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ARTIFICIAL INTELLIGENCE SOLVES 100 YEAR OLD WORM CHALLENGE

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For the first time, an artifical intelligence system has reverse-engineered how a planaria worm regenerates. The work, published recently in *PLOS Computational Biology*, shows how much the robot science can help humans scientists going forward. Humans have been trying for more than 100 years to figure out how planarian regeneration works because the worms are seen as ideal models for human regenerative medicine.

"While the artificial intelligence in this project did have to do a whole lot of computations, the outcome is a theory of what the worm is doing, and coming up with theories of what's going on in nature is pretty much the most creative, intuitive aspect of the scientist's job," said the paper's lead author, Dr. Michael Levin of the Tufts Center for Regenerative and Developmental Biology. "One of the most remarkable aspects of the project was that the model it found was not a hopelessly-tangled network that no human could actually understand, but a reasonably simple model that people can readily comprehend. All this suggests to me that artificial intelligence can help with every aspect of science, not only data mining but also inference of meaning of the data."

In order to make complex organs, scientists need to understand how the shapes that make up the organs are normally produced by the living organism. But there's adearth of knowledge regarding how and why a particular complex shape is generated in the correct size, shape and orientation, said Levin.
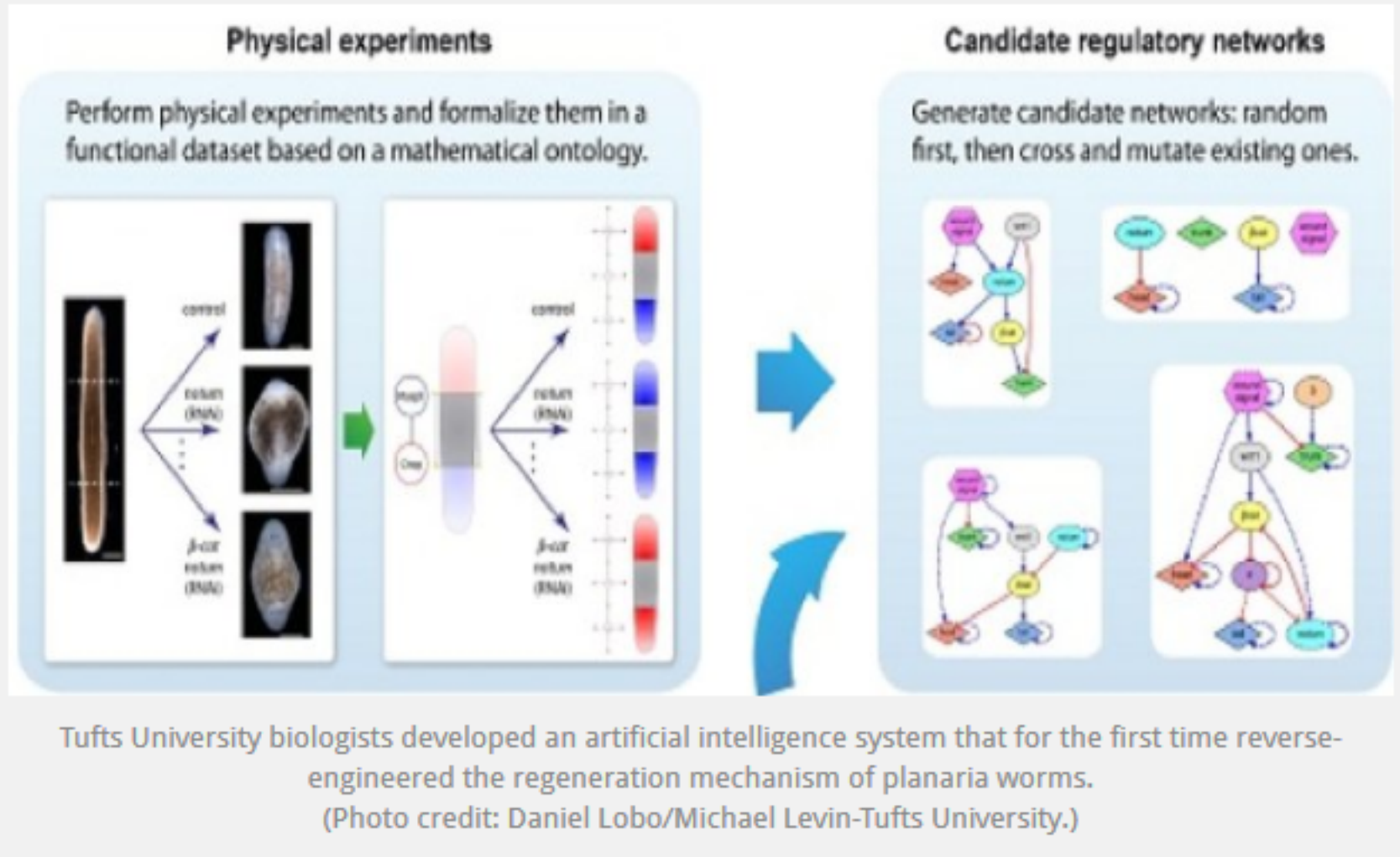
"Most regenerative models today derived from genetic experiments are arrow diagrams, showing which gene regulates which other gene. That's fine, but it doesn't tell you what the ultimate shape will be. You cannot tell if the outcome of many genetic pathway models will look like a tree, an octopus or a human," said Levin. "Most models show some necessary components for the process to happen, but not what dynamics are sufficient to produce the shape, step by step. What we need are algorithmic or constructive models, which you could follow precisely and there would be no mystery or uncertainty. You follow the recipe and out comes the shape."

Such models are required in order to know what triggers could be applied to such a system to cause regeneration of particular components, or other desired changes in shape. However, no such tools yet exist for mining the fast-growing mountain of published experimental data in regeneration and developmental biology, said the paper's first author, Dr. Daniel Lobo, Ph.D., a post-doctoral fellow in the Levin lab.

To address this challenge, Lobo and Levin developed an algorithm that would use evolutionary computation to produce regulatory networks able to "evolve" to accurately predict the results of published laboratory experiments that the researchers entered into a database.

Their work was successful and the researchers ultimately applied the algorithm to a combined experimental dataset of 16 key planarian regeneration experiments to determine if the approach could identify a comprehensive regulatory network of planarian generation. After 42 hours, the algorithm returned the discovered regulatory network, which correctly predicted all 16 experiments in the dataset. The network comprised seven known regulatory molecules as well as two proteins that had not yet been identified in existing papers on planarian regeneration.

"This represents the most comprehensive model of planarian regeneration found to date. It is the only known model that mechanistically explains head-tail polarity determination in planaria under many different functional experiments and is the first regenerative model discovered by artificial intelligence," said Levin.

Tufts University biologists developed an artificial intelligence system that for the first time reverse-engineered the regeneration mechanism of planaria worms.
(Photo credit: Daniel Lobo/Michael Levin-Tufts University.)

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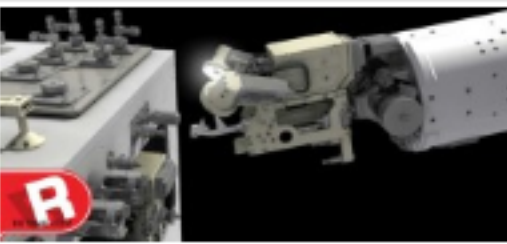
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