 11 |
| Appendix E: Review of Literature Exemplar.....                       | 12 |
| Appendix F: Review of Literature Outline Grading Rubric.....         | 18 |
| Appendix G: Junior Summer Work Rubric.....                           | 19 |
| Appendix H: Senior Summer Work Rubric.....                           | 20 |
| Appendix I: Competition Forms.....                                   | 21 |

## **Summer Assignments for Science Research**

**Due: Friday September 4, 2025**

These summer assignments are a requirement of the course and will count for 100% of your UAlbany grade and 20% of your Briarcliff 1<sup>st</sup> Qtr grade. Please note that if you fail to meet these requirements you may also jeopardize your standing in the course.

**All students must log at least 90 hours of work over the summer!**

**\*Note:** *All students should be sure to fill out all forms and confirm with Technology that they can take home their school computer for the summer. This is critical!*

**\*\*All students must contact their assigned summer instructor with updates and to schedule the required meetings. Instructors will not be responsible for initiating contact. If a student does not complete their summer work requirements, and/or does not contact their instructor for the required meetings, that student may be barred from continuing in the program the following September.**

**\*\*\*Summer meetings must be completed by Tuesday, August 25<sup>th</sup>, 2026. Summer work will be due Friday, 9/4/2026.**

### **All Rising Seniors:**

1. If not done already, complete the [Forms Wizard](https://ruleswizard.societyforscience.org) at <https://ruleswizard.societyforscience.org> and print out the results page.
2. While with mentor, have them complete all the required forms that the Wizard told you applies to your project (All forms can be found in Appendix I). *You should complete as much of the form yourself as possible before giving it to your mentor.*
  - Adult Sponsor = Your teacher
  - Designated Supervisor = Mentor/Person directly supervising you
  - Qualified Scientist = Head of Lab (if there is no head of lab, this may be the same person as the Designated Supervisor)

The following forms need to be signed and dated **prior** to data collection:

1,1B,2,3,4,5A,6A,6B (\*Note for Form 1B, leave the local fair part blank.)

The following forms need to be signed and dated **after** data collection:

1C,5B,7

3. Carry out research.
4. Complete data collection / Record work in **Lab Notebook (See lab notebook requirements from class)** (Appendix A)
5. Start the **Statistical Analysis**. The decision documents (Appendix B) will help you figure out what statistical test to do. **Students are encouraged to use Data Classroom to complete their statistical analysis.** If you need to use Excel to perform your statistical test, use the following instructions to enable most statistical tests to be conducted.
  - a. Under the “Data” tab, all the way on the right, select “Analysis Tools,5A” then check “Analysis Toolpak” and a “Data Analysis” button will appear. You can click on this to see what statistical tests are available.

- b. You should watch tutorials on YouTube to see how to do your test in Excel. Search "Excel" and the name of your statistical test on YouTube.
6. Write Introduction, Methods, Results and Discussion sections of paper.
7. Complete 1st draft of paper with 20+ citations.
8. View and print forms for WESEF and JSHS (Appendix I).
9. Meet your teacher twice during the summer. Once at the beginning of your research (July) and once by mid-August. **Your teacher will be waiting for you to initiate the contact, not the other way around!** Meetings can be in-person or virtual.

The rubric for how you will be assessed on your summer assignment is located in **Appendices H** and this will be prorated to be your first TriWeekly Meeting Grade of Q1.

### **Additional for Rising Seniors doing STS:**

1. Attend a 2-hour STS Meeting on **June 15<sup>th</sup> at 10am** in the Science Research Room.
2. Complete all assignments handed out at the 6/15 STS Meeting by the designated dates.
3. Complete your research project.
4. Stay in contact with your teacher throughout the summer and respond to their emails promptly.
5. Meet with your teacher at the end of the summer
6. View, print, and sign forms for Regeneron STS and WESEF (Appendix I) and PWrS^3 if available.

*If you change your mind during the summer and decide not to do STS, you must complete the "All Rising Seniors" assignment and notify your teacher immediately.*

**\*\*\*Do not** forget to take binders and lab notebooks home for the summer! Remember that if you do not collect data over the summer, you may be asked to drop the class.

### **Rising Juniors:**

1. Email the teacher you have been assigned to work with for the summer in June. Introduce yourself and briefly summarize what you are studying (if you are assigned to a new teacher).
2. By the end of this summer, you should have read at least 25 articles on your current topic, and at least 10 of these articles should be new articles not read during the previous school year. Your list of articles will be checked with your teacher from the previous year to confirm you have read at least 10 new ones and submitted the work below on the new articles. Re-submitting articles that you have previously read will be considered an academic integrity violation.
3. Read your personal required number of new articles (25 minus the number you read during the school year) and:
  - a. Annotate them
  - b. Write a ½ -1-page summary of the article
  - c. Write 2-3 questions that can be discussed with a mentor from the article
  - d. Outline the various sections of the paper
4. Complete daily log in **Lab Notebook** (Appendix A)
5. Write a **cite page**. This page should include citations for at least 25 papers related to your area of research. Below each citation, please summarize the main points of the article in 4-5 sentences.
6. Complete a detailed **Review of Literature Outline** (see Appendix D for instructions, Appendix E for exemplar, and Appendix F for grading rubric)
7. Submit at least 3 email exchanges with your mentor, showing that you are staying connected and working on your project.
8. Email and meet with your teacher at least once (more is better) during the summer to demonstrate the progress you have been making and plan any next steps. See the rubric in Appendix G. **This grade will be prorated to be your first TriWeekly Meeting Grade.**
9. Your teacher will be waiting for you to initiate the contact, not the other way around!

