**Magnetic Slime**

**Magnetic attraction can pull some special slime polymers way out of their preferred shape.**

There’s a good chance you’ve (1) already worked with magnets and (2) made slime many times. It’s a good bet you haven’t done it at the same time, however. To remedy that, here’s a way to make Magnetic Slime. You’ll likely be very “attracted” to this new kind of slime and enjoy using a super-strong neodymium magnet to form a miniature Devil’s Tower (Devil’s Tower, WY, USA) in the polymer. Check the Additional Information section to see how this slime models a cancer fighter. It’s chemistry, physics, biology, and geology all in one!

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1. Empty the entire bottle of white school glue into the large mixing bowl.
2. Fill the empty bottle nearly full with water, cap it, and shake it up to recover all the glue.
3. Pour the water and glue solution into the bowl.
4. Add a generous amount of iron filings to the water and glue mixture. Stir the new mixture thoroughly with a spoon.
5. Measure a 1/2 cup (118 ml) of warm water and pour it into the plastic cup.
6. Add 1 teaspoon of borax powder to the water in the cup and stir the solution. Be sure the borax dissolves completely.
7. Add the borax solution to the glue solution in the bowl.
8. Mix the glue and borax solutions together completely. It’s a totally safe combination so use your fingers but be sure to wash your hands with soap first. There’s no point loading your new slime with dirt from your hands. It may take a few minutes to get all of it to mix but it will come together. When the chemistry has done its job, you’ll be holding a large blob of a familiar looking toy. Lay the putty-like mass on the plate and flatten the goo so it has a smooth surface.
9. Bring the magnet close to the surface of the flattened slime and watch the slime spring upward and grab it. The slime is stretchy but it doesn’t want to move easily out of place. Use the magnet to build miniature volcanoes in the slime. If the slime is clean (because you made it with clean hands) then store it in the zipper-lock bag in the fridge. When you’ve made all the discoveries you want with it, you can toss it – bag and all – in the trash.

## HOW DOES IT WORK

1. The iron filings cause this slime to be magnetic. Iron is one of three elements (cobalt – Co, iron – Fe, and nickel – Ni) that are magnetic at room temperature.
2. The solution of school glue with borax and water produces a putty-like material that’s elastic and flows very slowly. The glue is actually made of a polymer material. In simplest terms, a polymer is a long chain of identical, repeating molecules. You can use the image of tiny steel chains to understand why this polymer behaves the way it does. Each link in a chain is a molecule in the polymer and one link is identical to another. When the chains are in a pile and you reach in to grab one, that’s what you get: one. If you dump them on the floor, they’re not connected to each other so they spread out everywhere like water. The strands flow over each other like the liquid glue in the bowl. Something caused a change, however.
3. Let’s say you toss a few trillion tiny, round magnets into the pile of steel chains. Now when you reach in to grab one strand, you grab hundreds because the magnets have linked the strands together. If the molecules stick together at a few places along the strand, then the strands are connected to each other and the substance behaves more like a solid. Sodium tetraborate is the chemical in borax that hooked the polymers in the glue together to form the putty-like material. This process is called cross-linking.
4. The magnet is very strong but something prevents the iron filings from leaving the slime and clinging to the magnet. The slime holds onto the iron filings by adhesion. Adhesion is a force that holds molecules of different substances together. In addition to adhesion, the slime polymer is bonded by cohesion. That’s a force that holds molecules of the same substance together. It’s the combination of magnetism pulling one way and adhesion and cohesion pulling the other that results in the weird, stretchy “volcanoes” appearing when you hover the magnet near the slime. So much is happening in such a small space!

## HERE IS A VARIATION ON THE RECIPE ABOVE

**Modeling a Cancer Fighter**

Like scientists around the world, City of Hope® researchers use models to better understand what they’re working with and to help explain a process or result. Believe it or not, Magnetic Slime is a great model to explain a method to fight cancer: immunotherapy! With a simple change to the slime you made, you can see the cancer-fighting model in action.

The change is to use **iron oxide powder** instead of iron filings when making your slime. Completely stir about one tablespoon of iron oxide powder into the glue solution before adding the borax solution. It may take some effort to stir it in completely because it’s such fine powder. The glue solution will turn a very dark gray color. Add the borax solution and mix the ingredients with your hands.

Plop the dark slime on a smooth tabletop and place the magnet close to it. The magnetic field draws the iron oxide powder to it and the slime engulfs the magnet completely as a result.

As a contrast, drop some coins near the slime and observe that there’s no reaction and no movement to engulf the coins.

This simple model shows the basic operation of immunotherapy. This includes treatments that work in different ways. Some boost the body’s immune system in a general way. Others help “teach” the immune system to attack cancer cells specifically and ignore healthy cells. It’s used by itself for some cancers, but for others it works better when used with other types of treatment. A person’s immune system is used to deliver specific medications directly to cancer cells and not healthy cells. The cancer cell is engulfed and destroyed in a process similar to the way the slime delivered the iron oxide to the magnet and engulfed it.

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