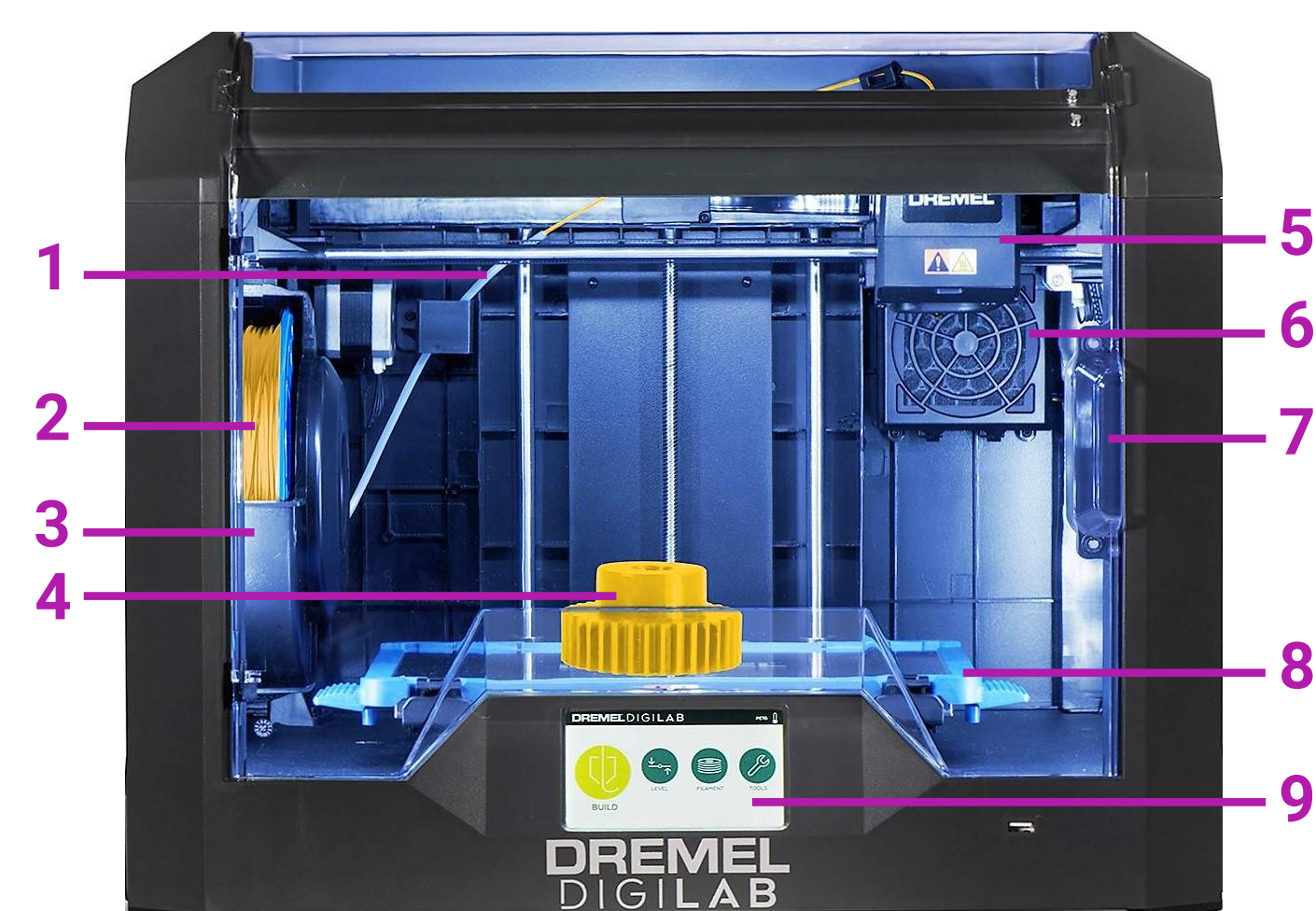
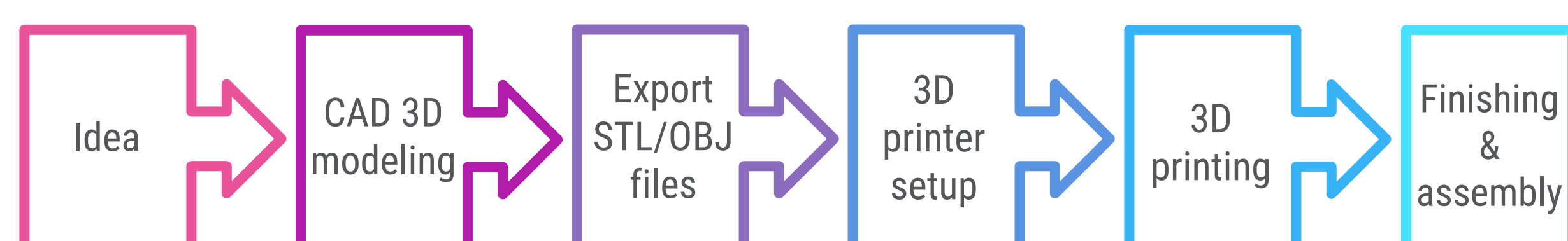


