ANSWER SHEET | Classifying Dinosaurs Based on Fossils

PART I: IDENTIFYING THE FEMUR

1. Discuss the distribution of the four different character states of the fourth trochanter (A, B, C, and D) on the dinosaur cladogram.

*The presence of a Type A fourth trochanter (symmetrical crest) is observed in non-dinosaur archosaurs, which in the cladogram are represented by **Lagosuchus talampayensis**. The presence of Type A among dinosaurs is interpreted as a secondary reduction of the fourth trochanter. In the cladogram, this is the condition recorded in hydrosaurid ornithischians, and, among saurischian dinosaurs, in sauropodomorphs and some theropods, such as **Allosaurus**.*

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*The presence of a Type B fourth trochanter (strongly asymmetrical without a finger-like process) is also interpreted as a secondary reduction of the trochanter recorded for some ornithischian dinosaurs, such as **Iguanodon**, and saurischian dinosaurs, such as **Herrerasaurus**.*

The fourth trochanter is further reduced in the more derived theropod dinosaurs, such as coelosaurian theropods.

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*The presence of a Type C fourth trochanter (asymmetrical with a small finger-like process) is observed in some ceratopsian ornithischians, such as **Protoceratops**.*

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*The presence of Type D fourth trochanter (asymmetrical with a strong finger-like process) is considered a shared derived character state supporting the Ornithischia clade. In the cladogram, this condition is reported in **Heterodontosaurus**, **Pssitacosaurus**, Hypsilophodontidae species, and **Tenontosaurus**.*

2. How do you explain the presence of A, B, and C types of fourth trochanters among the ornithischians?

Among ornithischians, the presence of fourth trochanters Types A and B is interpreted as secondary reduction. In Type C, the fourth trochanter is similar to Type D, but the finger-like process is smaller.

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3. Based on this analysis, in what groups of the phylogeny could you place the fossil? Explain your reasoning.

*In the mystery fossil, the fourth trochanter is asymmetrical with a strong finger-like process, which is consistent with Type D. Based on the available evidence, the mystery fossil could be assigned to any of four groups: Heterodontosauridae (such as **Heterodontosaurus)**, **Psittacosaurus**, Hypsilophodontidae (such as **Hypsilophodon)**, and basal iguanodontians (such as **Tenontosaurus)**.*

PART II: FURTHER IDENTIFYING THE FEMUR

4. Fill out the table with descriptions of the fourth trochanter for each type of dinosaur.

	Position of the fourth trochanter relative to the midline of the femur	Shape of the fourth trochanter
Heterodontosaurus	*The fourth trochanter is above the femur midline. The tip of the finger-like process doesn't reach the femur midline.*	*The fourth trochanter presents a pointy and relatively straight finger-like process.*
Psittacosaurus	*The tip of the finger-like process of the fourth trochanter extends below the femur midline.*	
Hypsilophodon	*The fourth trochanter is above the femur midline. The tip of the finger-like process doesn't reach the femur midline.*	*The fourth trochanter presents a hanging or hook-like finger-like process.*
Tenontosaurus	*The tip of the finger-like process of the fourth trochanter extends below the femur midline.*	
Mystery femur	*The fourth trochanter is above the femur midline. The tip of the finger-like process doesn't reach the femur midline.*	*The fourth trochanter presents a hanging or hook-like finger-like process.*

5. In which group do you think the mystery fossil belongs? Summarize your reasoning in a short paragraph.

Based on the data of the comparative table, the mystery femur could be placed in the Hypsilophodontidae. This claim is based on the observation that in both ***Hypsilophodon*** *and the mystery fossil. However, when we compare the shape of the process, the condition of the mystery femur is more similar to the condition observed in* ***Hypsilophodon.***

Based on this evidence, we can infer that the place of the species, of which we only know its femur, is in the clades Dinosauria, Ornithischia, Genosauria, Ornithopoda, and Hypsilophodontidae.

