The Universe in my Pocket

The smells of the Universe

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TUIMP No. 7 THE UNIVERSE IN MY POCKET

What do the astronauts say?

Astronauts who have gone into Space say that the Universe
smells like:

Anousheh Ansari: "It smells like toasted almond cookies".

Don Petit: "It reminds me of the gases given off by welders, it's a pleasant sensation, metallic and sweet".

Alexander Gerst: "A mixture of nuts and the brakes on my motorcycle".

Reid Wiseman: "Like damp clothes after a day in the snow".

Kevin Ford:"Like something that I've never smelled before and that I'll never forget".

Smell

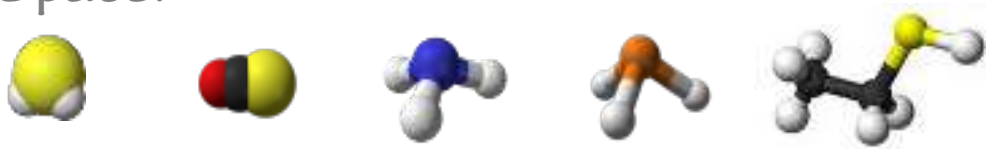
The sense of smell, like that of taste, is chemical in nature, but it acts at greater distances: it is easier to smell something than it is to taste it.

The molecules that float through the air arrive at our nasal passages and are absorbed by the mucous membranes. At the top of our nasal passages there is olfactory epithelium tissue, whose sensory receptors are similar to taste buds.

These cells are activated when odor molecules reach them, and they transmit information to the olfactory bulbs, which send messages directly to the brain. When these signals arrive at the brain, they can stimulate emotions and memory and are able to affect our thoughts.

Thus, smells remind us of people, places and events that we thought we had forgotten.

Above: ALMA, in the Atacama desert of Chile. These antennas capture millimeter-wave light, and can detect molecules in Space.



From left to right: hydrogen sulfide, carbonyl sulfide, ammonia, phosphine and ethanethiol. The first two smell of rotten eggs and manure, respectively. In high concentrations they can cause nausea, eye irritation, and even lead to respiratory collapse. Ammonia smells of decaying fish, while phosphine smells of garlic, and ethanethiol has a most repugnant smell: a mixture of garlic, onion, leek, and boiled cabbage.

These molecules have been found in very diverse places throughout the Universe, including planets, star-forming clouds, and comets.

How do we know what the Universe smells like?

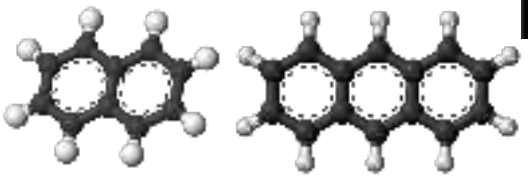
When molecules in Space collide with one another, they can begin to rotate, vibrate, and bend. These movements can produce light, usually infrared or microwaves, with the wavelength of the light being different for each molecule.

Pointing our telescopes to the sky and using spectrometers, we can see subtle details of the light, and we can determine which molecules are present in different corners of the Universe.

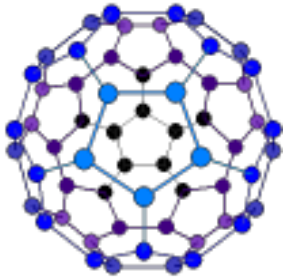
Although we cannot smell the Universe directly, we can imagine what it must smell like by identifying the molecules that are present, since we know what these molecules smell like here on Earth.

Right: The Orion Nebula. The red glow is emitted by **PAH** molecules.

Below: Other carbon molecules that have been found include **naphthalene** and **anthracene**, which smell of tar. Both were detected in a cloud in the constellation of Perseus, about 700 light years from Earth.



Right: **Fullerenes** are a stable form of carbon. Though hard to find on Earth, they are abundant in the interstellar medium of Space.



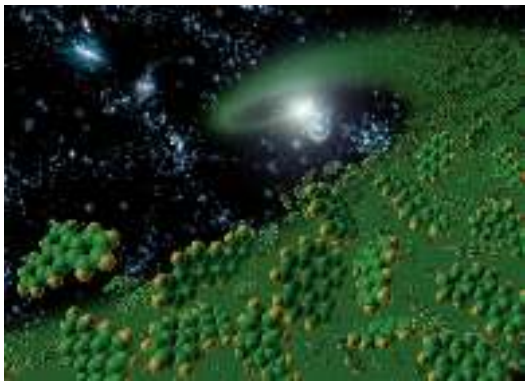
Carbon chain molecules

Molecules made from carbon atoms have been found in almost all areas of the Universe: protoplanetary disks, evolved stars, galaxies, planets, and moons, among other places.

