3D Bioprinting

Standard Operating Procedure

Issue Date: 3/30/22

# Description [Provide additional information as it pertains to your research protocol]

Three-dimensional (3D) printing is the design of a 3D object using various additives and manufacturing

approaches in a layer-by-layer pattern. An emerging area of research involves the use of 3D printers for

the creation of tissue-like structures that imitate natural tissues, referred to as 3D bioprinting. 3D

bioprinting uses biomaterials such as living cells to fabricate 3D tissue structures such as skin, cartilage,

tendons, muscle and bone (Munaz, 2016).

The main areas of focus in the field of bioprinting are biomimicry, self-assembly, and mini tissues.

Biomimicry aims to completely mimic a biological system, such as creating whole organs. Self-assembly

is a term used to describe cells grown in specific environments to create mini simplified organs. Lastly,

mini tissues, also called organs-on-a-chip, uses microfluidics technology to study how fluids move

through small spaces. These mini cell culture systems have great use in understanding the fundamental

biology of events.

Bioprinting involves the use of two materials. First is a biomaterial or a non-living scaffold. Second is

bioink, the living part of the structure. A biomaterial can be any material designed to interact with a

living system. Bioink is generally a living cell slurry (Haage, 2018). The key steps in bioprinting are; 3D

imaging to create a digital model, create a layer-by-layer instruction blueprint using a computer

program, preparation of bioink, printing (depositing the bioink), and solidification in which the liquid

layers solidify to hold its shape (Mashambanhaka, 2018).

For the use of 3D printers in a lab space that do not utilize biological materials, please refer to the EHS Makerspace Guideline at the following link: [EHS Makerspace Guideline](https://ehs.umich.edu/wp-content/uploads/2018/09/MakerspaceGuideline.pdf).

# Potential Hazards [Provide additional information as it pertains to your research protocol]

Potential hazards from 3D Bioprinting include, but are not limited to:

* Mucous membrane exposure to bloodborne pathogens while prepping human-derived bioink or cleaning printer
* Inhalation of bloodborne pathogens through aerosolized human-derived or other potentially infectious materials during the printing process or deposition of bioink
* Inhalation of respirable particulate or volatile organic compounds (VOCs) while printing scaffold

# Occupational Exposure Limits (OELs):

No specific OELs are applicable for this activity. OELs may apply if certain materials are used for the printing of scaffold, please consult with EHS prior to selecting materials used to develop scaffold.

# Engineering Controls [Provide additional information as it pertains to your research protocol]

If bioink is not made of human-derived materials and bloodborne pathogens are not one of the hazards posed by the process, then no additional engineering controls are necessary. However, EHS still recommends an enclosure for 3D printers to reduce the amount of respirable and ultrafine particulate generated in the space.

If bioink is made of human-derived materials, bioink would be considered biohazardous. 3D printers used with biologically hazardous materials would need to be assembled within a Biological Safety Cabinet. If a new Biological Safety Cabinet is to be purchased for use with a 3D bioprinter, contact EHS’ Technical Services and Solutions group for recommendations, special considerations, and for initial certification. If an existing Biological Safety Cabinet is to be used, EHS’ Technical Services and Solutions group would need to recertify it with the 3D bioprinter inside.

# Work Practice Controls [Provide additional information as it pertains to your research protocol]

For work conducted with biological materials, or human-derived material bioinks, refer to measures to prevent exposure to bloodborne pathogens in the [University of Michigan Bloodborne Pathogens Exposure Control Plan](https://ehs.umich.edu/wp-content/uploads/2016/02/ECP.pdf). The Exposure Control Plan must be followed whenever laboratory staff are handling, preparing, or using bioink consisting of human-derived materials, as well as anytime laboratory staff are conducting cleaning or maintenance on a 3D printer used for bioprinting materials with human-derived bioinks.

