Self-Filling Water Bottle

Abstract

The Self-Filling Water Bottle's main objective is to provide a solution to the lack of water in our world today. This invention can even be used for a simple activity, like a hike. The Self-Filling Water Bottle will allow people to have clean water anywhere. Through the use of an innovation inspired by MIT's MOFs (Metal-Organic Frameworks), this can become a reality. In the invention, the MOFs extract the water vapor in the air and condense it through a condenser in the water bottle, producing the clean water. The issue being addressed in this project is to increase the water production rate. Since MOFs are composed of both metal and organic compounds, this project focuses on finding the best possible combination of MOFs by modifying the metal ions to create larger pores that can absorb more water vapor. The Self-Filling Water Bottle changes the way that water can be accessed.

Self-Filling Water Bottle

Present Technology

The ExploraVision invention is a water bottle that is able to extract water from the air. The invention is based on the technology currently being developed by the scientists at MIT and the University of California at Berkeley. They have created a device which uses "porous crystals that form continuous 3D networks" (Goshal, 2018) called metal-organic frameworks (MOFs). They can be made by combining different types of metals with any organic compound which results in many varieties of MOFs (Georgiou, 2018). The MOFs have hydrophilic surfaces which enables it to attract water vapor from the air and convert it to drinking water. This occurs with the scientific principle of condensation. According to the scientists, condensation occurs when the MOFs are placed between a black surface (to attract solar heat) and a lower surface at the same temperature as the outside air (Perlman, 2016). Then the "water is released from the pores as vapor and is naturally driven by the temperature and concentration difference to drip down as liquid" (Chandler, 2017). The technology does produce water, but not as much to satisfy thirst. Currently, it produces only a "few milliliters of water" (Chandler, 2018). The purpose of this ExploraVision innovation is to increase the production rate of the water.

History

For most of the twentieth century, the synthesis of crystalline solids was a major milestone in science. Over the years, scientific discoveries from crystalline solids arose, such as, porous crystals and zeolites (which are microporous, aluminosilicate minerals commonly used as commercial adsorbents and catalysts). Reports on creating zeolites surfaced from 1860s, but the work of Richard Barrer in the 1940s prompted the study of synthetic zeolites. The synthetic zeolites opened more research for the scientists to use both organic and inorganic components in the preparation of porous crystals. In the

1990s, there was an "explosion" of research interest in crystals known as metal-organic frameworks (MOFs) (Vaughan, 2014). MOFs are molecular scaffolds made up of metal-containing nodes linked by carbon-based struts (Peplow, 2015). The MOFs are made by linking inorganic and organic units by strong bonds (reticular synthesis) (Furukawa, Cordova, O'Keeffe, & Yaghi, 2013). Many MOFs were reported in the early 1990s, however, in 1999 two key papers appeared. In February, Ian Williams reported a MOF known as HKUST-1, a structure made from copper-based clusters and benzene tricarboxylate linkers and in November, Yaghi reported MOF-5, a structure made from zinc-based clusters and benzene dicarboxylate linkers (Krämer, 2017). Today, there are thousands of different MOF structures that have been synthesized. MOFs can be used to store hydrogen and can reversibly absorb carbon dioxide (Vaughan, 2014). MOFs can also potentially be used to "pull water out of thin air" considering the fact that the MOFs have considerably impressive abilities, like storing oxygen and absorbing carbon dioxide for many years.

Future Technology

In 20 years, the self-filling water bottle would be a unique structure. The water bottle would consist of an attachment at the top to produce water. At the top of the attachment would be a solar panel to use solar energy to power the MOFs, placed beneath the panel. There would then be an airway that would allow air to enter for the scientific principle of condensation to take place. Condensation is the process in which a substance is transformed from a gas to a liquid state ("Condensation", n.d.). At the bottom of the attachment is a condenser which will help in the process for producing water. (Service, 2017). When the vapor touches the condenser, condensation occurs and it makes the water being produced denser. After water is produced, it would drip down and then be collected in the water bottle. A drinking straw would be attached to the side of the bottle to provide easy access to the water. The solar panel can be used during the day with the use of the sun's energy. During the day, the airway is

closed and the solar energy causes the MOF to release the water as vapor, that is collected in the condenser. At night, however, the airway is opened, allowing air to flow into a porous MOF that holds water molecules to be collected as vapor. The current limitation is the lack of water being produced. For the future technology, there would be more MOFs that have larger pores in order to produce more water at a faster rate. The larger pores will allow for more water vapor to be collected. (Chandler, 2017)