The most abundant of these are called PAHs: Polycyclic Aromatic Hydrocarbons.

On Earth, PAHs are found in car exhaust fumes and burned toast. They smell like scorched material and are a health risk.

Right: **PAHs** are large chains of ring-shaped molecules, made up of carbon and hydrogen. They are found in nearly every place that we point our telescopes.



Right: Image of Jupiter created from data taken by the Voyager spacecraft in 1979. The colors have been modified to bring out the detailed structure.

Left: An artistic representation of Jupiter's atmosphere, by Don Dixon.

Jupiter is an interesting case: its odor changes layer by layer.

The outer layers would smell of rotting fish, because **ammonia** molecules are abundant.

Moving inward, the fish smell would mix with that of rotten eggs, because **hydrogen sulfide** is also present.

Finally, we would detect the smell of bitter almonds, arising from **hydrogen cyanide.**

There would also be a smell of garlic because of the presence of **phosphine** in this giant planet.

Odorless molecules

Methane is found in the atmospheres of several planets (Jupiter, Uranus, Saturn and Neptune), in comets (67P/Churyumov-Gerasimenko), and in the largest moon of Saturn (Titan). Methane can have a geological or a biological origin.

This gas is odorless. Does that surprise you? Methane (like butane) has no smell. In fact, a small amount of a smelly substance is added to tanks of these gases so that people can detect leaks.

The noble gases (helium, neon, argon, …), and also carbon dioxide and water, are other molecules that have no odor.

Sodium is present in the atmosphere of the exoplanet HD189733b. It has no smell, but it burns the mucous membranes of our noses, causing terrible pain.

Sagittarius B2 is a molecular cloud whose mass is about three million times the mass of the Sun and whose size is about 150 light years. It is located near the center of our Milky Way Galaxy.

Sgr B2 contains dozens of different molecules. For example, pre-biotic molecules such as **glycolaldehyde** (a sugar) and **ethylene glycol** (an alcohol) have been found there.

One of the most interesting molecules found in this cloud is **ethyl formate**, which forms when formic acid (found in ant venom) reacts with ethanol. Ethyl formate has a subtle smell of rum and a flavor of raspberries. Finally, a pleasant aroma in the Universe!

Grilled meat or car exhaust?

There is more carbon than oxygen in the Solar System. If we could smell it, it would have a smell of soot or diesel exhaust fumes.

An artist's representation of the Sun, the planets and their moons, and of the comets and asteroids that form the Solar System.

In the nebulae around oxygen-rich stars, for example in the planetary nebula M 2-48, the smell would be like that of grilled meat.

An image of the oxygen-rich planetary nebula M 2-48.

What does the Moon smell like?

Picture of the Moon with an astronaut during the NASA space mission Apollo 16.

Astronauts smelling fresh samples of moon dust say that it smells like burned gun powder. But when the dust is brought back to Earth, the gun powder smell disappears. No one knows why.

The lunar surface consists of **silicon dioxide** crystals (which come from meteorites that have crashed onto the Moon's surface during its lifelime) and also of **iron, calcium and magnesium**. None of these smells of gun powder, which is made of potassium nitrate, carbon and sulfur.

Does the Universe really smell?

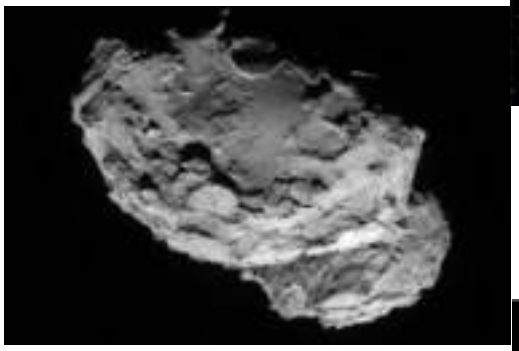
Our noses need a minimum number of molecules to detect odors.

Densities (number of particles per unit volume) in the Universe are often significantly lower than those on the Earth.

To have the same number of molecules, we would need a much larger volume of the Universe than we need on Earth, and therefore we would need a much larger nose for the molecules to enter into.