### ***If you plan to conduct your research over the summer, you must additionally:***

1. Collaborate with your mentor to develop your **Research Plan** (Appendix C). This should be written in the future tense before you collect your data. (second page of ISEF Form 1A)
2. Carry out research, documenting all your work in your **Lab Notebook** (Appendix A) as you proceed.
3. Complete data collection, continuing to document all your work in your **Lab Notebook** (Appendix A).
4. Start the Statistical Analysis. The decision documents (Appendix B) will help you figure out what statistical test to do. Students are encouraged to use Data Classroom to complete their statistical analysis. If you need to use Excel to perform your statistical test, use the following instructions to enable most statistical tests to be conducted.
  - a. Under the “Data” tab, all the way on the right, select “Analysis Tools” then check “Analysis Toolpak” and a “Data Analysis” button will appear. You can click on this to see what statistical tests are available.
  - b. You should watch tutorials on YouTube to see how to do your test in Excel. Search “Excel” and the name of your statistical test on YouTube.

5. Complete Steps 1 and 2 under "All Rising Seniors" by having your mentor fill out the forms for WESEF that apply to your project. Stay in good contact with your teacher to keep them informed about your progress. You will likely need to meet with them a second time over the summer.

***If you do not yet have a mentor, you now have probationary status, and you will need to do the following in addition to #1-7 under Rising Juniors:***

1. Get a mentor – show emails and telephone logs. You must try to contact at least 15 people or until you obtain a mentor. CC your assigned summer teacher on these emails. If you get a mentor, contact your assigned summer teacher immediately. ***YOU MUST HAVE A MENTOR BY JANUARY TO CONTINUE IN THE PROGRAM.***

Do not forget to take binders and lab notebooks home for the summer! Remember that if you do not do this work and get a mentor you may be asked to drop the class.

The rubrics for how you will be assessed on your summer assignment are located in **Appendices F and G**. *These will be prorated to be your first TriWeekly Meeting Grade of Q1.*

## **Appendix A: Lab Notebook (Log) Formatting**

General Format (hard copy or digital- can be a lab notebook you purchase, a lab notebook given to you by your mentor, or a composition notebook that you purchase or done in Excel or Word):

Students who are keeping a digital copy of their lab notebook (log) should format either a Word document or an Excel page to keep track of their work over the summer.

Each entry should include the date the work was completed, *specific* details about the work completed, and the time the task took (in minutes).

If working in a lab, use the following guidelines for your hard copy lab notebook:

- Put your name and course outside of the notebook.
- Lab Notebooks should only be filled out **IN INK**. Cross out any mistakes with a ~~single line~~. You can learn from your mistakes, even minor ones, if you keep a record of them. Never erase!
- At the beginning of each lab session, write the date and location of your research.
- Write every procedure that you did that day in detail so that it is reproducible. Include exact amounts, versions of software, model numbers of all apparatus, etc.
  - **DO NOT** include abbreviations unless you also write down a key for those abbreviations in your lab notebook.
  - If you change a protocol in any way or decide between alternative methods, then the correct information must be recorded in the notebook.
- Draw diagrams of any setups and apparatuses that you used for your experiments that day. You can take a photograph and paste it in your notebook in lieu of a drawing.
- Take pictures or print copies of your data and any graphs and paste them into your lab notebook.
- You should sign and date the bottom of each page in ink when you are done with experimentation for the day.

If you are doing a computational project where you are writing code (electronically):

- Every day that you edit your code, save a version of that code with the date. You will need a record of these versions and they can also be helpful to you when you make a mistake and need to go back to an earlier version. Save them all in the same folder.
- Embed within your code `#explanations#` of what each section does so that someone can go back and look at them and follow along.

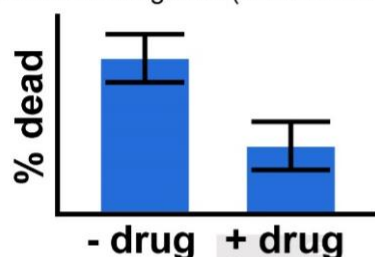
## Appendix B: Statistics Information

You can use the information in this packet to help you decide what statistical test is appropriate for your project. The first two pages are decision trees/graphs that can help you figure out which of the more common statistical tests may work based on the type of data that you are generating. Those are followed by a more detailed explanation that includes an expanded list of statistical tests that may be appropriate for your data.

### ***Statistical Significance Tests***

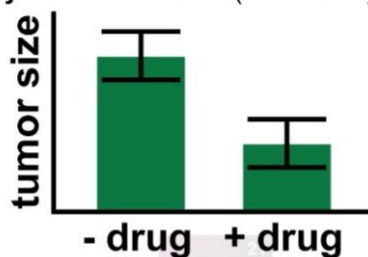
#### **Fisher's Exact Test**

x-axis: 2 categories (- or + drug)  
y-axis: 2 categories (dead or alive)



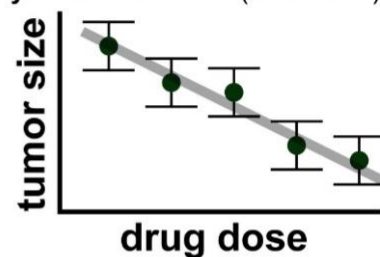
#### **Students T-Test**

x-axis: 2 categories (- or + drug)  
y-axis: continuous (tumor size)



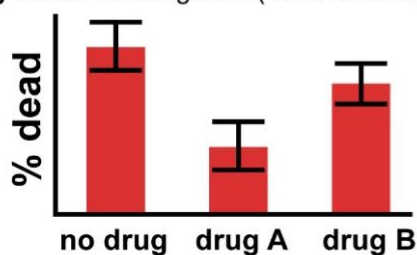
#### **Regression Analysis**

x-axis: continuous (drug dose)  
y-axis: continuous (tumor size)