Breakthroughs

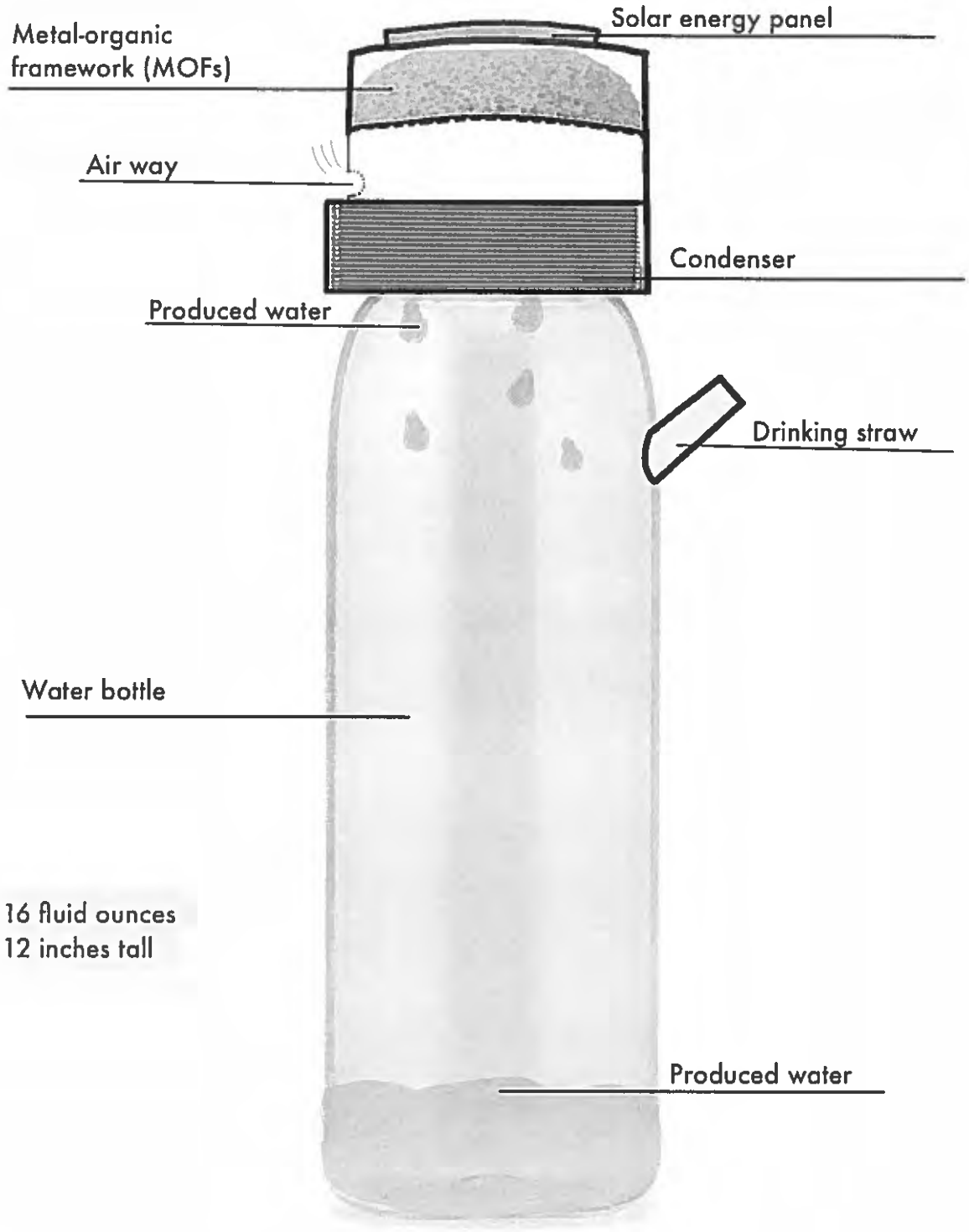
In order to make the Self-filling Water Bottle a reality, as stated previously in the Present Technology portion, the production rate of the water must be increased. The device uses MOF's which are "chemically diverse artificial compounds" made by combining metals with any organic compound (Georgiou, 2018). Presently, more than 20,000 varieties of MOFs have been produced (Chandler, 2017). A breakthrough for this ExploraVision project would be to discover the perfect combination of materials that form a more effective variety of MOFs. Since MOFs have a porous "sponge-like configuration" with hydrophilic surfaces (Chandler, 2017), the ideal new variety of MOFs would be made of compounds with surfaces that are more hydrophilic and therefore, capture more water molecules from the air. Because MOFs are generated based on the relative humidity of the air, another breakthrough for this future design would be to use solar energy to generate the water bottle instead. However, designing a new variety of MOFs rather than using solar-powered devices is preferable for those in poorer countries. In a recent study, scientists discovered that MOFs made with manganese, cobalt, or nickel ions bound to triazolate linkers have the most favorable pore sizes to absorb more water (Lim, 2017). Thus, a possible research project to test a new variety of MOFs would be based on this. The organic compounds that link with the metal ions could be modified and altered by either adding or removing amounts of compounds or ions. In this research project, the independent variable is the three types of metal ions (manganese, cobalt, or nickel) and the dependent variable is the efficiency rate of

