Trophic levels and ecological pyramids worksheet answers part

So, in the diagram above, what's left to be transferred to the next trophic level? Make a prediction: As, you've just seen, here are the numbers: 1) Harvestable food energy available in plants 2,000,000 calories 2) Harvestable food energy available in animals that eat the plants 200,000 calories Harvestable energy means exactly what it says. Consider a forest ecosystem where one tree might support thousands of insects, which are preyed upon by birds. Or, using the terms related to trophic levels that we learned in the previous tutorial, the harvestable energy in the producers (plants) is ten times as great as the harvestable energy in primary consumers. To make sure that you're getting this, try to label the diagram below. The diagram below, which shows a caterpillar harvesting energy from a leaf, shows heat loss, and one additional source of energy loss (note that this diagram uses Joules (J) instead of Calories. Similarly, many of the food calories that you feed to a cow, as they are used by the cow to keep itself alive, dissipate as heat into the environment. Ecological Pyramids Ecologists have organized this notion of energy loss in ecosystems into a pyramid of energy. I've tried to capture a lot of these ideas in my Food Chain song. The loss of 90% of the available food energy from producers to consumers is a widely known rule in ecology. In my Food Chain Song (embedded below), I refer to the heat loss as "metabolic rent." But there are more reasons why energy transfer between trophic levels is so inefficient. What the 10% rule says is this: If you gathered up all of the primary producers and measured their chemical energy, and then did the same with the herbivores/primary consumers, the herbivores would have only 10% of the total chemical energy that was available in the producers. The vegetarian strategy is the wiser course of action. 7. At an average of 2,000 calories/crewmember, that would get you a crew of 1,000. If the sun stopped shining, energy would stop flowing, and life would cease. The rule is called the 10 Percent Rule. But what happens if we wanted to eat as carnivores? As this chemical energy moves from trophic level to trophic level, most of the energy diffuses away as heat. But remember that this an analysis of one animal eating a part of a plant. Consequently, fewer and fewer organisms can be supported at higher trophic levels. Each level in a food chain yields only ten percent Of the former level's energy you might ask where it went There are bones and leaves you can't digest that really make a dent And don't ignore the weighty cost of metabolic rent. Note that in this ecosystem, the energy available in the producers starts at 600,000 units of energy. Producers transform this light energy into chemical bond energy through photosynthesis, capturing it as carbohydrates. Concluding Thoughts The key idea from this module is that while matter in ecosystems is endlessly recycled, energy dissipates as it flows from one trophic level to the next. Here's a haiku that captures this: In ecosystems Energy will dissipate But matter cycles The energy doesn't disappear. And, if you gathered up all of the secondary consumers/carnivores, and compared the energy in that trophic level to the energy in the primary consumers, you'd find that once again, you'd only transferred 10% of the energy. Your spaceship is to carry colonists on a decades-long journey to your new home. In the pyramid, you can see available energy dropping by 90% from one trophic level to the next. Rather, much of the energy is lost as heat: heat that you can feel coming off a car's hood. One reason is that the work that cells do to keep themselves alive is not performed with perfect efficiency. If you are watching it in a classroom setting, please use headphones or earbuds so as not to disturb the students around you. But given the limits of size of ship and amount of energy it can produce, it makes sense to have the crew eat primarily as herbivores, instead of primarily as carnivores. Only the 33J labeled as "growth." The fact that 33/200 is 16.5%, as opposed to to 10% might seem confusing. 3. Or consider eating an apple: there's the whole rest of the tree that you're not consuming. 4. Let's feed our grain to the cows and eat as carnivores. If you want to read more about pyramids of biomass, you can follow this link to Wikipedia. All of the chemical energy lost as heat is not going to be available to the next trophic level: the carnivores who eat the cow. Eating as secondary consumers/carnivores, you've have 200,000 calories available for the crew. The Easy Math of Energy in Trophic Levels To keep the math easy, let's set 2000 Calories/day as our average target calorie intake for each crewperson. But that goes beyond the scope of our efforts here. Let's check your understanding of ecological pyramids with this quiz. When you eat chicken, you mostly eat the muscle tissue around the breasts, back, and legs. MISCONCEPTION ALERT: Before going further, let's clear up a possible point of confusion. To translate what's above into actual crew numbers, here's the math. It just becomes less useful. Remember that our ship can produce a lot of energy: enough to grow 2,000,000 food calories worth of food each day. That would be the first row: harvestable energy available in plants. At the end of the last module, you responded to this scenario: You're the director of a mission to colonize a planet