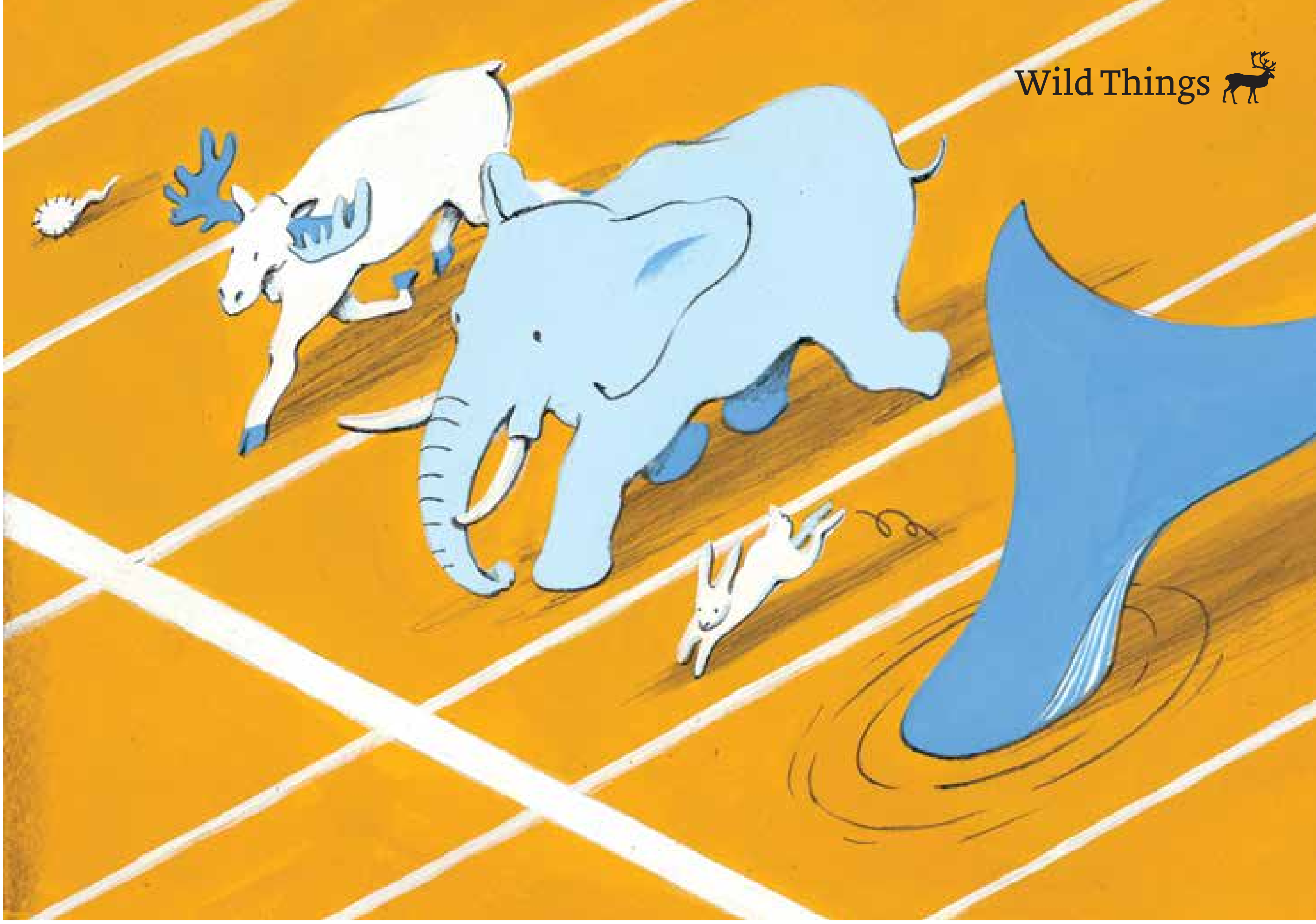


You Can't Really Go Over the Limit

You can try. But the physics of wildlife suggests that animals have a built-in top speed. And it's pretty much the same for all of them