Introduction

- 3D printers use fused filament fabrication to create physical objects from digital 3D models by extruding thin layers of molten thermoplastic filament to build up a solid structure.
- Over the last 10 years, 3D printing has become popular due to its small footprint, low cost, and flexibility.
- At Bode, 3D printing is used for in-house rapid prototyping, development, and production of single-use and reusable lab supplies.

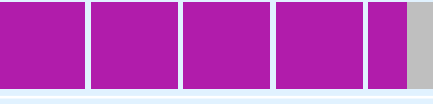
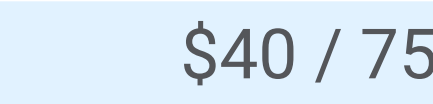
How It Works



- Filament Guide Tube
- Filament Spool
- Filament Spool Holder
- 3D-Printed Object
- Extruder
- Chamber Fan
- Door
- Build Platform
- Touch Screen

Getting Started

- Select the computer-aided design (CAD) software, 3D printer, and thermoplastic filament that best suit your needs and budget.
- Bode's first 3D printer was an UP! Plus 2 purchased in 2014. It was replaced with a Dremel® 3D45 in 2018.
- Thermoplastic filament types include PLA, ABS, PETG, nylon, etc.
 - Varying levels of volatile organic compounds and ultrafine particles are emitted during 3D printing, depending on the filament type.^{1,2}
 - Enclosures & ventilation will minimize exposure to emissions.

Item Needed	Bode's Choice	Selection Criteria	Specifications
CAD software	Autodesk Tinkercad®	Price	Free
		Features	Basic
		Application type	Web
3D printer	Dremel 3D45	Price	~\$2,000
		Dimensions	20.25" x 15.9" x 16"
		Build volume	10" x 6.7" x 6"
		Enclosure	Built in
Filament	Dremel Eco-ABS (modified PLA)	Printability	 9/10
		Strength	 65 MPa
		Stiffness	 7.5/10
		Durability	 4/10
		Price	\$40 / 750 g
		Emissions	Low

Challenge

- New automated DNA purification SOP used spin baskets in 96-well deep well plates for lysis & spins
- Spin basket caps needed for minimizing cross-contamination
- Commercial caps did not meet our needs
 - Overdesigned
 - \$1.25 each



Challenge

- Spin collars raise the 96-well spin baskets after lysis & allow lysate to be spun out of the substrate and collected
- Commercial 96-well spin basket adapters were discontinued
 - Reusable up to 5 times
 - \$10 each



Challenge

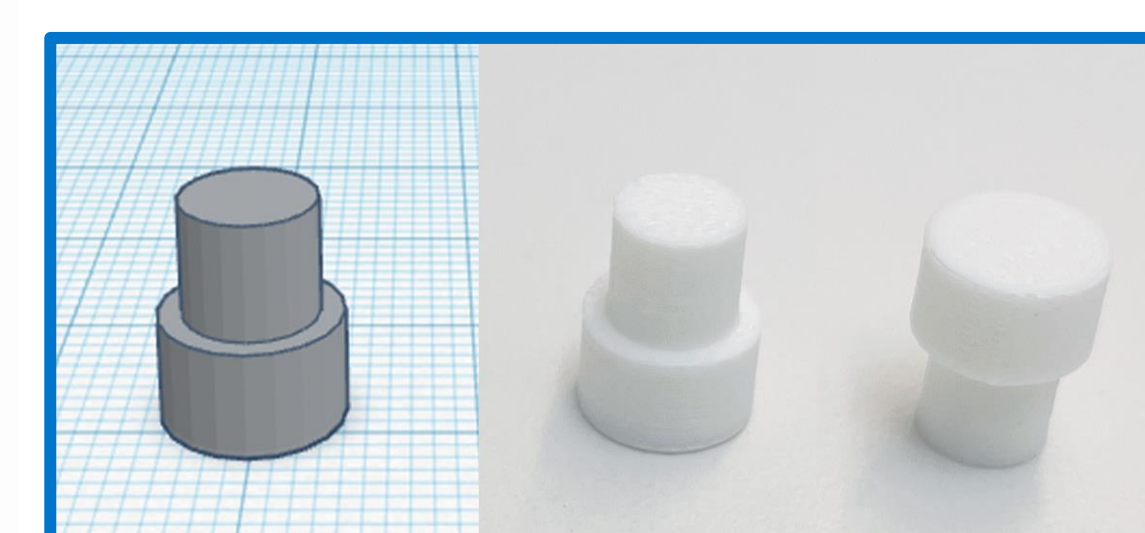
- DNA extracts are stored in 96-well plates sealed with adhesive seals
 - Can introduce cross-contamination if peeled
- Pierce plates puncture seals & minimize contamination
- Commercial pierce plate puncture openings were insufficient
 - \$300–600 each



