T. rex: The Ultimate Predator

ACTIVITIES FOR GRADES 9-12

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Activity Overview

Fossils show how animals changed over time and how they are related to one another. While fossils also reveal what ancient animals looked like, they keep us guessing about the animals' colors, sounds, and most of their behavior. So scientists observe animals living today for clues to what ancient animals may have looked like, how they may have moved and behaved, and how they may have interacted with other animals in the ecosystem.

In this three-part activity, students will engage in the practice of obtaining, evaluating, and communicating information and apply the crosscutting concept of structure and function to explore the phenomenon that ancient animals in the fossil record have similarities to and differences from modern animals.

1. **Before the Visit:** Through videos, a reading, and an online quiz, students are introduced to the exhibition and its major themes. Students then generate questions about the evidence scientists use to understand *T. rex*, including similarities and differences between ancient and modern animals.

2. **At the Museum:** In four sections of the exhibition, students use worksheets to help them record observations of fossils and models, as well as other information to explore similarities and differences between *T. rex*, its ancient and living relatives, and other living animals for clues about this predator.

3. **Back in the Classroom:** Students process and share what they've learned at the Museum about *T. rex* and the similarities and differences between ancient and living animals. They will also make connections between the information gathered and what they have been learning in class.

This activity supports the following Next Generation Science Standards:

Science & Engineering Practices

- ŏ Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts

- ŏ Structure and Function

This activity can serve as a connector to the following Next Generation Science Standards:

Disciplinary Core Ideas:

- ŏ LS4.A: Evidence of Common Ancestry and Diversity
- ŏ LS4.B: Natural Selection
- ŏ LS4.C: Adaptation

Before the Visit

Through short videos, a reading, and an online pre-assessment quiz, students are introduced to the *T. rex: The Ultimate Predator* exhibition and its major themes. Students then generate questions about the evidence scientists use to understand *T. rex*, including similarities and differences between ancient and modern animals.

TIME	40 minutes
PREPARATION	ŏ Review the Educator's Guide to see how themes in the exhibition connect to your curriculum and to get an advance look at what your students will encounter. ŏ Review this three-part activity and decide how you would like students to engage with the content before, during, and after the visit.
PROCEDURE	1. Students become familiar with the exhibition content by exploring one or more of the following resources: ʒ **Video: What did a baby *T. rex* look like?** (6:20) amnh.org/explore/videos/exhibits/growing-up-tyrannosaurus-rex Students see that the giant, ferocious *T. rex* began as a small, helpless hatchling. ʒ **Video: How long did a *T. rex* live?** (3:10) amnh.org/explore/videos/dinosaurs-and-fossils/how-long-did-t-rex-live Students learn the methods and evidence paleontologists use to determine the age and lifespan of dinosaurs, including *T. rex*. ʒ **Article: *Tyrannosaurus rex*** amnh.org/dinosaurs/tyrannosaurus-rex Students gain a basic understanding of *T. rex*, including what it ate, where and when it lived, and how big it grew. ʒ **Quiz: What do you know about *T. rex*?** amnh.org/explore/ology/paleontology/what-do-you-know-about-t.-rex Students take this 10-question pre-assessment quiz that covers the major themes of the exhibition. 2. In response to the resources, students generate questions about the evidence scientists use to understand *T. rex*, including similarities and differences between ancient and modern animals. Questions can be recorded on a class or small-group chart so that students can revisit the questions after their trip to the Museum.

At the Museum

In four sections of the *T. rex: The Ultimate Predator* exhibition, students use worksheets to help them record observations of fossils and models, as well as other information to explore similarities and differences between *Tyrannosaurus rex*, its ancient and living relatives, and other living animals for clues about this predator.

TIME	40 minutes
PREPARATION	ŏ Familiarize yourself with the student worksheet, answer key, notes to educators, and the map of the exhibition. ŏ Decide how students will explore the exhibition using the worksheets. For example, students can explore all four sections of the exhibition in pairs, with each student completing their own worksheet; or students can be divided into groups of four, with each student responsible for one of four locations.
PROCEDURE	1. Explain the goal of the Museum visit to students. They will explore: ʒ what fossil evidence reveals about how animals change over time, how they are related to one another, and what they looked like ʒ how scientists observe animals living today for clues to the appearance, movement, behavior, and interaction of ancient animals 2. Distribute and review the worksheet and map with students. Clarify the information they should collect, and where they can find it in the exhibition.