each MOF. According to research by MIT, the nickel metal ion is referred to as a "porous catalyst" that "shows superiorities" over other metal alternatives (Zhang, 2017). If the nickel metal ion is modified to obtain a larger surface area, then the nickel MOF will produce the highest rate of water. The data collected would be the percentage differences amongst the three different MOFs which represent the rate of water produced.

Design Process

Three alternative ideas for the Self-Filling Water Bottle were: the MOF attachment would be located at the bottom, the MOF attachment would be separate from the water bottle, and the water bottle would be a bigger jug in which the water would be produced in a larger scale. The attachment on the bottom would be the MOF based device, but located on the bottom of the bottle. This idea was rejected because if the water was produced at the bottom of the bottle, then there was no way to have the water get collected inside the bottle. The idea of the MOF attachment being separate from the water bottle would include two parts, one being the bottle and one being the MOF attachment located on the outside. To refill the bottle, the water being produced in the MOF attachment would go through a tube which is connected to the bottle. This technique was rejected because it is inconvenient to have two parts and would not be one device. One part can be lost, or the water bottle can become unsanitary because it would not have a top. Another alternative idea for this project would be similar to the chosen future technology feature, except the device would produce water in a larger scale. The device would be larger, somewhat like a jug, and therefore, would have larger amounts of MOFs in the attachment. This idea was rejected because if the device was too big, there are possibilities it cannot be filled all the way overnight due to its size. Also, a bigger jug can become heavy to carry around, contradicting the purpose of the water bottle's individual use. As a result, the future technology feature of having the MOF attachment positioned at the top of the bottle is better than these alternative ideas because the attachment

is on the top where water can drip down and get collected. In addition, the size of the water bottle is manageable for an individual's use unlike a large jug.


Solar energy panel
Metal-organic framework (MOFs)
Air way
Condenser
Produced water
Drinking straw
Water bottle
16 fluid ounces
12 inches tall
Produced water

Consequences

The Self-filling Water Bottle has many advantages, but considering that it is an intricate and complex system, it has disadvantages as well. The potential positive effect that the invention will bring will be life changing. People will have better access to filtered water. For example, the Flint Water Crisis. Although it is safe to drink the water there now, it was dangerous to even bathe in the water before because of the lead that seeped into the state's water supply (Kennedy, 2016). If something were to happen again like what happened in Flint, the state would be prepared because of this invention. Not only is the invention helpful in a situation like Flint's, it could also be used in places where water is hard to reach, for example, South Africa (Leahy, 2018) and the Dominican Republic (Ostalkiewicz, 2017). The potential negative effect that the invention may bring would be if it were to malfunction, due to a defective water bottle where the technology may be the problem because of its complex design, for example, the cause of it malfunctioning could possibly come from the MOF breaking by accidentally being dropped on the floor with great force. No harm will come from the defective water bottle, but it will not be able to function. If the invention were to malfunction in times where people needed it most, the consequences would be catastrophic. People depend on inventions like the Self-filling Water Bottle to help fulfill their needs and if it is not working, then millions of people would be let down and without water, especially if there was no other way or plan to collect water.

