



Al-Mustaqbal University
College of Sciences
Intelligent Medical System Department



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Lecture: (4)

**Medical Visualization and Rendering in
Blender 3D**

Subject: Medical Multimedia

Class: Fourth

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Medical Visualization and Rendering in Blender 3D

Medical visualization in Blender 3D involves creating accurate and realistic 3D representations of anatomical structures, physiological processes, surgical procedures, and medical devices. It combines scientific accuracy with advanced rendering techniques to produce clear, educational, and visually compelling outputs.

1 What is Medical Visualization?

Medical visualization is the process of transforming medical data (CT scans, MRI, anatomical references) into detailed 3D models and animations used for:

- Medical education
- Surgical simulation
- Patient communication
- Scientific research
- Pharmaceutical presentations

Blender is widely used because it is:

- Open-source and free
 - Powerful for modeling and sculpting
 - Advanced in rendering and animation
 - Compatible with add-ons for scientific workflows
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2 Workflow for Medical Visualization in Blender

Step 1: Data Collection

- Reference anatomical atlases
- Use DICOM data from CT/MRI scans
- Import mesh data from medical segmentation software

Step 2: Modeling

- Use **Sculpt Mode** for organic anatomy (muscles, organs, tissues)
- Use **Hard Surface Modeling** for medical devices and implants
- Maintain anatomical proportions and scientific accuracy

Step 3: Texturing and Materials

- Apply realistic skin shaders
- Use subsurface scattering (SSS) for organic tissues
- Add procedural textures for veins, muscle fibers, etc.

Step 4: Lighting Setup

- Three-point lighting for educational clarity
- HDRI for realistic rendering
- Rim lighting for anatomical emphasis

Step 5: Rendering

Blender provides two main render engines:

◆ **Cycles**

- Physically accurate
- Best for realistic tissue rendering
- Supports subsurface scattering and global illumination



◆ **Eevee**

- Real-time rendering
 - Faster previews
 - Good for animations and interactive demonstrations
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3 Rendering Techniques for Medical Accuracy

✓ **Subsurface Scattering (SSS)**

Simulates light penetrating skin and tissues — essential for realism.

✓ **Depth of Field (DOF)**

Focuses attention on surgical areas or specific anatomy.

✓ **Transparent and Cross-Section Shaders**

Used to reveal internal structures (e.g., showing bones inside the body).

✓ **Volumetrics**

Used for:

- Blood flow visualization
 - Lung air simulation
 - Infection spread representation
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4 Applications in Medical Fields

- Anatomy teaching modules
 - Surgical procedure animation
 - Pathology visualization
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- Biomechanical motion studies
- Pharmaceutical product demonstrations

Medical universities and research centers increasingly use Blender for cost-effective, high-quality visualization.

5 Advantages of Using Blender in Medical Rendering

- No licensing cost
 - High customization
 - Python scripting for automation
 - Strong community support
 - Compatible with scientific plugins
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6 Example Use Cases

