

**Title:** 3D Printing: Bioinspired Technology

**Topics:** biological systems engineering, structure/architecture, computer modeling, beehive construction, emergence, medicine

**Related Disciplines:** biological systems engineering, architecture, computer science

**Objectives:**

- A. Students will understand the basic process of 3D printing.
- B. Students will understand where 3D printing is found in nature.
- C. Students will understand the materials used for 3D printing.
- D. Students will look at potential applications of 3D printing across disciplines.
- E. Students will make their own “3D printed” structure.

**Lesson:**

#### A. Introduction (20 minutes)

Nature is full of 3D printers. For example, bees construct hives, termites build castles, and spiders spin their own webs. In each of these examples, the organism makes its own material to be used throughout this process. 3D printers work in a similar manner using a filament. The filament enters the extruder in the printer, which heats it a little to melt it and then pushes it out the other end, layer by layer, to build an object. You might wonder how it knows what to build. 3D printers read files like a regular printer, except those files come from 3D modeling software instead of something like Microsoft Word. This modeling file tells the printer exactly how to lay down the filament and build the object. The filament is generally made of plastic, but it can also be made of metals or other resins. These other materials also come with slightly different printing techniques, such as using a laser to melt a powder or an electron beam to polymerize a liquid. (Looking at these different techniques and materials is a great thing for students to do in a follow-up assignment).

While 3D printing is a relatively new technique, it’s quickly expanding into many fields and uses. 3D printers are becoming increasingly affordable, and researchers are trying to use 3D printing to make organs for transplant. Artists are using 3D printing to create sculptures, construction companies are using this technology to create 3D models of homes and buildings before they begin construction, and items such as shoes and furniture are also being made.

#### B. Class Project (60 minutes)

*Here are step-by-step instructions on how to build a model of a 3D printed structure. These instructions do not need to be read aloud to the class. They can be summarized verbally or printed for groups of older students to read and follow in small groups.*

**Materials:** Wax strips, wax paper

**Steps:**

1. Each student should get one sheet of wax paper to build their project on as well as a handful of wax sticks.
2. Students should choose what they want to build; it can be a model, pattern, whatever they can think of and have resources for. It's a good idea to have students sketch their idea first and get it approved before they start building. That way the instructor can review it for potential structural issues.
3. Once the design is approved, students can begin construction. Form one wax stick in the shape of the base of the design, and layer wax sticks on top of that. Press the wax sticks together to make them stick. Continue doing this until the design is built. This technique is very similar to how certain types of 3D printers actually print. Note that you could also have the students build something large (like a house or some other structure) in teams.
4. These models should stay together on their own (although they are fragile), but for a more permanent state you can lightly melt the wax between each layer (using a fire wand, for example). Please do not let students play with fire; only adults should melt wax layers.

**C. Discussion (10 minutes)**

To conclude the activity, it's a good idea to have a class discussion. Ask the students what some challenges were to constructing things in this way; mention that sometimes, structural supports are needed during the building process and can later be removed. Talk about what this means in terms of nature's 3D builders and the challenges they must overcome as well as some barriers for 3D printing things such as organs, homes, and cars.

**Homework:**

1. Find examples of 3D printing in nature. What animals use this method? What structures do they make and what function(s) do they serve?
2. Pick one application of 3D printing and describe it in detail. Include the method, materials, time it would take to print, and a description of how the final product will be used.
3. Describe how 3D printing works. Talk about different methods and describe the materials used for each strategy.
4. Pretend you are a creature that lives in the rainforest. You have the ability to build structures. What would you build and why? What materials would you use? Would you be capable of building it yourself or would you need other members of your species to help?