Back in the Classroom

Students process and share what they've learned at the Museum about *T. rex* and about the similarities and differences between ancient and living animals. They will also make connections between the information gathered at the Museum and what they have been learning in class.

TIME	40 minutes
PREPARATION	ŏ Review the answer key to worksheets. ŏ Plan how you will help students process and share information collected. ŏ Make connections between the exhibition content and what students have been learning in your class.
PROCEDURE	1. As a class or in small groups, students share and discuss the information they collected on their worksheets. Their findings can be recorded on a three-column chart (suggested column titles: "What do scientists know about *T. rex* and other ancient animals?" "How do scientists know this from fossils?" "How do scientists know this by studying living animals?"). 2. Students make connections between the exhibition findings and what they have been learning in class (e.g. evolution, natural selection, adaptation, process of scientific inquiry). Suggested prompts: ʒ How does what you learned about *T. rex* connect to what we've been learning in class about _____? ʒ How would you use your existing knowledge about _____ to explain what you learned about *T. rex*? 3. Students revisit the list of questions they generated before their Museum visit to see which questions have been answered and which unanswered ones they would like to investigate further. 4. Students construct an explanation for *T. rex* based on their understanding of fossil evidence and the study of living animals. Ideas include: ʒ Exhibition review ʒ Science magazine article ʒ PowerPoint ʒ Social media post

Ideas for further exploration:

- Students investigate their unanswered questions through research.
- Students go deeper into related concepts such as geologic time, common ancestry, comparative anatomy, evolution, and the bird-dinosaur connection.
- Students explore careers in science and questions such as: Who put this exhibition together? How do you become a scientist, an exhibition designer, a science writer, or a visual artist (models, graphics, interactive media)?

Student Worksheet

NAME: _____

!.37%2 +%9 µ ./4%3 4/ %$5#!4/23

Welcome to the American Museum of Natural History!
Fossils show how animals changed over time and how they are related to one another. While fossils also reveal what ancient animals looked like, they keep us guessing about the animals' colors, sounds, and most of their behavior. So scientists also observe animals living today for clues to what ancient animals may have looked like, how they may have moved and behaved, and how they may have interacted with other animals in the ecosystem.

In the *T. rex*: *The Ultimate Predator* exhibition, you will explore similarities and differences between *Tyrannosaurus rex*, its ancient and living relatives, and other living animals for clues about this predator.

These stops are highlighted in the worksheets:

STOP 1: "Meet the Family" Section

STOP 2: "Getting Big" Section

STOP 3: "Getting Bad" Section

STOP 4: "Sensitive Side" Section

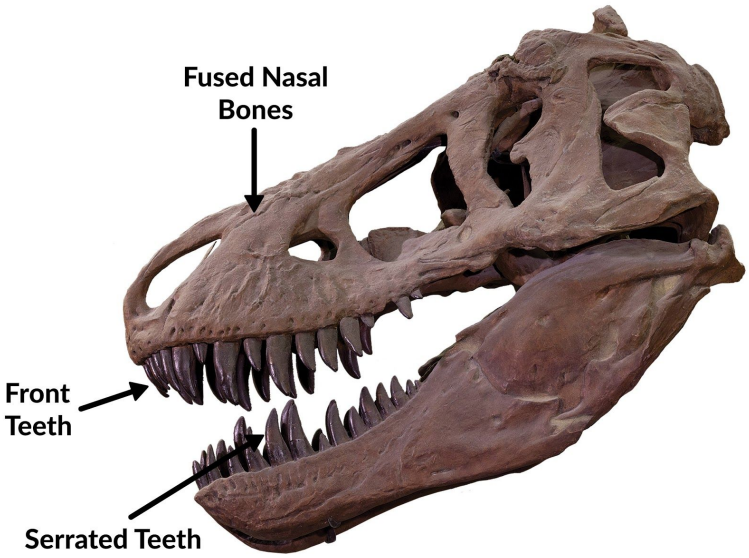
STOP 1: "Meet the Family" Section

1. **Observe the model of *Dilong paradoxus* and read the "Fierce and Feathered" panel.** What evidence do scientists use to hypothesize that this animal most likely had simple feathers covering its entire body?

