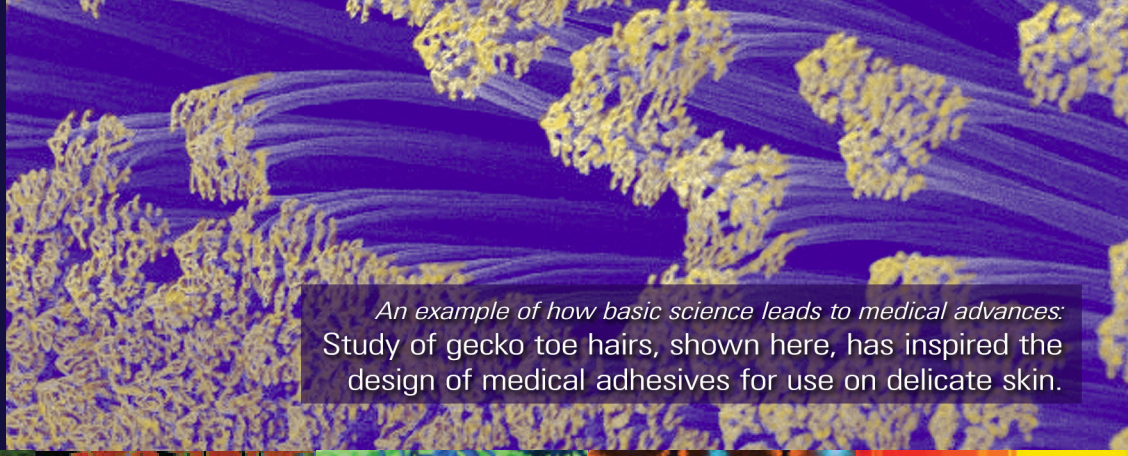
Curiosity Creates Cures

The Value and Impact of Basic Science



An example of how basic science leads to medical advances: Study of gecko toe hairs, shown here, has inspired the design of medical adhesives for use on delicate skin.

What is BASIC SCIENCE and why is it important?

Basic science, sometimes called "pure" or "fundamental" science, helps researchers understand living systems and life processes. This knowledge leads to better ways to predict, prevent, diagnose, and treat disease.

Through basic science, researchers try to answer fundamental questions about how life works. Examples include:

- How do cells talk to each other?
- What controls gene activity?
- How do proteins fold so they can work properly?
- How do diseases develop?

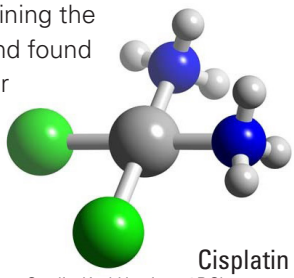
Sometimes, basic science has unexpected applications, and the knowledge gained is used in fields outside of health and medicine—for example, in making food and household products, and for improvements in paternity testing and criminal forensics. Basic science also benefits the U.S. economy by providing jobs and helping launch new companies. The National Institute of General Medical Sciences (NIGMS), part of the National Institutes of Health (NIH), funds much of the nation's basic biomedical research.

What advances are a result of BASIC SCIENCE?

The following are just a few of the many success stories of the translation of basic science into practical applications. These types of advances are the result of thousands of researchers over decades building the scientific base required to move forward.

Medicines

Platinol (cisplatin): In studying the effect of electrical fields on bacteria, a researcher noticed the bacteria were not dividing normally. He traced the cause to platinum chemicals formed by the electrodes in contact with the liquid containing the bacteria. A range of platinum-containing compounds were tested and found to affect cell division, with cisplatin being the most effective. Further testing found cisplatin was able to stop or slow the growth of certain cancer cells. Cisplatin is now commonly used to treat testicular, ovarian, and bladder cancers. In fact, millions of people have benefited from cisplatin treatment and, when used with other chemotherapy drugs, its cure rate for testicular cancer is more than 90 percent.[1] [Barnett Rosenberg's early research funded by GM10890]



Cisplatin
Credit: Karl Harrison 3DChem.com

Velcade (bortezomib): Researchers discovered that cells use an internal machine, called the proteasome, to break down and remove damaged proteins and control cell growth. Other scientists thought a molecule known to slow the action of the proteasome might also slow

[1] The "Accidental" Cure—Platinum-based Treatment for Cancer: The Discovery of Cisplatin. National Cancer Institute, National Institutes of Health, U.S. Department of Health and Human Services. www.cancer.gov/research/progress/discovery/cisplatin, May 30, 2014. Accessed October 15, 2018.

