

Station 6: Under Pressure



Summary

Students use storytelling and exploration with suction cups to learn about relative air pressure.

Real-world connection

- Vacuums as lower pressure.
- Sea breezes and land breezes.
- Low pressure associated with inclement weather.
- The history of science.
- Communication through storytelling and relating history through oral tradition.

Materials

- Suction cups (at least two)
- **Optional:** CD/tape player for students to listen to recording of story

Preparation

- “Under Pressure” story, one per station
- Student Handout, one per student
- **Optional:** Read aloud and record the “Under Pressure” story for students to listen to at the station.

Curriculum outcomes

Theme: Movement of Air: Low and High Pressure. For a complete list of curriculum outcomes, please go to the appropriate table at the end of this document.

References

Basca, Belinda and T. Grotzer. 2001. Focusing on the Nature of Causality in a Unit on Pressure: How Does it Affect Student Understanding? National Science Foundation. ED 456 029.

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Isabelle, Aaron D. 2007. Teaching Science Using Stories: The Storyline Approach. ScienceScope. 31(2):16-25.

Khan, Ian. (Personal communication with Environment Canada meteorologist. December 1, 2008.)

Sample, Sharon. It's a Breeze: How Pressure Affects You. http://kids.earth.nasa.gov/archive/air_pressure/index.html. Updated 22 January 2003.

Sea breeze. http://en.wikipedia.org/w/index.php?title=Sea_breeze&oldid=254561685. Edited 28 November 2008.



Station 6: Under Pressure – Student Instructions

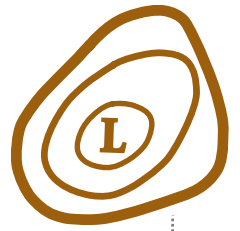


The story *Under Pressure* and its associated suction cup questions are used with permission of Aaron D. Isabelle.

- 1 BEFORE YOU START:** Push the suction cups tightly together.
- 2** In your cooperative group, discuss what is happening. On your handout, write two or three sentences to explain how the suction cups stay together and draw a picture to convey your ideas.
- 3** Read or listen to the story *Under Pressure* by Aaron D. Isabelle.
- 4 AFTER:** Now that you have heard the story, discuss what you have learned about how the suction cups are staying together. Write a new sentence to explain and draw a new picture to help convey your ideas.
- 5** Finish the Student Handout to apply these new ideas to weather.



Station 6: Under Pressure – Student Handout A



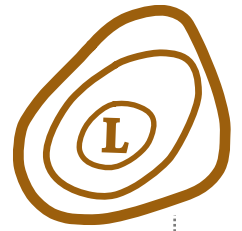
1 BEFORE YOU READ THE STORY: Explain what is happening to the suction cups.

SENTENCE(S):	PICTURE:

2 AFTER YOU READ THE STORY: Explain what is happening to the suction cups. Indicate where there is “higher air pressure” and “lower air pressure.”

SENTENCE(S):	PICTURE:





3 When Otto let the air back into the globe it fell apart onto the ground. The air moved from higher pressure (outside) to lower pressure (inside). Then, the air pressure inside and outside the globe became equal.

Air pressure “wants” to be in balance but sometimes the air around us does not have equal pressures everywhere.

If there is a difference in air pressure in the atmosphere, the air will move. Which way will the air move? From higher pressure to lower pressure!

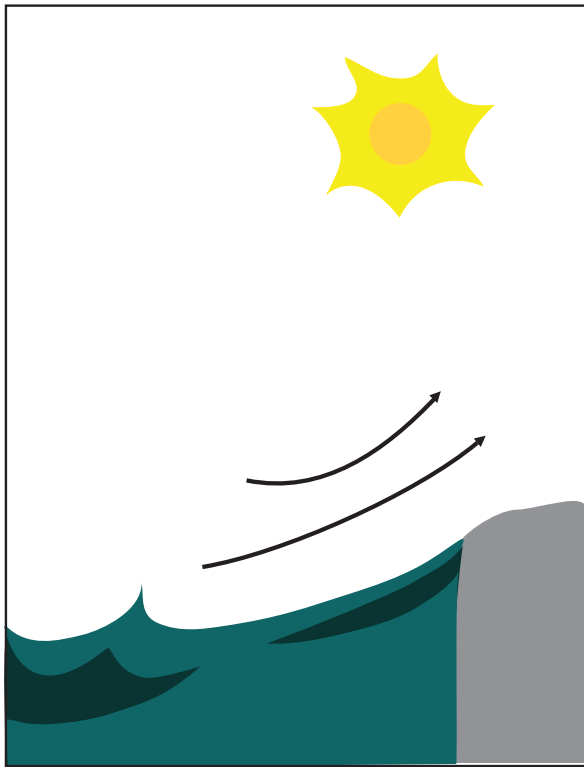
Predict the air pressure in the following situations. Fill in the blanks with the word “lower” or “higher.”

