<u>Designing a Contact Lens Lab - Instructor Manual</u>

<u>Overview:</u>

Statement of Purpose: This lesson plan will require designing and testing biomaterials to be used in a contact lens, and students will learn about optical, mechanical, and surface properties of biomaterials. They will also explore the effects of biomaterial modifications by testing bulk additives and surface coatings. The lesson plan was originally designed for middle school students (grades 6-8), but can be modified for students of different ages.

Methods, Materials, and Budget: An introduction to the design process, biomaterials, and commonly used hydrogels will be presented, and then the instructors will guide the class to work together to create design criteria for a contact lens. Students will be provided with multiple types of hydrogel compositions to mimic the materials that may be used in a contact lens (unflavored gelatin at various concentrations and some containing additives, e.g. cornstarch and/or olive oil). They will conduct experiments to test these materials using the class design criteria. These tests will include visual assessment of optical clarity, physical manipulation to determine stiffness, and mock protein (sprinkle) adhesion testing to determine the best materials for their designs. We estimate that this lesson will cost ~$26 for a class of ~25 students. Materials required include unflavored gelatin (Jello), corn starch, sprinkles, and olive oil spray. Preparation only requires setting the gelatin the night before, and the in-class testing is simple and easy to conduct in small groups.

Assessment Methods and Results: Practice questions will be answered and design criteria will be recorded for each group during the introductory activity. While completing the experiments, students will record their observations and design decisions. Concept questions will be completed at the end of the class period to determine the students' understanding of the design process, biomaterial modifications, and optical, mechanical, and surface properties of biomaterials.

<u>Student Learning Objectives:</u>

- Determine independent variables and test dependent variables
- Formulate testable hypotheses
- Use the design process in biomedical engineering
- Identify common polymers and biomaterials
- Differentiate bulk and surface modifications
- Infer how material modifications affect optical properties, mechanical properties, and surface properties
- Understand contact lens design

Materials Required:

Material	Quantity	Cost
Unflavored Gelatin	5 oz (~20 packets)	$10
Corn Starch	2 tsp	$1
Olive Oil Spray	1 can	$3
Rainbow Sprinkles	1 shaker	$2
2 oz. Plastic Condiment Cups	100 cups	$8
Paper Plates	25 plates	$2
Total for 25 Students		**$26**

Protocol for Instructor:

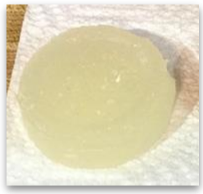
Preparation (night before activity):

1. Bring a large pot of water to a boil
2. Add 2 oz of unflavored gelatin to a large mixing bowl.*
3. Add 2 cups of the boiling water to the gelatin in the mixing bowl and stir until the gelatin has dissolved.
4. Add 2 cups of cold water to the gelatin in the mixing bowl and stir well.
5. Use a ladle to distribute this gelatin mixture into 25 2 oz plastic condiment cups.
6. Close the lids on the cups and label them "High Concentration Gelatin."
7. Add 2 oz of unflavored gelatin to a large mixing bowl.*
8. Add 2 cups of the boiling water to the gelatin in the mixing bowl and stir until the gelatin has dissolved.
9. Add 2 tsp cornstarch to the mixture and stir well.
10. Add 2 cups of cold water to the gelatin in the mixing bowl and stir well.
11. Use a ladle to distribute this gelatin-cornstarch mixture into 25 2 oz plastic condiment cups.
12. Close the lids on the cups and label them "Gelatin+Cornstarch."
13. Add 1 oz of unflavored gelatin to a large mixing bowl.**
14. Add 4 cups of the boiling water to the gelatin in the mixing bowl and stir until the gelatin has dissolved.
15. Add 4 cups of cold water to the gelatin in the mixing bowl and stir well.
16. Use a ladle to distribute this gelatin mixture into 50 2 oz plastic condiment cups.
17. Close the lids on the cups and label them "Low Concentration Gelatin."

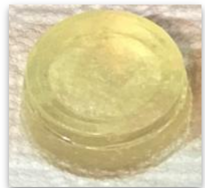
**Boxes are typically sold with at least 4 pouches that contain 0.25 oz gelatin each. 2 oz = 8 pouches of this size*

*** 1 oz = 4 pouches*

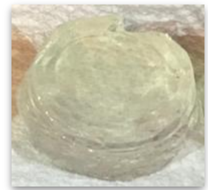
Note: This procedure is appropriate for a class of ~25 students. Material amounts can be adjusted based on the number of students/groups.



Gelatin + Corn Starch



High Gelatin

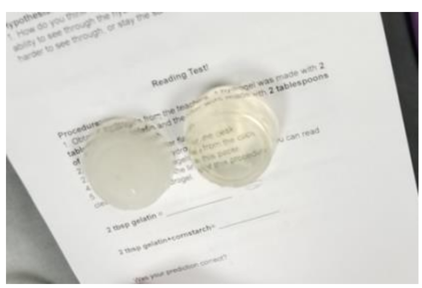


Low Gelatin

In Class Procedure:

1. Present the powerpoint to familiarize students with terms and definitions as you move through the activities.
2. The students should answer the pre-lab questions on page 1 of the student packet as a warm up activity while you pass out the materials for the experiment.
3. Hand out one paper plate to each student (or group).
4. Hand out one “High Concentration Gelatin” gel, one “Gelatin+Cornstarch” gel, and two “Low Concentration Gelatin” gels to each student.
5. The students should follow the protocols in the student packet (attached with key).
6. Ensure that at each stage the students stop to make a hypothesis before testing.
7. The students should also write about the accuracy of their hypothesis after each test.
8. In part 3 of the lab, the students will need to coat one of their “Low Concentration Gelatin” gels with olive oil spray. When they raise their hands, walk around to each group to coat one of their gels and give them sprinkles for the test.
9. The students have 5 post-lab questions to complete after finishing all three steps of the lab.

