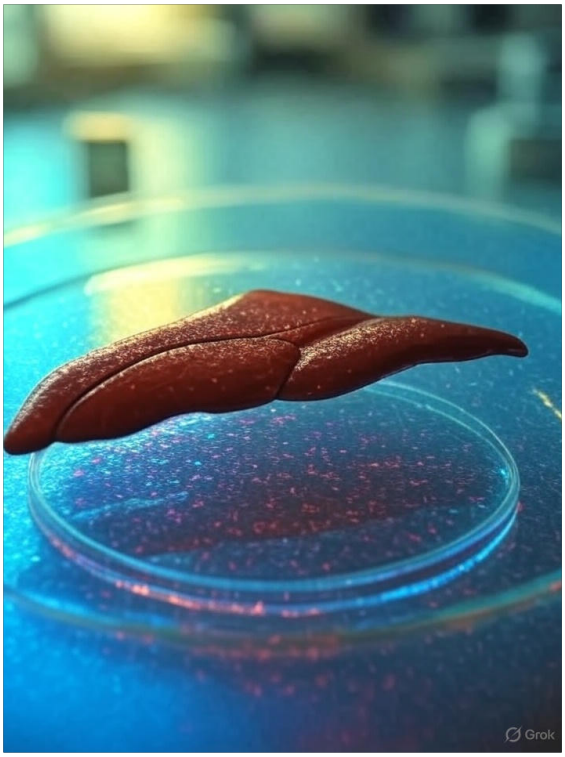
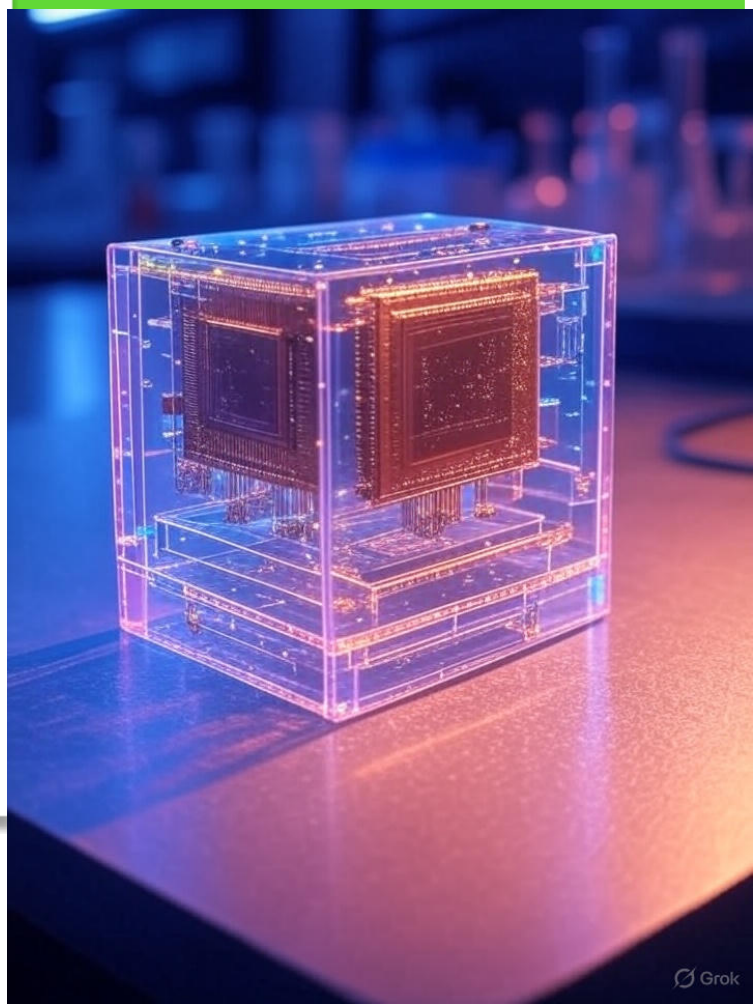
Liver on a CHIP
Cost comparison with animal testing
2025
Science for the Public





LIVER ON A CHIP COST PERFORMANCE.
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Liver-on-a-chip (LoC) technology, a microfluidic platform that mimics human liver functions, has emerged as a promising tool for drug development, toxicity testing, and disease modeling.
Its cost-effectiveness compared to traditional methods like animal testing and conventional in vitro models is a key driver of its adoption.
Below is a cost analysis of LoC technology based on available data, focusing on its economic benefits, cost components, and comparisons with alternative methods.

