Night Comes to the Cretaceous Discussion Worksheet Solutions

Questions 2, part of 3, 4, and 4 from the second section are largely opinion-based. The grading of those questions was based primarily on how well you supported your opinion.

1. *There are two predictions in Ch. 9 regarding the mass extinction part of the Alvarez Theory. This question focuses on Prediction #2.*

   (a) *Would finding just one fossil of an extinct species above the K-T layer be bad? Explain your answer.*

   Yes, finding just one fossil above the K-T layer would be bad. This is assuming that the fossil wasn't put there after it was fossilized because of the processes of reworking or erosion.

   Only a small percentage of organisms are fossilized when they die. Of that small number, we only discover a small fraction of all possible fossils. That means that if we find one fossil in a certain geologic layer, there were probably lots of those organisms alive then. This is another application of the Signor-Lipps effect.

   If such a fossil was found, it would mean that that species did not become extinct from the K-T impact and lived on into the Tertiary period.

   (b) *Would finding such a fossil completely disprove the Alvarez Theory? Explain.*

   However, this discovery would not completely invalidate the Alvarez Theory. The theory says that the mass extinctions were caused by the large impact. Finding that one species did **not** go extinct from the impact doesn't mean that the mass extinction didn't occur - it just means that that particular species was not included.

   There is a special case: the dinosaurs. Although the dinosaurs are not explicitly stated in the Alvarez Theory, it is obviously the type of organism that started the whole mystery to begin with. If a dinosaur fossil was confirmed to be above the K-T layer, then the idea behind the Alvarez Theory is not invalid, but it is weakened. It's hard to imagine a global catastrophe causing extinctions in most other species, but that doesn't kill off the animals at the top of the food chain: the dinosaurs.

2. (a) *Explain the process of natural selection.*

   The process of natural selection is how organisms change over time to better fit their environment. In one generation of a species, those organisms of the species that are better able to take advantage of their environment survive longer and have more offspring, which carry on the advantageous traits. Those organisms that are not as well-suited to their environment would die sooner, because of predation or inability to attain enough sustenance, and do not have as much of a chance to pass on their traits to their offspring.

   Over thousands of years, the small, advantageous changes that are passed along to offspring accumulate so that the organism becomes more and more different from the original organism.

   If the environment changes slowly, organisms that survive better in the changing environment similarly pass on their traits, so that the surviving organisms gradually change with their environment.

   It is important to note that **individual organisms do not change**. The species as a whole gradually changes because those organisms that are fittest survive to procreate.

   (b) *How do you think large impacts and their subsequent mass extinctions fit into this process? Do they help with the natural selection process, or do they act as roadblocks?*

   Well, those species that become extinct from a large impact obviously can no longer evolve. The species that do survive, however, would probably have to evolve dramatically over relatively few

generations in order to be able to survive in a very different environment. (One that is cooler, for example.) A drastic, global event can cause organisms from the same species but in different locations on the Earth to evolve in different ways so that they become different species.

But is this part of natural selection? Sure. Meteors hitting the Earth aren't artificial in any way. Large impacts just change the conditions that a species has to survive in, so that they either evolve and survive, or fail to evolve and become extinct.

3. *Consider Fig. 27 in Ch. 12 and the accompanying text. Do you think the idea presented in this figure is believable, or do you think it's taking a good theory (a large impact causing a mass extinction) and pushing it too far?*

   Scientists are always trying to figure out "the big picture". They always search for the root causes of processes, in this case geologic processes. Scientists do not yet know all of the reasons for why volcanoes form in certain areas, or why the sea level changes drastically, or why the Earth's magnetic field flips direction. It would be very exciting to think that there was one basic cause behind all of these processes (and more, as in the figure).

   Certainly Fig. 27 in Ch. 12 is very plausible and logical. It is also very provocative, which is good: it gets other scientists to go out and try to find evidence to disprove (or support) it. It will be very hard to find evidence either for or against the theory. So far, the evidence listed is that there seems to have been a lot of volcanism at the same time as some of the major mass extinctions. The question is whether or not this is coincidence.

   There is some evidence against this idea: we have many geologic processes on-going today, such as volcanism and sea floor spreading, and yet we have not had a large impact (to our knowledge) since the hypothetical Eocene-Oligocene mass extinction about 35 million years ago (Ch. 11, Table 4). Is the current geologic activity on the Earth still powered by that impact? Or is there another cause?

Part 2, dealing with the article on the research by Gerta Keller.

