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PATHWAYS

The Regeneration Issue

What researchers are learning from animals

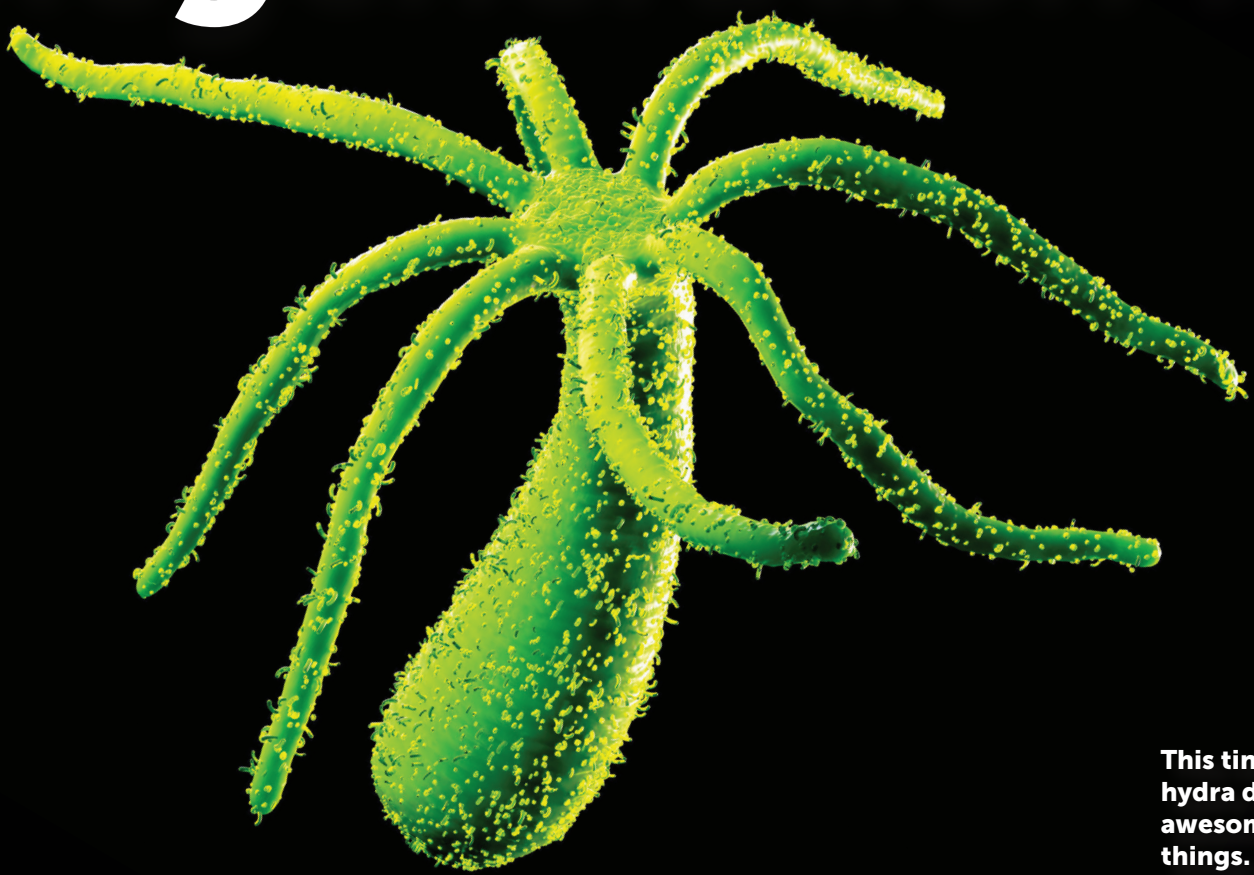
Science jobs of the future

What Do You and These Zebrafish Have in Common?

Hint: It's more than you think!

National Institute of General Medical Sciences

Regeneration Is



This tiny hydra does awesome things.

Some animals can regrow an amputated limb—or even a severed head! Scientists are studying these incredible creatures to help treat human diseases.