- Creating a realistic beating heart animation
 - Demonstrating joint movement mechanics
 - Visualizing tumor growth progression
 - Explaining surgical implant placement
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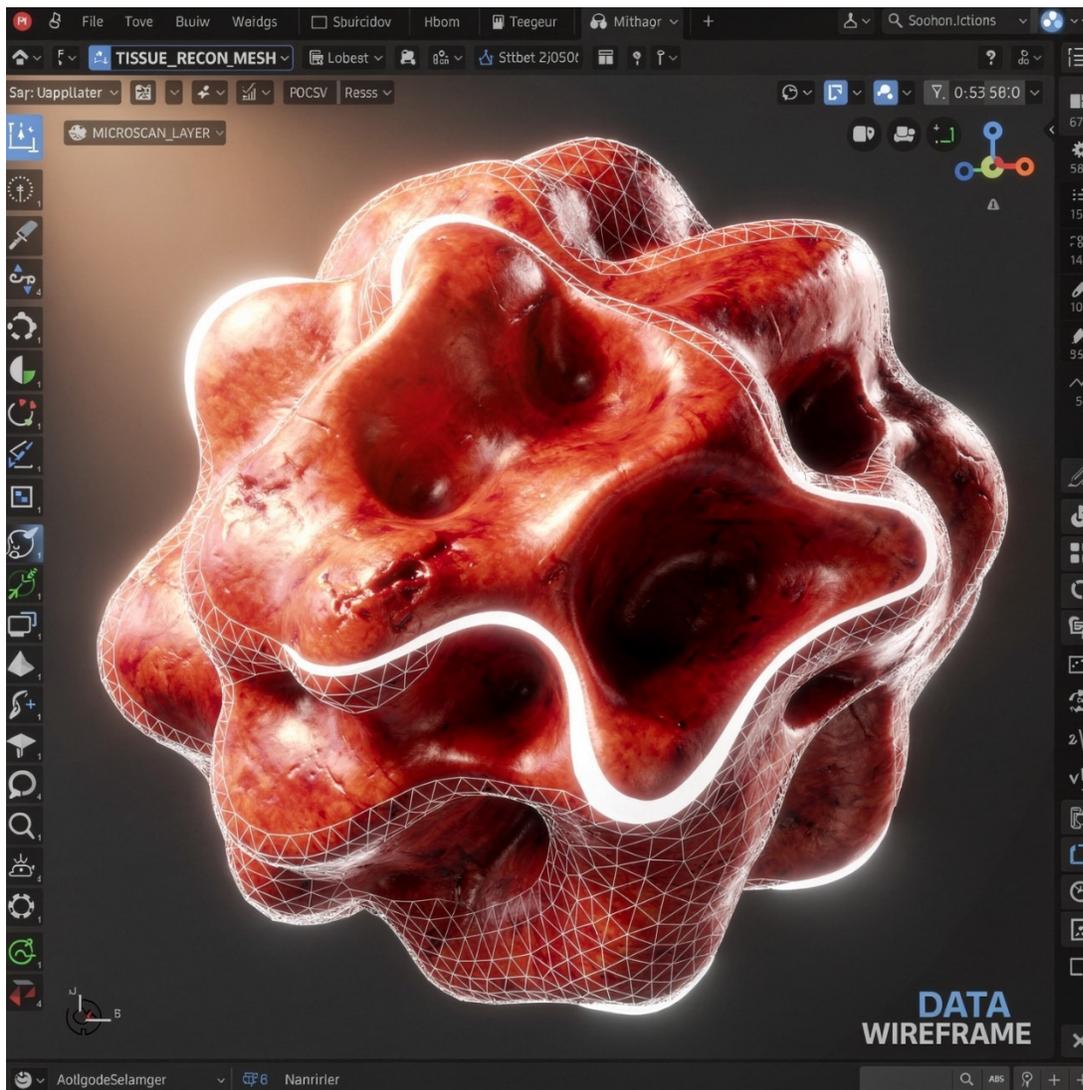
7 Best Practices for Medical Visualization

- Always verify anatomical references
- Avoid exaggerated colors unless educationally necessary
- Keep lighting neutral for clarity
- Optimize mesh topology for animation
- Render at high resolution for publications



issue Cartography: Mapping Biological Surfaces in Blender

Tissue cartography is a sophisticated technique that addresses a fundamental challenge in developmental biology and tissue analysis: how do you study processes that occur on curved, irregularly shaped biological surfaces? The answer lies in extracting these curved surfaces from volumetric microscopy data and converting them into flattened, easier-to-analyse **2D maps** — much like a cartographer projects the curved Earth onto a flat map.





Integration & Compatibility

Designed for **Blender 4.2+**, the add-on integrates seamlessly with established scientific tools including **Ilastik** for machine-learning-based segmentation and **MeshLab** for advanced mesh processing and surface reconstruction. This interoperability means researchers can build complete analysis pipelines — from raw imaging data through segmentation, surface extraction, and final visualisation using a combination of free, open-source tools. The result is an efficient, accessible workflow that enables researchers to visualise and analyse complex tissue structures without expensive proprietary software.





Surface Extraction & Mapping

The Tissue Cartography Blender add-on automates the complex process of identifying and extracting curved tissue surfaces from 3D volumetric image stacks. Once extracted, these surfaces are unwrapped into 2D projections that preserve spatial relationships, enabling quantitative analysis of cell distributions, gene expression patterns, and morphogenetic movements that would be extremely difficult to study in their native 3D context.

