EDITOR'S NOTE:

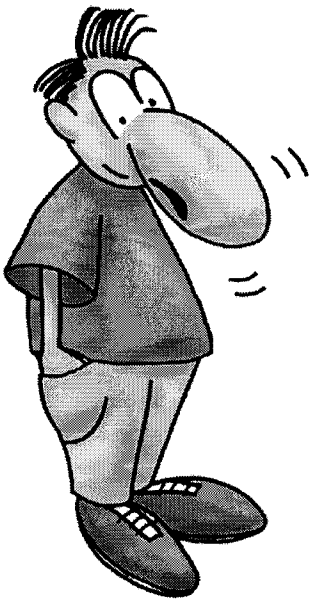
We begin our third year of partnership with the California Institute of Technology's Jet Propulsion Laboratory (JPL) in regularly bringing you space technology related activities for the classroom. These articles will continue to appear on our special "The Space Place" framed pages and link to NASA/JPL web site The Space Place (http://spaceplace.jpl.nasa.gov), also supported by ITEA. The Space Place site has further space-related activities and amazing facts for kids to pursue on their own.

Most children are fascinated by space and the idea of space exploration. As this month's activity will demonstrate, space-related technology brings together many different scientific disciplines. Bringing news of the latest developments in space technology into the classroom gives us an opportunity to introduce a wide variety of other topics, showing exciting new ways of applying scientific knowledge.

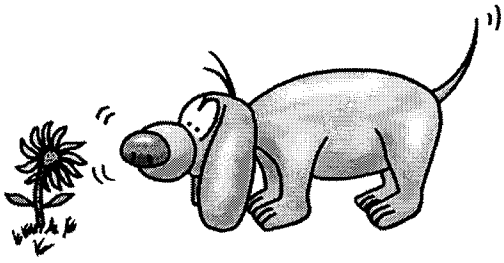
This activity to follow is unusual because it raises our consciousness of what is undoubtedly the most neglected of our five senses: smell. The sense of smell is extremely complex, and scientists working on artificial olfaction have had to study this biological system extensively to extract some basic principles upon which to build their devices.

Further information about the Electronic Nose, or Enose, described in the article can be found at http://mishkin.jpl.nasa.gov/enose.html .

This article was written by Richard Shope and Diane Fisher of JPL. Richard is the Space Science Education Outreach Liaison and Diane is a science and technology writer and creator of The Space Place web site. The research described in this article was carried out by the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, under a contract with the National Aeronautics and Space Administration.



ENOSE IS ENOSE IS ENOSE...



ENOSE BY ANY OTHER NAME IS STILL A NOSE

Do you have a nose for space science? We have plenty of reasons for wanting to detect airborne chemicals in space. The Space Shuttle, the Space Station, and future long-term space voyages all require monitoring of the air. One possible danger is that hydrazine, the rocket fuel carried on board, might leak into the cabin area. We need a way to detect it early and fast--for survival's sake!

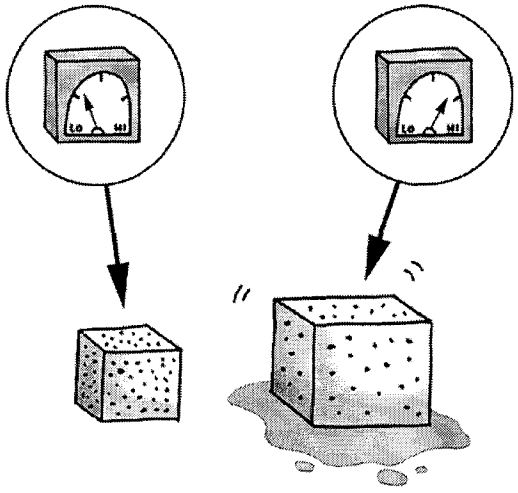
But we also want to explore planetary atmospheres within the solar system. We know the volcanoes of Jupiter's moon Io spew sulfur--does it smell like rotten eggs? We know that Pluto has a mixture of ammonia and methane ices--hmm, what a smelly combination! We have instruments called spectrometers that can detect the presence of basic elements by analyzing the light coming from a star or passing through a planet's atmosphere. But a spectrometer does not function like a nose.

