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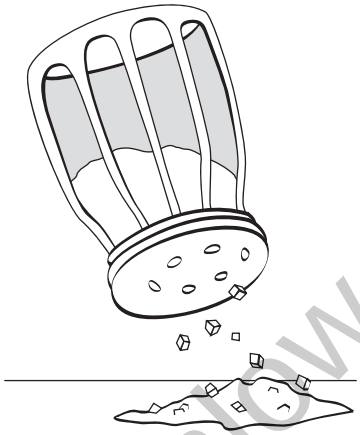
Salt Crystals

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about crystalline solids. The probe is specifically designed to determine how students think atoms are arranged and move in a crystalline lattice.

Related Concepts

atoms, crystal, crystalline lattice, ionic bond

Explanation

The best answer is Portia's: "I think I would see vibrating atoms arranged in an orderly way with spaces between them. There would be nothing in the spaces, not even air." Salt is an example of a crystalline ionic lattice. A salt crystal is made up of an orderly repeating array of sodium and chloride ions. This repeating array is caused by the electrostatic attraction between negatively and positively charged atoms called ions and forms the salt crystal's distinct cuboid shape. The tiny crystals are made up of the atoms (in the form of ions). They are in the form of a solid in which the atoms are closely locked in position and can only vibrate. They are not free to move around as in a gas. There is empty space between the atoms that make up the salt crystal. There is no air in these spaces because the material is salt (sodium chloride), not a mixture of salt and air. The crystalline matter is sodium and chlorine atoms only. Sometimes models, such as ball and stick models, depict sodium chloride (table salt) as a repeating cuboid, three-dimensional array of atoms connected by lines representing the ionic bonds. These lines are not actual physical structures but rather represent the attraction among the ions.

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Curricular and Instructional Considerations

Primary Students

In the primary year levels, students observe macroscopic properties of matter and details they can see using magnifiers. Their observations focus on the features of objects and materials. Using magnifiers, they can see that salt has a cuboid shape. But explaining that microscopic structure in terms of atoms exceeds expectations for this year level.

Middle Years Students

In the middle years, students begin to use atomic and molecular ideas to explain phenomena and structural arrangements. They distinguish between molecular substances and crystalline lattices, although the details of ionic and covalent bonding can wait until high school. They should know that solids are rigid structures made up of atoms and that the atoms, with some empty space between them, can only vibrate in place, not move about.

High School Students

Students at the high school level should be able to use ideas about atomic/molecular motion to explain phenomena and structural arrangement from a microscopic view. They should be able to explain the difference between ionically bonded compounds and other types of chemical bonds. They frequently use ball and stick models to explain structure and behaviour. But even though they may understand what an ionic bond is, they may still hold on to misconceptions about the space between atoms.

Administering the Probe

This probe is most appropriate at the middle years and high school level. Consider having students examine grains of salt macroscopically before answering the probe.

Related Ideas in the *F–10 Curriculum: Science* Content Descriptions (ACARA 2014a)

Foundation Year Chemical Sciences

- Objects are made of materials that have observable properties (ACSSU003)

Year 8 Chemical Sciences

- The properties of the different states of matter can be explained in terms of the motion and arrangement of particles (ACSSU151)

Year 9 Chemical Sciences

- All matter is made of atoms which are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms (ACSSU177)

Related Ideas in the *Senior Secondary Curriculum: Chemistry* Content Descriptions (ACARA 2014c)

Unit 1 Properties and Structures of Atoms

- Atoms can be modelled as a nucleus surrounded by electrons in distinct energy levels, held together by electrostatic forces of attraction between the nucleus and electrons; atoms can be represented using

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electron shell diagrams (all electron shells or valence shell only) or electron charge clouds (ACSCH018)

- The properties of atoms, including their ability to form chemical bonds, are explained by the arrangement of electrons in the atom and in particular by the stability of the valence electron shell (ACSCH020)