Reading Test



Sprinkle Test

Instructor KEY

Name: ____________________

Date: _____________________

Designing a Contact Lens Lab

What are three examples of things made with polymers in this classroom?

many acceptable answers, e.g. plastic bag, rubber eraser, plastic chair, etc.

A hydrogel is a type of polymer that really likes _water___.

When placed in the solution they like, hydrogels __________________ (get bigger, get smaller, or stay the same?).

The design process moves in a ___cycle___ instead of a line so that it can be repeated and the design will continue to

___improve__.

What are the 3 design criteria we chose as a class?

1. ___Easy to see through_____________

2. ___Comfortable to wear_____________

3. ___Resist protein adhesion__________

Design question 1: How does mixing in a different material (changing the bulk properties) affect a hydrogel?

Hypothesis:

1. If you add cornstarch to the hydrogel, then what do you think will happen your ability to see through the hydrogel? Will it be easier to see through, harder to see through, or stay the same?

Reading Test!

Procedure:

1. Obtain 2 hydrogels from the teachers. 1 hydrogel was made with **2 tablespoons of gelatin** and the other was made with **2 tablespoons of gelatin + cornstarch.**
2. Place this sheet of paper flat on the desk.
2. Carefully remove the hydrogels from the cups.
4. Look through the hydrogels at this paper.
5. Record how many of the lines of this procedure you can read clearly through the hydrogel.

2 tbsp gelatin = _______________

2 tbsp gelatin+cornstarch= ______________

Was your prediction correct?

Design question 2: How does changing the concentration of gelatin (changing the bulk properties) affect the contact lens?

Hypothesis:

2. If you use less gelatin to make the hydrogel, then what will happen to the stiffness of the hydrogel? Will it be stiffer, more flexible, or stay the same?

Shake Test!

Procedure:

1. Obtain 1 new hydrogel from the teachers. This hydrogel was made with **1/2 tablespoon of gelatin.** You will also need the hydrogel with **2 tablespoons of gelatin** from the Reading Test.
2. Carefully remove the new hydrogel from the cup.
3. Lightly tap the hydrogel with ½ **tablespoon of gelatin** on 1 side and count how many seconds it shakes from side to side. Record this number here:

   ½ **tbsp gelatin**-1 = ____________

4. Repeat this step 2 more times, then calculate the average of these 3 tests.

½ **tbsp gelatin**-2 = ____________ ½ **tbsp gelatin**-3 = ____________

   ½ **tbsp gelatin**-Average = _________________

5. Lightly tap the hydrogel with **2 tbsp gelatin** on one side with the same amount of force you used on the hydrogel with **½ tbsp gelatin** and count how many seconds it shakes from side to side. Record this number here:

   2 tbsp gelatin-1 = ____________

6. Repeat this step 2 more times, then calculate the average of these 3 tests.

2 tbsp gelatin-2 = ____________ **2 tbsp gelatin**-3 = _____________

   2 tbsp gelatin-Average = _________________

Was your prediction correct?

Design question 3: How does adding a coating to the surface affect the contact lens?

Hypothesis:

3. If you add an olive oil coating, then how do you think it will affect protein adhesion to the hydrogel (stickiness)? Will it be more sticky, less sticky, or stay the same?

Sprinkle Test!

Procedure:

1. Obtain 1 new hydrogel from the teachers. This hydrogel was also made with **1/2 tablespoon of gelatin.** You will still need the hydrogel with **1/2 tablespoon of gelatin** from the Shake Test so that you have 2 hydrogels with the same ingredients.
2. Carefully remove the new hydrogel from the cup.
3. Raise your hand to ask the teachers to help coat the top surface of the new hydrogel with olive oil.
3. Drop sprinkles onto the top of each Hydrogel and leave them there for about 20 seconds.
4. Wipe the sprinkles off the Hydrogels onto the paper plate.
5. Record how many colored marks were left on the top of each Hydrogel.

Olive Oil-Coated= _____________ No Olive Oil= _____________

Was your prediction correct?

Post Lab Questions:

1.) Which material did we use for "bulk" modification of the hydrogels?

cornstarch

2.) Which solution did we use for "surface" modification of the hydrogels?

olive oil

3.) Would a stiffer hydrogel or a more flexible hydrogel be more comfortable as a contact lens?

more flexible

4.) Which hydrogel that you experimented with today would be the best for a contact lens material?

Low concentration gelatin + olive oil coating

5.) How could you make your contact lens better? What would you do next?

Many acceptable answers

Name: ____________________

Date: _____________________

Designing a Contact Lens Lab

What are three examples of things made with polymers in this classroom?

_________________   ____________________   _______________

A hydrogel is a type of polymer that really likes __________________.

When placed in the solution they like, hydrogels __________________ (get bigger, get smaller, or stay the same?).

The design process moves in a ________________________ instead of a line so that it can be repeated and the design will continue to

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1. ____

2. ____

3. ____

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