Name:_____

GEOL 104 Dinosaurs: A Natural History
Homework 6: The Cretaceous-Tertiary Extinction

DUE: Fri. Dec. 8

Part I: Victims and Survivors

Below is a list of various taxa. Indicate (by letter) if the taxon:

A. Was already extinct by the Cretaceous-Tertiary Boundary

X. Died out at the Cretaceous-Tertiary Boundary

S. Survived the Cretaceous-Tertiary Boundary (although it may have died out subsequently)

1) Inoceramids	_____	2) Ammonoids	_____
3) Plesiosaurs	_____	4) Ichthyosaurs	_____
5) Placentals	_____	6) Rudists	_____
7) Multituberculates	_____	8) Champsosaurs	_____
9) Coccolithophorids	_____	10) Pterosaurs	_____
11) Ornithischia	_____	Extra Credit) Saurischia	_____

Part II: Causal Agents and Physical Evidence

There are three environmental changes at or near the K/T boundary that might have had the potential to produce the extinction events. These three potential **causal agents** were introduced in class, but here they are again:

- **Chicxulub Impact**: collision of a 10-15 km asteroid with the Earth at 65.5 Ma, blasting an enormous volume of ash and dust into the atmosphere. Expected effects:
    - Blotted out sunlight, stopping photosynthesis on land and sea, causing starvation of herbivores, causing starvation of carnivores
    - Possibly other short-term effects (blast wave, increased acid rain, wildfires, etc.)
    - Immediate effects would be **very intense** but very **short term** (< 1 day to a year or less)
- **Deccan Traps Volcanism**: eruption of vast lava fields in western India starting around 66 Ma, and lasting for a million years or less, sending huge amounts of ash and dust into atmosphere. Expected effects:
    - Blotted out sunlight, stopping photosynthesis on land and sea, causing starvation of herbivores, causing starvation of carnivores
    - Possibly also increased amounts of various pollutants into atmosphere
    - Immediate effects would be **intense** and extend over **hundreds of thousands of years** prior to K/T boundary
- **Maastrichtian Regression**: huge drop in global sea levels, exposing large areas of land previously submerged, starting around 69 Ma and ending around 65 Ma. Expected effects:
    - Change planetary albedo (reflectivity), changing both amount of heat absorbed by Earth and that heat's distribution
    - Change in oceanic circulation patterns
    - Decrease in oceanic productivity (how much nutrients are produced) because of loss of warm shallow seas
    - Increase in continentality of climate (more intense summers and winters)
    - Immediate effects would be **gradual** and extend over **millions of years**

Name:_____

These different causal agents would leave different types of records in the rocks. For each of the questions below, circle the appropriate answer as to which causal agent(s) (Asteroid Impact, Deccan Traps Volcanism, or Maastrichtian Regression) would leave such a record.

12) Ash from very short term but global forest fires:

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

13) Replacement of one set of plant fossils over the last several million years of the Cretaceous:

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

14) Iridium spike:

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

15) Chemical evidence for decreased amount of photosynthetic activity (indicating reduction in sunlight):

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

16) Tsunami deposits on the Atlantic & Gulf Coasts of the Americas:

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

17) Extensive lava flows in India:

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

18) Shocked quartz:

A. Asteroid Impact B. Deccan Traps Volcanism C. Maastrichtian Regression

D. A & B, but not C E. A, B & C

Extra Credit) All of these three agents would have had global effects. However, two of them would have DIRECT evidence over much of the world, while one would have direct physical evidence that was much more limited in its coverage. Which one would have the most restricted coverage?

[Asteroid Impact | Deccan Traps | Maastrichtian Regression] (Circle)

Name:_____

Part III: K/T Extinction Patterns in the Terrestrial Realm

Let's look at the patterns of extinctions at the K/T boundary for major clades of terrestrial vertebrates, with emphasis on dinosaurian clades. For each taxon the diet, the adult size, and the likely physiology (warm- or cold-blooded) are listed. (Note that sizes of the late Maastrichtian representatives are shown: earlier or later representatives may have been larger).

Survivors

Taxon	Habitat	Adult Size (kg)	Physiology
Aves (various lineages)	Flying	<1 – 5 (most <1)	Warm
Crocodilians (various lineages)	Semi-aquatic	~10 – 50+	Cold
Champsosaurs	Semi-aquatic	10 – 25	Cold
Lepidosaurs (lizards and snakes)	Land	<1 – 10 (most <1)	Cold
Turtles	Land & semi-aquatic	<1 – 10	Cold
Mammals (various lineages)	Land	<1 – 5 (most <1)	Warm
Amphibians	Semi-aquatic	<1	Cold