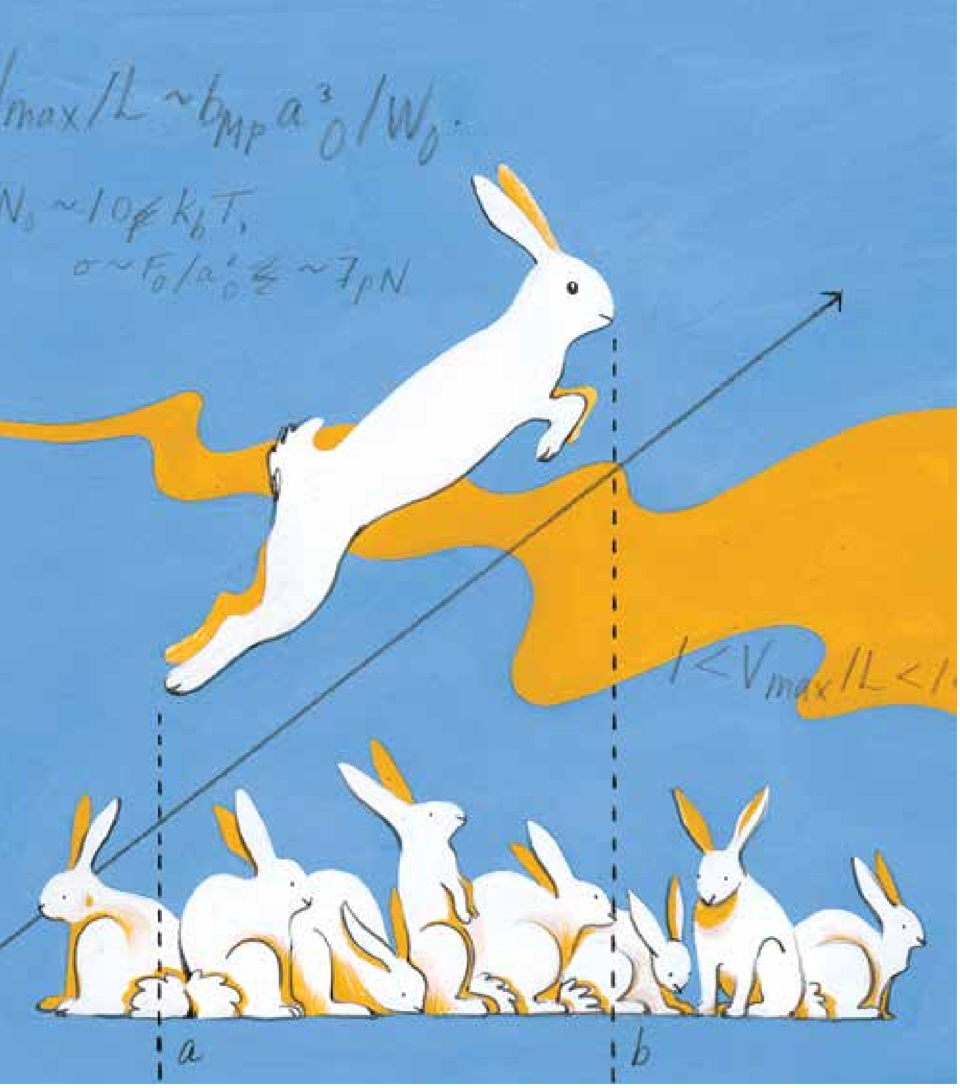
By Jay Ingram Illustration by Christy Lundy

You might not expect to find revelations about wildlife in the *American Journal of Physics*, but in the August 2015 issue, French researchers Nicole Meyer-Vernet and Jean-Pierre Rospars made an extraordinary claim: All living things move at about the same top speed. Not absolute kilometres per hour of course, but body lengths per second. It is nearly the same for everything from bacteria to whales, hovering around 10 body lengths per second.

There are some qualifications that I'll get to in a minute, but first it's worth savouring this extraordinary finding.

Think about it: The bacterium Meyer-Vernet and Rospars reference in their work is *Bacillus subtilis*. It's a common and unremarkable bug — you likely harbour some in your gut right now — that propels itself through the liquid in which it's immersed by means of a single flagellum, a rigid, rotating spiral attachment to its body. (And that's no mean feat. At just five-millionths of a metre long, the drag forces faced by *Bacillus subtilis* are about the same as we'd experience swimming through honey.)

At the other end of the scale: the blue whale, the largest animal ever to exist on earth. It is about 30 metres long. That's six million times longer than *Bacillus subtilis*. Yet for both, their speeds per body length are in the range of 10 per second. By any measure that is surprising, although I suppose you could argue there's a distant similarity between the two. Both are, in a sense, "swimming."



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But Meyer-Vernet and Rospars don't stop at "swimming" bugs and whales. They compare humans, mites, rabbits, lizards, fish, elephants and many, many more species. That most should travel at comparable top speeds is dumbfounding. After all, locomotion across this range is variously provided by two legs, four legs, eight legs, fins and cilia.

Now, it should be said that the maximum speeds are not numerically identical: there is a range amounting to a factor of 10. You might say that's substantial, but it's trivial when you consider that the lengths of the organisms being considered, and the actual distance they cover every second, differ by as much as 10 million. Consistency within a factor of 10 looks pretty good by comparison.

So what is the mystery common factor that underlies this? Meyer-Vernet and Rospars argue there are three. First, the average density of all living things is approximately the density of water (remember that we are something like 60 per cent to 70 per cent water ourselves). Density is obviously an important factor in the ability to move quickly, and organisms everywhere share that challenge.

Second, there is a consistent range for the amount of force that can be applied to living tissue. Yes, there is a wild diversity among the organisms considered in this study, but they all share the fundamental biological motors that convert chemical into mechanical energy to be able to move. In this sense, even a muscle can be compared to a flagellum by seeing it as a collection of fibres versus a single fibre.

Finally, Meyer-Vernet and Rospars argue that the amount of power available for movement — in any organism — is consistent. Metabolic rates, the amount of energy expended, are as remarkably consistent among a huge range of animals as are the maximum speeds that are the subject of this current study. In other words, bacteria and whales — even algae and trees — expend (again, roughly) the same amount of energy to sustain their lives.

So this triad of density, force and metabolism are, according to the authors, the factors that conspire to limit the maximum speeds possible to a very narrow range.

There are exceptions. Meyer-Vernet and Rospars left flying animals out of their study because wing flapping is their principal expenditure of energy and it doesn't correlate directly to maximum speed. Air drag also complicates the situation, putting flying animals outside the capabilities of the physics models used in this study.

Extremely large animals also begin to deviate from the rule (although, like the whale, still remaining within reasonable bounds) because muscle strength to move limbs or fins in the extreme angles necessary to move at maximum speed becomes a limiting factor. Even so, the blue whale is just slightly out of the range of all the rest.

Again it is important to see that while there is variation in the maximum number of body lengths per second, the variation is minor, even minuscule compared with the range of sizes, shapes, locomotor apparatus and just about anything else you can think of among these organisms. Nature: almost infinitely variable. Physics: numerically precise. Yet here they meet.