I BET YOU DIDN'T KNOW...

What happens underground when humans stay indoors

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There are many reasons why the ground might shake. Earthquakes, volcanic eruptions and even ocean swells release a large amount of energy. This energy causes the earth to shake (*vibrate*) and the *vibrations* travel outwards in all directions through the Earth, like the ripples on a pond, in the form of a *seismic wave*. The seismic waves shake the earth as they move through it and when they reach the surface of the Earth, they shake the ground. Sometimes when the ground shakes, there can be enough energy to cause landslides and damage to buildings (Figure 1). Seismic activity takes place all the time and is not always as noticeable.

Questions to ask children (Note: when talking to younger children, you might prefer to use the word shaking, rather than vibrating).

How do you know something is, or was, vibrating?

Can you think of other sources of vibrations?

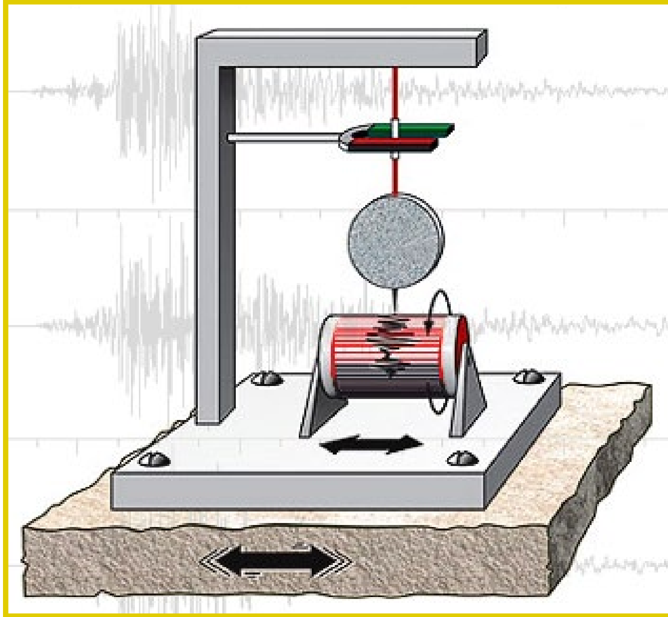
Sometimes we feel vibrations (seismic waves) and sometimes we hear vibrations (sound waves). Sound is a vibration that travels through the air, liquids and solids, and is detected by your ear.

How can we measure vibrations underground?

A simple *seismometer* is an instrument that responds to ground motions. It consists of a weight hanging from a spring that is hanging on a frame. Attached to the bottom of the frame there is a rotating drum of paper (Figure 2). When there is movement underground, the frame and the rotating drum will move slightly. The weight does not move because it is heavy, which makes it slow to start moving, and as it is only hanging by a spring, it stays still when the rest of the seismometer starts to move. A pen attached to the weight can record the relative movement between the frame and the weight. The seismometer could be regarded as an artificial ear that 'hears' (detects) the very low frequency waves which are outside the human hearing range.

Figure 1. A building destroyed by an earthquake..

Figure 2. A simple horizontal motion seismograph. The heavy weight holds the pen still while the base moves back and forth.



The first seismometers were made in China during the 2nd century. By the 13th century, a Persian scientist and astronomer had built an observatory in Iran (known then as Persia) which housed seismometers. At the time, this observatory was regarded the most advanced scientific institution in Europe and Asia. Modern seismometers are more complex and use electronic sensors, amplifiers, and digital recording devices, rather than pen and paper. Children could create their own seismometers in the classroom and ideas for how to do this and possible investigations are detailed in the Teacher Guide.

Humans generate seismic waves through their activities. These might be large events such as nuclear explosions, but everyday human activities, for example building work, can be recorded on seismometers in densely populated areas (*urban environments*). It is important to have seismometers in urban areas to warn of natural events such as earthquakes which could cause harm. However, human seismic activity in urban environments makes it difficult to detect signals linked to earthquakes and volcanic eruptions.

In 2020, most countries of the world imposed a *lockdown* on their populations to try to limit the spread of COVID-19. Seventy-six scientists from research centres around the world have worked together to look at the effects of COVID-19 lockdowns on seismic activity. They collected data from 337 seismometer stations in different countries from December 2019 to May 2020. The data showed that there was a reduction in seismic noise almost everywhere in the world, starting in China in late January 2020, then followed by Europe in March 2020 and the rest of the world in April 2020. It is normal for scientists to observe quieter periods of seismic noise during the Christmas and New Year holidays in countries where these are celebrated. However, the seismic noise levels observed during lockdowns lasted longer and were often quieter than previously seen during these holiday periods.

