

A More Ethical Science: The Future of Animal Testing and Alternatives

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In 2022, Congress passed the FDA Modernization Act 2.0, declaring that the FDA was no longer required to implement non-human animal testing as part of drug development. Due in part to this act, the FDA announced a plan in April of this year to replace its non-human animal testing requirements with non-animal alternatives. According to their roadmap, “In the long-term (3–5 years), FDA will aim to make non-human animal studies the exception rather than the norm for pre-clinical safety/toxicity testing” (Thomasy 2025). The stakes for this plan could not be higher. Non-human animal testing is based on the unjust principle that places perceived human benefit above non-human animal lives and welfare. Paradoxically, research and basic observation and experience have allowed us to recognize the feelings of intense pain, fear, distress, and depression that non-human animals undergo (Ferdowsian & Beck, 2011). Despite these facts, the status quo of anthropocentric tunnel-vision that has alienated and damaged humanity, the planet, and countless species remains dominant in society and scientific thought and practices. In 2015, an estimated 192 million non-human animals were abused in educational training, drug testing, and research (Taylor & Alvarez 2015). Unfortunately, many believe that animal testing is a necessity in the quest for further knowledge to improve human lives. Fortunately, as technology advances, it is becoming increasingly feasible to use “New Approach Methodologies” (NAMs) in lieu of unethical and barbaric non-human animal tests (Taylor 2019), the development of which is responsible for the announcements by Congress and the FDA (Thomasy 2025). Non-human animals must be given equal consideration with humans, and these NAMs are crucial tools towards this ideal due to their speed, efficiency, low cost, and promise to save more human and non-human animal lives than traditional methods.

Almost 70 years ago, when NAMs began to develop, replacement was difficult and slow. However, progress was still made in many key tests, which are now accepted standards (Taylor 2019). Once developed, standards are often accepted quickly due to their efficiency, as NAMs can be far faster and less expensive than conventional non-human animal testing methods. Due to differences between human and non-human animal anatomy, around 90% of all non-human animal-tested drugs never make it past human testing. This results in a colossal waste of time, money, and human and non-human animal lives (Thomasy 2025). One of the NAMs demonstrating the most success is the Ames test, an *in vitro* test for mutagenicity, widely accepted as an industry standard in lieu of previous mouse-based tests. More *in vitro* cell cultures replaced horrific testing of polio, yellow fever vaccines, and even pregnancy tests (Taylor 2019). Advancing technology has led to five main NAM categories, all of which have demonstrated success, feasibility, and convenience, but the most excitement and promise lies with *in silico* and *in vitro* techniques.

In silico approaches make use of computational and AI/machine learning advances to model and predict the outcomes of a drug or treatment in the early stages of development. One such promising NAM is the Collaborative Acute Toxicity Modelling Suite (CATMoS). This uses computational modelling to predict the toxicity of compounds, and has so far shown extremely accurate results. In the future, models like this could replace notoriously painful acute toxicity tests. During its development, CATMoS published toxicity predictions for over 800,000 chemicals (Mansouri et al. 2021).

Thanks to these advances in NAMs and a shift in societal ethics, the end may be near for non-human animal testing, especially for toxicity testing where *in vitro* tests are simply better and more accurate than animal tests (Taylor 2019). However, some experts are skeptical. To many, the biggest challenges faced by new NAMs are that they are

simply not complex enough and not as accurate as they need to be in predicting the complexity and chaos of a living body. However, simple human-based NAMs are much more relevant to humans than the chaos of a non-human animal system, and non-human animal tests are very poor predictors of human conditions (Taylor 2019; Ferdowsian & Beck 2011). Even so, researchers are building model complexity to address these criticisms by developing *in vitro* techniques reminiscent of science fiction: organoids and organs-on-chips (Singh et al. 2022). These models are layers of organ cells (induced pluripotent stem cells of human origin) supported by a vascular system and a 3D extracellular matrix. The models can effectively model the intricate intracellular interactions of human cells and organs, as well as the effects of drugs on these systems. These new technologies have been wildly successful. A liver-on-a-chip developed in 2022 was able to correctly identify the toxicity of drugs to the liver with near-perfect accuracy (Thomasy 2025; Singh et al. 2022). Most drug trials fail due to their liver toxicity, so such a simulacrum could vastly reduce the costs—in money, suffering, and time—of drug development. Other successful advancements include lung, brain, heart, kidney, skin, and gut-on chips, as well as combinations of multiple organs to mimic organ interactions. For example, an intestine-kidney chip was created to test both the absorption and nephrotoxicity of drug combination treatments (Singh et al. 2022). Such devices can even be utilized in personalized medicine to develop treatments tailored to each patient’s needs (Skardal 2024).