   !fko]jk eYq af[dm\]Æ 3[a]flaklk ^gmf\ ^gkkad]na\]f[] g^ hjaealan]Ä `Yajdac] ^]Yl`]jk gf l`] lYadÄ kg l`]q l`afc l`Yl kaeadYj ^]Yl`]jk Ydkg [gn]j]\ egkl g^ l`ak kh][a]kÎ Zg\qÇ 4`]q ZYk]\ l`ak `qhgl`]kak gf l`] ]na\]f[] l`Yl Zaj\kÚdanaf_ \afgkYmjkÚYdkg `Yn] kaehd]jÄ ^mrrq ^]Yl`]jk [Ydd]\ \gofÇ

2. **Observe the "*T. rex* Traits" wall.** Related species often look similar because they share a common ancestor, from whom they inherited similar traits. This is true of tyrannosaurs. What three traits do all tyrannosaurs share? Label them on the skull.

   ,YZ]dk gf kcmddÆ ^mk]\ fYkYd Zgf]kÅ ^jgfl l]]l` Yj] $Èk`Yh]\ af [jgkkÈk][lagfÅ k]jjYl]\ l]]l`



3. **Try the "Tail Balance" interactive and read the "Bodies in Balance" panel.** What evidence do scientists use to hypothesize about how *T. rex* used its tail?

   !fko]jk eYq af[dm\]Æ 3[a]flaklk gZk]jn] danaf_ YfaeYdk l`Yl Ydkg mk] l`]aj lYadk ^gj ZYdYf[]Ä km[` Yk l`] jgY\jmff]j Yf\ cYf_YjggÄ ^gj [dm]k lg `go lqjYffgkYmjk dac] ***4Ç j]p*** eYq `Yn] egn]\Ç !dkgÄ hYd]gflgdg_aklk [Yf [Yd[mdYl]Ä ZYk]\ gf o`]j] emk[d]k eYq `Yn] YllY[`]\ lg l`] Zgf]Ä `go kljgf_ Yf\ Za_ ]Y[` emk[d] `Y\ lg Z] lg egn] l`] Zg\qÇ

STOP 2: "Getting Big" Section

4. **Examine the *Tarbosaurus* adult skull and juvenile skeleton.** Sketch each specimen in the boxes below.

adult skull	juvenile skeleton

Scientists think that *Tarbosaurus*, like *T. rex*, lived a very different life as a juvenile than it did as an adult. Compare the adult and juvenile specimens. What does each specimen tell you about how the animal may have hunted at different ages?

```
!fko]jk eYq af[dm\]Æ 4`] Y\mdl oYk em[` dYj_]jÄ oal` `]YnqÄ Zgf]È[jmk`af_ bYok Yf\
l]]l` l`Yl o]j] mk]\ lg ]Yl dYj_] YfaeYdkÇ 4`] bmn]fad] `Y\ Y keYdd Yf\ Y_ad] Zg\qÄ
o`a[` `]dh]\ al ]k[Yh] dYj_] hj]\Ylgjk Yf\ `mfl ^YklÄ keYdd YfaeYdkÅ al Ydkg `Y\ l`afÄ
ZdY\]dac] l]]l` l`Yl o]j] _gg\ ^gj [Yl[`af_ keYdd n]jl]ZjYl]k Yf\ afk][lkÇ
```

5. **In the "*Tarbosaurusī* panel, read about ecological niches.** How does the life history of the living animal Komodo dragon help support the inference that adult *T. rex* and *Tarbosaurus* occupied different ecological niches than their respective juvenile forms?

```
!fko]jk eYq af[dm\]Æ 4`] +geg\g \jY_gf ak Y lgh hj]\Ylgj Yk Yf Y\mdlÄ Zml al `Yk Y n]jq
\a^^]j]fl da^]klqd] o`]f qgmf_Ç ! qgmf_ +geg\g [daeZk lj]]k lg Ynga\ dYj_]j hj]\Ylgjk
Yf\ `mflk afk][lk Yf\ darYj\kÅ Yf Y\gd]k[]fl ak Y _jgmf\ \o]dd]j Yf\ `mflk Zaj\kÄ ]__kÄ
Yf\ [jYZkÅ Yf\ Yf Y\mdl mk]k alk eYkkan] Yf\ hgo]j^md Zg\q lg YeZmk` hj]qÄ af[dm\af_
`meYfkÄ \]]jÄ Yf\ ]n]f gl`]j \jY_gfkÇ )^ +geg\g \jY_gf `Yk l`ak kljYl]_qÄ k[a]flaklk
l`afc al ak dac]dq l`Yl lqjYffgkYmjk dac] 4YjZgkYmjmk Yf\ 4Ç jjp \a\ lggÇ
```

STOP 3: "Getting Bad" Section

6. **Examine fossils of teeth.**

   Sketch a *T. rex* tooth.