in another solar system. But note the 100J arrow to the left labeled "feces." Not everything that an organism ingests goes making more of that organism. Some ingested food is indigestible, and passes right through you. Understanding the 10% Rule Why is so little energy transferred from one trophic level to the next? Just think of yourself as a primary consumer. Let's apply the 10% rule to the issue of largest possible crew size on our spaceship to Alpha Centauri. If you widen the analysis to thinking about the actual organisms living in an ecosystem, you can find additional reasons for energy loss between trophic levels. We'll do that in a moment, but first, answer the questions below. Of course, the actual decision would be much more nuanced. One is a pyramid of numbers. If you feel confident that you've mastered the ideas in this module, take this quiz. In almost every ecosystem on Earth, energy starts as sunlight. On an ecological level, all of that defecated matter doesn't become available to the next trophic level. Like a pyramid of numbers, there are biomass pyramids that are inverted, with the base more narrow than the layers above. The proportions would be the same). Image source: . Imagine taking all of the plants that we can grow on the ship, and measuring their energy. Biological Magnification: Interactive Reading 6. In the pyramid of numbers below, you see that 1,500,000 producers support 200,000 herbivores. If we measured the amount of chemical energy available to us from the cows, how much energy would be available for the crew? That heat is wasted energy that dissipates (disperses, diffuses) into the environment. A spaceship for founding a space colony: crew size depends on your decisions about diet. Biomass is living matter, and a biomass pyramid shows the amount of living matter in each trophic level. All the rest of the chicken (bones, innards, head, feet, etc). 2. These herbivores support 90,000 secondary consumers, who in turn support one top-level carnivore. In terms of founding a colony, more colonists is better. doesn't get transferred to you. Note that the total food energy that we could harvest from the cows is only 10% of the energy in the plants that we fed to the cows. Let's take a look. Here's how I summarize this in my Food Chain Song. The gasoline in the gas tank is not perfectly transformed into the kinetic energy that moves the car. A pyramid of numbers for a grassland ecosystem But unlike a pyramid of energy, which is always widest at its base, the pyramid of numbers can have a base that's narrower than the levels above. The second row is the energy available to us from the meat of the animals that ate the plants. Decision: to maximize crew size, are you going to direct your crew to eat as vegetarians or carnivores? If we stick to a strict vegetarian diet, then the math is straightforward: 2,000,000 calories of plant food/day, divided by 2000 calories/day/crewperson= 1000 crew people. Only 10% is transferred. Remember: 90% of the energy is lost. Add to that the fact that a cow is a mammal with a body temperature similar to yours, and you get an even greater loss of energy to heat. There are other ecological pyramids that show other aspects of ecosystem structure. You have to grow your food on the ship. It's a comparison of the energy available between trophic levels. 5. Permission Pending. We would take the seeds, grain, leaves, and other plant food that we produced on our ship's farms, and we would feed it to cows (or other animals, such as chickens). This is NOT a comparison of energy between organisms, or types of food. Eating as primary consumers/vegetarians, you'd have 2,000,000 calories available for the crew. Humans are omnivores: it's probably wise for the crew to have access to some animal protein. It maximizes genetic diversity, keeping your population more adaptable. Here's a typical biomass pyramid. The 67 J arrow on the right side (cellular respiration) is the heat loss that we've described above: it's the energy that the caterpillar is burning just to keep itself alive. And the energy equation becomes very different if you're considering animal products (eggs from chicken, dairy from cows) as opposed to meat. That pyramid would look like this: A pyramid of numbers for a forest ecosystem Ecosystems can also be represented through a pyramid of biomass. At an average of 2,000 calories/crewmember, your crew size drops to 100. As sugar is transformed to ATP, and as ATP is broken down to ADP and phosphate to perform cellular work, a lot of energy is lost as heat. It's the same thing that happens in a car. Then, instead of eating plant foods like bread and apples, we'd eat steak. There is an answer, and it lies in the principles of ecology. If you eat rice, for example, you're eating only a tiny portion of that plant. What we're discussing does NOT mean that a pound of meat (steak, or chicken, for example) has less energy than a pound of rice or a pound of broccoli. Similarly, when you eat as a carnivore, you eat only a tiny portion of the animal that was killed to feed you. Trophic Levels and Energy Pyramids Quiz Next steps This ends this series of tutorials about energy and ecology. What we're growing, of course, are plants. A food web showing trophic levels The primary consumers are not going to be able to eat every last piece of the plants below them. This pyramid shows the actual number of organisms at each trophic level.

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