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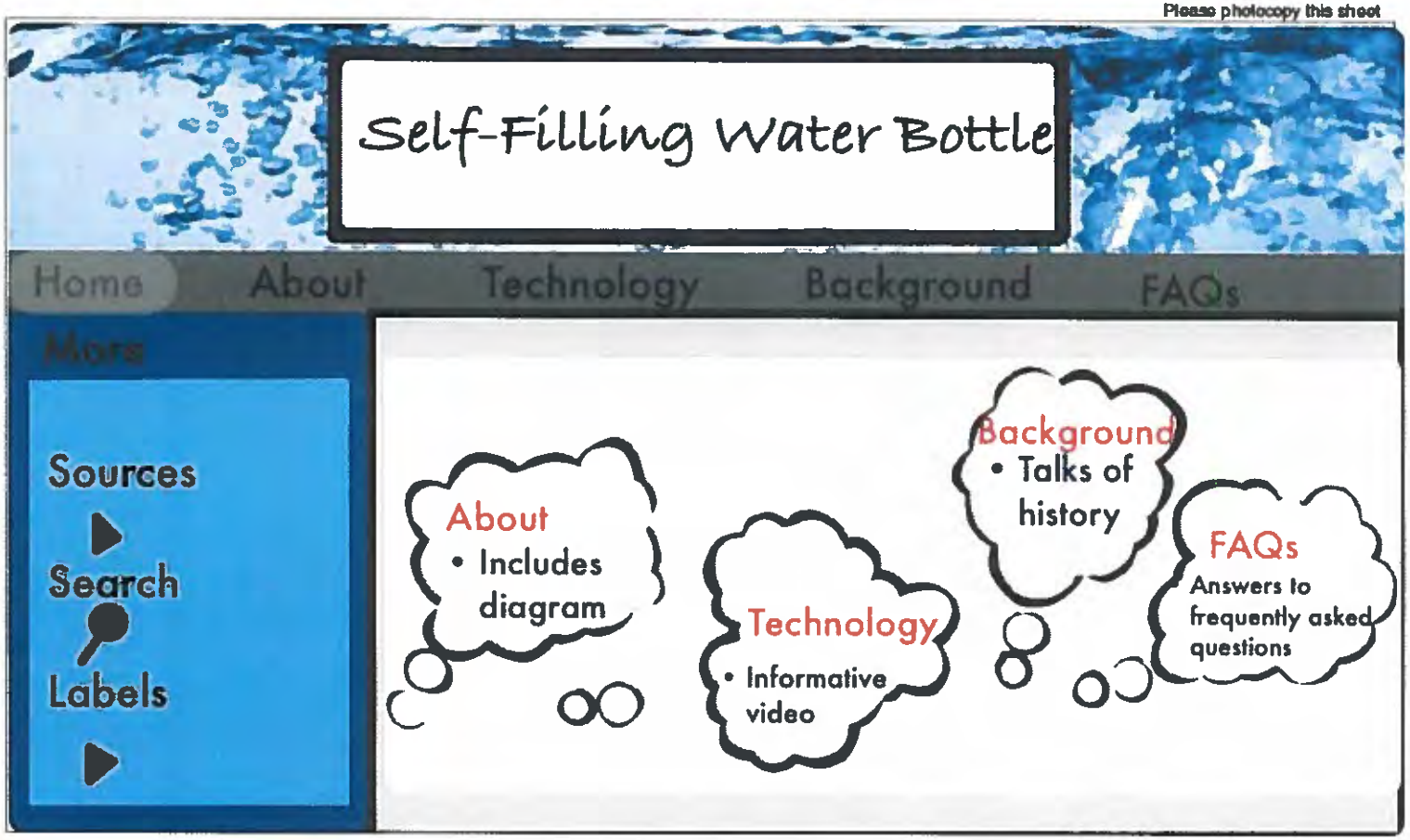

