Sound of Science
(理聲)

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Science Society,
Dec 2020
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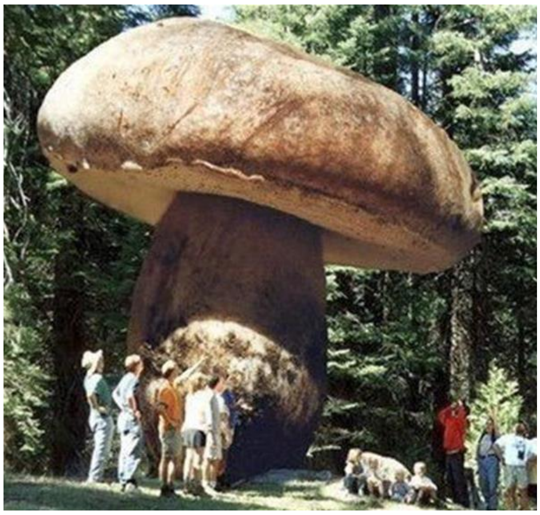
Can a Creature Expand As Big As an Universe?

Introduction

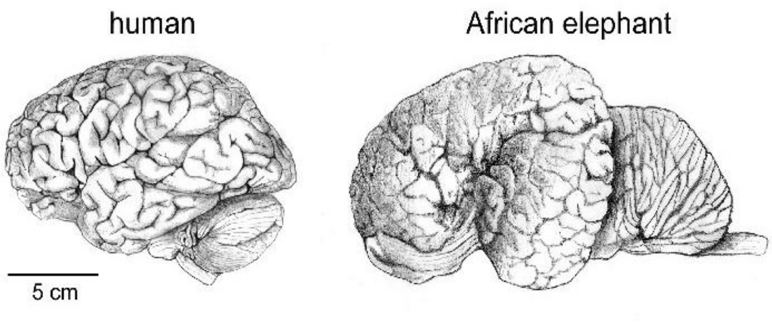


The size of things in our universe runs all the way from the tiny 10^{-19} meter scale to the cosmic horizon 10^{26} meters away. In these 45 possible orders of magnitude, life, it is confined to roughly in the middle of the universal range: Bacteria and viruses can measure less than a micron, or 10^{-6} meters, and the height of the largest trees reaches roughly 100 meters. The honey fungus that lives under the Blue Mountains in Oregon, is about 4 kilometers across. When it comes to known sentient life, the range in scale is even smaller, at about three orders of magnitude.

Could Things Be Any Different?

Given that our brains are composed of neurons, we can conclude that biological computers need to be about the physical size of our own brains in order to exhibit the capabilities that we have.

We can imagine building neurons that are smaller than our own, in artificially intelligent systems. Electronic circuit elements, are now substantially smaller than neurons. But they are also simpler in their behavior, and require a superstructure of support (energy, cooling, intercommunication) that takes up a substantial volume. It’s likely that the first true artificial intelligences will occupy volumes that are not so different from the size of our own bodies, despite being based on fundamentally different materials and architectures.



Limits on Animal Size and Shape

1. Insufficient Time for Formulation

Interesting thoughts require not only a complex brain, but also sufficient time for formulation. The speed of neural transmissions is about 300 kilometers per hour, implying that the signal crossing time in a human brain is about 1 millisecond. A human lifetime, then, comprises 2 trillion message-crossing times. If both our brains and our neurons were 10 times bigger, and our lifespans and neural signaling speeds were unchanged, we'd have 10 times fewer thoughts during our lifetimes.

If our brains grew enormously to say, the size of our solar system, and featured speed-of-light signaling, the same number of message crossings would require more than the entire current age of the universe, leaving no time for evolution to work its course. If a brain were as big as our galaxy, the problem would become even more severe. From the moment of its formation, there has been time for only 10,000 or so messages to travel from one side of our galaxy to the other.

2. Constraints of Environment on Physical Bodies

Remarkably, the constraints of environment on physical bodies also constrain life to be roughly the same size that intelligence requires. The height of the tallest redwoods is limited by their inability to pump water more than 100 meters into the sky, a limit set by a combination of the force of gravity on the Earth (which pulls the water down) and transpiration, water adhesion, and surface tension in the plant xylem (which pushes it up). If we suppose that the force of gravity and atmospheric pressures of most habitable planets will be within a factor of 10 of Earth's, we will be left within a couple orders of magnitude of the same maximum limit.

If we also assume that most life will be bound to a planet, moon, or asteroid, then gravity also sets a natural scale. As the planet gets bigger, and its gravity gets stronger, the force on the bones of some hypothetical animal increases. Tat animal would therefore need to increase the cross section of its bones to handle the greater force, which increases as the square of the animal size.

These bodybuilding efforts however, would ultimately be self-defeating because mass rises as body size cubed. In general, the maximum mass of mobile terrestrial organisms decreases roughly linearly with the increasing strength of gravity. Conversely, a planet with

10 times lower gravity than Earth's could potentially have animals that are 10 times bigger.

3. Difficult for Cooling Effects

Life also needs to be cooled. Computer chip designers continually face the challenges inherent to removing the heat generated by computation. ***Living things have the same problem: Large animals have a high ratio of volume to surface area.*** Since the skin is what's responsible for cooling the animal, and the volumes are where all the heat is produced, big animals are less efficient at cooling themselves off. The metabolic rate per kilogram of Earth's animals decreases in proportion to the mass of the animal raised to the power of 0.25.

Assuming that the minimum observed whole-body metabolic rate of one-trillionth of a watt per nanogram is necessary for a mammal to function, we arrive a maximum thermally limited organism size of just over 1 million kilograms, or somewhat larger than a blue whale, Earth's all-time record-setting animal in terms of size.

4. Difficult to find sufficient nutrients

An Earth-sized object has a low surface area to volume ratio, so it is questionable whether a process like photosynthesis could generate sufficient energy to sustain the creature. It would have no viable means of gaining nutrients and would have to be entirely self-contained, something that is not compatible with life as we know it. Creatures need to take nutrients in and excrete wastes, a process which does not seem very compatible with planet-sized entities.

Conclusion

Scientists cannot find any Earth-sized living creatures in the universe now, not without coming up with some extremely novel definitions of life. But still you never know what secrets behold the universe .

Comic Corner

Relaxing Zone

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3			7		9			
			4		1			9
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Daily SuDoku: Mon 23-Nov-2020 medium

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5	6	3	9	1	2	7	8	4
1	9	4	6	8	7	5	2	3
3	4	2	7	6	9	8	1	5
6	1	9	5	3	8	4	7	2
7	8	5	4	2	1	6	3	9
4	3	9	8	7	6	2	5	1
6	2	7	1	5	3	8	4	9
8	5	1	2	9	4	3	6	7

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