Economic Benefits

1. Reduction in Preclinical Costs:

- Studies suggest that LoC technology can significantly reduce drug development costs by improving the prediction of drug-induced liver injury (DILI).
A 2022 study estimated that adopting LoC for DILI prediction across small-molecule drug programs could save the pharmaceutical industry approximately $3 billion annually ($2.1B–$3.4B, 95% CI) due to increased R&D productivity by reducing clinical trial failures.
https://www.nature.com/articles/s43856-022-00209-1
https://pubmed.ncbi.nlm.nih.gov/36473994
https://www.biorxiv.org/content/10.1101/2021.12.14.472674v3.full

- By identifying toxic compounds earlier, LoC reduces the need for costly late-stage clinical trial terminations, where 21% of drug withdrawals and 13% of clinical trial failures are attributed to DILI.
https://www.tandfonline.com/doi/full/10.1080/17460441.2023.2255127

2. Comparison with Animal Testing:

- A case study by Emulate, Inc. highlighted by Dr. Samantha Atkins at Moderna showed that screening 35 lipid nanoparticle (LNP) candidates using LoC cost $325,000 over 18 months. In contrast, equivalent non-human primate (NHP) studies would have cost over $5 million and taken 60 months. This represents a cost reduction of over 15 times and a 3.3-fold reduction in time.
https://emulatebio.com/organ-chips-vs-nhps-cost-calculator/
https://emulatebio.com/lnp-cost-calculator/

- LoC's ability to use human cells reduces reliance on animal models, which often fail to predict human outcomes due to species-specific differences, further saving costs associated with inaccurate predictions.
https://wyss.harvard.edu/news/liver-chip-identifies-distinct-drug-toxicities-in-human-rat-and-dog-models/
https://www.nature.com/articles/s41575-019-0244-5

3. High-Throughput Efficiency:

- LoC platforms, particularly when automated, support high-throughput screening. For instance, a study analyzed 870 Liver-Chips, demonstrating scalability for industrial applications, which reduces per-unit testing costs.
https://www.nature.com/articles/s43856-022-00209-1
https://www.biorxiv.org/content/10.1101/2021.12.14.472674v3.full

Cost Components

The costs associated with LoC technology include:

1. Chip Fabrication and Materials:

- Microfluidic chips require specialized materials like biocompatible polymers and extracellular matrix (ECM) components. While mass production can lower costs, custom or scaffold-free designs (e.g., Weng et al.'s scaffold-free LoC) may increase initial development expenses due to complex microengineering.
https://www.elveflow.com/microfluidic-reviews/organs-on-chip-3d-cell-culture/liver-on-chip-microfluidic/
https://microfluidics-innovation-center.com/reviews/liver-on-chip-microfluidic/

- The use of off-the-shelf sensors (e.g., oxygen or electrochemical sensors) can reduce fabrication costs compared to custom-built components.
https://www.pnas.org/doi/10.1073/pnas.1522556113

2. Cell Sourcing:

- LoC systems often use primary human hepatocytes or induced pluripotent stem cell (iPSC)-derived hepatocytes. Primary cells are costly and have limited availability, while iPSC-derived cells may require additional processing, increasing expenses.
https://inflammregen.biomedcentral.com/articles/10.1186/s41232-022-00248-0

- BioKits, such as those from Emulate, include pre-qualified human cells, chips, and reagents, streamlining costs but requiring investment in proprietary systems.
https://emulatebio.com/liver-chip/

3. Operational Costs:

- Operating LoC systems involves costs for culture media, perfusion systems, and real-time monitoring equipment (e.g., biosensors for glucose, lactate, or oxygen). Automated platforms reduce labor costs but require upfront investment in instrumentation.
https://pmc.ncbi.nlm.nih.gov/articles/PMC9646254/
https://www.pnas.org/doi/10.1073/pnas.1522556113

- Long-term culture (up to 28 days or more) is feasible with LoC, potentially increasing media and maintenance costs but offset by extended experimental windows compared to traditional 2D cultures.
https://www.pnas.org/doi/10.1073/pnas.1522556113

