

AST 105IN ANSWERS TO ASSIGNMENT 4

Chapter 3, “The Universal Context of Life” (except Unit 3.4, covered in previous assignment.)

Does it Seem Reasonable?

29. Not reasonable. Gold can separate itself from its rocky matrix (ore), but the rock is still around it. There is no conceivable natural process that would get rid of all the other refractory materials and leave one element, much less the relatively rare gold, as the sole constituent of a planet.
30. Not reasonable. Too far! The other side of our galaxy is tens of thousands of light years away. That means the message we received took that long to reach us and our return message will take the same long time to be received. That civilization may not still be extant—or remember their ancestors had sent the message.
33. Not reasonable. The evidence for gravitational attraction throughout the universe, starting with our solar system, is incontrovertible and overwhelmingly abundant. Physical binaries are a great example of seeing gravitational effect. Galaxies rotating. The discovery of planets orbiting other stars. The clustering of galaxies. Collisions of galaxies. Star formation. Too many to list.

Quick Quiz

35. c
36. b
37. b
38. b
39. a
40. a
41. a
42. c
43. c

Quantitative Problems

60. 4.4 light-years divided by 384,000 km gets you the ratio sought, but we must convert our units to get the unit of the numerator the same as the unit in the denominator. Wait, where did the moon’s distance come from? That sounds like data I should find in a data table at the back of the book, in some appendix. Looking in the Table of Contents, I find Appendix E, Planetary Data, on page A-15. Nothing there, so I turn the page, and—Bingo! Table E.3, Satellites of the Solar System and right at the top we see the number I just gave you above, to one more significant figure. You may use it if you want, but the answer’s accuracy is still limited by the three significant figures of the number of km in a light-year. Oh, you don’t know that yet, because you haven’t read the next paragraph...

Now that we have the numbers we need, we have a choice of ways to go to solve for the ratio. The simplest is to look up somewhere in the textbook the number of km in a light-year and multiply by 4.4, then divide by 384,000 ba da bing! The first place I thought to look for the value was in the glossary at the end of the book and, *voilà*, there it is with the value of 9.46 trillion km.

So then, $(4.4 \times 9.46 \times 10^{12}) \text{ km} \div 3.84 \times 10^5 \text{ km} = 10.84 \times 10^7:1$ or in strict scientific notation, 1.084×10^8 to one. Auf Englisch, that means that the nearest star is 108 *million* times farther from us than the moon!

63. Current technology has boosted spacecraft to something like 50,000 km/h or 30,000 mi/h. Stick with the metric system throughout this course. The nearest star is 4.4 ly away. That's how long its light takes to travel the distance. This speed is nothing compared to the speed of light. But we can make better technology..

There are a couple ways to solve this. I think it will be simpler to just calculate Alpha Centauri's distance in km. Since one light year is 9.46 trillion km, then 4.4 ly is 41.6 trillion km.

Then just divide this by the speed of the poky Voyager to get how long it will take Voyager to get to this distance. (But not to the star itself as Voyager is not heading its way.) Given its speed of 50,000 km in one hour, then we get the number of km traveled in one year by multiplying by the number of hours in a year (= $50,000 \times 24 \times 365.25$) to get 438 million km/y.

So then, $41.6 \text{ trillion km} \div 438 \text{ million km/y} = (4.16 \times 10^{13}) \div (4.38 \times 10^8) = 0.95 \times 10^5$ years, or, basically about 100,000 years for our current spacecraft to get to the distance of the nearest star system. I note this agrees with the value the authors give in one of the early chapters.

65. The number of Earth's will be that ratio, 1/ten million, multiplied by the 100 billion stars in our galaxy, or $10^{11} \div 10^7 = 10^4$ or about 10,000 Earths in our galaxy.

Then the authors expand our conception by taking into account that our Milky Way galaxy is just one of perhaps 100 billion galaxies in the universe. Assuming they're all about the same (not really a good assumption), we derive the number of Earths in the universe— $10^{11} \times 10^4 = 10^{15}$ or about a quadrillion Earths. Whew! But we're all in quarantine. The intergalactic distances are overwhelmingly large. But there is the relativistic effect of time dilation, which...oh, never mind, let's get onto the final problem.

66. Each planet has 50/50 odds of going either way. The odds of going one of those two ways is, simply, 1 out of 2 or $\frac{1}{2}$. The odds that 2 planets orbit the same way by chance are $\frac{1}{2}$ of $\frac{1}{2}$ or $\frac{1}{4}$. Notice that for 1 planet the odds are $\frac{1}{2}$ or $\frac{1}{2}^1$ and for 2 planets is $\frac{1}{2}^2$. Extrapolating to 10 planets, the odds of all of them orbiting the same way by chance alone are $\frac{1}{2}^{10}$. Plugging these numbers in a calculator (or just dividing by $\frac{1}{2}$ all those times) we get 0.00098 or 9.8, oh, make it 10, chances in 10,000 or about one chance in a thousand, not very likely by chance at all. (Note: had you just raised 2 to the 10th power and then took the inverse of the answer, you would get 1/1024 or, again, about 1 in a thousand.)

What does this mean? It means that since random chance is very unlikely to be the cause, then there must a cause-effect relation here and we need a theory that predicts we should see this highly, nonrandom state, that is, ordered state. And we do—the star formation theory, with gravity as the organizing force. It's gravity that brings order out of chaos. We'll be covering the origin of stars and planets soon enough in class.