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THE NEXT 10 YEARS IN MEDICINE

We asked experts in the fields of neuroscience, biology, immunology and more to tell us their biggest goals for the next decade. Here are 10 breakthroughs they want to accomplish (in no particular order)

Now that researchers at the Human Genome Project have finished mapping the body's 25,000 genes, scientists are hard at work on an even bigger task. Genes produce potentially millions of proteins that form most cellular structures and perform virtually all the tasks necessary for life, and calculating which genes code for which proteins is one of the most ambitious undertakings in medicine.

Scientists must also come to a better understanding of the metabolic processes that occur within each cell. The metabolic system controls all of the body's biochemical processes, including extracting energy from the environment and using it to help build new cells. Obesity and diabetes are considered metabolic diseases, and recently researchers have even begun investigating the role of metabolism in cancer. One major goal for the coming decade is creating the "metabolome," a complete map of the metabolic system that would let doctors observe the body's processes on a cellular level and give them insight into the chemical differences between healthy and diseased tissues, perhaps leading to new tests or treatments. Yet another groundbreaking mapping initiative will detail the complex networks of the brain and help us determine what goes wrong in diseased brains.

In the next 10 years, we'll see research strides in aging, obesity and cancer. Scientists will tackle scourges such as malaria, multiple sclerosis, Alzheimer's and Parkinson's disease, and they will develop antibiotics that don't promote deadly bacterial resistance. This is how they'll do it.

6

The overuse of antibiotics promotes bacterial resistance.

BETTER ANTIBIOTICS

BACKGROUND: Widespread use of antibiotics has resulted in the mutation of many disease-causing bacteria, making them resistant to treatment. In 2007, the CDC reported 19,000 deaths from methicillin-resistant *Staphylococcus aureus*.

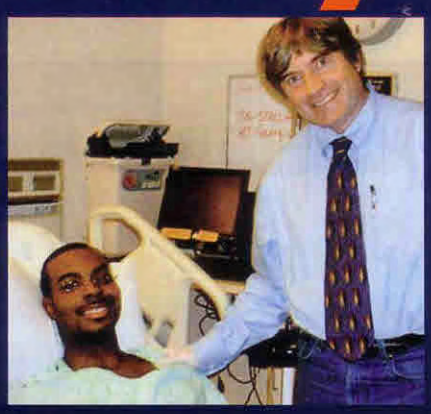
WHAT'S NEXT: Researchers will continue developing drugs to attack new bacterial targets. Novel compounds called quorum-sensing inhibitors, which disrupt bacteria's communication systems and are less likely to promote resistance, are also in the works.

CHALLENGES: Each type of bacteria may use a different communication pathway, which means researchers would have to tailor quorum-sensing inhibitors for each strain.

BEATING MULTIPLE SCLEROSIS 7

BACKGROUND: In multiple sclerosis, the immune system attacks myelin, the fatty material that insulates nerve fibers and helps propagate nerve signals. Northwestern University researchers, led by stem-cell expert Richard Burt, used immunosuppressant drugs to destroy the immune systems of 21 early-stage MS patients and then reconstructed their immune systems with the patients' own stem cells. To date, 75 percent of the patients have experienced an improvement in their condition.

WHAT'S NEXT: Human trials are ongoing. Trials for later stages of MS are being conducted on animals using embryonic stem cells. The team has also successfully tested the treatment in other autoimmune diseases, including lupus, Crohn's disease and rheumatoid arthritis.



Richard Burt rebuilds the immune system of multiple-sclerosis patients using their own stem cells.

CHALLENGES: The therapy for early-stage MS makes patients susceptible to infection. Later-stage treatments require controversial embryonic stem cells; they face government restrictions and a lack of funding.

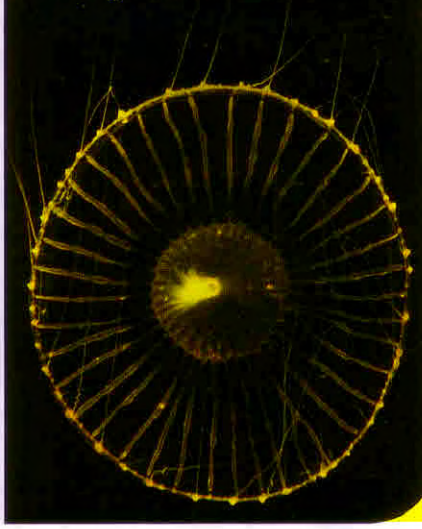
DECODING THE BRAIN 8

BACKGROUND: Neurologists want to create a map (connectome) of the 100 billion brain cells and their trillions of connections. Many psychiatric disorders may be explained by changes in these brain networks.

NEXT STEPS: The National Institutes of Health's Human Connectome Project is scheduled to conclude in 2015. The researchers are scanning the brains of 1,200 healthy adults.

CHALLENGES: While the Connectome project will provide a good overview of the human brain's connectivity, its noninvasive techniques don't allow researchers to see what is happening on the level of individual brain cells. More-invasive techniques are typically used only in animal models. Researchers will work to develop new ways to explore connectivity in postmortem human brains.

Top: An MRI reveals the structure of an owl-monkey brain. Bottom: Fluorescent proteins from jellyfish are used to trace the path of nerve signals in animal models.



