

7 Cool New Findings About the Brain

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The human brain is the most complex and least understood biological structure in the known universe. President Obama's new BRAIN Initiative, which is co-led by the National Science Foundation (NSF), is designed to advance brain research. Here are examples of ongoing NSF-funded brain research that runs the gamut from discoveries about the brains of dinosaurs and birds to research involving Alzheimer's and beyond.

- 1. Surprise! Some types of wrinkles are good.



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Mouse brain



Human brain



Credit: Elizabeth Atkinson, Washington University in St. Louis

Humans have an advantage in the animal kingdom because our brains are bigger and more wrinkled than those of other animals. Brain size and wrinkle numbers correlate with intelligence across species.

Brain wrinkles are now thought to be almost as hereditary as height, and the more of them, the better. Why? Because wrinkles increase the surface area available for brain cells without increasing head size--which is good for mothers during childbirth.

Elizabeth Atkinson of Washington University in St. Louis recently discovered genetic regions, comprised of groups of chromosome segments and genes, that

correlate with fold numbers in about 1,000 baboon brains—animals that are genetically similar to humans. The next step is to pinpoint where in these genetic regions folding patterns originate, which would provide insights on the human brain's evolution.

2. Dinosaurs: Not big and dumb, after all -- just big?

A new map of a general dinosaur brain suggests dinosaurs may have had cerebrums, which control complex cognitive behaviors in mammals. Although scientists haven't identified the functions of dinosaur cerebrums, their existence would suggest that dinosaurs may have performed more complex behaviors than previously believed, such as forming social groups and possibly communicating.

The map is based on inferences from the genetics and organization of crocodile brains, which pre-date many dinosaurs and are their closest living relatives, and of birds, which post-date dinosaurs—and thereby form a chronological evolutionary chain with dinosaurs.

Created by a team led by Erich Jarvis of Duke University, the map is also based on features of the dinosaur brains' shape implied by their fossilized skull cavities.

3. Scientists may be able to predict when you'll engage in risky business.

Recent advances in brain imaging technology may allow researchers to predict whether someone will make a safe or a risky financial decision based on certain types of brain activity prior to deciding.

According to Brian Knutson and Charlene C. Wu of Stanford University, people who expect to win big show increased activity in certain brain regions, including the nucleus accumbens, which is associated with reward and pleasure, whereas those who expect to lose show increased activity in the anterior insula, which is linked to anxiety and disgust.

The more money at stake, the more activity is seen in those regions. But while more activity in the nucleus accumbens encouraged risk-taking, more activity in the anterior insula reduced risk taking.

These findings imply that when people are more excited, they will take bigger risks. Long-shot wins (like potential lottery wins) increased both excitement and nucleus accumbens activity, encouraging people to take risks, even as they strayed from the choices of a "rational" person.

Studying people's brains while they consider their risk-taking options reveals insights about why people make certain financial decisions.

4. Cell-based therapy may ultimately help beat back brain tumors.

Brain tumors, which are invariably deadly, are the second-leading cause of U.S. cancer-related deaths, with 70,000 diagnoses annually.

Now, Stefan Bossmann and Deryl Troyer of Kansas State University are working to improve a promising type of cell therapy that has yet to be used successfully. The researchers' therapy would work by collecting a cancer patient's blood; refurbishing selected white blood cells with "cargo holds" or closed cavities filled with anticancer drugs; and then re-injecting the patient's blood so that treated white blood cells would deliver the drugs directly to virulent tumors.

Previous efforts to develop such cell therapies produced weak, leaky cavities that killed carrier cells, not tumors. But the researchers are developing a new material for the cavities that would be selectively absorbed by the white blood cells, reliably hold drugs and self-destruct upon reaching tumors.

This therapy would deliver more anticancer drugs to tumors than other therapies, without damaging immunity.

With preliminary experiments in mice completed, the therapy will soon be specifically targeted to mice brain tumors for the first time, with the hope that this will ultimately be able to be used successfully on human brain tumors.

5. Designer antibodies may ultimately help fight Alzheimer's.

Antibodies—proteins traditionally produced by the body's immune system in response to invaders—are already established allies in our fight against the flu virus and other harmful entities. Now, they are being engineered to treat and possibly protect against disease-linked proteins, such as those associated with Alzheimer's disease.

Such engineering requires designing antibodies that have extreme targeting capabilities, so they can be directed to go where and do exactly what we want.

But antibodies used for therapeutic or experimental applications are usually taken from immunized animals or enormous antibody libraries; it's difficult to custom-order them.

Peter Tessier of Rensselaer Polytechnic Institute is working to engineer antibodies that have precise properties. By placing DNA sequences from a target protein within antibodies, Tessier may design the antibodies to bind to select proteins, such as proteins linked with Alzheimer's called beta-amyloid plaques. Further research may lead to the development of antibodies that recognize and remove toxic particles before they do harm.

6. Birds' responses to climate change: It's all in their heads.

Different bird species use different cues to determine when to migrate and reproduce. Whether a particular species will adjust its timing fast enough to keep up with climate change may partly depend on the cues it uses.

To varying degrees, all bird species use day length as a cue. They measure day length and anticipate seasonal changes via light-activated receptors located deep in their brains. The light penetrates their skulls without even necessarily passing through their eyes.

Because day length is unaffected by climate change, some long-distance migrators whose main migratory cue is day length have kept fairly consistent arrival times at their spring breeding grounds. Yet, spring temperatures now tend to increase earlier in the year because of climate change. So such migrators now tend to arrive at their breeding grounds late relative to premature springs—and therefore now miss insect population peaks upon which they previously feasted. With less to eat, such migrators are now having fewer chicks, which may cause population declines.

Some bird species augment day length cues with others such as temperature, which are likely also processed in their brains. Changes in the migration timing of some temperature-sensitive species correlate with climate change-related temperature changes.

Most studies of how birds process day length have addressed only males. But Nicole Perfito of the University of California, Berkeley, is now studying how females of two bird species process day length and other cues that influence the timing of egg laying—an important factor in their potential responses to climate change.

7. Still wanted: a complete parts list of the human brain.



A neuron in the human brain. Credit: ThinkStock

The human brain has about 100 billion neurons. But scientists don't yet have a complete inventory of the many types of brain cells that exist. They also don't fully understand how electrical and chemical signals from neurons produce thoughts and actions.

Without such knowledge, scientists cannot yet explain how major traumatic injuries and neurodegenerative diseases impair brain function or should be treated. By comparison, imagine a mechanic trying to fix a car without a complete parts list or an understanding of how it runs.

Yet, new types of brain cells are often being identified, partly because of new imaging techniques that can zoom in on the brain in increasing detail, just as Google Maps can zoom in on neighborhoods.

But without a universal classification system, cell types that have already been discovered have been named and classified according to inconsistent criteria, such as shape, function or location.

Therefore, some newly "discovered" cell

types may really be rediscovered, renamed cell types.

To create a universal inventory of brain cells types and standardize their names, Edward Boyden of MIT and others are working with the Allen Institute for Brain Science to create the first comprehensive database of types of brain cells.

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