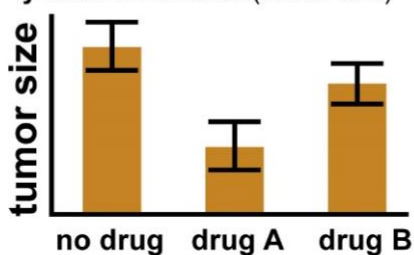
#### **Chi-Square Test**

x-axis: >2 categories (drug A, B, etc.)  
y-axis: >2 categories (dead or alive)



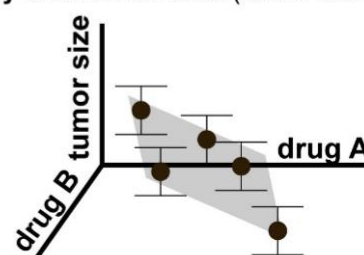
#### **ANOVA**

x-axis: >2 categories (drug A, B, etc.)  
y-axis: continuous (tumor size)



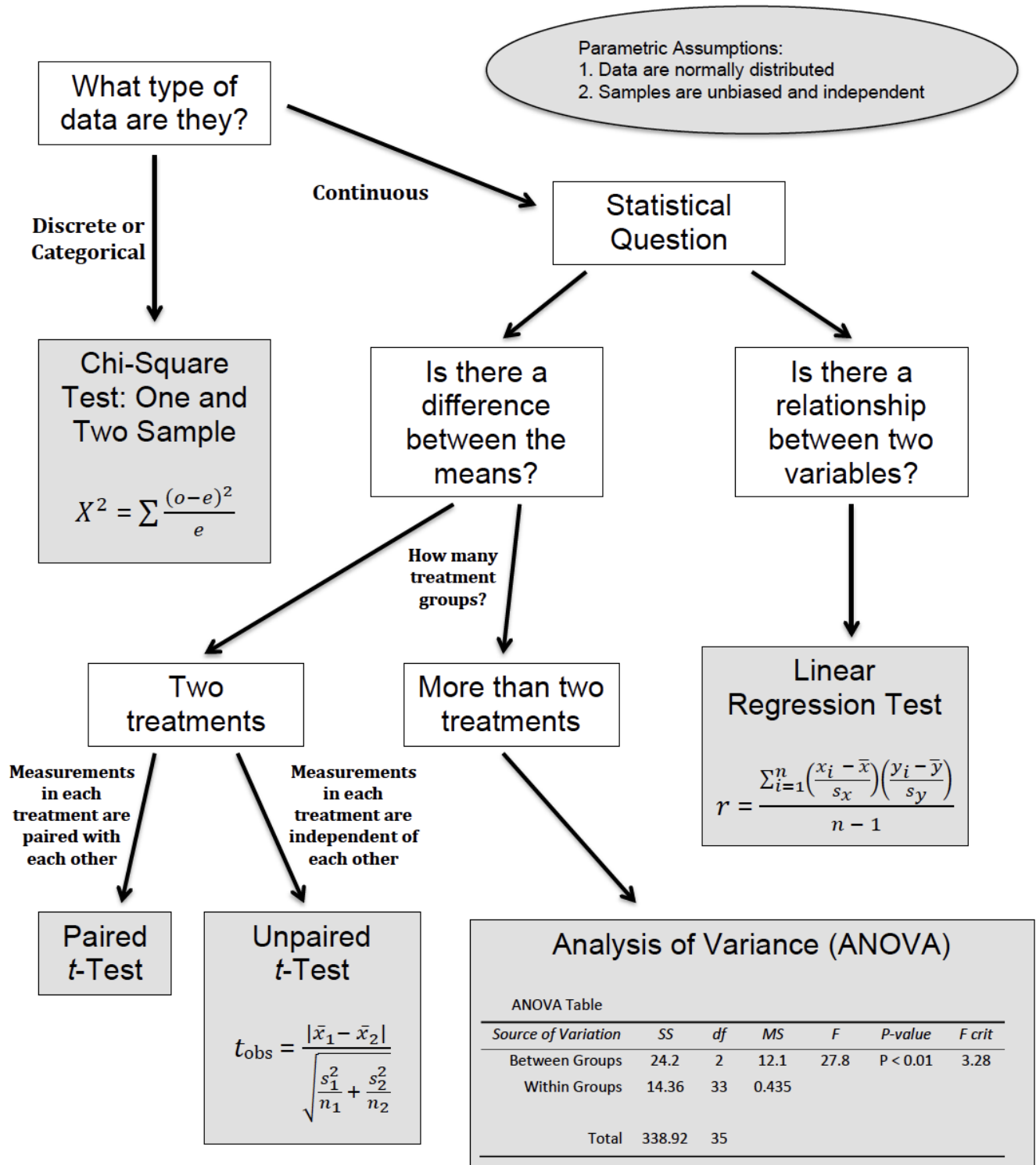
#### **Multiple Regression**

x/z-axis: >2 continuous (drug dose)  
y-axis: continuous (tumor size)





# Simple Flowchart for Statistics Used in Biology



## **Appendix C: Writing a Research Plan**

A research plan is a succinct detailing of the rationale, research question, methodology, and risks of a research project that should be completed prior to the start of any experimental research. You will prepare a research plan during the fall semester for a project that you could conceivably start (and hopefully finish) in the spring semester. Since situations can change without warning, you will not be penalized if you do not perform this exact project next semester. You are only describing a possibility right now.