If you've ever accidentally cut yourself, you probably didn't think much about the scab or new skin that formed. The process of healing, repairing, and replacing damaged tissue is what scientists call regeneration.

In the case of a scraped knee, it's mostly just skin that's regrowing. But all around us, living things demonstrate mind-blowing abilities to regenerate entire limbs, internal organs, even a full-grown body from a bit of tissue.

"Scientists in the field of regenerative medicine look at animals that can naturally regenerate and heal types of wounds that humans can't," explains **Thomas Lozito, Ph.D.**, assistant professor at the University of Southern California in Los Angeles, who was fascinated by reptiles and amphibians as a child. "We try to map out a blueprint for getting humans to do the same thing," says Dr. Lozito. (Today he runs a lab with over 1,000 lizards!)

Take the **axolotl**, a salamander that can lose its entire tail—and grow it back. Or organisms known as **hemichordates**, which can lose their heads and then create new ones! Or the **hydra**, a freshwater creature that regenerates its cells every 20 days.

Scientists study these research organisms to learn how their regenerative processes work. Their goal: to use their understanding to develop treatments for human health issues like spinal cord injuries, Alzheimer's disease, the loss of an arm or a leg, and much more.

AMAZING (Find Out Why!)

An axolotl can regrow its tail...and its legs, jaws, spinal cord, brain, and more!

Celina Juliano, Ph.D., assistant professor at the University of California, Davis, was also an animal lover as a kid. Today she studies the hydra—one of the first animals in which regeneration was discovered, way back in the 1700s. A hydra is a minuscule freshwater creature that's related to jellyfish, sea anemones, and coral. It's basically a tube with tentacles on the top and a sticky disk on the bottom, but it can do amazing things. "A hydra can be cut into little pieces, and each piece will grow back into a full hydra," Dr. Juliano says. "You can even separate a hydra into single cells, form those cells up into a ball, and they'll rearrange themselves back into a hydra. And a hydra continually renews itself, replacing all of its cells with new cells."

Helping others motivates **Voot P. Yin, Ph.D.**, director of scientific services at MDI Biological Laboratory in Maine. Dr. Yin works with zebrafish, salamanders, and mice. "We have found that zebrafish can fully regenerate a missing or damaged muscle, even in their heart," he says. Many of the genes in zebrafish are closely related to those in humans. One of the major goals of regenerative medicine is discovering how to decode the genetic circuitry that allows regeneration to occur. "Then we need to reactivate those circuits in humans, so that if you have an injury like a heart attack, we can use the body's own genetic programming to allow regeneration to happen," Dr. Yin explains. This type of research can lead to important discoveries in regenerative medicine that can be applied to almost any organ system.

The quest to make people's lives better will continue to ignite scientists' imaginations. And maybe it will also lead you on a journey into the exciting field of regenerative medicine!

Regenerative medicine is a field of science that focuses on restoring or healing damaged body parts so that they function normally. The long-term goal is to stimulate tissue and organs to heal themselves.

EARLY-CAREER SCIENTISTS IN THE SPOTLIGHT

Lamont R. Jones, M.D., M.B.A., vice chair, Department of Otolaryngology, Head and Neck Surgery, Henry Ford Health System, Detroit, Michigan

What kind of research are you doing? My current project is focused on better understanding why patients are at risk of developing keloids, which are noncancerous skin growths.

How did your interest in science develop? As a Detroit Public High School student, I was involved in a summer program performing research, in a basic science lab. Along with my parents and teachers, the lab experience and exposure fueled my interest in science and helped influence me to go to medical school.

What made you want to be a physician-scientist? The value of research discoveries is that you're able to magnify your impact. Being a researcher and physician lets me take a problem and work on discoveries that can improve the lives of many patients.

Mansi Srivastava, Ph.D., assistant professor of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts

Did you always dream of becoming a scientist? Growing up in India, I never imagined that I'd someday be a Harvard professor. But my mother was a high school biology teacher, and my best friend's mom was a botany professor. I give these women full credit for getting me engaged in science.