1. *From NCC, list at least four different age determinations of the Chicxulub crater, including their error bars. (Error bars are the plus/minus numbers after the ages. They indicate the range of ages that the result includes. For example, if I measured your age as* $21 \pm 1yr$*, I would consider my measurement to be accurate if your age was 20, 21, or 22 yrs.) Give the page numbers where you got the ages. Do you think that it would be easy for Dr. Keller to distinguish layers in rock formations that were made 300,000 yrs apart? Explain.*

   Ages determined for Chicxulub (You only had to list four):

   - 64.5 ± 0.1 million years, for Haitian tektites, pg. 109.
   - 64.75 million years for separate analysis of Haitian tektites, pg. 109.
   - 64.98 ± 0.05 million years, for melt rock from Chicxulub, pg. 109
   - 65.2 ± 0.4 million years, from a radioactive dating method used on melt rock, pg. 109.
   - 65.5 ± 3 million years, from radioactive dating of zircon, pg. 119.
   - 65 ± 3 million years, from another dating of zircon, pg. 119.
   - 59 ± 10 million years, from another dating of zircon, pg. 119.

   The error bars indicate the range of ages which are included in the measurement. For example, the first measurement has an error bar of 0.1 million years. That means that the tektite analyzed could be 64.4 million years old to 64.6 million years old. The second age doesn't have an error bar, so it's hard to know how precise the measurement was.

   As mentioned in *NCC*, the ages don't quite all overlap because it's hard to get different laboratory's measurements to agree very well. Scientists have accepted that these measurements are all measuring the same age.

The average error bar on these measurements is 2.8 million years. However, this might not be a fair assessment, since the method used to date the zircons was obviously much less precise. Let's not include those. That means that the average error bar is 0.18 million years. That is 180,000 years. Also note that the Haitian tektites are remarked as having ages in exceptionally good agreement. That's why the error bar on the melt rock was larger – it is a more typical error for radioactive dating.

So the average error bar, even excluding the ages with high errors, is 180,000 years. That means a rock could have an age plus or minus 180,000 years and it would be OK. That's a range of 360,000 years.

Dr. Keller is claiming that her new work shows that there were two impacts, separated by 300,000 years. Given our estimate of how precise age dating can be, it must be extremely difficult for her to date rocks precisely enough to show that the Chicxulub impact occurred 300,000 years earlier than the mass extinctions and a possible second impact.

2. *What geologic evidence would you look for to locate a second crater that formed at about the same time as the Chicxulub crater?*

   To find a second crater, we would need to find evidence similar to the search for Chicxulub. First, it would be very helpful to identify a sediment layer (from tidal waves) or an ejecta layer that could have been caused by the impact. We would expect the crater to be located where these layers are the thickest.

   We would also search for circular patterns in rock structures or gravitational anomaly maps, similar to Chicxulub and the Bedout crater (discussed in class). Of course, this could turn up any crater, so the age of it would have to be confirmed.

3. *Dr. Keller theorizes that three events together caused the dinosaurs' extinction: lots of volcanism, climate change, and asteroid impacts. How does this theory go against the principle "The simplest explanation is usually correct?"*

   The principle "The simplest explanation is usually correct" is sometimes called Occam's Razor. It is the idea that if you have to competing explanations for why something happens, the simpler one is probably right. That's because nature tends to do things the easy way – whatever method takes less energy and is more direct.

   For example, you might ask the question: How does my mail arrive every day? One theory might be that someone from the postal service stops by each day and puts the mail in the mailbox. A competing theory might be that miniature elves hide in everyone's houses and wait for outgoing mail, then they read it and telepathically send the contents to elves hiding in your house, who write it all down and put it in your mailbox.

   The simplest explanation of course is that the postal service delivers the mail. Why add extra steps that have no proof to the process and make it more difficult?

   Similarly, if one large impact that has been proven to have occurred (Chicxulub) could in fact have caused the mass extinctions observed at the K-T layer, then why add extra factors like an extra impact, volcanism, and the greenhouse effect? It is possible that the scenario put forward by Dr. Keller did occur, but without further proof, the simpler explanation is more believable.

4. *How do you think Dr. Keller's personal agenda influenced her scientific analysis? Would you believe her results? Explain, giving at least one example from* ***Night Comes to the Cretaceous****.*

   Throughout the debate over the Alvarez Theory portrayed in *NCC*, Dr. Keller has been on the opposing side of the theory. On pgs. 111-112, she and her colleagues argued against an interpretation of rocks at the K-T boundary by Jan Smit. On pgs. 153-154, other scientists have stated that her results on K-T microfossils are not reproducible and inconsistent. Even when she and another scientist examined the same sample, they could not agree. On pg. 156, scientists who studied the same rock samples that she had, found that the sample had been extensively reworked, which changed the position of fossils in the rocks, and which Keller had denied was the case.

In several of the above situations, Dr. Keller has seemingly presented results that either cannot be confirmed or blatantly ignore geologic evidence. It seems that for some reason she is set on disproving the Alvarez Theory no matter what. In regard to the recent work she presented in the article, she may be purposely interpreting the results of her analysis to support her theory. Because of her past views on the subject, any scientist would take her results skeptically and require more proof, since she has such a strong bias.

There is, of course, an additional fact to consider. We have only read the debate over the Alvarez Theory from the author's point of view. While he seems to present both sides of the argument reasonably fairly, he is definitely a believer in the Alvarez Theory – how much did that influence how he wrote *NCC* and represented the opposition? This is something to think about when reading about any debatable topic.