A research plan consists of the following parts:

### **1. Rationale**

Provide a brief synopsis of the background research that supports your hypothesis or motivates your scientific question or engineering goal and explain why this research is important. Include at least 5 citations from high value sources. Anything with a DOI is probably good. Additional citations from lower value sources are also OK. Do not cite Wikipedia, WebMD, Google, "some people", "many people", "they", etc. No "click bait" references either. This part is typically 2 to 3 pages long.

### **2. Hypothesis / Research Question / Engineering Goal ← CHOOSE ONE**

State your hypothesis / research question / engineering goal. State it in a way so that it logically follows from the background research described in your rationale. This typically requires 1 to 3 sentences.

### **3. Methods**

#### **a. Procedure**

Describe your experimental design including all procedures for gathering data. If your procedure was influenced by any previously performed experiments, you must cite your sources. All images, diagrams, renderings, drawings, flowcharts, photographs, etc. must be original. If you absolutely need to use an image produced by someone else, you must cite your source. This part is typically 1 to 2 pages long.

#### **b. Analysis**

Describe the analytical methods you will use to test your hypothesis / answer your research question / decide if you have reached your engineering goal. This part is typically 1 page long.

#### **c. Risk Assessment**

All students must provide an assessment of risk with techniques to minimize this risk. Categories of risk include, but are not limited to, human subjects; vertebrate animals; potentially hazardous biological agents; hazardous chemicals, activities or devices. (See the guidelines for subject specific items that must be included in your research plan on WESEF form 1A.) If you believe there are no risks associated with your project, you must explain why you are making this claim. Very few projects have zero risk associated with them. This part is typically 1 to 3 paragraphs long.

#### 4. References

Follow the formatting style that is consistent with your discipline. Include DOIs or URLs (but never both) as applicable. Be sure that URLs do not include tracking code. Provide at least 5 references. (Image references do not count towards this total.)

Below are sample entries for a journal article, YouTube video, book, and newspaper article cited in A.P.A style.

- a. Ahn, J. H., Hu, Y., Hernandez, M., & Kim, J. R. (2011). Crocetin inhibits beta-amyloid fibrillization and stabilizes beta-amyloid oligomers. *Biochemical and Biophysical Research Communications*, 414(1), 79-83. doi:10.1016/j.bbrc.2011.09.025
- b. Cowern, Dianna. (2020). Friction - Physics 101/Ap Physics 1 Review with Dianna Cowern. Retrieved October 14, 2020, from <https://youtu.be/fCe6UyNyPTg>
- c. Myers, D. G. (2011). *Myers' psychology for AP*. New York, NY: Worth.
- d. Sims, W. (1920, January 16). The Moon Rocket.: Admiral Sims Explains Its Action In a Vacuum. *New York Times*, p. 8. Retrieved October 14, 2020, from <https://www.nytimes.com/1920/01/16/archives/the-moon-rocket-admiral-sims-explains-its-action-in-a-vacuum.html>

## **Appendix D: Review of Literature Outline**

### **Review of Literature Outline**

*What is a review of literature?*

Generally, the purpose of a review is to analyze critically a segment of a published body of knowledge through summary, classification, and comparison of prior research studies, reviews of literature, and theoretical articles.<sup>1</sup>

For our course, the review of literature (ROL) serves as a living document that allows students to find and present the pertinent work from the primary literature they have read in a logical, organized manner. Primary literature is defined as peer-reviewed journals that publish the original research findings.

*Each students' outline for their ROL should have the following:*

#### **Introduction**

- Broad overview of topic
- Why this is an important topic to research (The Big “Why?”)
- Citation for each claim

#### **Body**

- Each paragraph has an implied purpose (topic sentence)
- Key findings are addressed
- Logical flow
- Citation for each claim

#### **Gap/Future Research**

- Final paragraphs
- Discussion of gap in the field
- Why that gap in knowledge is important to fill
- Research proposal to fill in the gap in knowledge

#### **References**

- Appropriate citation style for your discipline

#### **Formatting**

- This should be an outline (not essay format)

For Further Reading Visit

<https://writing.wisc.edu/handbook/assignments/reviewofliterature/>

\*A student exemplar is available after this document\*

---

<sup>1</sup> *Learn how to write a review of literature.* The Writing Center. (n.d.). Retrieved October 8, 2021, from <https://writing.wisc.edu/handbook/assignments/reviewofliterature/>.

## **Appendix E: Review of Literature Outline Exemplar**

### **Paragraph 1.1/Introduction: Intro to Meniscus/Composition/Function**

\*Regenerative/Stem Cell treatments act as an alternative treatment to surgery that incorporates regeneration of damaged tissue instead of replacement\*

- The meniscus (a piece of tough, rubbery cartilage) is crucial to the body's ability to move (Fox et. Al, 2012)
- The meniscus is crucial to good and proper knee health (Fox et. Al, 2012)
- Meniscus is located between the tibia and the femur and comprised of 75% water and 22% collagen (Fox et. Al, 2012)
- The arrangements and structural hierarchy of collagen fibers in musculoskeletal tissue is crucial to the strength of the meniscus (Puetzer et. Al, 2020)
- Proper collagen fiber arrangement/hierarchy is necessary for proper load bearing and movement (Fox et. Al, 2012)
- The meniscus is mostly avascular with limited blood supply only to the peripheral region (Fox et. Al, 2012)
- The meniscus provides the body with load/stress transmission, shock absorption, stability, nutrition, joint lubrication, and more (Fox et. Al, 2012)
- Vascularization of the meniscus begins to subside as the body ages -> smaller ability to self-repair an injury (Athanasίου et. Al, 2011)
- The lateral menisci are 'greater in size, shape, thickness, and mobility' compared to the medial menisci (Athanasίου et. Al, 2011)
- Musculoskeletal injuries have managed to become one of the most prevalent injuries around the world (Smith et. Al, 2015)
- The outer area of the meniscus (peripheral/red-red zone) is highly vascularized where the inner area of the meniscus (white-white zone) has close to no vascularization and receives its nutrients from synovial fluid (Athanasίου et. Al, 2011)
- The menisci are two "wedge-shaped" discs that help to stabilize and cushion any impact between the femur and the tibia during "normal everyday movement" (Klarmann et. Al, 2021)
- The abilities of the meniscus to facilitate painless joint movement are because of the well-ordered and maintenance of the collagen fiber network/hierarchy (Klarmann et. Al, 2021)
- Proteoglycan molecules and GAGS in the meniscus contribute to tissue abilities and properties (Klarmann et. Al, 2021)