Laboratory staff working with human-derived bioinks must:

* Read the laboratory’s biosafety manual
* Complete training consistent with the biological hazards they are working with
* Complete the Bloodborne Pathogen Training Course through MyLinc
* Set up, use, maintain, and clean 3D bioprinting equipment in a manner consistent with manufacturer guidance

Laboratories performing 3D bioprinting should also complete a risk assessment, write a detailed and lab-specific standard operating procedure, and provide lab-specific training on use and maintenance of 3D bioprinting equipment and materials. Laboratories using biological materials must also register their work with the Institutional Biosafety Committee (IBC). The IBC application is initiated through eResearch.

# Personal Protective Equipment [Provide additional information as it pertains to your research protocol]

Personal Protective Equipment must be worn in a manner consistent with the University of Michigan Bloodborne Pathogens Exposure Control Plan. This includes, but is not limited to:

* Use of a lab coat at all times when working in the laboratory
* Use of clothing that covers the skin (i.e. no shorts, skirts, open toe shoes, etc.)
* Use of safety glasses at all times when working in the laboratory
* Use of goggles when working with materials that have the potential to splash
* Use of non-latex gloves when handling biological materials

# Transportation and Storage [Provide additional information as it pertains to your research protocol]

Human-derived bioinks and materials that pose the hazard of exposure to bloodborne pathogens must be appropriately labeled and stored in leak-tight containers as consistent with the University of Michigan Bloodborne Pathogens Exposure Control Plan. Transportation of bioink or other biologically hazardous materials must be done within a closed secondary container in addition to the closed leak-tight primary container.

Materials that do not pose the hazard of exposure to bloodborne pathogens, but are otherwise hazardous must be properly labeled with a manufacturer’s label or GHS-compliant label and stored in a container consistent with the manufacturer’s recommendations as listed on the Safety Data Sheet.

# Waste Disposal [Provide additional information as it pertains to your research protocol]

Because most spent, unused, and expired chemicals/materials are considered hazardous wastes, they must be properly disposed of.  **Do not dispose of chemical wastes by dumping them down a sink, flushing in a toilet or discarding in regular trash containers, unless authorized by Environment, Health & Safety (EHS) Hazardous Materials Management (HMM)**. Refer to the EHS [Hazardous Waste](http://ehs.umich.edu/haz-waste/) Web page for more information. Contact EHS-HMM at (734) 763-4568 for waste containers, labels, manifests, waste collection and for any questions regarding proper waste disposal.

For biohazardous materials, clean/disinfect equipment and containers that came into contact with the biohazardous materials using an appropriate surface disinfectant (i.e. 70% ethanol or a Microcide™). Additional information for handling biological waste, and preparing containers for disposal may be found at the following website: [EHS Biological Waste](https://ehs.umich.edu/haz-waste/biological-waste/).

# Exposures/Unintended Contact [Provide additional information as it pertains to your research protocol]

If the employee is in need of emergency medical attention, call 911 immediately.

For a chemical exposure/injury:

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| injury type | action | notes |
| Exposure-Eyes | 1. Flush with water for at least 15 minutes
2. Seek medical attention.
 | Removal of contact lenses after an eye injury should only be undertaken by skilled personnel. |
| Exposure-Skin | 1. Flush with water for at least 15 minutes.
2. Remove contaminated clothing.
3. Seek medical attention.
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| Inhalation (including from spills outside the fume hood) | 1. Remove patient from the contaminated area.
2. Encourage patient to blow nose to ensure clear breathing passages.
3. Ask patient to rinse mouth with water but to not drink the water.
4. Seek medical attention.
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| Ingestion | 1. If swallowed, refer for medical attention, where possible, immediately.
 | Urgent hospital treatment is likely to be needed. |
| **NOTE**: If an ambulance is needed, call the University of Michigan Division of Public Safety and Security (DPSS) at 911 to request assistance. |

Contact EHS for advice on symptoms of chemical exposure, or assistance in performing an exposure assessment.

Report all work related accidents, injuries, illnesses or exposures to Work Connections within 24 hours by completing and submitting the [Illness and Injury Report Form](http://www.workconnections.umich.edu/employees/work-related-illness-injury/step-one/). Follow the directions on the Work Connections website [Where to go for treatment](http://www.workconnections.umich.edu/treatment.html) to obtain proper medical treatment and follow-up.