CLOCKWISE FROM TOP LEFT: MIKE DEVLIN/SCIENCE PHOTO LIBRARY; VOLKER STEGER; HIROYA MINAKUCHI/MINDEN PICTURES; RICHARD BURT

10 YEARS OF BREAKTHROUGHS

We still have a long way to go, but this is a snippet of what medical science has accomplished in the past decade

The past decade saw some medical leaps seemingly pulled from the pages of science fiction. Doctors performed surgeries on patients located across the globe. They transplanted entire body parts, grew others from scratch in the lab, and fixed a faulty organ by manipulating its genetic makeup. There were also breakthroughs in treating and preventing cancer: Researchers developed new ways to treat tumors, zapping them with particles invisible to the human eye. And the world's first cancer vaccines were created, ushering in a new stage in cancer prevention and treatment. Doctors still haven't cured AIDS, but clinical studies on preventative measures showed strong promise and, for the first time, a vaccine may be on the horizon. Here, we present some of the top medical breakthroughs of the past 10 years.

Large-Scale Transplants

People with debilitating injuries now have new treatment options. Researchers have developed the ability to transplant entire body parts. In 2005 a French woman received a new face in the world's first such transplant, and in 2008 a German man got two new arms, also a first.

Remote-Control Surgery

In 2001, surgeons in New York City performed the world's first transatlantic remote surgery on a patient in Strasbourg, France, using advanced robots guided by fiber-optic cables. Surgeons also sometimes use the 'bots on-site to handle small instruments and delicate movements.

The Human Genome: Mapped

The three billion genetic base pairs for the roughly 25,000 human genes were decoded, two and a half years ahead of schedule. Researchers published the final results in 2003, which will have incalculable significance for research in molecular biology.

FROM TOP: LUWE LEIN/AP/POLFOTO; VOLKER STEGER/SPL/FOCI; SPL/FOCI

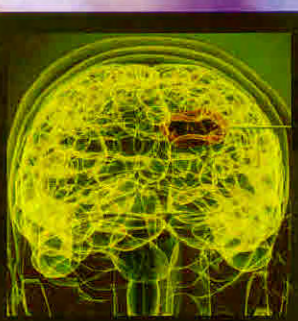
The Experts: Carol Bult, Jackson Laboratory; Richard Burt, Northwestern University Feinburg School of Medicine; Omid Farokhzad, Harvard Medical School; Ken Fujioka, Scripps Clinic; GlaxoSmithKline; Shawn Gomez, University of North Carolina; David Harrison, Jackson Laboratory; Stephen Hoffman, Sanaria; Michael Huerta, National Institute of Mental Health; Andreas Jordan, MagForce Nanotechnologies; Nagesh Kolishetti, University of Georgia; Michael Okun, University of Florida; Bernhard Palsson, University of California at San Diego; Vern Schramm, Albert Einstein School of Medicine; William Scott, Miami Institute of Human Genetics; Christopher Walsh, Harvard Medical School

Tissue Engineering

In 2008, researchers got a cadaver rat heart to beat on its own by stripping the organ of its cells and regrowing them with live stem cells from another animal. The technique could be used to grow organs on scaffolds using a patient's own cells, eliminating the need for a donor organ.

Immunotherapies

The battle against incurable autoimmune conditions such as diabetes, rheumatoid arthritis and multiple sclerosis achieved a breakthrough in 2009 when Richard Burt of Northwestern University showed that doctors could rebuild patients' immune systems with adult stem cells.



Nano-med Miracles

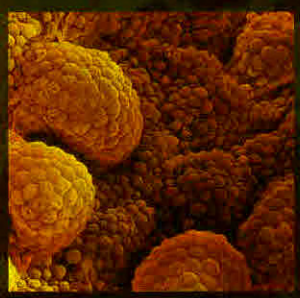
New nanoparticle cancer treatments have made their way through clinical trials. In one version, tumors are injected with iron nanoparticles. The iron is excited by a rapidly alternating magnetic field, raising the temperature and killing the cancer cells while leaving healthy cells unharmed.

HIV Preventers

In 2009 a vaccine tested on 16,000 people in Thailand proved to be 31 percent effective—the first time a vaccine showed any signs of working—and in a study last year, a vaginal microbicide was 39 percent effective in preventing HIV in South African women.

Successful Gene Therapies

In American and European clinical trials, researchers successfully injected a gene to replace a faulty one in the retinas of six patients with a congenital retinal disease that causes blindness. Since then, the teams have found that the treatment is particularly effective in young patients.



Cancer Vaccines

In 2006 the FDA approved a preventative vaccine that targets cervical-cancer-causing human papillomavirus. And in 2009, Dendreon, a biotech company in Seattle, completed clinical trials of a treatment vaccine against prostate cancer [left]. The FDA approved the vaccine last year.

MAIN IMAGE: SPL/FOCUS; INSETS, CLOCKWISE FROM TOP LEFT: T. MATTHIESEN/UNIVERSITY OF MINNESOTA; LABORATORIES AT THE ARMED FORCES RESEARCH INSTITUTE OF MEDICAL SCIENCES/BANGKOK, THAILAND; DANIEL BURKE; MAGFORCE NANOTECHNOLOGIES; NORTHWESTERN UNIVERSITY