Please show **all** work and justify your responses.

A Fermi problem with a twist

Just to stay alive, how much more salad should a triceratops eat on an average day compared to you? *Hint: assume humans and dinosaurs are blackbody emitters.* $\sigma_{SB} \approx 5.67 \times 10^{-8}\ W/m^2\ K^{-4}$.

A Possible Solution

This is an illustration of a problem which is rather ambiguous and has no definitive answer. In physics and especially in astronomy, we often run into problems like this that are loosely constrained. This is where our order of magnitude estimation skills becomes relevant. We are free to look up what we know about dinosaurs and their properties, but we are forced to make many assumptions along the way.

We need to find the amount of energy required to keep us (humans) alive compared to a dinosaur. To do this, we need to calculate the luminosity of a human and derive its power per unit mass. A human is made mostly of water, so we assume a density of 1000 kg/m^3. Let us say the mass of the human in question is 60 kg. We can derive the volume to be 0.06 m^3 if we approximate the shape as a sphere and we can get the effective radius of an "average" human.

$$V = \frac{4}{3}\pi R^3 = 0.06\ \text{m}^3 \rightarrow R = 0.243\ \text{m} \tag{1}$$

Then, we can find the luminosity of the human. Let's assume a body temperature of 98°F = 310 K.

$$L_{human} = 4\pi R^2 \sigma_{SB} T^4 = 389\ \text{W}\ [=]\ 389\ \text{J/s} \tag{2}$$

At this rate, humans require 3.35×10^7 J of energy to stay alive. Let us assume that 1 serving of salad is equivalent to 1 kilogram of salad which yields about 1000 kilocalories (4.164×10^6 J) of energy if you were eating a McDonald's Fruit and

Walnut Salad. This means that if we were eating this salad, we would need 8.06 kg (or servings) of it a day to survive.

OK, now for the triceratops. To find the amount of energy a triceratops needs to radiate in a day, we treat the animal as a blackbody and find its luminosity. The "radius? of a triceratops is found the same way as before, but using an assumed mass of 14,000 lb. = 6350 kg [1] and a density of 1000 kg/m3. This means that its volume is 6.35 m^3 and approximating the animal as a sphere, we find it has a radius of 1.15 m. We take the body temperature to be 38°C = 311 K [2].

$$L_{dino} = 4\pi R^2 \sigma_{SB} T^4 = 8816 \text{ W } [=] \text{ 8816 J/s} \tag{3}$$

This means that a dinosaur needs an input of 7.62×10^8 J per day. That amounts to 183 kg of salad a day just to stay alive, which is nearly 23 times the amount of salad a human requires to stay alive per day.

Sources:

[1] https://www.dinopit.com/how-big-was-triceratops/

[2] https://phys.org/news/2011-06-body-temperatures-dinosaurs.html