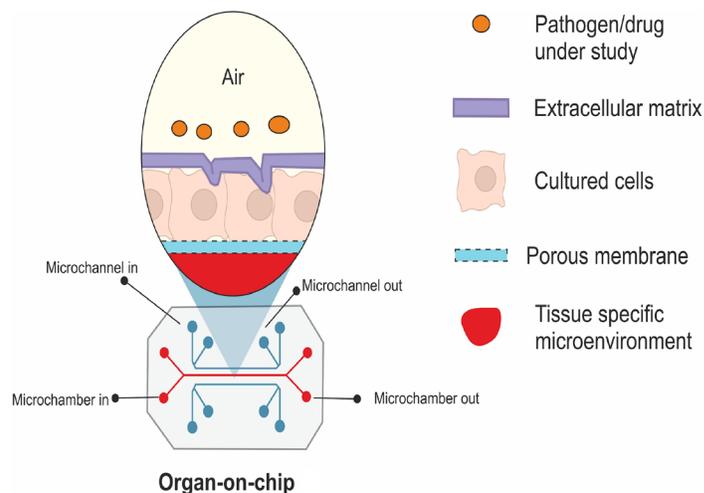


Figure 1. A diagram showing the typical arrangement of an organ-on-a-chip. Source: <https://www.xiahepublishing.com/2572-5505/JERP-2023-00006S>

Organs-on-chips have begun to attract attention from pharmaceutical companies and regulatory agencies, hence the FDA’s announcement this April. Despite advances in biomedical and computational technology that seemed previously impossible, challenges remain. For example, the interactions between organs *in vivo* are still poorly understood (Thomasy 2025). Furthermore, the regulation of these new NAMs must be developed and standardized. Unfortunately, such advancements in new NAM technology and collaboration are at risk due to the Trump administration’s funding cuts (Thomasy 2025). These cuts come at a crucial moment when funding is needed most to spur market demand, development, and innovation in these technologies and their fields (Singh et al. 2022).

In summary, NAMs have advanced greatly in the past three decades, allowing for the replacement of many unethical non-human animal tests with ethically and economically conscious NAMs; many entrenched benchmark tests have been completely replaced by NAMs. The importance of these advancements for both human and non-human animal welfare cannot be exaggerated. Researchers and politicians alike must do all they can to fight back against cuts and societal resistance while continuing to develop and refine NAMs (Taylor 2019). Going forward, regulatory agencies must implement more policies regarding and accepting the use of NAMs, such as organs-on-chips (Skardal 2024). Perhaps animal testing will remain a necessity in some fields, in which case society and science must be

willing to back down, especially if the research is knowledge for the sake of knowledge. There is most always a more ethical choice, if one cares to choose it (consenting humans in an experiment judged safe by predictive NAMs, for example). Non-human animals must be protected from unethical research to the same standards as humans are protected. The recent developments in NAMs and the announcements by Congress and the FDA are great strides towards a future where this ideal becomes reality, and science is truly used for what it should be—for the betterment of all.

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References:

1. Mansouri, K., Karmaus, A. L., Fitzpatrick, J., Patlewicz, G., Pradeep, P., Alberga, D., Alepee, N., Allen, T. E. H., Allen, D., Alves, V. M., Andrade, C. H., Auernhammer, T. R., Ballabio, D., Bell, S., Benfenati, E., Bhattacharya, S., Bastos, J. V., Boyd, S., Brown, J. B., Capuzzi, S. J., ... Kleinstreuer, N. C. (2021). CATMoS: Collaborative Acute Toxicity Modeling Suite. *Environmental health perspectives*, 129(4), 47013. <https://doi.org/10.1289/EHP8495>
2. Singh, D., Mathur, A., Arora, S., Roy, S., & Mahindroo, N. (2022). Journey of organ on a chip technology and its role in future healthcare scenario. *Applied Surface Science Advances*, 9, 100246. <https://doi.org/10.1016/j.apsadv.2022.100246>
3. Skardal, A. (2024). Grand challenges in organoid and organ-on-a-chip technologies. *Frontiers in Bioengineering and Biotechnology*, 12. <https://doi.org/10.3389/fbioe.2024.1366280>
4. Taylor, K. (2019). "Recent developments in alternatives to animal testing." In K. Herrmann & K. Jayne (Eds.), *Animal Experimentation: Working Towards a Paradigm Change* (pp. 583-609). Brill.
5. Taylor, K., & Alvarez, L. R. (2019). An Estimate of the Number of Animals Used for Scientific Purposes Worldwide in 2015. *Alternatives to laboratory animals : ATLA*, 47(5-6), 196–213. <https://doi.org/10.1177/0261192919899853>
6. Thomasy, H. (2022). "Is This the End of Animal Testing? FDA Announces Plans to Phase Out Animals in Drug Safety Studies." *The Scientist*, LabX Media Group. www.the-scientist.com/is-this-the-end-of-animal-testing-fda-announces-plans-to-phase-out-animals-in-drug-safety-studies-73031.