   Read the "Tough Teeth" panel. What inference can scientists make by comparing the teeth of a modern predator such as a lion to those of *T. rex*?

   !fko]jk eYq af[dm\]Æ 3[a]flaklk [Yf dggc Yl l`] k`Yh]Ä kar]Ä Yf\ hdY[]e]fl g^ l`] l]]l` lg \]l]jeaf] `go hj]\Ylgjk `mfl]\ Yf\ [gfkme]\ l`]aj hj]qÇ 4`] dagfÎk ^Yf_k Yj] o]dd hdY[]\ ^gj klYZZaf_ Yf\ _jYZZaf_Ä o`ad] ***4Ç j]p*** l]]l` o]j] o]dd kmal]\ ^gj [jmk`af_ Zgf]Ç

7. **Read the "Room at the Top" panel.** Scientists think that *T. rex* was not the only top predator in its ecosystem; it shared this title with *Alioramus* and *Tarbosaurus*. How could these animals have coexisted?

   !fko]jk eYq af[dm\]Æ 3[a]flaklk l`afc l`]k] \afgkYmjkÄ \]khal] Ydd Z]af_ lgh hj]\YlgjkÄ hjgZYZdq kh][aYdar]\ gf \a^^]j]fl lqh]k g^ hj]qÇ 4`]q [gmd\ `Yn] Ynga\]\ \aj][l [geh]lalagf Zq Z]`Ynagj Ydgf]Ä ]Ç_ÇÆ `mflaf_ Yl fa_`l gj \YqÅ `mflaf_ Ydgf] gj af hY[ckÅ hmjkmaf_ Za_Ä kdgo YfaeYdk gj keYddÄ ^Ykl gf]kÇ

   What evidence from animals living today do scientists use to infer that multiple top predators can coexist in an area?

   !fko]jk eYq af[dm\]Æ 4`] dagfÄ d]ghYj\Ä Yf\ [`]]lY` Ydd `mfl gf l`] !^ja[Yf kYnYffY`Ç 4`]q Yj] Ydd lgh hj]\YlgjkÄ Yf\ l`]q Ynga\ \aj][l [geh]lalagf oal` ]Y[` gl`]j Zq `mflaf_ \a^^]j]fl hj]q af \a^^]j]fl hdY[]k Yl \a^^]j]fl lae]k Yf\ af \a^^]j]fl oYqkÇ
   ð ,agfÆ Y kdgo Zml kljgf_ hj]\Ylgj l`Yl `mflk af hY[ckÅ dagfk YeZmk` dYj_] hj]q l`Yl l`]q klYdc kl]Ydl`adqÅ l`]q kl]Yd hj]q ^jge keYdd]j hj]\Ylgjk
   ð ,]ghYj\Æ Yf YeZmk` `mfl]j l`Yl kf]Yck mh gf kdgo]jÄ keYdd]j hj]q Yl fa_`l gj YeZmk`]k l`]e ^jge lj]]k
   ð #`]]lY`Æ Y ^Ykl hj]\Ylgj l`Yl [`Yk]k \gof kh]]\q hj]q dac] _Yr]dd]kÅ [`]]lY`k `mfl af \Yqlae] Yf\ jYj]dq [daeZ lj]]k

8. **Explore the coprolite and related panels.** *T. rex* could digest bone. How do scientists know that?

   !fko]jk eYq af[dm\]Æ 7] cfgo l`ak ^jge l`] #4 k[YfkÄ 8ÈjYq ^dmgj]k[]f[]Ä Yf\ ea[jghjgZ] YfYdqkak g^ ***4Ç j]p*** \mf_ Ý[ghjgdal]ÞÇ 4`] k[Yfk k`go Zgf] ^jY_e]flk af l`] [ghjgdal]Ç

STOP 4: "Sensitive Side" Section

9. **Read the "Eyes of a Killer" panel.** What evidence do scientists use to hypothesize that *T. rex* may have seen in the ultraviolet spectrum?

