Using Research Organisms to Study Health and Disease

National Institute of General Medical Sciences

What is a research organism?

A research organism can be any creature that scientists use to study life. Examples range from single-celled organisms such as bacteria to more complex ones such as mice. Researchers funded by NIGMS use research organisms to explore the basic biology and chemistry of life.
Scientists decide which organism to study based on their research questions. Worms and zebrafish, which can regrow missing or injured body parts, are used to learn how cells and tissues regenerate. Insects such as fruit flies and honeybees are important research organisms for learning how genes and the environment interact to affect behavior. Sea urchins are able to reproduce and regrow body parts throughout their lives, making them of interest to scientists who study aging.

Zebrafish. Credit: Monte Westerfield, University of Oregon.

Scientists can study animals in ways that they cannot study people. For example, animal studies conducted in the lab allow scientists to control temperature, humidity, light, diet, and other factors that might affect the outcome of the experiments. These rigorous controls allow for more precise understanding of the biological factors being studied and provide greater certainty about experimental outcomes when pursuing additional studies.

What are model organisms?

Model organisms are a small group of research organisms that serve as a proxy for understanding the biology of humans. Examples include yeast, fruit flies, worms, zebrafish, and mice. Many aspects of these organisms' biology are similar to ours, and much is already known about their genetic makeup. For these and other reasons, studying model organisms helps scientists learn more about human health.

Why are model organisms useful for studying diseases?

The natural course of a disease in humans may take dozens of years. In contrast, a model organism can quickly develop a disease or some of its symptoms. That allows researchers to learn about the disease in a much shorter time.

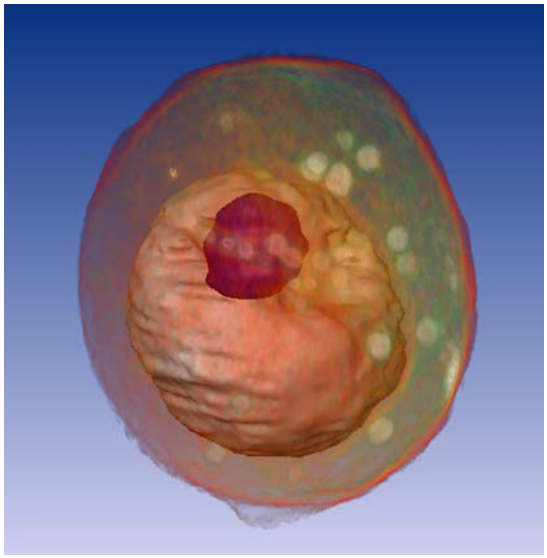
When scientists discover a link between a particular gene and a human disease, they typically find out what that gene does in a model organism. This information can provide important clues about what causes a disease. It also can help researchers develop potential diagnostic tests and treatments that are later tested in clinical trials. Mice, for example, have served as a model for studying the genetics of Down syndrome, cystic fibrosis, heart disease, and cancer.

Drosophila. Credit: iStock.

Any NIH-funded study that involves animals or humans must follow laws, regulations, and policies to ensure participants' welfare and minimize risks stemming from the research.

How has work with research organisms influenced human health?

Much of what we know about biology comes from studies using model and other research organisms. In addition to advancing knowledge of our own biology, these studies have led to the development of new tools doctors can use to diagnose and treat disease. Here are a few of the many examples from NIGMS-funded research:



Yeast cell. Credit: Carolyn Larabell, University of California, San Francisco, and the Lawrence Berkeley National Laboratory.

- Yeast studies sorted out how cells divide. They revealed the orderly sequence of events that cells use to duplicate their contents and multiply, a process called the cell cycle. Millions of people with cancer have benefitted from this information, because many cancer drugs interfere with the cell cycle.
- Yeast studies clarified how genes are turned on or off and informed our understanding of diseases that occur when genes are active at the wrong time or in the wrong cell.
- Studies in fruit flies and tiny worms taught scientists new things about how fertilized eggs develop into complex organisms.
- Research with bacteria, viruses, and yeast revealed how all living things pass on their genes to offspring. This work detailed the ways cells copy DNA and repair mistakes made during the copying process.
- Researchers have used laboratory mice and rats for decades to test drugs. Basic research with rats also has taught us much of what we know about cancer-causing molecules.
- Studies with fruit flies, bread mold, bacteria, and mice identified the basic components of circadian clocks, which drive daily biological rhythms. The research revealed connections between these clocks and sleep deprivation, obesity, diabetes, depression, and other human health conditions.
- Studies using research organisms produced powerful tools that scientists use in human health studies worldwide. Examples include DNA chips for studying all the gene activity in a cell and the CRISPR tool for editing DNA in living organisms.

What more can research organisms tell us?

Scientists continue to work toward understanding all of the molecular processes that underpin human biology and health. They are currently using research organisms to see how these animals fix damaged pieces of DNA, regenerate missing or injured body parts, and pass certain genetic changes to their offspring.

Studying research organisms can also help reveal molecular changes that are associated with diseases and show the connections between certain diseases that seem unrelated.

How are computer models used?

Computers can serve as virtual laboratories that advance biomedical knowledge in areas such as infectious disease spread and drug interactions in the body. With virtual labs, scientists can perform experiments that are difficult to do in actual labs. They also can quickly identify factors that are important to include in lab-based experiments. Researchers use computer simulations to track biological processes in cells and research organisms. This allows them to computationally test, for example, the possible effects of drugs on those processes. The drugs that seem the most promising can then be studied in living cells or organisms.

Because the computer models are so complex, researchers need to use high-performance computers. Often, these computers run for weeks at a time, generating millions of different possible outcomes.

No single set of results or single computer model can accurately predict an outcome. Therefore, researchers often ask the same questions using different models. When multiple models yield similar results, scientists have more confidence in the predictions.

Can computer models replace research organisms?

Computer models have limits. Researchers create them based on what they already know about a process or disease. Scientists use information and data gained from real-world experiments to enhance computer models and predictions to help design additional experiments. Thus, computer modeling and lab experiments go hand in hand—both are needed to advance our understanding of health.

NIGMS is a part of the National Institutes of Health that supports basic research to increase our understanding of biological processes and lay the foundation for advances in disease diagnosis, treatment, and prevention. For more information on the Institute's research and training programs, see https://www.nigms.nih.gov.

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