### **Paragraph 1.2/Introduction: Common Injuries and Diseases That May Require Treatment**

\*Skeletal muscle injuries are among the most common injuries in the world -> They can result from trauma accidents, diseases, and even simply aging\*

- Skeletal (muscle) tissue is the most abundant type of tissue in the human body (Yang et. Al, 2018)
- Most common cause of skeletal muscle tissue injury is mechanical trauma (Yang et. Al, 2018)
- Muscle cells experience necrosis (death) as a response to trauma (Yang et. Al, 2018)
- T-cells and acute inflammation have proven crucial to create an adequate microenvironment for the proliferation and differentiation of muscle stem cells (Yang et. Al, 2018)
- Meniscal injuries/lesions occur increasingly frequently in elderly patients. Such lesions are usually a result of "long-term degeneration" that comes with age in older patients (Athanasίου et. Al, 2011)

- Osteoporosis, Osteoarthritis, Rheumatoid arthritis, standard bone fractures, and more (Kangari et. Al)
- The vascularization of the meniscus decreases dramatically with aging (on top of the fact that the vascularization is practically non-existent in most of the meniscus to begin with) (Athanasίου et. Al, 2011)
- The location, thickness, angle, and geometry of the tear classifies its healing capabilities and provides information on how to go about treating the tear (Bansal et. Al, 2021)
- There can be “vertical tears in the longitudinal direction, and in the radial direction from the medial rim toward the lateral rim, or complex tears encompassing multiple directions (Klarmann et. Al, 2021)

### **Paragraph 1.3/Body: Current Treatments/Surgery is No Longer Sufficient/Alternative Treatment Must Be Found**

\*Surgery often leaves patients with life-lasting symptoms and does not fix the root of the problem leading to onset of disease and disability \*

- The meniscus has an increasingly unique structure which makes it more complicated to find an adequate treatment (Fox et. Al, 2012)
- Long term-damage and reoccurring symptoms and injury lead to degeneration of the knee joint (Fox et. Al, 2012)
- Past treatments involve total meniscectomy -> no shock absorption or cushion -> joint degeneration/osteoarthritis (Fox et. Al, 2012)
- Total removal of the meniscus/total meniscectomy -> more damage (Bansal et. Al, 2021)
- Other treatments include a partial meniscectomy -> same problems (most surgical treatments are not successful) (Athanasίου et. Al, 2011)
- Collagen based meniscal implants have proven to produce better recovery and tissue restoration 1 year after procedure compared with the routine partial meniscectomy (Athanasίου et. Al, 2011)
- “Articular cartilage has a poor capacity to self-heal and damage often progresses to osteoarthritis (OA) (Gentleman et. Al, 2022)
- Injuries to the meniscus often require surgical repair (Klarmann et. Al, 2021)
- Surgery often treats pain and symptoms therefore it is crucial to develop a treatment that solves the underlying issue to prevent reoccurring injuries (Kangari et. Al)

### **Paragraph 2.1/Body: What are Regenerative/Stem Cell Treatments?**

\*Regenerative Stem cell treatments work to regenerate damaged or lost tissue instead of replacing it or fixing it -> Promising, efficacious, and longer lasting asymptomatic results\*

- “The muscle stem cells expanded *in vitro* have been proved to be able to repair muscle injury *in vivo* efficiently after cell transplantation” (Yang et. Al, 2018)
- The immune system is activated post trauma -> immune cells are sent to the damaged or injured area -> the immune cells can help to facilitate the inflammatory environment and benefit the differentiation abilities of stem cells (Yang et. Al, 2018)
- Goal is to “encourage well functional tissue formation and help stem cells proliferate and differentiate” (Athanasίου et. Al, 2011)
- Another goal is to save and preserve native tissue whenever possible in order to maximize native function and ability (Athanasίου et. Al, 2011)

- “Materials can be used, both with and without contained biologics, to further support matrix deposition and tear integration, and novel tissue adhesives may provide the mechanical integrity that the meniscus requires” (Bansal et. Al, 2021)
- New cells integrate with host tissue (Gentleman et. Al, 2022)
- The whole tissue regeneration process includes and is aimed to replace any damaged, injured, or even dead cells with supplied healthy stem cells that proliferate and differentiate where needed (Kangari et. Al)
- Treatments heavily depend on severity of injury, locations, and more (Genever et. Al, 2014)

## **Paragraph 2.2/Body: Tissue Engineering Methods Based on Previous Studies/Trials/Benefits of Using Stem Cells for treatment**

\*There are many different methods of tissue engineering and cell therapy involved in clinical studies as of recently -> Scientists are now finding what the most efficacious strategies are\*

