



# VERTICAL FARMING:

**A**BOUT 33 METERS (108 FEET) UNDER the busy streets of Clapham in southwest London, United Kingdom, lies one of the most unexpected places for a farm. Instead of growing crops in open fields, a British company, called Growing Underground, is using abandoned World War II bomb shelters to grow herbs and micro-greens with only nutrient-rich water and artificial-light sources.

This seemingly odd way of growing fruits and vegetables could mean that food will not need to be refrigerated and transported long distances and farmers can reduce their use of chemical fertilizers and pesticides. Food grown in Clapham's underground farm is kept at stable temperatures and is available year-round. As this food is grown for the surrounding community, it can be picked, packed, and delivered to a store or a market within 2 to 8 hours; there is no need to ship and store produce for weeks to get it to its final destination. Is this the future of farming?

DOES  
IT  
STACK  
UP?



By David Latchman

## Vertical farming

The Clapham project is an example of a vertical farm. In these types of farms, food is grown indoors, usually in buildings or skyscrapers, in vertically stacked layers. As crops are stacked on top of each other, the productivity of a farmed surface is increased by a factor of four to six.

Instead of using irrigation to grow crops in open fields, plants are grown hydroponically in greenhouse skyscrapers that are located in urban areas. Hydroponics is the process of growing plants without soil by using nutrient-rich solutions to feed the plants. It uses 70% less water than open-field agriculture.

Plants can also be grown through a process called aeroponics, in which the plants' roots are suspended in the air, and nutrients are sprayed directly to the root structures in a fine mist. This process uses 70% less water than hydroponics, saving even more water.



An underground farm under the busy streets of London uses abandoned World War II tunnels to grow a variety of vegetables, such as watercress, radish, garlic chives, and coriander.

Growing indoors can also protect crops from the effects of climate change, such as increased global temperatures and drought, which can reduce crop yields in some areas. When crops are grown indoors, the controlled internal environment protects plants from these effects.

## Challenges

If vertical farming is so great, why isn't everyone adopting it? Vertical farming has its challenges. Open-field agriculture relies entirely on energy from the sun, so, when it is available, this source of energy is free. Crops grown indoors receive their energy from artificial light sources, which rely on electricity.

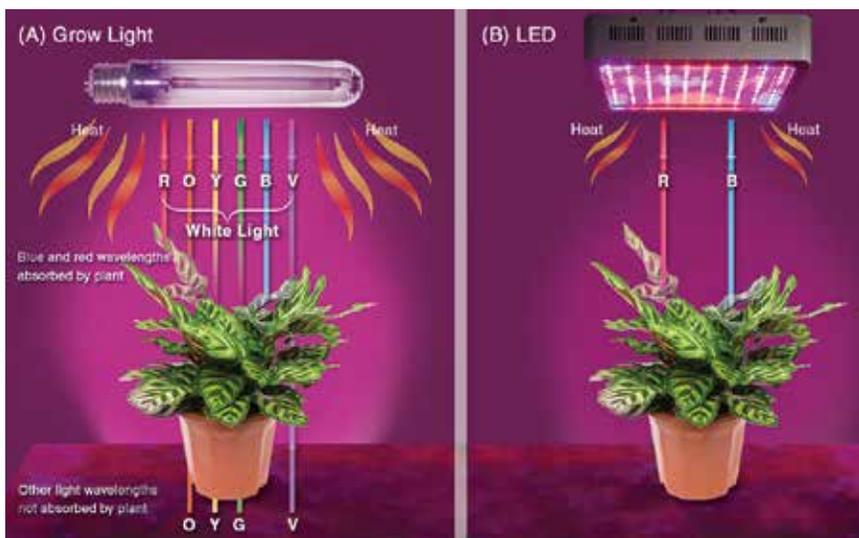
Another issue is that the artificial light sources, called grow lamps, emit heat, which can damage plants if they are placed too close to the plants. So the plants need to be spread out, and the indoor space needs to be cooled to compensate for the added heat from the lamps.

To address this particular challenge, vertical farmers are increasingly using another type of lamp, called a light-emitting diode (LED), which is a light source that is compact, energy-efficient, and can be designed to emit a particular wavelength (unlike a grow lamp, which emits light from the entire visible spectrum).

Plants do not use the entire spectrum of light. Research has shown that plants mainly absorb only portions of the light spectrum. Chlorophyll—a pigment that gives plants their green color—absorbs peak wavelengths around 450 nanometers and 650 nanometers (blue and red color, respectively) (Fig. 1). LEDs can be designed to emit only these wavelengths, so giving plants only the light they need—red and blue light—saves energy.

LEDs are also less costly than grow lamps and produce little to no heat and can be placed next to a leaf, which allows crops to be closely stacked on top of each other.

Another challenge of underground farming is cost, which can be high—city land is expensive and LED lights are expensive, too. Current estimates for the price of food grown underground are on the order of



**Figure 1.** (A) A traditional grow light, which is used to grow crops underground, emits light from the entire visible spectrum, even though many crops absorb only portions of the visible spectrum. A green plant—such as the one shown here—typically absorbs wavelengths that are only in the blue and red regions of the visible spectrum. Also, grow lights emit a lot of heat. (B) A light-emitting diode (LED) lamp saves energy because it generates only the wavelengths of light the crops actually absorb, and it emits less heat than grow lamps.



Vegetables that are grown underground do not need soil and sunlight. Instead, the vegetables shown here grow in solutions that contain water and nutrients and rely on artificial lamps for lighting.

\$5 per kilogram (\$2.50 per pound), which is reasonable for fruits and vegetables but is not practical for bulk crops, such as grains, corn, and soybeans.

## Controlling plants with light

Light can also influence how a plant grows. According to Kevin Folta, a scientist who studies the effects of light color on plant growth at the University of Florida, Gainesville, **the light spectrum emitted by LEDs can be tuned by varying the amount of red, infrared, and blue light in order to optimize the growing conditions of specific plants.**

Also, a specific combination of light colors tells a plant how to grow in a specific way. For example, a large amount of red light causes a plant to flower, and a predominantly blue light causes a plant to grow.

Plants convert the energy from light—whether from the sun or from LEDs—into chemical energy, a process called photosynthesis. This process uses water and carbon dioxide from the air to produce carbohydrate molecules, such as sugars, which are used by the plants to grow. Photosynthesis can be summarized by the following chemical reaction:



Growing plants underground with LEDs can be applied in many parts of the world, including urban areas, which reduces the demand for arable land. This explains why the abandoned World War II shelters under the city of London are being used to grow crops and why similar projects are being built in South Korea, Singapore, and Sweden.

Agriculture has a huge influence in our lives because everyone needs to eat. As the global population grows, so does our need to produce enough food to meet everyone's needs. But more land will be required to grow the crops needed to feed more people, which places an increasing demand on the limited arable land available on Earth. One way to solve this problem is to produce food sustainably, and vertical farming might be part of the solution. 

### SELECTED REFERENCES

- Hickey, S. The Innovators: London Air-Raid Shelters Sprout a Growing Concern. *The Guardian*, Sept 13, 2015: <http://www.theguardian.com/business/2015/sep/13/the-innovators-london-air-raid-shelters-sprout-a-growing-concern> [accessed July 2016].
- Spence, C. Plant Whisperer. University of Florida, Office of Research. Explore, Dec 14, 2014: <http://explore.research.ufl.edu/plant-whisperer.html> [accessed July 2016].

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