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TOSHIBA/NSTA EXPLORAVISION SAMPLE WEB PAGE FORM

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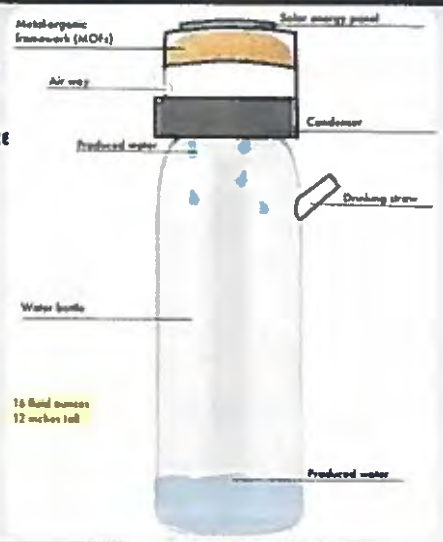
Labels

- The Self-Filling Water Bottle uses MOF technology to produce water.
- This current technology was developed and is being modified by MIT scholars.



- Diagram on the process of water production.
- The MOFs are powered either by air or solar energy to vaporize air. This air is then condensed and the produced water is collected in the bottle.

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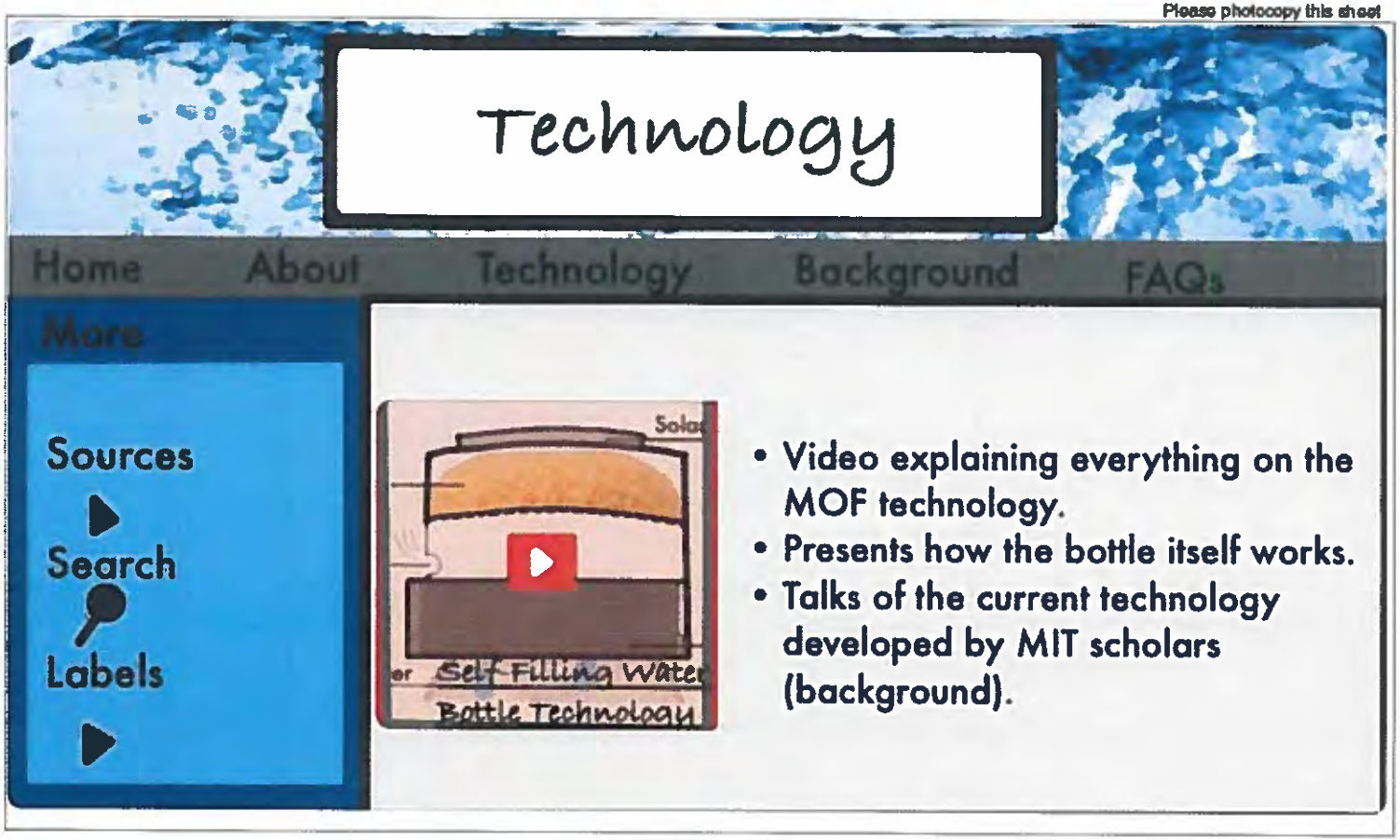

