

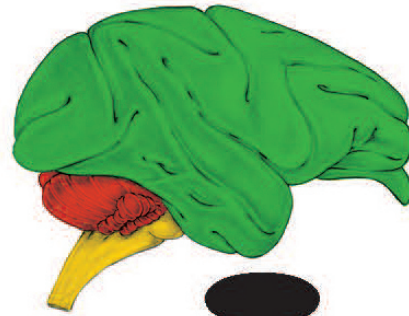
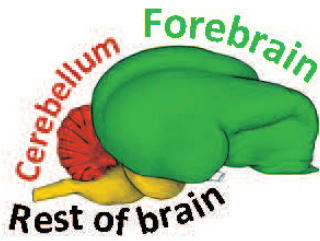
Research gives new meaning to the term 'bird brain'

June 13 2016

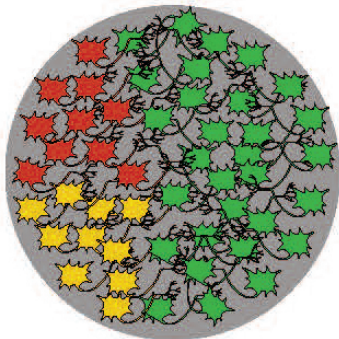
Bird

vs.

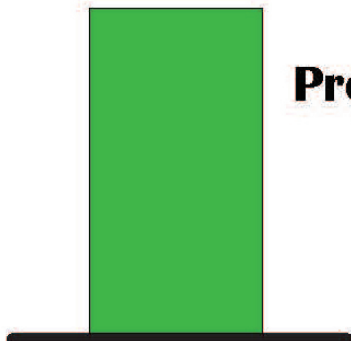
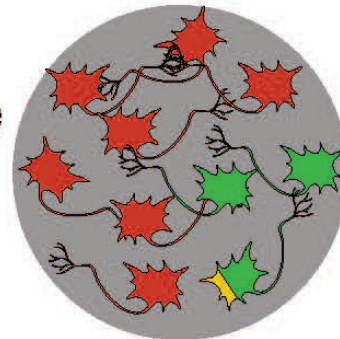
Mammal



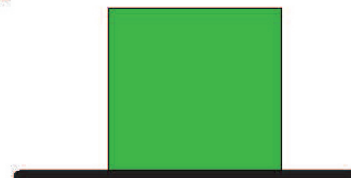
Brain mass



Density and size of neurons



Proportion of neurons in the forebrain



Graphic abstract illustrates the results of the study of the number of neurons in avian brains. Credit: Pavel Nemeč, Charles University at Prague

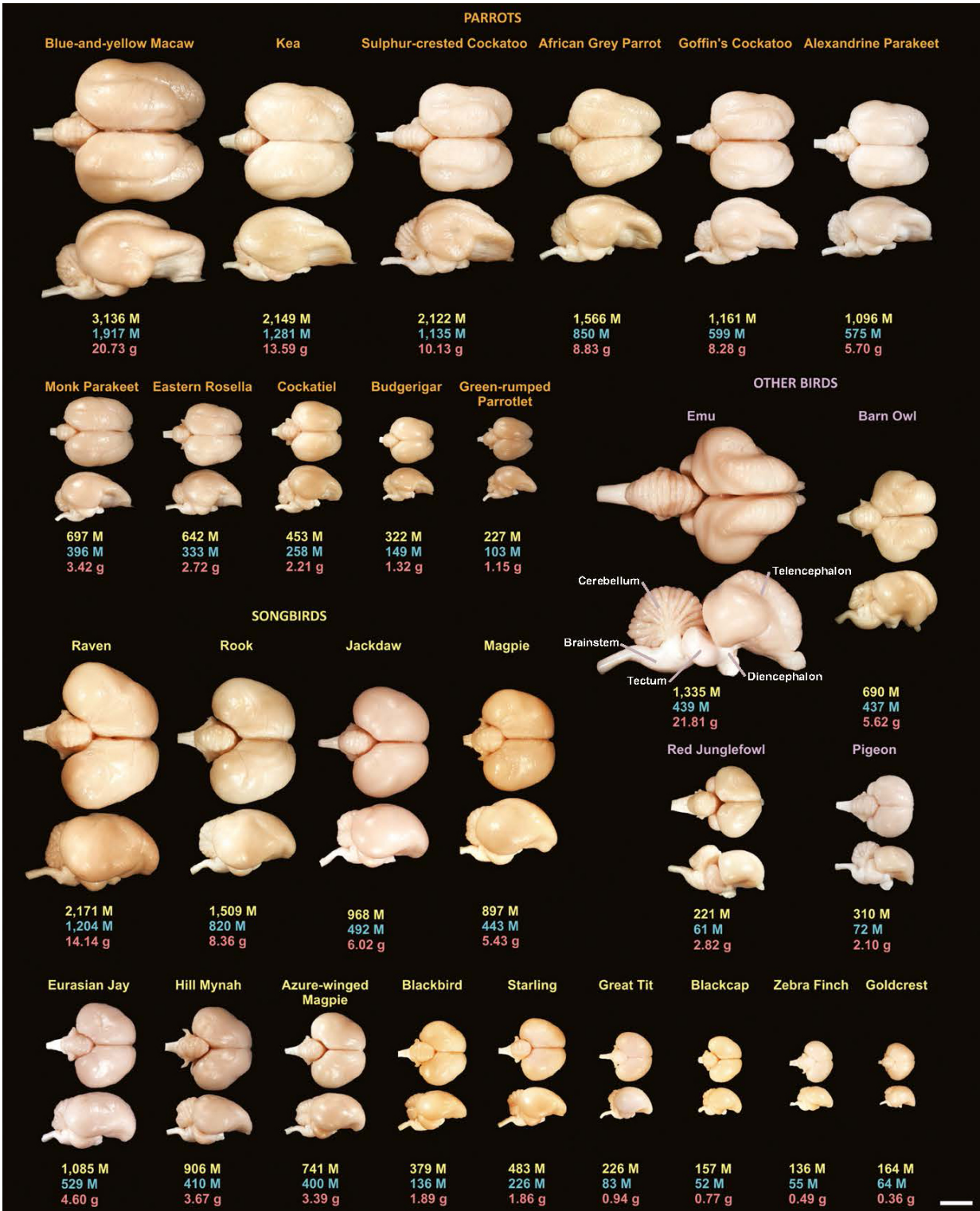
The macaw has a brain the size of an unshelled walnut, while the macaque monkey has a brain about the size of a lemon. Nevertheless, the macaw has more neurons in its forebrain - the portion of the brain associated with intelligent behavior - than the macaque.