Sea breeze (daytime):

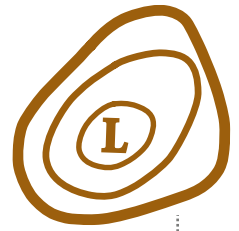
On a hot, sunny day on the coast, air expands. The wind blows from the ocean to the land. Air moves from a _____ pressure zone to a _____ pressure zone. During the day, the air pressure is _____ over the ocean than over the land.

Land breeze (nighttime):

At night the land cools down faster than the ocean, compressing the air. The wind blows from the land back to the ocean. Air moves from _____ pressure to _____ pressure. At night, air pressure is _____ over the land than over the ocean.



Station 6: Under Pressure – Student Handout B – Story



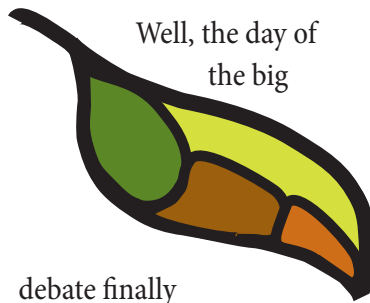
Under Pressure

By Aaron D. Isabelle

It was only a couple days left until Election Day and the two candidates for Mayor were preparing for the last big debate. The people of the town of Magdeburg, a small town in Germany, were all taking this election very seriously. There were a lot of serious issues at hand, like job opportunities and health care. But above all of the problems to be discussed, the people of Magdeburg wanted one problem solved more than any other: they wanted their mayor to put their town on the map; they wanted their town to be heard of and admired across the country! Berlin and Munich were cities in Germany that people spoke about all the time. But, no one knew anything about Magdeburg; most people never heard of such a town, never mind where it was in Germany.

“But, what could the town of Magdeburg ever be famous for?” the people asked. It was not as large as Berlin or Munich. No one famous had ever been born there.

Magdeburg didn’t manufacture or produce anything important. Basically, Magdeburg was an average size town, with an average population; it had an average location; the lives of its citizens could even be considered to be quite average. Everything about the town of Magdeburg was average and the people were sick and tired of being just average. They wanted to be known as “The Great Town of Magdeburg” or “The Incredible Town of Magdeburg,” or at the very least, “The Above Average Town of Magdeburg.” The only problem was that they didn’t know how to achieve this. That was why this election was so important to them. They wanted their new Mayor to have an answer to their problem.



Well, the day of
the big

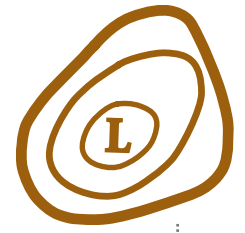
debate finally arrived. Excitement was in the air and the people were hopeful that their city would soon make a name for itself. All were attentive as the first of the two candidates stepped

onto the stage. The first candidate for Mayor, by the name of Hans, was the more experienced of the two. Hans had invested a lot of time and money into the town of Magdeburg and he was pretty confident that he would be the next mayor of Magdeburg. And, if this had been a normal election, Hans’s probably would’ve won. But, this was by no means a normal election. As experienced in politics as he was, he was also a very quiet, soft-spoken person. The crowd was so excited that Hans’s soft-spoken nature was, unfortunately, not a good thing at that moment. The people wanted someone on the platform as fired up and loud as they were.

Hans quietly and calmly said, “I want to give this town a good name as much as you do. So, I have a plan to clean up this town. Magdeburg will be known as “The Cleanest Town in Germany...”

Someone at the back of the crowd interrupted Hans and shouted, “Speak up, Hans! We can’t hear a word you’re saying!”





Hans started to repeat his idea when another person yelled back, “He’s talking about cleaning up the town or something like that...” Once the people heard what Hans had been saying, the whole crowd began to “Boo” him and his idea. Granted, it was a good idea to clean up the town, but the people of Magdeburg were aiming a little higher than: “Welcome to Magdeburg: The Cleanest Town in Germany.”

As Hans walked off the stage, the crowd continued to grumble. In the midst of all the emotion, no one had even noticed that the next candidate for mayor, a person by the name of Otto, had walked onto the stage and was standing in front of them. Although Otto did not have the same political experience that Hans did, he not only had a bellowing voice, but he also had a way with crowds; he was quite an entertainer and a showman.

Otto suddenly spoke clearly and loudly: “My good people of Magdeburg. There is no reason for such anger. If you will all just calm down and gather around me, you will be able to witness my plan for making this town known to all of Germany.”

Otto’s calming, commanding presence affected the crowd and they began to settle down and walk closer to him to see what he had to say.