Victims

Taxon	Habitat	Adult Size (kg)	Physiology
Ichthyornithiform birds	Flying	<1 – 3 (most <1)	Warm
Enantiornithine birds	Flying	<1 – 5 (most <1)	Warm
Deinonychosauria	Land	10	Warm
Oviraptorosauria	Land	10 – 175	Warm
Therizinosauroidea	Land	500 – 3000	Warm
Alvarezsauridae	Land	1 – 5	Warm
Ornithomimosauria	Land	175	Warm
Tyrannosauridae	Land	6000	Warm
Abelisauroidea	Land	5 – 3000	Warm
Titanosauria	Land	30,000	Warm
Ceratopsidae	Land	6000	Warm
Leptoceratopsidae (ceratopsians)	Land	100	Warm
Pachycephalosauria	Land	200	Warm
Hadrosauridae	Land	6000	Warm
Thescelosauridae (ornithopods)	Land	90	Warm
Rhabdodontidae (ornithopods)	Land	150	Warm
Ankylosauridae	Land	3000	Warm
Nodosauridae	Land	2500	Warm
Pterosauria	Flying	5 – 200	Warm

Name:_____

19) Many scientists have said that there is a strong size bias in survivors vs. victims in the K/T boundary on land. Look at the data on the previous page. In general, the majority of the survivor groups are
[smaller | the same size | larger] than the majority of the victims

20) Semi-aquatic animals [mostly became extinct | mostly survived] the K/T extinction.

21) Compare the list of survivors and victims. [Warm-blooded | Cold-blooded] animals tended to survive better than the others.

22) Overall, circle which of the following types of animals had the worst survivorship (i.e., most likely to die out) at the extinction:

A. Small, semi-aquatic cold-blooded
B. Small, terrestrial or flying warm-blooded
C. Large, semi-aquatic cold-blooded
D. Large, terrestrial or flying warm-blooded

23) Small animals need less total amount of food than large ones. Cold-blooded animals need less total amount of food than warm-blooded ones of the same size. Given this information and your answer to question 23, what might this indicate about conditions at the K/T boundary?

24) Crocodilians and turtles include the only large-bodied terrestrial survivors from this list. What aspects do they share (in terms of habitat, physiology, etc.) that they did NOT share with dinosaurs or pterosaurs?

Name:_____

Part IV: Late Cretaceous North American Dinosaur Diversity Patterns

Western North America has the best fossil record of the terrestrial realm during the late part of the Late Cretaceous of any region on the planet, and thus gives us our best record of the types of changes in dinosaur populations over time. Below is a chart examining species diversity (number of species in a particular group at a particular time) for some of the best-studied dinosaurs: hadrosaurids and ceratopsids.

"NA Vert. Age" refers to the North American Land Vertebrate Ages: different faunal assemblages through time. Of the three listed the Judithian is the oldest and the Lancian is the youngest: indeed, the end of the Lancian is the K/T boundary. The numbers in the table represent the number of species of that particular group found in the listed group at that Land Vertebrate Age: for example, there are 4 helmet-crested lambeosaurines present in the Judithian. The dotted line running through the Edmontonian is the boundary between the Campanian and Maastrichtian Ages. The Maastrichtian Regression would begin sometime during the Edmontonian.

Period	Age	NA Vert. Age	Hadrosauridae				Ceratopsidae		Date (millions of years ago)
			Lambeosaurinae		Hadrosaurinae				
			Tube-crest	Helmet-crest	Short-snout	Long Snout	Centrosaurinae	Ceratopsinae	
									65.5
Cretaceous	Maastrichtian	Lancian	0	0	0	3	0	5	
									67
		Edmontonian	0 (present in Asia)	1	0 (present elsewhere)	3	2	5	70.6
	Campanian								72
		Judithian	1	4	6	3	8	6	
									78.0

25) In terms of species number the [Judithian | Edmontonian | Lancian] has the highest diversity.

26) *Tyrannosaurus rex* only lived during the Lancian and only in western North America. *T. rex* [could have | could not have] eaten centrosaurines and lambeosaurines.

Extra Credit) Justify your answer to 26

Name:_____

27) Note the dates of the boundaries between the Land Vertebrate Ages (and the Campanian-Maastrichtian boundary date) along the right side of the chart. Given this time information, the over-all diversity change seen here is most consistent with the [asteroid impact | Deccan Traps volcanism | Maastrichtian Regression].

28) Justify your answer to 27.

29) Based on the table on the previous page, dinosaur groups with [longer | shorter] relative snout length were most likely to survive until the end of the Cretaceous.

Part V. Wrapping Things Up

30) Considering all the information throughout this packet, which of the following best describes the patterns of Late Cretaceous extinctions:

A. All of it was instantaneous, and can only be explained by the Chicxulub Impact.

B. All of it was **geologically** instantaneous, but we cannot definitely tell apart those extinctions that might be caused by the Deccan Traps volcanism and those caused by the Chicxulub Impact.

C. All of it was **gradual**, and is best explained by the Maastrichtian Regression.

D. Both gradual and instantaneous extinctions were occurring, indicating a combination of causes, of which the Chicxulub Impact was the last (and perhaps the largest)

31) Just to make sure everyone is paying attention, when did the clade Dinosauria go extinct?