Gecko toe hair image in header credit: Oskar Gellerbrant

Principles of Basic Science to Medical Breakthroughs

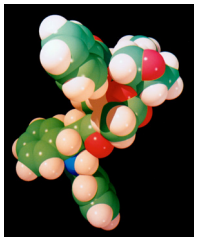
- "Chance favors only the prepared mind." *(Louis Pasteur)*
- Breakthroughs emerge from complex foundations of fundamental knowledge contributed by many people over many years. "If I have seen further it is by standing on the shoulders of Giants." *(Sir Isaac Newton)*
- Breakthroughs often come from unexpected and surprising areas.
- Organisms distant from humans often provide key insights or novel properties that lead to advances in medicine and technology.
- Similar to investing in the stock market or startup companies, supporting a broad and diverse scientific portfolio maximizes the chances for breakthroughs (big payoffs) and builds the strongest foundation on which discoveries can emerge.

NIH National Institute of General Medical Sciences

down the destruction of key proteins that help cells fight off cancer. This molecule, bortezomib, is now used as a drug to treat a bone marrow cancer called multiple myeloma.

Lynparza (olaparib): Every day, our DNA is damaged by environmental causes, like the sun's UV rays and random errors during cell division. To stay healthy, our cells must rapidly repair their damaged DNA. Scientists identified a specific protein that repairs damaged DNA, did many studies to understand how it works, and then used this information to develop a drug that blocks the repair process in cancer cells. Cancer cells die if they can't repair damaged DNA. This drug is now used to treat ovarian cancer.

Making carbon-carbon bonds: Carbon-based chemistry is the foundation of life. To make the chemicals of life, scientists must be able to join carbon atoms together. But carbon atoms don't naturally tend to join together. To help the process along, scientists have developed catalytic substances that contain a metal called palladium. These substances are used to make the cancer drug Taxol (paclitaxel) and the asthma drug Singulair (montelukast).



Taxol structure
Credit: NCI

Other Medical Applications

Recombinant DNA technology: Genes serve as instructions for making protein molecules—each gene tells the cell how to make a specific protein molecule. Researchers have figured out how to change genes to get bacteria and yeast to make large quantities of important molecules, such as medicines. To do this, scientists use specialized molecules to snip out a specific gene from a long strand of DNA and stick it into bacterial or yeast cells. Bacteria and yeast accept the transplanted gene as if it were their own. They reproduce quickly and, following the gene's instructions, make large amounts of the desired molecule. Molecules made in this way include insulin to treat diabetes and a hormone to treat children who have growth problems.

NMR spectrometer
Credit: Center for Eukaryotic Structural Genomics, University of Wisconsin, Madison

Nuclear magnetic resonance (NMR) imaging: Scientists developed NMR machines that use magnets to help study physical, chemical, electrical, and structural information about molecules. The same technique is now used for magnetic resonance imaging (MRI) in hospitals. MRI allows doctors to see tissues and organs inside the body, such as the brain, heart, and kidneys. It can be used to diagnose many conditions, from torn ligaments to tumors.

What will the next big advance be?

There's no way to know for sure which basic science projects will lead to major scientific advances. For example:

- Learning how cells move might show ways to stop the spread of cancer.
- Studying the way cells die could point to treatments for conditions like Alzheimer's and Parkinson's, which are linked to excess cell death.
- Utilizing new research technologies might improve diagnostics and therapies for the treatment of human diseases.
- Finding easier ways to make medicines in the lab could allow companies to make more at a lower cost or in a way that's better for the environment.

NOBEL PRIZES

Physiology or Medicine *and* Chemistry

These awards are two of the top prizes in science. They are awarded to people who "have conferred the greatest benefit on mankind." In most of the past 60 years, at least one Nobel winner received funding from NIGMS. This strong record of earning science's top honor shows that NIGMS-funded basic science is of great value to humanity.

NIGMS is a part of the National Institutes of Health that supports basic science 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, visit https://www.nigms.nih.gov.

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