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By clicking the red play button, a video describing the technology behind the self-filling water bottle will be seen. In the "more" sidebar, search, sources, and labels tabs are provided. By clicking on the search tab, key words can help find a page. In the sources tab, further information can be found about the source. Clicking on the labels tab will direct to provided labels. By clicking on any of the tabs labeled Home, About, Technology, Background, or FAQs, you will be directed to the page selected.

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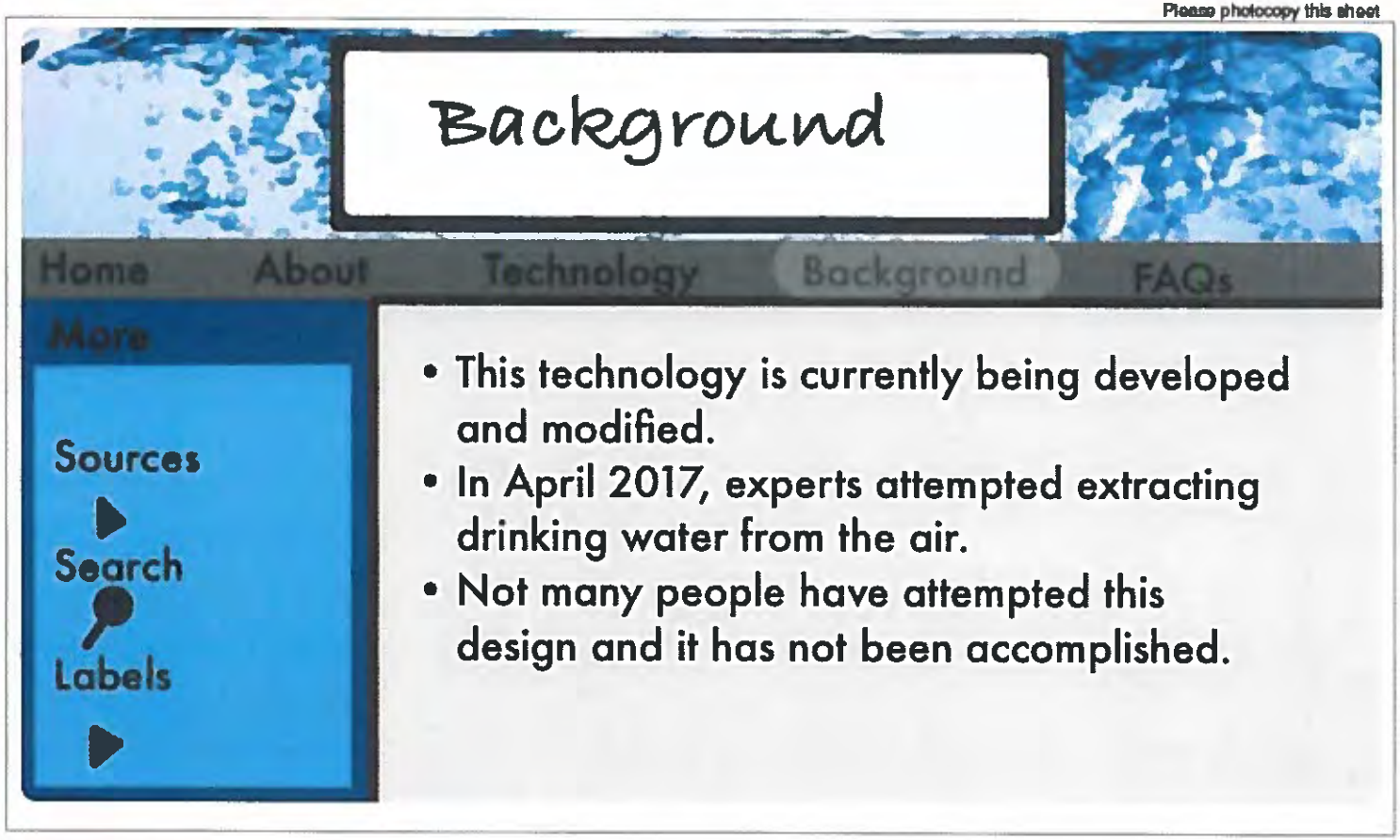