4. Validation and Regulatory Compliance:

- Validating LoC systems for regulatory acceptance (e.g., under the FDA Modernization Act 2.0) involves costs for standardization and testing against benchmarks, such as the 27 hepatotoxic and non-toxic drugs evaluated by Emulate with 87% sensitivity and 100% specificity.
https://www.nature.com/articles/s43856-022-00209-1
https://www.sciencedirect.com/science/article/pii/S2590006424002023
https://pubmed.ncbi.nlm.nih.gov/36473994/

Cost Comparison with Traditional Methods

1. Traditional In Vitro Models:
  - Conventional 2D cell cultures (e.g., HepG2 or sandwich cultures) are cheaper upfront but lack physiological relevance, leading to higher downstream costs due to poor predictability. LoC's 3D architecture and dynamic flow improve accuracy, justifying higher initial costs.
https://emulatebio.com/liver-chip/
https://www.tandfonline.com/doi/full/10.1080/17425255.2017.1246537

  - LoC requires smaller quantities of test compounds due to its microscale size, reducing material costs compared to macroscale in vitro systems.
https://www.tandfonline.com/doi/full/10.1080/17425255.2017.1246537

2. Animal Models:
  - Animal studies, such as NHP testing, are significantly more expensive due to animal procurement, housing, and ethical compliance. LoC's ability to mimic human liver responses reduces the need for such models, offering both cost and ethical benefits.
https://emulatebio.com/organ-chips-vs-nhps-cost-calculator/
https://emulatebio.com/lnp-cost-calculator/

  - The high specificity of LoC (100% in some studies) minimizes false positives, avoiding unnecessary rejection of viable drug candidates, unlike animal models with lower predictive accuracy.
https://www.tandfonline.com/doi/full/10.1080/17460441.2023.2255127

Market and Scalability

The global organ-on-a-chip market was valued at $157.3 million in 2024, with a projected compound annual growth rate (CAGR) of 35.11% through 2030, driven by demand for alternatives to animal testing and advancements in microfluidics.
https://www.grandviewresearch.com/industry-analysis/organ-on-a-chip-market-report

Mass production of microfluidic chips reduces per-unit costs, as their small size (e.g., 1€ coin-sized) allows integration of multiple systems on a single chip, saving space and materials.
https://www.elveflow.com/microfluidic-reviews/organs-on-chip-3d-cell-culture/organs-chip-review/

Investments, such as CN Bio's $21 million Series B funding in 2024, indicate growing industry confidence in scaling LoC for cost-effective drug development.
https://www.grandviewresearch.com/industry-analysis/organ-on-a-chip-market-report

Challenges and Cost Considerations

Initial Development Costs:
Designing and validating LoC systems, especially scaffold-free or multi-organ chips, requires significant upfront investment in R&D and microfabrication.
https://www.elveflow.com/microfluidic-reviews/organs-on-chip-3d-cell-culture/liver-on-chip-microfluidic/
https://microfluidics-innovation-center.com/reviews/liver-on-chip-microfluidic/

Standardization:
Lack of standardized protocols can increase costs for regulatory validation, though initiatives like the FDA Modernization Act 2.0 are encouraging adoption.
https://www.grandviewresearch.com/industry-analysis/organ-on-a-chip-market-report
https://www.sciencedirect.com/science/article/pii/S2590006424002023

Cell Longevity and Maintenance:
While LoC supports longer cell viability (up to 15–28 days), maintaining hepatocytes in dynamic 3D cultures can be costlier than short-term 2D cultures. However the accuracy is improved.
https://pmc.ncbi.nlm.nih.gov/articles/PMC9646254/
https://inflammregen.biomedcentral.com/articles/10.1186/s41232-022-00248-0

Conclusion

Liver-on-a-chip technology offers substantial cost savings in drug development by reducing clinical trial failures, minimizing reliance on expensive animal models, and enabling high-throughput screening with human-relevant data.

While initial costs for chip fabrication, cell sourcing, and validation are notable, the long-term economic benefits—potentially $3 billion annually for DILI prediction alone—make LoC a compelling investment.

Compared to traditional in vitro and animal models, LoC's superior predictive accuracy and scalability position it as a cost-effective alternative, particularly as market growth and technological advancements further reduce per-unit costs.