Unit 1 Properties and Structures of Atoms

- Chemical bonds are caused by electrostatic attractions that arise because of the sharing or transfer of electrons between participating atoms; the valency is a measure of the number of bonds that an atom can form (ACSCH029)

Related Ideas in the *Senior Secondary Curriculum: Physics* Content Descriptions (ACARA 2014e)

Unit 1 Heating Processes

- The kinetic particle model describes matter as consisting of particles in constant motion, except at absolute zero (ACSPH017)

Related Research

- Students of all ages show a wide range of beliefs about the nature and behaviour of particles. For example, they attribute macroscopic properties to particles; do not accept the idea there is empty space between particles, and have difficulty accepting the intrinsic motion of solids, liquids and gases (AAAS 1993).
- Children frequently consider atoms of a solid to have all or most of the macroproperties they associate with the solid (Driver et al. 1994).
- Twenty-eight Australian 17-year-olds were interviewed in an Australian study conducted by Butts and Smith (1987) that focused on the formation of sodium chloride and use of the ball and stick model. The students referred to molecules of sodium chloride and stated that there were ionic bonds between the molecules.

Suggestions for Instruction and Assessment

- Use magnifiers to see the cuboid shape of salt crystals. Challenge students to think what these cubes would look like at the microscopic level of the atom. Help them distinguish between the properties of the material (salt crystal) and the properties of the atoms. Just because a material has a certain shape does not mean the atoms have the same shape.
- A variety of materials, including ball and stick models, can be used to illustrate the ionic arrangement of the sodium and chloride atoms in table salt. But make sure students do not think the sticks are actual physical structures between atoms.
- Clarify the difference between an ion and an atom.
- The PRISMS website at *http://mmsa.org/archive/prisms/analysis.html* has a collection of reviewed web representations to help students visualise the atoms in a crystalline array. This website is part of the National Science Digital Library and can also be accessed through *http://nsdl.org*.

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Related Resources

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Adaptation

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit students' ideas about adaptation. The probe is designed to find out if students think animals intentionally adapt to a change in their environment.

Related Concepts

adaptation, natural selection, variation

Explanation

The best answer is Gerald's: "I think none of the rabbits will try to adapt to the change." The key word here is *try*. Adaptation involves genetic variation that allows some individuals to survive a particular change, such as a change in the environment, better than others. These individuals are then able to survive and reproduce, passing on their genes to successive generations of offspring that will be better adapted for the particular environment. This process is called natural selection, and it leads to adaptation. If the genetic variation that allows an individual to survive the change is not present, the individual cannot intentionally change its structure, physiology or behaviour in an attempt to "try" to adapt to the change and pass on its genes so that its offspring will be adapted. Either the genes are there that allow the rabbit to survive and pass on its traits that enhance survival to its offspring (natural selection) or they are not there. If they are not there, they can't intentionally adapt or change their genes by "trying". Adaptation is not intentional. The rabbits may try to survive by acclimating to the change, but trying to survive is different in a biological sense from trying to adapt. Another problem is the use of the verb

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adapt, which implies that an action is being taken by an individual.

Curricular and Instructional Considerations

Primary Students

In the primary year levels, students build understandings of biological concepts through direct experience with living things and their habitats. They observe and learn about structures, functions and behaviours that help organisms survive in their environments. They develop an understanding that some organisms are better suited than others to survive in certain environments. They develop beginning ideas about heredity – that is, that some characteristics are inherited and passed on to offspring. These basic ideas establish a foundation that will lead to a later understanding of natural selection.

Middle Years Students

Understanding adaptation is still particularly troublesome at this level. Many students think *adaptation* means that individuals change in deliberate ways in response to changes in the environment (NRC 1996). At this level, it is important to develop the idea of variations in populations of organisms that may give some individuals an advantage in surviving, reproducing and passing on those traits to their offspring. Teaching students about the selection of individuals is the first step in helping them understand natural selection as a mechanism for species' change.