- Regeneration process -> “death of muscle cell that has been injured, activation of muscle stem cells, differentiate of various stem cells (from muscle or not), proliferation of activated stem cells, differentiation of activated stem cells, formation of new formed muscle fibers” (Yang et. Al, 2018)
- High density collagen fiber hydrogel/scaffolds can be helpful with it comes to stem cell treatments (Puetzer et. Al, 2020)
- A study that performed a total meniscectomy on knee menisci shows that post operation, there was an overall increase in contact forces “by 2-3 times” (Athanasίου et. Al, 2011)
- 8 weeks following the transplantation of MSCs into “meniscal defects” in rats, it was seen that the MSCs were able to survive, proliferate, and differentiate to the surrounding tissue and additionally develop an extracellular matrix which benefits the process of healing (Athanasίου et. Al, 2011)
- Most promising studies have shown that it is crucial to recreate proper collagen fiber arrangement/hierarchy -> this will most closely allow the meniscus to mock native abilities and functions (Bansal et. Al, 2021)
- “Here we used a porcine model explant of cartilage tissue damage to identify drivers of natural cartilage repair that might be harnessed to improve integration between engineered/grafted cartilage constructs and native tissue (Gentleman et. Al, 2022)
- From previous study, using a scaffold seeded with stem cells such as MSCs may be a better approach to increase the healing of the meniscus compared to a scaffold alone (Klarmann et. Al, 2021)
- “...Observations suggest that catabolic enzyme-mediated proteoglycan depletion likely allows existing collagen fibrils to undergo cross-linking” (Gentleman et. Al, 2022)
- Certain times there can be a lack of integration between the host and the implanted regenerated cartilage preventing recovery (Gentleman et. Al, 2022)
- Catabolic enzymes may play a large role in repairing cartilage by way of fostering and initiating integration of the existing collagen network and the newly formed collagen network (Gentleman et. Al, 2022)

## **Paragraph 3.1/Body: Problems with Current Stem Cell Treatments/ Research Question/ Can New Treatment Be Developed to Compensate for Failed Integration?**

- Function of new tissue does not mimic function of native tissue (Athanasίου et. al, 2011)

- Body rejects/Immune rejection of implanted material/stem cells (Shang et. al, 2020)
- Poor of failed integration with host material/stem cells -> incorrect tissue formation; limited function ability (Bansal et. al, 2021)
- How can failed integration be avoided? Can treatment be developed that can avoid failed integration of native tissue and biological material

### **Paragraph 3.2/Body: Proteoglycan Molecules in Articular Cartilage/ Articular Cartilage Vs. Meniscal Cartilage/ Proteoglycan Molecules in Meniscal Cartilage? / Hypothesis**

- Articular cartilage has a poor capacity to self-heal and damage more often than doesn't usually progress into more serious problems such as osteoarthritis (Gentleman et. Al, 2022)
- The number of proteoglycans is one eighth that of articular cartilage (Fox et. al, 2012)
- By depleting a specific amount of proteoglycan molecules, tissue engineering strategies may be able to better integrate and assimilate into affected area (Gentleman et. Al, 2022)
- Proteoglycans are essential for normal function in articular cartilage (Fox et. al, 2009)
- They are the largest molecule in the articular cartilage (Fox et. al, 2009)
- Depletion of proteoglycan molecules in porcine model allowed for greater integration of stem cells into host articular cartilage (Gentleman et. al, 2022)
- Can something similar be done in meniscal cartilage to allow for increased integration between host and implanted biological material?
- Despite differences between meniscal and articular cartilage, the depletion of proteoglycan molecules in meniscal cartilage enhances regeneration and repair abilities of stem cell treatments

### **Paragraph 4/Body: The Addition of Scaffolds and Stem Cells to Treatments**

\*Scientists have found that the addition of a biocompatible scaffold provides structure and support to the damaged area. Additionally, these scaffolds can be seeded with various types of stem cells which can also work to enhance regeneration ability and results\*

- Stem cells from muscle contribute heavily to muscle regeneration (Yang et. Al, 2018)
- For a "biomimetic" copy of a patients' native meniscus to be effective, it is necessary to utilize a biocompatible/biodegradable scaffold (Athanasίου et. Al, 2011)
- Biocompatible scaffolds can be seeded with stem cells as well which has proven successful in enhancing the regeneration capabilities of these treatments (Athanasίου et. Al, 2011)
- Sense of urgency and more of a need recently to "restore long-term function to injured, damaged, and degenerated menisci" (Bansal et. Al, 2021)
- Different types of stem cells are adequate for trial; however, mesenchymal stem cells have shown the most promise -> MSCs come from adult bone marrow and appear to be able to differentiate into various specialized cell types that can function in various types of tissues (Athanasίου et. Al, 2011)
- The addition of biologics (like MSCs) is intended to tend to the defected area by introducing additional healthy cells to activate regeneration process and capabilities (Bansal et. Al, 2021)
- It is crucial to ensure that scaffolds have controlled degradation rates to prevent degradation before sufficient tissue is formed (Athanasίου et. Al. 2011)
- Scaffold delivery of biological material can help to achieve localized and sustainable delivery in order to provide correct amounts at the right time (Bansal et. Al, 2021)
- "MSCs are considered to be a more appropriate cell source for bone tissue engineering" (Shang et. Al, 2020)

- Certain biomaterials are more natural than others and can be beneficial in a sense that they are accordingly bioactive, have adequate biocompatibility, tunable degradation rates, and can closely resemble native tissue structures (Shang et. Al, 2020)
- Cells must go through a proper process (one being autologous) in which they are extracted from the patients' bodies, cultured, and processed, and then once they are ready to return, they are inserted back into the damaged area (Genever et. Al, 2014)

### **Paragraph 5.1/Conclusion: Discussion/Future Research**

\*One of the next steps towards ensuring stem cell/regenerative treatments are the most effective they can be is discovering what the most safe and effective materials are whether it be for the scaffold or the cell type\*

