

Name: \_\_\_\_\_

Period: \_\_\_\_\_

### Disulfide Bonds in Hair

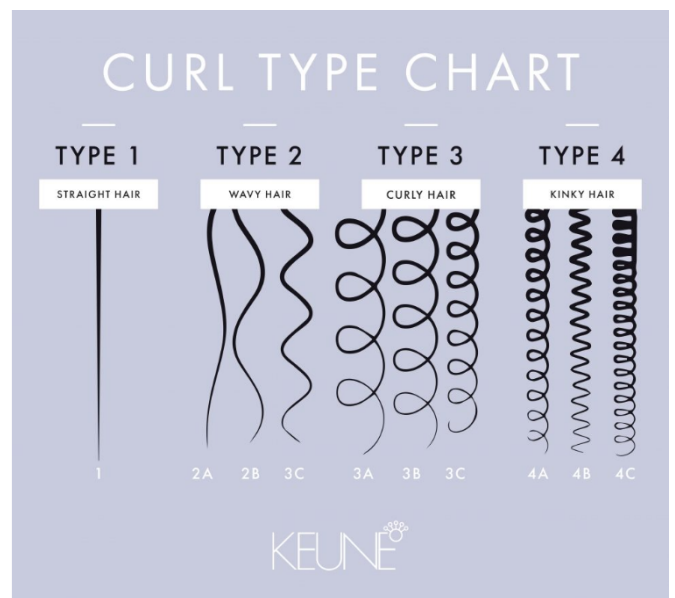
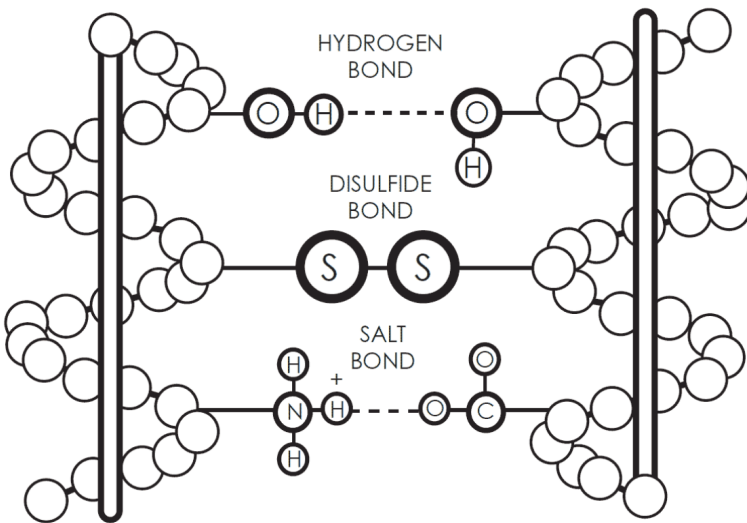
I can make a claim about the relationship between the structure and function/properties of macromolecules that is supported by evidence.

#### Pre-Lab

Write down any questions you have after watching the video clip and class discussion. Use these questions to help you: What experience have you or someone you know had with perms? What kind of hair did they have and did the perm hold well? Why do you think it did or didn't hold a perm?

#### Introduction

Your hair is made up of keratin which is held together by disulfide bonds. These disulfide bonds give your hair its straight or curly structure. Some people have a tendency for straight hair over curly hair because of how these bonds interact with each other. Disulfide bonds can be manipulated by certain chemicals which is the basis for the hair treatment perming. In this lab you will be perming one of your hairs and then explaining how the process works using chemical evidence.



## Materials

- Gloves
- Goggles
- Hair perming solutions
  - Waving lotion (6mL)
  - Neutralizer (6mL)
- Distilled water
- Test tubes
- Pipettes
- Test tube rack
- Sharpies
- Masking tape
- Pencils or wooden dowels

## Safety Information

The chemicals that you are working with are skin irritants, wear gloves at all times during the lab. Wear chemical splash goggles to avoid contact with your eyes and perform this activity in a well ventilated area. Do not directly inhale the chemicals, if you need to perform any tests involving smell do so by wafting.