High School Students

Biological evolution and its mechanism, natural selection, is a major focus of high school biology. At the high school level, students shift from a focus on selection of individuals with certain traits that help them survive to a focus on the changing proportion of such traits in a population of organisms. Their growing understanding of genetics builds on middle years ideas about variation. But students at this level may still hold on to the misconception that adaptations can be controlled by an individual.

Administering the Probe

Make sure students understand this is a hypothetical situation and that there is a drastic change in the environment when the rabbits move from the southern climate to the northern climate. This change also involves more than just temperature. There may be changes in food, shelter and predators as well. You might consider having students describe each of the environments first. Feel free to change the context of the probe to an animal and two different environments with which your students are most familiar.

Related Ideas in the *F–10 Curriculum: Science* Content Descriptions (ACARA 2014a)

Foundation Year Biological Sciences

- Living things have basic needs, including food and water (ACSSU002)

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Year 1 Biological Sciences

- Living things have a variety of external features (ACSSU017)
- Living things live in different places where their needs are met (ACSSU211)

Year 2 Biological Sciences

- Living things grow, change and have offspring similar to themselves (ACSSU030)

Year 4 Biological Sciences

- Living things, including plants and animals, depend on each other and the environment to survive (ACSSU073)

Year 5 Biological Sciences

- Living things have structural features and adaptations that help them to survive in their environment (ACSSU043)

Year 6 Biological Sciences

- The growth and survival of living things are affected by the physical conditions of their environment (ACSSU094)

Year 9 Biological Sciences

- Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (ACSSU175)

Year 10 Biological Sciences

- The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)

Related Ideas in the *Senior Secondary Curriculum: Biology* Content Descriptions (ACARA 2014b)

Unit 3 Continuity of Life on Earth

- Natural selection occurs when selection pressures in the environment confer a selective advantage on a specific phenotype to enhance its survival and reproduction; this results in changes in allele frequency in the gene pool of a population (ACSBL090)
- In additional to environmental selection pressures, mutation, gene flow and genetic drift can contribute to changes in allele frequency in a population gene pool and results in micro-evolutionary change (ACSBL091)
- Mutation is the ultimate source of genetic variation as it introduces new alleles into a population (ACSBL092)

Related Research

- Many students tend to see adaptation as an intention by the organism to satisfy a desire or need for survival (Driver et al. 1994).
- Middle years and high school students may believe that organisms are able to intentionally change their bodily structure to be able to live in a particular habitat or that organisms respond to a changed environment by seeking a more favourable environment. It has been suggested that the language about adaptation used by teachers or textbooks may cause or reinforce these beliefs (AAAS 1993, p. 342).

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- Many students ages 12–16 display Lamarckian beliefs about inheritance of acquired characteristics. This belief has been demonstrated both before and after instruction in genetics and evolution (Driver et al. 1994).

Suggestions for Instruction and Assessment

- Refrain from using the words adapt (particularly as an action verb that implies intentionality) or adaptation in primary year levels. Instead talk about characteristics and features that help organisms live in their environments. Teachers' early use of the words adapt or adaptation, before students understand the genetic basis for passing on traits that enable an organism to adapt, may imply that plants and animals intentionally adapt. This idea is particularly resistant to change at the middle years level, perhaps because the idea of intentional adaptation was developed early on.
- Some individual organisms, such as humans, do control changes in their structure or behaviour in response to an environmental change and are said to "adapt". *Acclimatise* would be a better word to use for these non-inheritable changes made by an individual during its lifetime.
- A common activity used in primary and middle years classrooms is to have students design an imaginary organism that is adapted to a particular habitat. Be aware, though, that this activity may reinforce the idea that an individual intentionally adapts during its lifetime.
- Compare and contrast with students the everyday common use of the word adaptation with the scientific meaning of the word. Add this to students' growing number of examples of the way we use words in our society that are not always the same as the way they are used in science.
- Help students develop the notion that natural selection leads to adaptation and not the other way around (that adaptation leads to natural selection). It is the genetic variation that leads to natural selection and thus to adaptation of a population.

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