PART III: IDENTIFYING A SKELETON

1. For each of the 11 characters, use this table to record the condition observed in the fossilized skeleton. Does it show the shared derived state or the ancestral condition? 1, 2, and 3 are filled out for you as a model.

1. Hole in the hip socket: *The fossil has a hole in the hip socket, which is a shared derived condition for the Dinosauria clade. (Note: All branches in the Dinosauria clade are marked with black squares on the cladogram.)*	**7. Number of fingers:** The fossil presents three fingers, which is considered a shared derived character state supporting the Tetanurae clade.
2. Grasping hand: *The fossil has a grasping hand. This is a shared derived condition for saurischian dinosaurs. (Note: All branches in the Saurischia clade are marked with black squares on the cladogram.)*	**8. Uncinate process connecting the ribs:** Three uncinate processes connecting the ribs on the right side of the body are visible on the fossil. Presence of bony uncinate processes is a shared derived character state supporting the Pennaraptora clade.
3. Femoral fourth trochanter: *The femur does not have a well-developed fourth trochanter. This is a derived character for the Ornithischia clade. Since our fossil does not have this character, it does not help us with the identification of the fossil. (Note: The Ornithischia clade is marked with a gray square on the cladogram.)*	**9. Scapula/humerus length**: The fossil's scapula is longer than its femur, which is the ancestral condition within the Pennaraptora clade. Having the humerus longer than the scapula is a shared derived condition of Paraves within the Pennaraptora.
4. Furcula: A furcula is observed in the fossil. It is an L-shaped bone in contact with the proximal end of the right scapula. The presence of fused clavicles forming a furcula is a shared derived character state supporting the Theropoda clade, within Saurischia.	**10. Neck length**: The fossil presents eleven cervical vertebrae. Having 11 to 13 cervical vertebrae is considered a shared derived character state supporting the Oviraptorosauria clade within Pennaraptora.
5. Length of the leg bones: In the fossil, the tibia is longer than the femur (453 mm and 402.4 mm, respectively), which is the ancestral condition. Having the tibia shorter than the femur is a shared derived character state supporting the Saurapodomorpha clade.	**11. Relative length of the fingers**: In the fossil, finger 3 is slightly shorter than finger 2. This is considered a shared derived character state supporting the Oviraptoridae clade within the Oviraptorosauria.
6. Fusion of the hip bones: In the fossil, the sacral vertebra appear to be independent bones, not fused to the ilia. This is the ancestral condition within Theropoda. Having sacral vertebrae fused to the ilia is proposed as a shared derived character state supporting the Ceratosauria clade within Theropoda.	

2. Below is a cladogram showing the relationships among dinosaur groups relevant to the Gobi Desert fossil skeleton investigation. Use the table to visualize the distribution of the shared derived characters included in the analysis. For example, the distribution of the character “presence of a hole in the hip socket” is a shared derived character state of dinosaurs. On the cladogram, use the fill or highlight function to color in the cells for all the branches in the clade that share the derived character state. The first three characters are completed for you to use as models. You may want to use one color to indicate characters that your fossil has and another color to indicate clades that do not include the fossil.
3. Summary for Part III: What group of dinosaurs does the fossil in **Figure 5** of the instructions come from? Explain your reasoning based on the characters you examined and what they tell you about the classification of this dinosaur fossil.

Based on the available data, we can infer that the Gobi Desert fossil could be an oviraptorid dinosaur. This claim is based on having identified the following shared derived characters in the fossil:

- a hole in the hip socket, which places the fossil within the Dinosauria clade;
- a grasping hand, which places it within the Saurischia clade;
- a furcula, which places it within the Theropoda clade;
- hand with three fingers, which places it within the Tetanurae clade;
- neck with eleven cervical vertebrae, which places it within the Oviraptorosauria, and
- hand with finger 3 slightly shorter than finger 2, which finally places it within the Oviraptoridae.

PART III: IDENTIFYING A SKELETON CLADOGRAM