Introduction: Today you are going to electroplate a coin (nickel) using copper. You will also investigate patterns forming during electrodeposition from a thin film of solution.

Safety: You will be using a copper sulphate (CuSO₄) solution. All the experiments with this liquid should be performed on a plastic tray. You must wear gloves and goggles during this lab.

Electroplating of Nickel: There are many cases where we may want to coat the surface of a material with a thin film of metal. This can be achieved using electroplating.

1. In order to electroplate a metal we will use a solution of aqueous CuSO₄. The solution contains Cu⁺² ions, which gives its blue color. What other ion or ions might be present in this solution?

2. We will be providing CuSO₄ solutions with varying concentrations of Cu⁺² ions ranging from 1 M to 0.01 M. In one liter of 1 molar (1 M) solution there are 1 mole (around 6x10²³) of ions. How do you think the color of the solution changes with the concentration of Cu⁺² ions?

3. For electroplating you will be using the 0.25 M CuSO₄ solution. Pour 400 mL of this solution into a plastic beaker. You will make an electrodeposition cell by inserting a copper electrode and a coin attached to an alligator clip into this solution. For electroplating you will need to form a circuit containing a 6 V battery, a switch, a current meter and the electrodeposition cell. The copper electrode will be connected to the positive side of the battery. Make a drawing of this circuit below.
4. Clean your coin (nickel) in a petri dish using rubbing alcohol (isopropanol). After cleaning the coin, hold it with an alligator clip near its edge and insert the nickel into the \( \text{CuSO}_4 \) solution. The coin should be about an inch from the copper electrode. Secure the electrodes before electroplating. Make a drawing of how the coin is placed with respect to the copper electrode.

5. Build your circuit as you have drawn above. The electroplating will start when you close the switch. There should be a flow of current after the switch is closed. Electroplate your coin for 90 seconds. After electroplating remove your coin from the solution and inspect the electroplating on both sides of the coin. Is the coating uniform? Are there any differences between the copper plating occurred on the surface of the coin facing the electrode versus the back surface? Why?

6. Put your coin back into the solution change the polarity of the cell (this time the coin must be connected to the positive battery) and run the reverse cell for 5 minutes. Remove your coin from the solution and inspect your coin. Discuss possible reactions that might have taken place on the surface of the coin during electroplating. Are these reactions reversible?
**Question:** We have run the reverse electroplating setup on old and new pennies. The pictures of the pennies before and after we ran the experiment are shown below. Based on these pictures, discuss what is the difference between the old and new pennies.

![Figure 1. 2013 penny before (left) and after (right) reverse electroplating.](image1)

![Figure 2. 1970 penny before (left) and after (right) reverse electroplating.](image2)

**Electrodeposition:** You are going to create a thin film of CuSO₄ solution in your Petri dish. Similar to electroplating, when you place a voltage across the solution, the copper will flow and deposit on the
negative lead.

Place the concentric circle transparency on top of blank paper for an easy viewing background. Notice the molarities labeled on the transparency. Each Petri dish is meant to have a different molarity solution so you can compare how different molarities create different types of growth.

Figure 3: Electrodeposition apparatus

Take the four Petri bases (no wire or copper tape) and use the pipette to insert 3 to 4 cc’s of CuSO₄ solution into each base. There are four solutions of CuSO₄ in separate jars: 1M, 0.1M, 0.05M, and 0.01M. Each Petri should have a different solution.

To create a thin film you must place the Petri lid on top of the base. Gently lay an edge of the Petri lid (pin side out) on the base and slowly close lid on like a hinge. Make certain there are no air bubbles near the center, re-seat the dish if necessary.

One member then holds the Petri dish like a sandwich tightly, and another member attaches the two dishes together using a rubber band. It is not a problem if some solution spills; just make sure the solution makes contact with foil copper ring. Repeat this process for all the different molarities until all four dishes are constructed. Place them on their appropriate concentric circle.

7. Predict which molarity will grow the fastest, explain your prediction.

8. Connect the Petri dishes to a power supply. Insert the banana-plug tails into the power supply. Multiple alligator test leads can be attached to the banana-plug tails; this will allow the Petri dishes to be attached in parallel to ensure equal voltage across each. We recommend using a color scheme in the test leads such as red, yellow, and white for the positive lead and black and green for the negative lead.

Caution: Do not short the Alligator test-leads across the power supply.
Attach the Petri dishes in parallel with the device. **Place the positive lead (red terminal on power supply) on the outside ring and the negative lead (black terminal on the power supply) on the inside pin.**

You are now ready to perform a run. Prepare to turn on the power supply and set to 10V. Set timer for 15 minutes.

After you apply the voltage, the electrodeposition should appear very quickly. Every minute make a note on the growth graph of the radial growth in 0.5 cm increments (the spacing between the rings). You will see at what rate the electrodeposition is taking place for different molarities.

Turn on the voltage to 10 V and begin taking data. Have one group member monitor the time, and another plot the data on a graph.

**Growth Graph**

![Growth Graph](image)

At the end of the 15 minutes, turn off the power supply and carefully remove the test-leads.
You can damage the growths if you shake the dish too severely. When there are no obstructions photograph each growth with one group member’s digital camera and make schematic drawings of what you saw. Be certain to note the molarity of the solution.

The deposition of copper is governed by a process called diffusion limited aggregation (DLA) which leads to fractal shapes.

Can you think of other examples of fractal objects in real life?

**Final Clean-up**
Please rinse and wipe all Petri dishes so they can be re-used.