

Re: Body Temperature

Source: <http://sci.tech-archive.net/Archive/sci.med/2004-07/0122.html>

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Date: 07/03/04

Date: 2 Jul 2004 23:05:06 -0700

bae@cs.toronto.no-uce.edu.yyz wrote in message news:<2004Jun30.111210.13021@jarvis.cs.toronto.edu>...

> *Still, we seem to routinely live several times longer than other mammals*
> *of comparable size under comparably good conditions.*

COMMENT:

Yes. The number you're really looking WRT aging is specific metabolic rate multiplied by maximum life span. That gives you a "calories/joules per gram per lifetime" number. More than a hundred years ago Perls noticed that this number is (very) roughly the same for all mammals. It's pretty close to the same for mice and elephants, for example— mice have 20 times the specific metabolic rate (specific means "per gram") that elephants do, but they live 3 years max instead of 60, so it works out the same number for each. An elephant-load of mice burn an elephant lifetime of food in only 3 years. Mice run very hot, because they need to keep warm and have a poor surface volume ratio, like everything small.

Not surprisingly, except in shrews (which have hit the heartrate limit), mammalian heartrate scales according to specific metabolic rate. So mice have 20 times the elephant's 30 bpm heart rate, and that gives both species the same number of heartbeats per lifetime.

A few species are way off this heartbeat calorie burned per life span curve. Humans get up to 3 times the number of calories per gram and heartbeats that elephants and mice do. Capuchin monkeys do nearly as well as humans.

Clearly, metabolic rate itself in placental mammals is a surface/volume thing, so it scales roughly as the $2/3$ power of body weight (actually more like $3/4$ for some reason— probably having to do with nature economizing on calories by fooling around with hair length). So the max calorie per lifetime limit generally makes large mammals live longer. [Specific metabolic rate is divided by weight, so it generally scales as $3/4 - 1 = -1/4$ power of size. A mouse weighs 30 g and a human 60 kg, with the ratio $1/2000$. Raise that to the $-.25$ power and you get 6.7, which is about the right ratio of specific

metabolic rates].

Big exceptions to the rule are primates like capuchins and humans, and we both have very large brain/body wt ratios. So evidently large brains are such a good evolutionary trick against predation that it's worth it for evolution to spend time repairing us, and thus we age more slowly metabolically and get 3 billion heartbeats in a lifetime, instead of the standard billion for mice, cats, cows, etc.

An even better trick is wings. Birds and bats both do several times better than even primates, including humans. Some bats don't cool in the day, and live 20 years anyway. This in an animal with twice the metabolic rate of the similar sized mouse which gets 3 years. Do the math.

Shells are a good trick against predation, and turtles do the best among reptiles. But if you do the heartbeat/heat calculation, even turtles at 200 years don't do better than primates/humans.

Body temp in placental mammals (naked mole rats excepted!) is almost completely independent of all this, except that critters with the need for high metabolic scope (really high aerobic capacity) tend to run higher temps. Birds all run very hot by mammal standards, and so do active bats. It's easy to see why dogs run 39–40 C. What's not so easy to see is why cats run almost as hot. As noted, the correlation isn't perfect. A better correlation is that carnivores/hunters, which have the need for really high metabolic bursts, then high rates of digestion afterwards, tend to have slight higher temps. So that gets cats in. We humans and omnivores, and in just a few million years haven't gotten our temps much above those of our vegetarian primate ancestors. We have great aerobic capacity— as good as anything except canids. But we learned to run on the really hot savannah, where the higher body temps weren't really needed. When we were running, we generated them for ourselves. Even now, your average marathoner gets up to at least 38 C and often 39.

Steve