## Activity Procedure: Hair Perming

1. Cut two pieces of masking tape long enough to wrap around the end of the pencil.
2. Pluck one long hair from your head.
3. Take a picture or draw a sketch of your hair.
4. Tape one end of the hair to the end of the pencil.
5. Then wrap (curl) the hair tightly around the pencil so that it is coiled around it, tape the other end of the hair once it is coiled.
6. Place 6 mL of the waving lotion in a test tube. Then place the pencil with the coiled hair inside the solution so that the hair is submerged. Add more solution if needed to fully submerge the hair.
7. Let hair soak in waving solution for 5 minutes.
8. Remove hair from waving solution and rinse with water for 30 seconds by swishing in a test tube of water.
9. Pat hair dry with a paper towel.
10. Place 6 mL of the neutralizer in a test tube and submerge the hair (once dry) in the solution. Add more solution if needed to fully submerge the hair.
11. Let hair soak in the neutralizer for 5 minutes.
12. Remove hair from neutralizer and rinse with water for 30 seconds following the same procedure as above. (use clean water)
13. Pat hair dry with a paper towel.
14. Remove tape from pencil and uncoil hair.
15. Hair should now appear curly/coiled.
16. Take another picture or draw another sketch of the hair after the procedures have been followed and compare it to your original sketch/picture.

## Resources

Use these resources to answer the questions in the report.

- <https://thebumblingbiochemist.com/365-days-of-science/cysteine-disulfide-bonds-perms/>
- <https://www.news-medical.net/life-sciences/Intermolecular-Forces-in-Tertiary-Protein-Structure.aspx>
- <https://www.science.org/content/article/want-cure-your-hair-s-split-ends-try-washing-the-m-wheat-gluten#:~:text=Human%20hair%20is%20made%20mostly,bridges%E2%80%944are%20secure%20and%20unbroken.>
- <https://www.philipkingsley.com/hair-guide/hair-science/the-biology-of-your-hair.html>
- <https://curlsmith.com/blogs/product-guides/how-to-strengthen-repair-hair-bonds>
- <https://certificate.olaplex.com/what-are-disulfide-bonds/>
- <https://certificate.olaplex.com/why-are-disulfide-bonds-important/>
- <https://www.beautyanswered.com/what-is-ammonium-thioglycolate.htm>
- <https://www.differencebetween.com/difference-between-alpha-keratin-and-beta-keratin/>
- [https://is.muni.cz/el/1431/podzim2013/C3804/The\\_chemistry\\_of\\_perming\\_\\_rebonding\\_.pdf](https://is.muni.cz/el/1431/podzim2013/C3804/The_chemistry_of_perming__rebonding_.pdf)
- <https://www.philipkingsley.com/hair-guide/hair-science/the-hair-structure.html>
- <https://keuneeducation.com/curl-patterns-101-whats-your-curl-type/>

## Report

Now that you have performed the procedure for perming hair you will perform research to explain the chemistry behind this process. Using the resources provided answer the following questions:

1. Insert or draw your before and after pictures of your hair from the initial activity.

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2. What is keratin?

3. What is the structure of keratin in hair and what is its function?
  
4. How is keratin held together? (what kind of bonds) How do the molecules in keratin interact with each other? (intramolecular or intermolecular forces?)
  
5. How are the bonds in keratin broken during a perm?
  
6. What type of reaction is occurring in a perm?
  
7. Make a claim about how disulfide bonds affect the structure of hair.
  - a. Claim:
  
8. List evidence to support your claim.
  - a. Evidence:
  
9. Justify your Reasoning. (why/how does your evidence support your claim)
  - a. Reasoning:

### Teacher Information

Standard CHEM 2.3 - **Engage in argument supported by evidence** that the functions of natural and designed macromolecules are related to their chemical structures. Emphasize the roles of attractive forces between and within molecules.

#### Pre-Lab/Introduction:

Introduce the phenomenon of perming by using this clip from the movie [Legally Blonde](#). You only need to play the first 2.5 minutes.

- After the video, have students discuss in small groups (maybe their lab group) about their experiences (or people they know with experiences) involving perming, hair types, etc.
  - You could also do this discussion as a whole class.
  - Have students write down questions they have in the **Pre-Lab** section. There are also questions there to help guide them.
- Then read over the **introduction** information on the lab. This will introduce the students to the idea of how the protein in their hair is held together and what different types of hair there are.