What organism do you study? I look at *Hofstenia miamia*, also known as **three-banded panther worms**. They're called panther worms because they're active predators: They hunt for little swimming brine shrimp that we include in their tanks in our lab.

What is your advice to students who want to be scientists? It's very important to be able to work with other people. Also, ask questions! There is no such thing as a dumb question.

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HELP WANTED

Job alert! A new regeneration lab is opening in your town and needs to fill the positions listed here. Think about which job you'd most like to do. Then write or share with your class the skills you could bring to the position, and what you hope to discover in your role. Good luck!

PRINCIPAL INVESTIGATOR

RESPONSIBILITIES: Serve as a "coach" leading a team of scientists who work on groundbreaking discoveries. Come up with goals and empower other scientists to conduct research in support of these goals. Mentor other scientists. Write research papers and give presentations about your progress and discoveries to share with scientists around the world.

RESEARCH ASSISTANT

RESPONSIBILITIES: Assist the principal investigator in managing and executing experiments. Plan, conduct, and analyze cutting-edge independent research in the lab. Supervise junior team members and further develop research-related activities to support the goals of the lab.

LAB MANAGER

RESPONSIBILITIES: Oversee instruments, computers, and devices in the lab. Know how to operate all machinery and teach other team members as needed. Keep lab animals healthy and happy. Maintain a log of what materials need to be replenished. Manage the budget for lab equipment and supplies.

DATA SCIENTIST

RESPONSIBILITIES: Develop computer programs to help scientists manage and understand huge amounts of data. Come up with unique ways to map, present, and share findings. Teach others new methods to compile statistics and questions to ask along the way.

EMPLOYER'S NOTE *All jobs require curiosity, teamwork, passion, and a willingness to learn from your mistakes. A good sense of humor will go a long way too!*

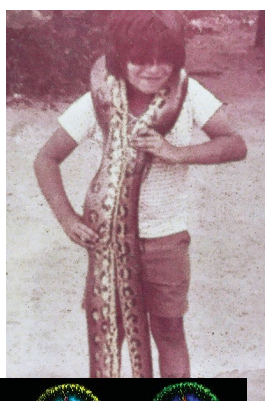
Science All-Star Alejandro Sánchez Alvarado

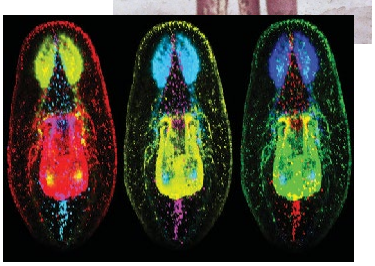
Alejandro Sánchez Alvarado, Ph.D., is a true pioneer. As the scientific director of the Stowers Institute for Medical Research in Kansas City, Missouri, Dr. Sánchez Alvarado oversees major regenerative research projects in his lab at the institute. The star of his research is the planarian flatworm, which he says looks like a cartoon character! "A planarian can be cut into a number of pieces, and each and every one of those fragments will go on to regenerate a complete planarian," he explains excitedly. "And we want to understand how they can do this."

Dr. Sánchez Alvarado has always loved scientific mysteries. Growing up in Caracas, Venezuela, he spent his summers on his grandfather's farm where he relished studying the creatures around him.

These days he goes on expeditions to find organisms in oceans as far away as French Polynesia; analyzes billions of pieces of information about organisms' cells and genes using computers; double-checks the computers' data by observing the organisms under microscopes; and much more.

Just what keeps Dr. Sánchez Alvarado so captivated? His answer is poetic: "I have a fascination for these very small and unheralded things. I'm certain they contain a large number of secrets waiting to be uncovered."





From top: Dr. Sánchez Alvarado as a child holding a green anaconda; three representations of planarian fatworm anatomy.

Photos: background image, Lemberg Vector studio/Shutterstock; adult and young Sánchez Alvarado, courtesy Alejandro Sánchez Alvarado; flatworm anatomy, © Sarah Elliott – Stowers Institute for Medical Research (on the cover: Arco Images GmbH/Alamy)

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