Complete the [Incident and Near-Miss Report](http://ehs.umich.edu/forms/reporting-injuries-and-incidents/) form.

## Treatment Facilities

**U-M Occupational Health Services -- Campus Employees**Mon-Fri 7:30 am - 4:30 pm
After hours - go to U-M Hospital Emergency Dept. -- Urgent Care Clinic
380 Med Inn building
1500 East Medical Center Drive, Ann Arbor (734) 764-8021

**University Health Services -- University students (non-life threatening conditions)**
Mon-Fri 8 am - 4:30 pm, Sat 9 am - 12 pm
Contact for current hours, as they may vary
207 Fletcher Street, Ann Arbor (734) 764 - 8320

**UMHS Emergency Department -- after clinic hours or on weekends**
1500 East Medical Center Drive, Ann Arbor (734) 936-6666

# Spill Procedure [Provide additional information as it pertains to your research protocol]

Spills and accidents should be immediately reported to the Principal Investigator (PI) and EHS (734) 647-1143. EHS may be contacted for assistance with biohazardous material spills.

### Spill in the Laboratory

* To prevent lab staff from potential aerosol exposure, leave the room immediately, lock the door, post a warning sign and inform your supervisor. Wait at least 30 minutes before reentering the lab to allow dissipation of aerosol created by the spill. During this time, review clean-up procedures, assemble decontamination materials and PPE.
* Don PPE; lab coat, gloves, and safety glasses.
* Remove sharp objects using a mechanical means and place into a sharps container.
* Carefully cover spilled material with a paper towel. After the paper towel is in place, wet with an appropriate disinfectant.
* Allow 15-20 minutes of contact time.
* Transfer all contaminated materials (paper towels, gloves, labware, etc.) into biohazard waste containers for disposal.
* Wipe surrounding surfaces with disinfectant to cover all splash areas.
* Place all remaining contaminated materials, including protective clothing, into an autoclave bag or biohazard waste container.
* Wash hands with soap and water.
* If a personnel exposure occurred, see information below and complete an Illness or Injury Report form.

### Spill in the Biosafety Cabinet

NOTE: Leave the cabinet turned on.

* Don double gloves, a lab coat, and eye protection if not already wearing them.
* Carefully cover spilled material with a paper towel. After the paper towel is in place, wet with an appropriate disinfectant. Let stand 15-20 minutes, wipe up and wash surface with appropriate disinfectant.
* Spray or wipe cabinet walls, other work surfaces, and equipment with the appropriate disinfectant
* If necessary, flood the work surface, drain pan, and catch basin below the work surface with disinfectant. Allow at least 15-20 minutes of contact time.
* Soak up the disinfectant and drain the catch basin into a container. Lift the front exhaust grille and tray and wipe all surfaces. Ensure that no foreign materials are blown into the area below the grille.
* If a 10% bleach solution is used on metal surfaces, rinse with water or 70% ethanol after decontamination is complete.
* If the spill overflows into the interior of the cabinet, more extensive decontamination of the cabinet may be necessary. Contact EHS (734) 763-6973 for decontamination of the cabinet.

For additional information regarding spill response procedures, refer to the EHS [Hazardous Waste Spill Response](http://ehs.umich.edu/hazardous-waste/spill-response/) Web page.

# Emergency Reporting

Report all emergencies, suspicious activity, injuries, spills, and fires to the University of Michigan Police (DPSS) by calling 911 or texting 377911. Register with the [University of Michigan Emergency Alert System](http://dpss.umich.edu/emergency-management/alert/) via Wolverine Access.

# Training of Personnel

All personnel are required to complete the **General Laboratory Safety Training** session (**BLS025w** or equivalent) vis [EHS' My LINC website](http://ehs.umich.edu/education/). Furthermore, all personnel shall read and fully adhere to this SOP when handling acrylamide.

# Certification

I have read and understand the above SOP. I agree to contact my Lab Director if I plan to modify this procedure.

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| Lab Director | Revision Date |

### Major Revisions (Tracking purposes only -- Do not print as part of SOP)

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