That is one of the surprising results of the first study to systematically measure the number of neurons in the brains of more than two dozen species of birds ranging in size from the tiny zebra finch to the six-foot-tall emu, which found that they consistently have more neurons packed into their small brains than are stuffed into mammalian or even primate brains of the same mass.

The study results were published online in a paper titled "Birds have primate-like numbers of neurons in the forebrain" in the *Proceedings of the National Academy of Sciences* early edition on the week of June 13.

"For a long time having a 'bird brain' was considered to be a bad thing: Now it turns out that it should be a compliment," said Vanderbilt University neuroscientist Suzana Herculano-Houzel, senior author of the paper with Pavel Nĕmec at the Charles University in Prague.

The study provides a straightforward answer to a puzzle that comparative neuroanatomists have been wrestling with for more than a decade: how can birds with their small brains perform complicated cognitive behaviors?



The collection of avian brains that the scientists analyzed. For each species, the

total number of neurons (in millions) in their brains is shown in yellow, the number of neurons (in millions) in their forebrains (pallium) is shown in blue and their brain mass (in grams) is shown in red. The scale bar in the lower right is 10 mm. Credit: Suzana Herculano-Houzel, Vanderbilt University

The conundrum was created by a series of studies beginning in the previous decade that directly compared the cognitive abilities of parrots and crows with those of primates. The studies found that the birds could manufacture and use tools, use insight to solve problems, make inferences about cause-effect relationships, recognize themselves in a mirror and plan for future needs, among other cognitive skills previously considered the exclusive domain of primates.

Scientists were left with a generally unsatisfactory fallback position: Avian brains must simply be wired in a completely different fashion from primate brains. Two years ago, even this hypothesis was knocked down by a detailed study of pigeon brains, which concluded that they are, in fact, organized along quite similar lines to those of primates.

The new study provides a more plausible explanation: Birds can perform these complex behaviors because birds' forebrains contain a lot more neurons than any one had previously thought - as many as in mid-sized primates.

"We found that birds, especially songbirds and parrots, have surprisingly large numbers of neurons in their pallium: the part of the brain that corresponds to the cerebral cortex, which supports higher cognition functions such as planning for the future or finding patterns. That explains why they exhibit levels of cognition at least as complex as primates," said Herculano-Houzel, who recently joined the Vanderbilt psychology department.

That is possible because the neurons in avian brains are much smaller and more densely packed than those in mammalian brains, the study found. Parrot and songbird brains, for example, contain about twice as many neurons as primate brains of the same mass and two to four times as many neurons as equivalent rodent brains.

Not only are neurons packed into the brains of parrots and crows at a much higher density than in primate brains, but the proportion of neurons in the forebrain is also significantly higher, the study found.

"In designing brains, nature has two parameters it can play with: the size and number of neurons and the distribution of neurons across different brain centers," said Herculano-Houzel, "and in birds we find that nature has used both of them."

Although she acknowledges that the relationship between intelligence and neuron count has not yet been firmly established, Herculano-Houzel and her colleagues argue that avian brains with the same or greater forebrain neuron counts than primates with much larger brains can potentially provide the birds with much higher "cognitive power" per pound than mammals.

One of the important implications of the study, the neuroscientist said, is that it demonstrates that there is more than one way to build larger brains. Previously, neuroanatomists thought that as brains grew larger neurons had to grow bigger as well because they had to connect over longer distances. "But bird brains show that there are other ways to add neurons: keep most neurons small and locally connected and only allow a small percentage to grow large enough to make the longer connections. This keeps the average size of the neurons down," she explained.

"Something I love about science is that when you answer one question, it raises a number of new questions," said Herculano-Houzel.

Among the questions that this study raises are whether the surprisingly large number of neurons in bird brains comes at a correspondingly large energetic cost, and whether the small neurons in bird brains are a response to selection for small body size due to flight, or possibly the ancestral way of adding neurons to the brain - from which mammals, not [birds](#), may have diverged.

Herculano-Houzel hopes that the results of the study and the questions it raises will stimulate other neuroscientists to begin exploring the mysteries of the avian brain, especially how their behavior compares to that of mammals of similar numbers of [neurons](#) or [brain](#) size.

More information: Birds have primate-like numbers of neurons in the forebrain, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1517131113

Provided by Vanderbilt University

Citation: Research gives new meaning to the term 'bird brain' (2016, June 13) retrieved 6 May 2024 from <https://medicalxpress.com/news/2016-06-term-bird-brain.html>

<p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p>
--