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Artificial Lung: A Biomedical Engineering Approach

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The Big Idea:

Due to the increasing demand of donor organs, biomedical engineers have found a way to address the shortage - artificial lung technology. This paper explores recent advancements in artificial lung technology and the potential and key features of implantable artificial lungs.

Key Terms and Concepts:

ECMO systems:
Extracorporeal membrane oxygenation (ECMO) systems are life-support machines that temporarily take over the work of the heart and lungs.

Biocompatibility:
Ability of a material to be in contact with the body system without any adverse effects.

Microfluidics:
The field that studies the behaviour of fluids through micro-channels, and the technology to manufacture devices that can allow the fluid to flow through them.

Biohybrid:
Material that is composed of both biological and non-biological components.

Hemocompatibility:
The tolerance of materials with blood without causing adverse effects.

Stem cells:
Unspecialised cells which can differentiate into specialised cells for specific functions.

Spatial accuracy:
How precisely something is made or arranged. In other words, how closely the shape, size, and position of parts match the real thing.

Patency:
The state of being open or unobstructed.

Organ rejection:
When the body’s own immune system is not able to recognise the foreign organ and proceed to attack the organ.

Mechanical integrity:
The process of managing the equipment so that they function correctly.

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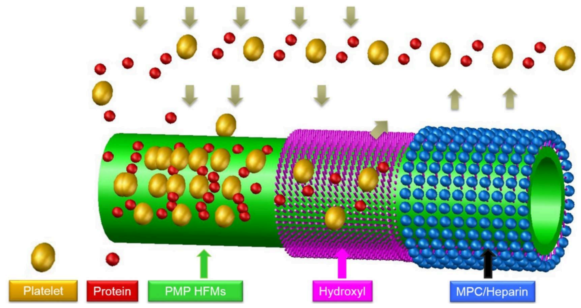
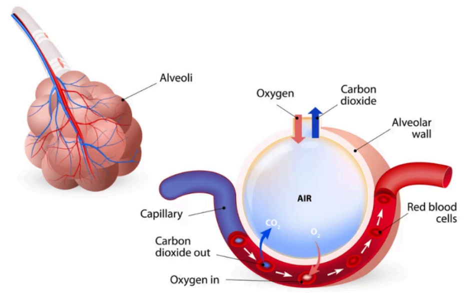
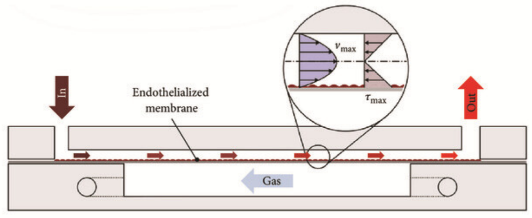
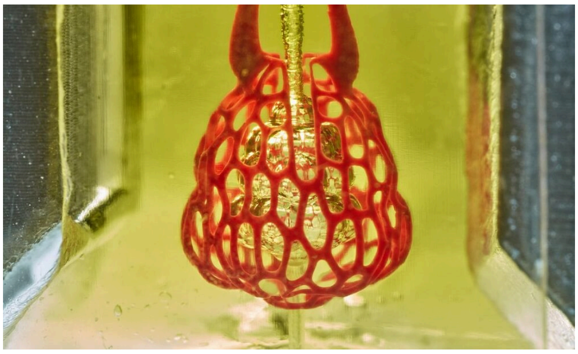
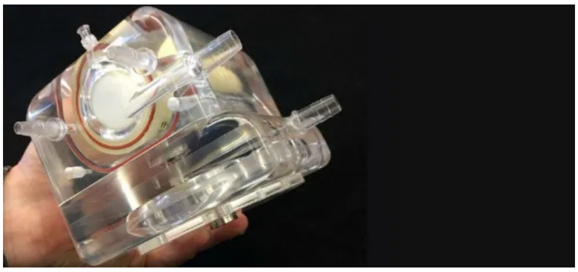
Key Findings:

- Although we have ECMO systems, they are impractical for long-term use as they are too large and non-portable. In addition, these machines are associated with high complication rates, such as bleeding and infections.
- As chronic lung diseases continue to rise, these limitations have led to the innovation of a more practical solution: the implantable artificial lung.

Key Characteristics:

	Polymethylpentene and surface-coated hollow fibres are used to line the membrane of artificial lungs. • Improves gas exchange rates • Great for biocompatibility
	Artificial lungs incorporate microfluidic designs inspired by the natural alveolar-capillary interface. • Increases surface area → more efficient gas exchange
	Artificial lungs are lined with endothelial cells (specialized cells found in blood vessels) to create biohybrid lungs • Promotes hemocompatibility and reduces inflammatory responses.

	3D printing techniques used to create lung scaffolds • Precise spatial accuracy • Helps overcome the structural complexity of human lung
	Prototypes: Paracorporeal Ambulatory Assist Lung (PAAL) • Portable • Provide effective oxygenation during preclinical trials • Potential to turn into a wearable product

- Engineering considerations:
    - Autologous cell use, anti-inflammatory coatings, immune-modulatory materials
        - Works to negate any extreme immune responses
        - Lengthens the lifespan of the technology

- Despite its promise, implantable artificial lungs encounter many challenges, like:
    - Maintenance of device patency
    - Risks of organ rejection
    - Maintenance of mechanical integrity
    - Consistent gas exchange

Future Directions:

- Miniaturization of artificial lung for full implantability
- Advanced materials engineering to increase gas exchange efficiency without risk of clotting
- Integration of sensors for monitoring purposes
- Clinical trials

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