“My name is Otto-Otto Guericke (GAY-rik-uh) (Hakim, 2005, p. 218). Most of you do not know me, but if you will lend me your eyes and your ears, I believe I will be able to help you. Now, what I have next to me might look strange to you, but it is simply a hollow bronze globe that I made with my own hands.”

The crowd stared in surprise at the shiny metal globe that was about two feet wide (about 60 cm). They did not know what to make of this spectacle.

Otto continued speaking in the face of their amazement, “As you can see, the bronze globe is cut in half so that the two halves of the globe can easily come apart.”

He showed the crowd that the bronze globe could easily be separated in two and that the inside was completely hollow. When separated, it was like the two halves of an orange with the inside taken out. He then put the globe back together and showed the people that both halves fit tightly together.

Otto went on to say, “When I put the two halves of the globe together, the globe is air tight! That means that when the globe is together, nothing, not even air or water, can pass in or out.”

To show them this, Otto forced the globe underwater for a few minutes. After he took the globe out of the water, he separated the two halves, showing that the inside of the globe was completely dry. Clearly, the two halves of the globe fit very tightly together.

Someone in the crowd then yelled out, “So what’s the point, Otto? How is this globe going to make us famous?”

“Well,” said Otto, “I want to make you all a proposition. I bet that once I put the two halves of this globe together that two teams of eight horses pulling on both sides of the globe will not be able to pull the globe apart.”

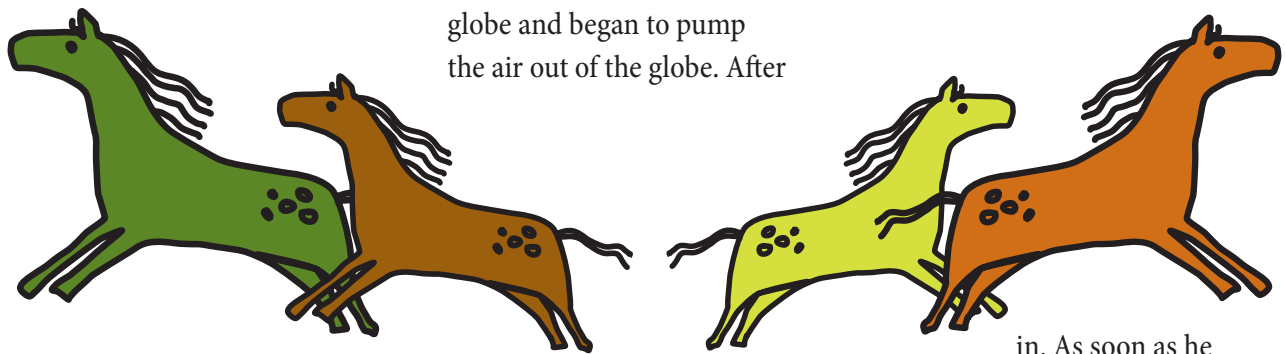
“Another person in the crowd shouted, “This must be a joke... You just showed us how easily the globe can be pulled apart!”

“This is no joke!” said Otto authoritatively. “I’m very serious. So serious that if I’m



right, word will spread all around Germany about this fantastic event in Magdeburg. You will be known as “The Great City of Magdeburg Where Anything is Possible,” and I, Otto Guericke, will be your Mayor.

At this point, as ridiculous as the idea sounded, the citizens of Magdeburg were willing to try anything. So, without hesitation, they cleared an area in the center of town and prepared two teams of eight



horses to pull apart the bronze globe. On each side of the globe, Otto had attached solid brass rings. The horses were tied with ropes onto these rings so that there were eight horses on each side of the globe, ready to pull in opposite directions. Everything was ready to go.

Otto walked to the center of the crowd where the bronze globe and the horses were and said to the people, “What you

are about to see is real. This is not some sort of magic show intended to fool you. Rather, what is going to happen here can be explained by science.”

Otto then placed before the people an interesting looking device. “What I have in my hands is a tool I constructed a few years ago. It is a type of air pump, but instead of pumping air into something (like a bicycle pump), this device pumps air out.”

Otto attached the air pump to a small valve on the bronze globe and began to pump the air out of the globe. After

a couple of minutes, he was finished and he said to the people, “All I did was take out most of the air that was inside the globe. Let the horses try to pull the globe apart now!”

At Otto’s command, the horses were released. Most of the people in the crowd thought that the globe would have immediately come apart, but it did not. One person in the

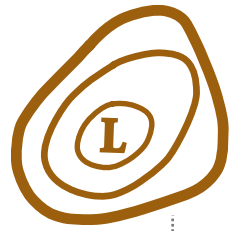
crowd said, “This won’t last. I’ll give it a minute at the most.” Surprisingly, more than a minute went by. At least five minutes went by and the horses were still pulling at hard as they could. Their hooves were even digging far into the dirt. They eventually had to stop the horses because they were tiring.