Solution

- Spin baskets measured; 3D cap model designed & printed; fit test performed
 - 3D model adjusted based on fit tests
- Cleaning procedure validated
- Disposable

Batch Size	Materials Cost	Print Time
104	\$2.54	5.5 h
1	\$0.03	3 min



Solution

- Spin plate and basket holder measured; 3D spin adapter model designed & printed
- Reusable indefinitely

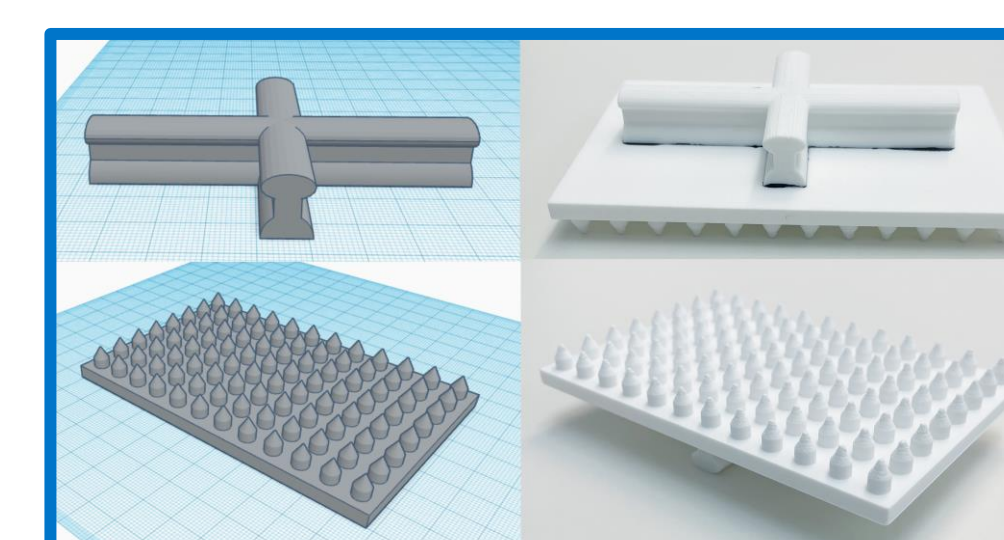
Batch Size	Materials Cost	Print Time
2	\$2.30	11.3 h
1	\$1.15	5.6 h



Solution

- 96-well storage plate measured; 3D pierce plate model designed & printed
- 3D handle model designed, printed, and affixed separately
- Cleaning procedure validated
- Reusable for ≥ 6 months

Batch Size	Materials Cost	Print Time
6	\$11.29	45.9 h
1	\$1.88	7.7 h



Training

- CAD: online courses & training modules available
- 3D printer maintenance
 - Filament changes
 - Calibration
- 3D printer operation
 - Starting run: leveling bed, preheating, loading a print file
 - Unloading: removing print from build platform, cleaning
- Finishing/assembly/cleaning
 - Remove excess plastic (e.g., scaffolding, brims)
 - Assemble pierce plate handles
 - Bleach, ethanol, UV decontamination

Advantages

- Allows for self-sufficient production of custom parts and consumables
- Easy to adjust 3D models as other consumables or lab processes change
- Easy to improve 3D models based on user feedback
- Relatively low start-up costs
- Inexpensive materials costs
- Excellent tool for developing prototypes for other types of production (e.g., injection molding)

Disadvantages

- 3D printer settings may require adjustment during development to accommodate:
 - Varying environmental conditions (e.g., temperature and humidity)
 - Filament variations (e.g., type, brand, etc.)
- Failed prints may be unrecoverable resulting in lost time and materials
- Labor intensive compared to purchasing ready-made products
- Supply chain issues may affect filament availability

Conclusions

- 3D printing reduces costs and addresses operational challenges that cannot be resolved with commercial products.
- 3D-printing is useful for development & prototyping of custom items.
- Software & hardware are easy to learn & use; minimal training is required.

References

- Azimi P, Zhao D, Pouzet C, Crain NE, Stephens B. Emissions of Ultrafine Particles and Volatile Organic Compounds from Commercially Available Desktop Three-Dimensional Printers with Multiple Filaments. Environ Sci Technol. 2016;50(3):1260-8.
- Steinle P. Characterization of emissions from a desktop 3D printer and indoor air measurements in office settings. J Occup Environ Hyg. 2016;13(2):121-32.