For years, scientists and engineers have been inventing complicated instruments to do "artificial olfaction." (Olfaction is just a fancy word for smelling.) Such artificial noses would be very useful for detecting spoilage in food or toxic substances in enclosed areas.

Now there are electronic nose-sized instruments that truly operate by some of the principles of the human olfactory system. Dr. Nathan Lewis and his team at the California Institute of Technology have been working on one of them. The JPL Electronic Nose (called Enose), using the sensors developed at Caltech, monitors the air around it and responds to changes. It was developed to monitor the air that the crew in the new International Space Station will breathe. Enose actually flew on a Space Shuttle mission (STS-95) in October-November 1998 (with John Glenn).

HOW THE ENOSE KNOWS!

Imagine a sponge as thin as a human hair. If you poured water onto that sponge, it would swell up, just like the sponge in your bathtub. So how can we make a nose out of that sponge? Put particles of carbon (similar to a pencil lead) into the sponge, just like blending chocolate chips into vanilla ice cream. Now, when the water makes the sponge expand, the distance



between the "chocolate chips" gets bigger. Carbon particles are good at conducting electricity, but the farther apart the particles the harder to pass electrical current from particle to particle. If you hook up the sponge to a meter that measures electricity, you can tell whether the sponge is swollen with water or not by how easily the electricity passes through it! Thus, this sponge can "smell" water.

But what about other substances?

It's simple: mix the carbon particles into a collection of different sponges made of different materials that swell up in the presence of different substances. Ahah! Smelling through swelling! Each odor produces a different pattern, or smell print, on the collection of sponges. So that's how we can know which smell is which. In the best electronic noses, no two smells produce exactly the same smell prints, just like no two people have exactly the same fingerprints.

In reality, instead of sponges, the Enose uses very thin films of different polymers (sort of like plastics) painted on a hard ceramic plate. This way, the entire device, including a computer to analyze the "smell print" can be quite small.

Who knows what a nose knows?

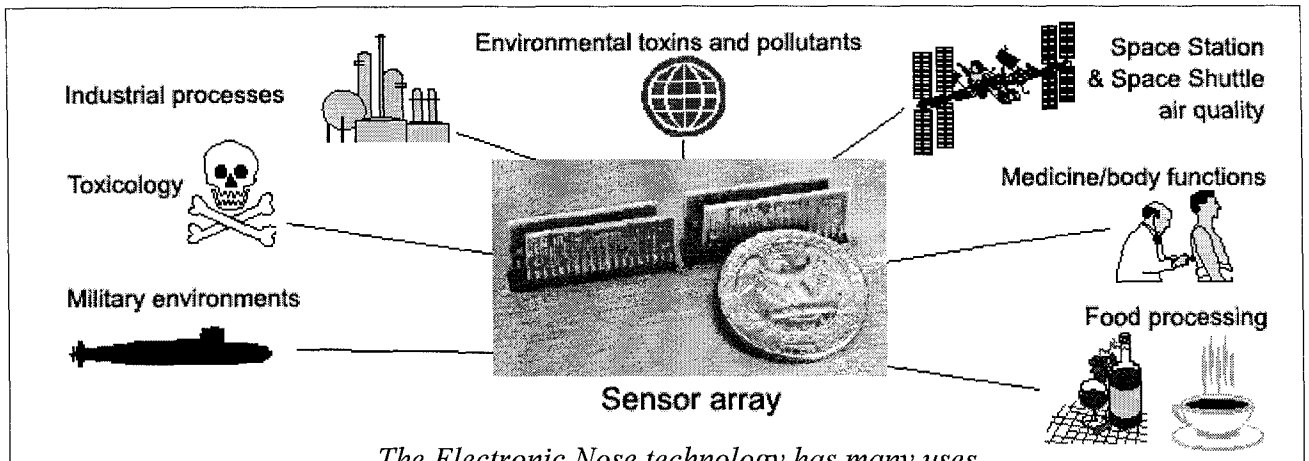
When our nose tingles with a new sensation, our mind perks up to notice. Hot chocolate brewing on the stove. Freshly squeezed lemon. A touch of perfume. Wet sneakers. The smell of the air after a rainstorm. The smell of the air after the spray of a scared skunk! The distinkiness . . . er, that is the distinctiveness, of an odor, an aroma, a smell, an "oh, what-in-the-world-is-THAT?" alerts us to something in the air that we may need to do something about.