Otto then went over and opened the air valve in the globe, letting all of the air back

in. As soon as he did this, the two halves of the globe fell right apart onto the ground.

Everyone in the crowd was in awe. One person remarked, “How is this possible? Anything else would’ve been torn apart in seconds by the power of those horses.”

“Two words,” said Otto, “Air Pressure! You see the air around us actually pushes upon us in all directions with great force.



If you were underwater, the pressure of the water would be pushing inward on every part of your body. Well, the same thing is happening right now with the air around us. Basically, we all live at the bottom of an ocean of air. In fact, the force of the air on our bodies is extremely large. There is close to 30,000 pounds of force (133,440 Newtons) pushing upon our bodies, from all directions, right now!”

A person nearby said, “30,000 pounds? If someone placed 30,000 pounds on one of us right now, that person would be crushed in a second. If what you say is true, why isn’t the air pressure crushing us right now?”

Otto said, “That’s a very good point. But remember as we breathe, air enters our bodies, our bloodstream, and our cells. Air exists in all of our tissues and body cavities. So, even though the air is pushing upon us with about 30,000 pounds, the air in our bodies is pushing out with the same force. So, we’re okay because the forces are balanced. If you could somehow take the air out of our bodies, then the

air pressure around us would certainly crush us because there would be no air to exert an outward force from inside our bodies. The force of air pressure inside our bodies and outside our bodies would no longer be balanced.”

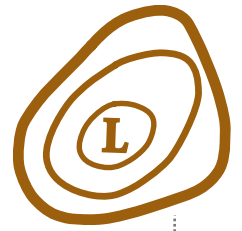
Otto went on to say, “That is exactly what I did in this demonstration. As long as there was air inside the globe, the two halves came apart quite easily. But, when I took most of the air out of the globe, there was hardly any air pressure left inside. I made a partial vacuum, or a space with hardly any air inside. When I did this, the air outside the globe was still pushing with 30,000 pounds, but there was very little air inside the globe to push back. In essence, the forces of air pressure were unbalanced. So, you have all that air on the outside pressing upon the globe from all directions, keeping it together. The only reason the globe wasn’t crushed by all that force was because it is made out of a strong metal. We saw the horses working against air pressure. Believe it or not, those horses were no match for

30,000 pounds of force exerted by the air on the globe.”

One of the leaders of the town spoke up and said, “This is truly amazing. But I wouldn’t have believed it if I hadn’t seen it with my own eyes. I don’t think other people will believe us when we tell them. They’ll just say, ‘It’s just those average people from Magdeburg desperately trying to be famous again.’”

“Well,” said Otto, “If you elect me to be the new mayor of Magdeburg, I will call the bronze globe ‘The Magdeburg Hemispheres’ and I will tour the countryside to carry out this experiment. Everyone in Germany will be shocked and delighted. People will come from miles away to see the indestructible Magdeburg Hemispheres and every one will say, ‘Magdeburg is truly an amazing town where anything is possible!’”

All the townspeople cheered with happiness for they knew their town would finally go down into history as great. They all carried Otto Guericke to the town hall and swore him in as their mayor. From that moment on, he became Otto “Von”



Guericke in respect for his new position.

It was quite a day in Magdeburg's history. It was also quite a day for Otto von Guericke. Just like his globe, he was under a lot of pressure in front of all those angry people. He knew that if his experiment hadn't worked, that he would've had to face a rioting crowd. But, Otto seemed so confident about the demonstration that there didn't appear to be a doubt in his mind. "Never let them see you sweat," so the expression goes. But, if everyone could've only heard what was going on in Otto's mind:

- Is the bronze strong enough to withstand the air pressure?
- Are the halves fitting tightly together so no air will leak in?
- Does the air pump work correctly?

- Did I pump out enough air?
 - Are the horses stronger than what I calculated?
 - Do I really want to be Mayor?
- In any case, putting all doubts aside, the day was a success for all. And even though most people have never heard of the

town Magdeburg, Germany today, I'm sure it was a pretty popular place 350 years ago.

THE END

Used with permission of Aaron D. Isabelle.

Fact

- Otto was the Burgomeister or Burgomaster (similar to a Mayor) in Magdeburg, Germany in the 17th century. He lived from 1602–1686.
- Otto was a scientist and inventor, but preferred conducting experiments on a large scale.
- He was a showman; the bigger the spectacle the better!
- His Magdeburg Hemisphere experiment did actually occur in 1654 and did bring fame to Magdeburg.

Fiction

- Otto did not conduct his experiment for the purpose of being mayor.
- Hans is a fictitious character.
- Otto did not actually tour the countryside with his globe; however, word did spread about this amazing display of air pressure and became a popular teaching device.