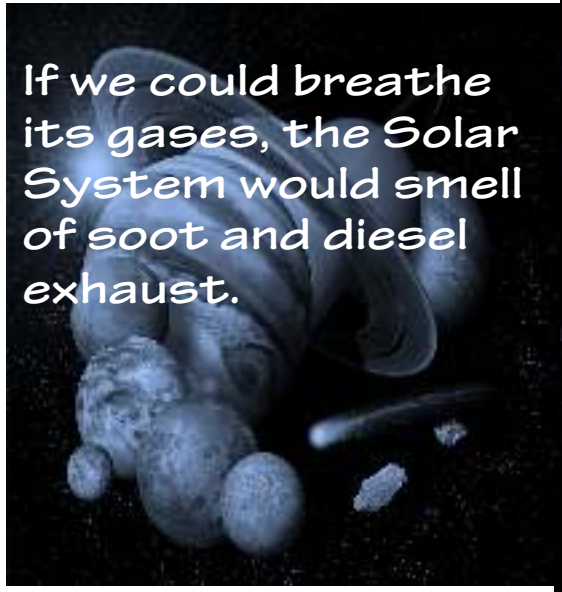
According to Mexican astronomer Daniel Tafoya, to be able to smell the ammonia in the Orion-KL cloud, we would need to be 11.4 km tall (to maintain proportion between nose size and height).

Quiz

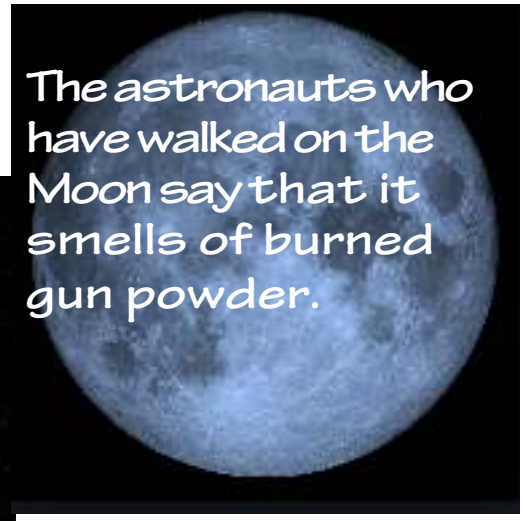


What do these objects smell like?

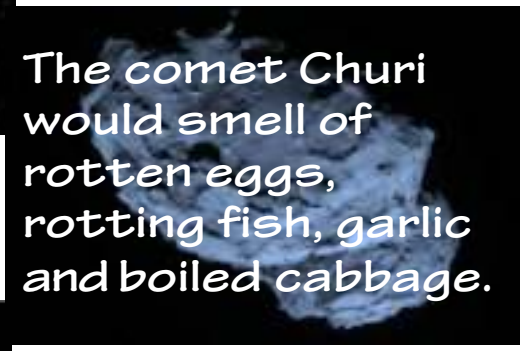
Answers on the back



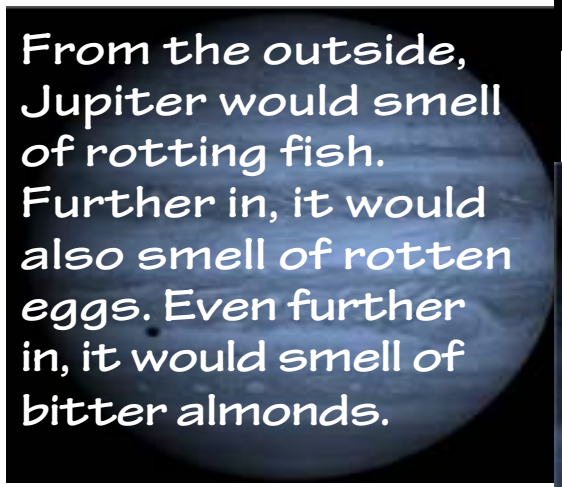
If we could breathe its gases, the Solar System would smell of soot and diesel exhaust.



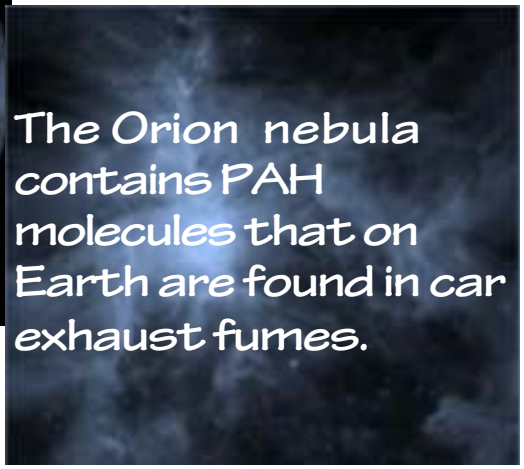
The astronauts who have walked on the Moon say that it smells of burned gun powder.



The comet Churi would smell of rotten eggs, rotting fish, garlic and boiled cabbage.



From the outside, Jupiter would smell of rotting fish. Further in, it would also smell of rotten eggs. Even further in, it would smell of bitter almonds.



The Orion nebula contains PAH molecules that on Earth are found in car exhaust fumes.

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This booklet was written in 2017 by Gloria Delgado Inglada of the Astronomy Institute of the National Autonomous University of Mexico and revised by Stan Kurtz.

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