What news does your nose know?

Molecules of the substance we are smelling are floating in the air. When they reach our nostrils, they stimulate our olfactory nerves (our nose nerves). The message is sent to our brain where it compares the impression to what it already knows. Our brain instantly summons memories of where we have noticed that smell before or tells us that it is a brand new smell experience. The most important kinds of smells are those that alert us to life or death conditions. Is the food spoiled? Is the substance toxic? Is something on fire?

Whose nose knows most?

Some people smell better than others--that is, some people's noses are more sensitive. Human noses have almost 1000 different odor sensors and over a million total sensors. The brain interprets the sum total as patterns from these millions of sensors that we recognize as smells. To a certain extent, we can educate our noses through practice. We can learn to pay attention to specific smells and to subtle changes in the air. We can compare different smells. We can notice similarities and differences. We can find words to express our sense of different odors.



The Electronic Nose technology has many uses.

Teaching an old nose new tricks . . .

Dogs smell much better than people--that is, a dog's sense of smell uses a much larger proportion of its brain than ours does. In fact, we use specially trained dogs to help us detect smells that our human noses just can't quite notice. A dog depends on its sense of smell the way we tend to rely on our sense of sight. A dog knows the world through its nose. If you can visualize how we might follow a map through a neighborhood with important landmarks drawn out in a picture form, a dog's map of the neighborhood would have important smellmarks. "To get to my house, follow this street until you smell the honeysuckle bush. Turn left, go on until you reach the lawn that was just fertilized (yum!). Sniff around until you notice the direction of the apricot tree in bloom and head straight to it--then you're there."

Getting Nosey: Smelly Activities

Draw out a map that tells how to go from your classroom to the cafeteria by following smell directions. Think of places you have been that you remember by their tell-tale smells.

Is your nose in the know? You probably have favorite smells yourself. You may have noticed that you can smell some things better than others. You may want to challenge your nose to find out how well it can identify smells.

Here's how you can do it:

Materials:

Containers: A variety of containers that have relatively neutral smells. We do not want the container itself to affect the smell of whatever we put into it. Most plastics are fairly neutral to our noses, so a plastic box or plastic bag may do. But you'll have to check for yourself. Some brand-new plastic containers have their own distinct smell. Sometimes cardboard containers absorb the smell of what you put into it. Sometimes the smell of whatever was in the container before still lingers--like in a coffee can.

Smelly things: Select a variety of samples of substances that have distinctive smells.

Now you can conduct a series of experiments, using the collection of smelly specimens. Experiments sort of like these led to the development of the Enose.

Experiment 1. Smell-telling:

Find words to describe each aroma--not necessarily identifying the substance, but describing the sensation itself in words that describe each different smell in a meaningful way. (You may soon realize that our language is very smell-word poor!)

For example, which of the following words might help describe the smell of a skunk (if you have had the good fortune to encounter one):

sharp, burning, sweet, bitter, floral, spicy, strong, pleasant, unpleasant, disgusting, stinky, woodsy, musky, dusty, fishy, metallic, mossy, fruity, pungent, acrid, smoky, rotten

Experiment 2. Smell Patterns:

Create categories for the different smells. Base your categories on patterns that make sense to you--strength, weakness, pleasantness, stinkiness.

Experiment 3. Smell Sensors:

Identify people to act as smell sensors. People in the class will be more sensitive to some smells than others. Choose a variety of people who are sensitive to a variety of smells.

Experiment 4. Human Nose Array:

Create a Nose Array. Place a set of smell sensors in position with instructions to respond to the presence of a smell. Test the accuracy of the Nose Array. Introduce different smells and smell combinations to see if the sensors can accurately detect the presence of a substance emitting a smell. Have everyone hold up five fingers when they really smell something strongly, four fingers if it's weaker, no fingers up if they can't smell that smell at all. This will

generate a smell print from the pattern of people holding up different number of fingers when they are all smelling something. If you've made a good nose array, every different smell should have its own smell print.

Experiment 5. Enose in Space:

Enose is a recent breakthrough that will bring the smells of our solar system for us to experience. Think of a space exploration mission that uses Enose technology and write the story of the smells that the mission discovers in such a way that we feel that we were right there in vivid smell-o-rama!