#### In Class Activity Tips:

- When students do the initial activity, have them do it in groups and only perm one hair so that everyone has a chance to participate even if they have short hair/no hair.
- You could use small rubber bands instead of tape to keep the hair in place on the pencil.
- Don't use pipe cleaners to try and curl the hair, the dye seeps out of them and the hair gets stuck when you are trying to remove them.
- There are acid perm kits and alkaline perm kits (either perm kit works) that you can purchase at Sally's Beauty stores (you do need an account to do this) or you can purchase them on Amazon. You could also contact a hair salon and see if they would be willing to sell you the chemicals.

#### Post-Lab Report Information:

After the students perform the activity but before they begin the report, have them debrief within their group about their observations and the experience they just had

#### Report

1. Insert or draw your before and after pictures of your hair from the initial activity.  
[Answers will vary](#)
2. What is keratin?  
[Keratin is a protein that helps form hair, nails, and skin](#)
3. What is the structure of keratin in hair and what is its function?  
[Keratin's structure is an alpha helix and its function/properties are structural to help hold shape](#)

4. How is keratin held together? (what kind of bonds) How do the molecules in keratin interact with each other? (intramolecular or intermolecular forces?)

Keratin is held together by hydrogen bonds, disulfide bonds, and salt bonds (salt bridges).  
Salt bonds & Hydrogen bonds - intermolecular, disulfide bonds - intramolecular

5. How are the bonds in keratin broken and reformed during a perm?

The waving solution is an ammonium thioglycolate solution that breaks the disulfide bonds in hair by reducing the Cystine (disulfide bond) into Cysteine (free amino acid side chain). This allows you to manipulate the structure and reform the bonds when you add the neutralizer to the hair. The neutralizer is a hydrogen peroxide solution that oxidizes the Cysteine and reforms the disulfide bonds in the new configuration you placed the hair in.

6. What type of reaction is occurring in a perm?

Redox reaction

7. Make a claim about how disulfide bonds affect the structure of hair.

**Answers will vary but could look like:**

The structure of keratin/hair is affected by perming by manipulating the disulfide bonds. The properties of keratin/hair are manipulated by redox reactions and that changes the structure.

Hair texture is determined by the molecular structure of disulfide bonds in hair proteins.

8. List evidence to support your claim.

**Answers will vary but could look like:**

- We permed a piece of hair in class by breaking and reforming disulfide bonds using ammonium thioglycolate and hydrogen peroxide
- Disulfide bonds breaking and reforming are a redox reaction
- Hair is made of keratin, keratin is held together by disulfide bonds
- Inter and intramolecular forces hold keratin together
- When we broke and reformed the disulfide bonds the texture of the hair changed

9. Justify your Reasoning. (why/how does your evidence support your claim)

**Answers will vary but could look like:**

Perming hair is caused by a redox reaction. Ammonium thioglycolate is added to reduce Cystine to Cysteine (breaking a disulfide bond). By curling the hair around a pencil we are changing the shape of the hair. Then we add hydrogen peroxide to oxidize the Cysteine back to Cystine (reforming a disulfide bond). This new disulfide bond holds the keratin together in a new configuration (curly).

The macroscopic properties of materials are determined by their molecular structures.

- Information on perming, alpha keratin, and ammonium thioglycolate are very readily available online so students should have an easy time with the research. The websites provided are to help them get started but as the teacher you could decide not to give them these resources if they are Honors/AP students.

**Extension Options:**

Have students research the chemistry behind other types of hair treatments and make a presentation.

- Can you use the same chemicals that perm hair to straighten/relax it?
- What is the chemistry behind hair dye?
- Are there structural differences between hair from different ethnicities?

**Safety Information:**

- The chemicals that students are working with are skin irritants so make sure students are wearing gloves at all times during the lab. They should also have chemical splash goggles and perform this lab in a well ventilated area. These chemicals have a very strong smell so make sure students are not directly inhaling the chemicals (sticking their noses right next to the chemicals).