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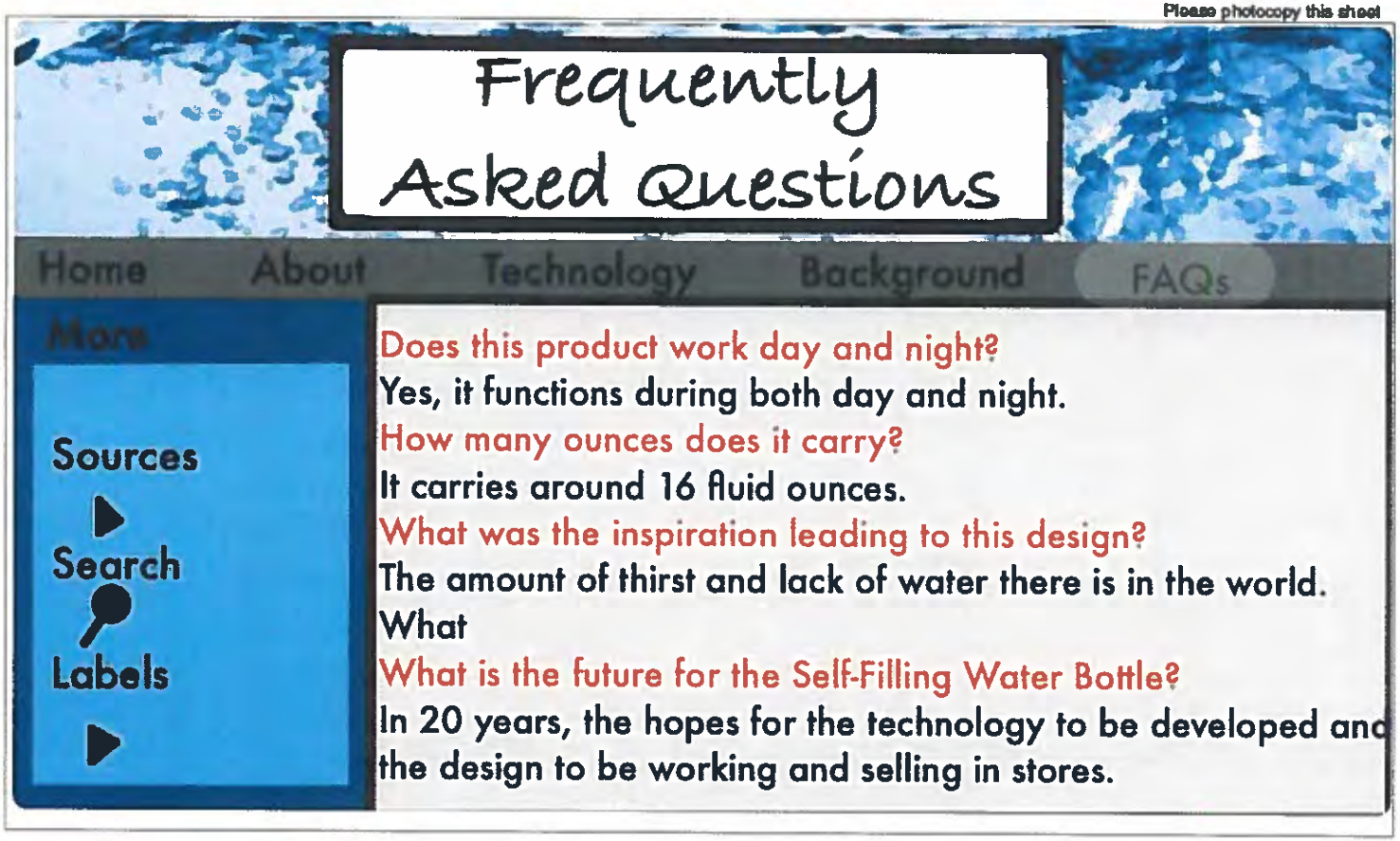

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