Some seismometers were located in boreholes (underground holes). One was 380 metres below the city of Auckland in New Zealand. Another was 90 metres below the uninhabited island of Motutapu (14 km away from Auckland). Before lockdown, the seismic activity varied between weekdays and weekends at both sites suggesting that both stations are sensitive to human activity. The scientists recorded a 2-fold reduction in seismic activity on these seismometers during lockdown, and an increase to pre-lockdown levels when New Zealand lifted restrictions. The Black Forest Observatory in Germany is an even more remote station, located 150–170 metres below the surface in crystalline bedrock. Even here the scientists found a small reduction in seismic activity during lockdown nights.

The scientists suggest that because the general seismic activity during COVID-19 lockdowns was so low, they could detect seismic activity from new sources. Such newly identified signals could be used as reference points for finding similar waveforms in 'noisier' data pre- and post-lockdown. They argue that characterising and minimising human seismic noise is increasingly important for accurately detecting the seismic patterns of potentially harmful events. As populations increase globally and urban environments increase in number and size, this could become increasingly difficult. The scientists also suggest that the publicly available data from the existing seismometer networks could be used to monitor human activity such as mobility and industrial activity and the 2020 'quiet period' is a baseline for using seismic properties to do this.

Figure 3. A European mole. These are small mammals adapted to living underground.

Questions for children to consider:

What human activities do you think might generate seismic waves?

What other environmental changes do you think there could have been during the global lockdown? Could any of these be measured? Would any be useful to monitor human activity?

Some animals, such as moles, live underground (Figure 3). They find their food (earthworms) by sensing vibrations when worms fall into their tunnel.

How might human activity affect the mole's ability to find food? How do you think the lockdown affected underground animals like the mole?

GLOSSARY

Lockdown
emergency measures imposed on a population such as full quarantine, enforced physical distancing, travel restrictions, widespread closure of services and industry

Vibration
a shaking or quivering

Vibrate
move continuously and rapidly to and fro

Seismic wave
vibrations that travel through the earth

Seismometer
an instrument which detects ground movements

Sound waves
vibrations that travel through gases, liquids or solids and can be detected by the ear

Urban environment
a human settlement with a high density of population, buildings, roads, and other infrastructure

The research paper that inspired this work was:

Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures.

By Thomas Lecocq[1], Stephen P. Hicks[2], Koen Van Noten[1], Kasper van Wijk[3], Paula Koelemeijer[4], Raphael S. M. De Plaen[5], Frédérick Massin[6], Gregor Hillers[7], Robert E. Anthony[8], Maria-Theresia Apoloner[9], Mario Arroyo-Solórzano[10], Jelle D. Assink[11], Pinar Büyükakpınar[12,13], Andrea Cannata[14,15], Flavio Cannavo[15], Sebastian Carrasco[16], Corentin Caudron[17], Esteban J. Chaves[18], David G. Cornwell[19], David Craig[20], Olivier F. C. den Ouden[11,21], Jordi Diaz[22], Stefanie Donner[23], Christos P. Evangelidis[24], Läslo Evers[11,21], Benoit Fauville[25], Gonzalo A. Fernandez[26], Dimitrios Giannopoulos[27,28], Steven J. Gibbons[29], Társilo Girona[30], Bogdan Grecu[31], Marc Grunberg[32], György Hetényi[33], Anna Horleston[34], Adolfo Inza[35], Jessica C. E. Irving[34,36], Mohammadreza Jamalreyhani[37,13], Alan Kafka[38], Mathijs R. Koymans[11,21], Celeste R. Labedz[39], Eric Larose[17], Nathaniel J. Lindsey[40], Mika McKinnon[41,42], Tobias Megies[43], Meghan S. Miller[44], William Minarik[45,46], Louis Moresi[44], Víctor H. Márquez-Ramírez[5], Martin Möllhoff[20], Ian M. Nesbitt[47,48], Shankho Niyogi[49], Javier Ojeda[50], Adrien Oth[51], Simon Proud[52], Jay Pulli[53,38], Lise Retailleau[54,55], Annukka E. Rintamäki[7], Claudio Satriano[54], Martha K. Savage[56], Shahar Shani-Kadmiel[21], Reinoud Sleeman[11], Efthimios Sokos[57], Klaus Stammler[23], Alexander E. Stott[58], Shiba Subedi[33], Mathilde B. Sørensen[59], Taka'aki Taira[60], Mar Tapia[61], Fatih Turhan[12], Ben van der Pluijm[62], Mark Vanstone[63], Jerome Vergne[64], Tommi A. T. Vuorinen[7], Tristram Warren[65], Joachim Wassermann[43], Han Xiao[66].

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This paper has a particularly large number of authors. Seventy-six scientists worked together to write this paper. See where they all worked.

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