- Leading question in tissue engineering -> should a regenerated meniscus be an exact copy of the native meniscus, or should it only mimic the native meniscus in a sense that it carries out the same functions (Athanasίου et. Al, 2011)
- What are the best cell types and biomaterials to construct biocompatible scaffolds with? -> collagen hydrogels seem to show promise as they can be easily seeded with cells and can be injected arthroscopically, however, scientists have looked at silk-based scaffold more recently as silk-based scaffolds work better when it comes to developing a strong extracellular matrix (Athanasίου et. Al, 2011)
- "Biocompatible scaffolds should degrade at an appropriate rate and facilitate the controlled release of the extracellular vesicles..." (Presen et. Al, 2019)
- How can scientists culture and process stem cells *ex vivo* prior to inserting them into the body to optimize results? (Genever et. Al, 2014)
- How can these newer developed treatments improve the quality of life for patients who experience and have experienced musculoskeletal injury in the past (Smith et. Al, 2015)

### **Paragraph 5.2/Conclusion: Research Gap and Proposal**

\*Certain limitations get in the way of regenerative treatments such as not being able to mimic native tissue, disruption of native environment, etc... -> Proposal: Depletion of proteoglycans in the knee meniscus leads to effective meniscus repair using cell therapy/regenerative treatments

- Risks include significant inflammatory reaction, disease transmission, immune rejections, etc. (Shang et. Al, 2020)
- Must find a way to accordingly develop regenerated collagen fibers with enough strength and size to mimic the natural collagen structure and hierarchy (Puetzer et. Al, 2020)
- Are Adipose Tissue-Derived MSCs more promising? There may be better sources with increased amounts of available cells to be used (Presen et. Al, 2019)
- The properties of Adipose Tissue-Derived MSCs may be resistant to aging whereas Bone Marrow-Derived MSCs become less beneficial with increased age (Presen et. Al, 2019)
- Hopefully cost will decrease significantly with new treatments over time, but it is unknown at the moment (Presen et. Al, 2019)
- How can immune reactions be prevented when working with certain biomaterials while crafting scaffolds (Smith et. Al, 2015)

## Work Cited

- Yang W, Hu P. Skeletal muscle regeneration is modulated by inflammation. *J Orthop Translat.* 2018 Feb 7;13:25-32. doi: 10.1016/j.jot.2018.01.002. PMID: 29662788; PMCID: PMC5892385. Accessed: 2022 July 8
- Fox AJ, Bedi A, Rodeo SA. The basic science of human knee menisci: structure, composition, and function. *Sports Health.* 2012 Jul;4(4):340-51. doi: 10.1177/1941738111429419. PMID: 23016106; PMCID: PMC3435920.
- Kyriacos A. Athanasiou. The knee meniscus: structure-function, pathophysiology, current repair techniques, and prospects for regeneration. Vol. 32, Issue 30. Published October 2011, Accessed July 18, 2022. <https://doi.org/10.1016/j.biomaterials.2011.06.037>
- Bansal S, Floyd ER, A Kowalski M, Aikman E, Elrod P, Burkey K, Chahla J, LaPrade RF, Maher SA, Robinson JL, Patel JM. Meniscal repair: The current state and recent advances in augmentation. *J Orthop Res.* 2021 Jul;39(7):1368-1382. doi: 10.1002/jor.25021. Epub 2021 Mar 19. PMID: 33751642; PMCID: PMC8249336.
- Merrild NG, Holzmann V, Ariosa-Morejon Y, Faull PA, Coleman J, Barrell WB, Young G, Fischer R, Kelly DJ, Addison O, Vincent TL, Grigoriadis AE, Gentleman E. Local depletion of proteoglycans mediates cartilage tissue repair in an ex vivo integration model. *Acta Biomater.* 2022 Jun 30:S1742-7061(22)00371-3. doi: 10.1016/j.actbio.2022.06.032. Epub ahead of print. PMID: 35779773.
- George J. Klarmann. A Review of Strategies for Development of Tissue Engineered Meniscal Implants. *Biomaterials and Biosystems* Vol. 4 Published December 2021, Accessed August 25, 2022. <https://doi.org/10.1016/j.bbiosy.2021.100026>
- Shang F, Yu Y, Liu S, Ming L, Zhang Y, Zhou Z, Zhao J, Jin Y. Advancing application of mesenchymal stem cell-based bone tissue regeneration. *Bioact Mater.* 2020 Sep 21;6(3):666-683. doi: 10.1016/j.bioactmat.2020.08.014. PMID: 33005830; PMCID: PMC7509590.
- Puetzer, Jennifer. "Driving Hierarchical Collagen Fiber Formation for Functional Tendon, Ligament, and Meniscus Replacement." *Biomaterials*, 3 Nov. 2020. *Science Direct*, <https://doi.org/10.1016/j.biomaterials.2020.120527>. Accessed 15 Apr. 2022.
- Marolt Presen D, Traweger A, Gimona M, Redl H. Mesenchymal Stromal Cell-Based Bone Regeneration Therapies: From Cell Transplantation and Tissue Engineering to Therapeutic Secretomes and Extracellular Vesicles. *Front Bioeng Biotechnol.* 2019 Nov 27;7:352. doi: 10.3389/fbioe.2019.00352. PMID: 31828066; PMCID: PMC6890555.
- Kangari P, Talaei-Khozani T, Razeghian-Jahromi I, Razmkhah M. Mesenchymal stem cells: amazing remedies for bone and cartilage defects. *Stem Cell Res Ther.* 2020 Nov 23;11(1):492. doi: 10.1186/s13287-020-02001-1. PMID: 33225992; PMCID: PMC7681994.
- Genever, Paul. "Stem cell treatment for musculoskeletal disease." *Current Opinion in Pharmacology*, vol. 16, June 2014. *Science Direct*, <https://doi.org/10.1016/j.coph.2014.01.005>. Accessed 2 Feb. 2022.
- Smith, Benjamin D. "The current state of scaffolds for musculoskeletal regenerative applications." *Nature Review Rheumatology*, vol. 11, no. 4, Apr. 2015. *Gale Academic OneFile*, <http://dx.doi.org/10.1038/nrrheum.2015.27>. Accessed 14 Jan. 2022