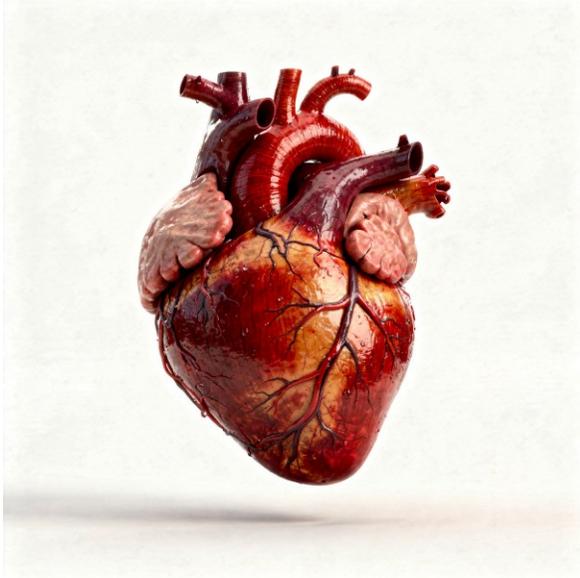
Example Use Case: Creating a Realistic Beating Heart Animation in Blender

1. Introduction

A realistic beating heart animation is one of the most valuable applications of medical visualization. It is widely used in:

- Medical education (cardiac physiology teaching)
- Surgical training simulations
- Cardiovascular research presentations
- Patient communication and awareness

This example outlines a scientifically grounded workflow for producing an anatomically accurate cardiac cycle animation using Blender.



2. Anatomical and Scientific Preparation

Before modeling begins, the following references are essential:

- Cardiac anatomy atlases
- MRI or CT-derived 3D data
- Peer-reviewed cardiovascular physiology sources

The animation should represent the **cardiac cycle**, including:

- Atrial systole
- Ventricular systole
- Diastole

Physiological timing ($\approx 60\text{--}100$ beats per minute at rest) must be respected for realism.



3. Modeling the Heart

3.1 Base Mesh Creation

Two approaches are possible:

1. Import segmented medical data (preferred for research accuracy)
2. Sculpt an anatomically accurate heart using Blender's Sculpt Mode

Key anatomical components to model:

- Left and right atria
- Left and right ventricles
- Aorta
- Pulmonary artery
- Major coronary vessels

Topology must allow deformation without distortion during contraction.

4. Rigging and Deformation

Unlike skeletal animation, the heart requires **organic deformation**.

4.1 Methods for Cardiac Motion

- Shape Keys (Morph Targets) for contraction phases
- Lattice modifiers for volume-preserving compression
- Armature with soft deformation weights
- Geometry Nodes for procedural pulsation control

Volume preservation is critical — the myocardium should contract realistically without collapsing unnaturally.



5. Simulating the Cardiac Cycle

The animation timeline can represent one full cardiac cycle:

Phase	Approximate Duration (at 75 BPM)
Atrial Systole	~0.1 s
Ventricular Systole	~0.3 s
Diastole	~0.4 s

Use the Graph Editor to create smooth sinusoidal contraction curves.

Optional additions:

- Valve opening and closing synchronization
 - Blood flow visualization using particle systems
 - Electrical impulse simulation (SA node propagation)
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6. Material and Shader Setup

Using the physically based render engine **Cycles** enhances tissue realism.

Recommended Shader Components:

- Subsurface Scattering (SSS) to simulate myocardium translucency
- Glossy component for moist surface appearance
- Slight bump or normal mapping for muscular texture

For faster previews, **Eevee** may be used during development.



7. Lighting and Rendering

Lighting Setup:

- Soft three-point lighting
- Slight rim light to define silhouette
- Neutral HDRI for subtle reflections

Rendering Specifications:

- 1920×1080 minimum (Full HD)
 - 24–30 frames per second
 - 300 DPI for still frames intended for publication
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8. Advanced Enhancements

To increase scientific value:

- Add transparent cutaway view to show ventricular contraction
 - Overlay ECG waveform synchronized with contraction
 - Display pressure-volume relationship graph
 - Include labels for anatomical clarity
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9. Educational and Clinical Applications

A realistic beating heart animation can be used for:

- Explaining heart failure mechanisms
- Demonstrating arrhythmias
- Visualizing valve replacement procedures
- Teaching cardiac physiology in medical schools



10. Challenges and Considerations

- Maintaining anatomical accuracy
- Avoiding exaggerated deformation
- Ensuring physiological timing consistency
- Validating the animation with cardiology experts

Scientific authenticity must always take priority over visual dramatization.



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