

## Avalanche



### Materials

2 CD jewel cases (regular thickness, not ultra-thin), with the inserts that normally hold the CD removed  
Masking tape  
Black sand -- in California, this is sometimes "magnetic" sand, containing the mineral magnetite  
Salt (ordinary table salt, not rock salt)  
Measuring spoon, 1 Tablespoon  
Paper or plastic cup, at least 3 ounces  
4x6 card  
Sheet of newspaper, or paper towel  
Electric drill  
Drill bit, 1/4 inch

### Assembly

1. On one of the CD cases, drill a 1/4 inch hole halfway across **each** of the two **SIDE** edges (**NOT** the **FRONT** or **BACK** edges).
2. On the second CD case, drill a 1/4 inch hole halfway across **one** of the side edges.
3. Remove any plastic burrs or shavings from the holes and from the cases.
4. Use masking tape to carefully tape around all four sides of each case except where the holes are drilled. The case should be completely sealed shut with tape, including the open space formed by the removal of the plastic insert that normally holds the CD in place.
5. Tape the two cases together so that the hole in the CD case with one hole exactly matches up with one of the holes in the case that has two holes. (If necessary, slide the cases slightly sideways to get the holes to line up before taping.) This will leave one uncovered hole in one of the cases. What you should now have is in effect an hour-glass made from CD cases, with a hole in one of the chambers
6. Place newspaper on table so that the sand and salt will not get all over the place.
7. Make a funnel out of a 4x6 card so that the funnel opening will just fit into the uncovered hole. Use masking on the edge of the funnel so that it will retain its shape.
8. Measure 3 level Tbs (45 mL) of black sand and 3 level Tbs (45 mL) of salt into the cup, and use the paper funnel to pour it into the uncovered hole.
9. Put a piece of masking tape over the uncovered hole to seal it.

## To Do and Notice

Shake and tilt the CD "hour-glass" until all the sand-salt mixture falls to the "bottom" case (it doesn't matter which CD case this is), and is mixed to a reasonable extent.

Tip the whole CD case hour-glass assembly upside-down so that the sand-salt mixture starts falling through the hole. Carefully observe what happens. If all goes well, you should see the formation of a "hill," with alternating layers of sand and salt. Some trials will produce layering patterns that are more dramatic than others, so you may want to try this several times.

At the conclusion of one of your trials, without further shaking or tilting the assembly, look at the back side. Is there any difference in the black and white pattern when seen from the front as compared to the back? You may find that where the front looks quite black, the back will look quite white, and vice-versa.

Tip the case assembly upside down once again, but this time tilt it backward somewhat as the sand-salt mixture falls, rather than having it stand vertically. When it is finished, again look at the front and back. Is there any difference from previous trials? Is the black and white contrast between the front and back more noticeable?

With the case assembly vertical, tip it slowly to one side or the other (clockwise, or counterclockwise), and keep tipping in the same direction until the sand-salt mixture is about to start falling through the hole again -- or even past this point. You should again see some sorting and pattern formation. Tip the assembly back the other way, and you should see more sorting and patterning.

Hold the CD case assembly so that it is almost flat. Gently shake it back and forth for a few seconds. Note that the top portion of the mixture (that you are looking down at) is now fairly whitish, and is composed mostly of salt. Without further shaking or tilting, raise the assembly so that you can look at the bottom side -- this is now largely black, and is composed mostly of sand. Turn the whole assembly over and repeat the process, and note that you can do the sorting all over again.

## What's Going On?

Two factors, the **angle of repose** and the **Brazil Nut Effect**, combine to create the sorting, layers, and patterns that occur in the sand-salt mixture as order emerges from chaos.

The **angle of repose** is the minimum angle at which a granular material can no longer support itself, and will flow under the influence of gravity, i.e., avalanche. (The term "granular" covers a wide range, since even large boulders that accumulate at the foot of a mountain have an angle of repose, and a rockslide or avalanche occurs if this angle is exceeded.) The steepness of the angle of repose is affected by such properties as the size and angularity of the grains. The angle of repose for the salt grains is different from that of the sand grains. In general, when the larger grains (the salt grains in our situation) have a larger angle of repose than the smaller grains (the sand), then layering tends to occur when the grains flow.

If you shake a can of mixed nuts, the largest nuts (the Brazil nuts) rise to the top. Hence the name **Brazil Nut Effect**, which now applies not only to the behavior of nuts, but also to the more general tendency of a large (but not necessarily less dense) particle existing amidst many small particles to rise when the whole collection is shaken or agitated. This behavior has been known and studied for decades, but is still not completely understood (and in fact under certain conditions does not actually operate). In our Avalanche snack, the salt grains are larger than the sand grains, and they end up on top, thus displaying the Brazil Nut Effect.

The angle of repose and the Brazil Nut Effect work together in the Avalanche snack to produce the patterns of sorting and layering that you observe.

## Credit

This snack is based on a previous version by Lori Lambertson, of the Exploratorium Teacher Institute. Hers, in turn, was a snack version of Eric Thogerson's Exploratorium exhibit. We would also like to acknowledge the contributions of Dr. Ken Brecher, while at the Teacher Institute in Summer, 2001, and of one of his graduate students prior to that time.