## **Appendix F: Review of Literature Outline Grading Rubric**

### **1. Introduction**

Student's introduction:

- Has a general introduction to area of research
- Leads to more specific area of research
- Demonstrates “big picture” or relevance of research

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

### **2. Organization and Flow of Paragraphs**

Student's paragraphs (body):

- Are logically organized
- Incorporates “funnel” organization (begins with a general intro, discusses more specific research, and proceeds to a discussion of current research and focus of the current project)
- Ties together different papers and areas of study and shows how they are related

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

### **3. Gap/Future Research**

Student's Gap/Future Research:

- Ties together previous work
- Shows how previous work is related to current research in the topic
- Includes information that will be used in concluding paragraph (transition to the current work research objectives /hypotheses OR potential areas of research)

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

### **4. Research & Citations**

- Thoroughly presents previous research in specific research areas in a scholarly way
- Cites a number of relevant research papers (12 – 15+)
- Correct format of in-text citations and bibliography

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

### **5. Formatting**

- Student used an outline format
- Outline has appropriate section headers

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

**Appendix G: JUNIOR SUMMER WORK RUBRIC**

**Directions:** Please check off and submit evidence that you have completed all of the tasks below. If you need to comment on or explain your progress in any area, please use the space provided or an additional sheet.

| WORK                                                                                                                                                                                                                          | Excellent                          | Good                     | Satisfactory           | Unsatisfactory         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------------|------------------------|------------------------|
| 1) Please list the summer goals you created last June. Alternatively, you can attach a copy of your summer goals.<br><br>To what extent have you fulfilled your goals?                                                        | (10 pts)                           | (7 pts)                  | (4 pts)                | (2 pts)                |
| 2) Please describe your contact and work with your Mentor this summer (frequency and what you did). Print & attach any emails or collaborative work completed. If you collected data this summer, submit methods and results. | (12 pts)                           | (10 pts)                 | (5 pts)                | (2 pts)                |
| 3) Please describe your contact with your course instructor this summer.                                                                                                                                                      | (5 pts)<br>(contacted 3 or more x) | (3 pts.)<br>(2 contacts) | (1 pts)<br>(1 contact) | (0 pts)<br>(0 contact) |
| 4) List any recent articles read/submit article summaries                                                                                                                                                                     | (15 pts)                           | (12 pts)                 | (8 pts)                | (5 pts)                |
| 5) Summer work log/time sheet (updated)                                                                                                                                                                                       | (3 pts)                            | (2 pts)                  | (1 pts)                | (0 pts)                |
| 6) Review of Literature Cite Page – please attach a copy                                                                                                                                                                      | (5 pts)                            | (4 pts)                  | (2 pts)                | (1 pts)                |
| 7) Review of Literature Outline Rubric                                                                                                                                                                                        | ____ / 50 points                   |                          |                        |                        |
| Total                                                                                                                                                                                                                         |                                    |                          |                        | ____ / 100             |

**Appendix H: SENIOR SUMMER WORK RUBRIC****The following is a general guideline for how your summer work will be graded.**

| WORK                                                                                                                                                  | Excellent              | Good                       | Minimally Satisfactory | Unsatisfactory              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------------------|------------------------|-----------------------------|
| 1. Has evidence of data collected, or engineering or computational goal tested.                                                                       | (60 pts)               | (50 pts)                   | (40 pts)               | (0 - 30 pts)                |
| 2. All work is recorded and dated in a lab notebook, as directed.                                                                                     | (30 pts)               | (25 pts)                   | (20 pts)               | (0 - 15 pts)                |
| 3. Statistical Analysis                                                                                                                               | (40 pts)<br>Completed! | (30 pts.)<br>Well Underway | (20 pts)<br>Started    | (0 – 15 pts)<br>Not Started |
| 4. Complete 1 <sup>st</sup> draft written w/20+ citations, including Introduction, Methods, Results, Discussion and References sections               | (100 pts)              | (90 pts)                   | (70 pts)               | (0 – 60 pts)                |
| 5. Has completed WESEF & JSHS forms as much as possible.                                                                                              | (30 pts)               | (25 pts)                   | (15 pts)               | (0 - 12 pts)                |
| 6. Has contacted teacher to update on progress and has proactively met with teacher at least twice at directed times and has documented meeting notes | (40 pts)               | (30 pts)                   | (20 pts)               | (0 - 12 pts)                |
| Total for Non-STS Seniors                                                                                                                             | _____ / 300            |                            |                        |                             |

## **Appendix I: COMPETITION FORMS**

### **WESEF**

The following link is for the [WESEF Student Handbook](#), which has all the rules and information for WESEF. (The 2025-26 Handbook has not been published yet, but it will not change much.)

Students should complete the [Forms Wizard](#) to determine which forms they need and print out the results.

Then students should fill out the required [WESEF forms](#) *at the appropriate time*. Note that some forms must be signed before data collection or any project work begins: others are filled out after the work is completed. Guidance for filling out forms is located at the back of the WESEF Student Handbook linked above. Pay attention to the yellow arrows!

### **PWRS^3**

The form is not yet available but you can tell your mentor you will forward it to them when it is available and your project is completed.