   !fko]jk eYq af[dm\]Æ "aj\k Yf\ [jg[g\ad]kÄ l`] [dgk]kl danaf_ j]dYlan]k g^ lqjYffgkYmjkÄ [Yf k]] Ydd l`] [gdgjk `meYfk [Yf k]]Ä Yk o]dd Yk aflg l`] 56 jYf_] g^ l`] kh][ljme ÝafnakaZd] lg `meYfkÞÇ 4qjYffgkYmjk dac]dq `Y\ [gdgj nakagf kaeadYj lg Zaj\k \m] lg _]f]k af`]jal]\ ^jge Y [geegf Yf[]klgjÇ

   What are the similarities between the eyes of *T. rex* and the mountain lion? How does this evidence support the idea that *T. rex* was a predator?

   !fko]jk eYq af[dm\]Æ "gl` ***4Ç j]p*** Yf\ l`] egmflYaf dagf `Yn] Zgl`]q]k ^Y[af_ ^gjoYj\Ç 4`ak hdY[]e]fl g^ l`]]q] _an]k l`] YfaeYd Z]ll]j \]hl` h]j[]hlagf ^gj `mflaf_Ç

10. **Sketch the *Daspletosaurus* jawbone and mark the small holes.**

    What do scientists think is the most probable explanation for these structures? Why?

    !fko]jk eYq af[dm\]Æ 3]fk] gj_YfkÇ 4afq `gd]k gf l`ak lqjYffgkYmj kcmdd Yj] f]Yjdq a\]fla[Yd af fmeZ]j Yf\ dg[Ylagf lg l`gk] gf Yf Ydda_YlgjÇ !dda_Ylgjk `Yn] `a_`dq k]fkalan] ^Y[]kÅ ***$Ykhd]lgkYmjmk*** dac]dq \a\ Yk o]ddÇ

    Read the "Touchy Feely" panel. What evidence supports the idea that *T. rex* had a very sensitive face?

    !fko]jk eYq af[dm\]Æ &gkkadk g^ ***4Ç j]p*** k`go jgm_`Ä hall]\ kmj^Y[]k kaeadYj lg l`gk] g^ ***$Ykhd]lgkYmjmk***Ä km__]klaf_ al Ydkg `Y\ kaeadYj k]fk] gj_YfkÇ

11. **Read the "Headgear," "Scales and Feathers," and the "Hear Me Roar!" sections.** Record one interesting information about *T. rex* appearance or sound and the evidence that supports it.

    !fko]jk eYq af[dm\]Æ
    ð 3[Yd]kÄ [j]klkÄ gj `gjfk [gmd\ `Yn] Z]]f YllY[`]\ lg l`] jgm_` kmj^Y[]kÇ -Yfq danaf_ YfaeYdk l`Yl `Yn] `gjfk Ydkg `Yn] kcmddk oal` Y jgm_` l]plmj] Yl l`] hdY[] g^ YllY[`e]flÇ
    ð &gkkadk g^ ***4Ç j]p*** j]dYlan]kÄ km[` Yk ***#Ym\ahl]jqp*** Yf\ ***9mlqjYffmk***Ä o]j] ^gmf\ oal` ^]Yl`]jk gf l`]aj]flaj] Zg\a]kÇ ***4Ç j]p*** eYq `Yn] `Y\ kge] ^]Yl`]jkÇ
    ð 3[a]flaklk klm\q alk [dgk]kl danaf_ j]dYlan]kÄ [jg[g\ad]k Yf\ Zaj\kÄ Yk o]dd Yk gl`]j dYj_] YfaeYdkÇ ,Yj_]j YfaeYdk eYc] dgo]jÈ^j]im]f[q kgmf\kÄ kg al ak dac]dq l`Yl ***4Ç j]p*** Ydkg `Y\ Y dgo jgYjÇ

Student Worksheet

NAME: _____

Welcome to the American Museum of Natural History!
Fossils show how animals changed over time and how they are related to one another. While fossils also reveal what ancient animals looked like, they keep us guessing about the animals' colors, sounds, and most of their behavior. So scientists also observe animals living today for clues to what ancient animals may have looked like, how they may have moved and behaved, and how they may have interacted with other animals in the ecosystem.

In the *T. rex*: *The Ultimate Predator* exhibition, you will explore similarities and differences between *Tyrannosaurus rex*, its ancient and living relatives, and other living animals for clues about this predator.

These stops are highlighted in the worksheets:

STOP 1: "Meet the Family" Section

STOP 2: "Getting Big" Section

STOP 3: "Getting Bad" Section

STOP 4: "Sensitive Side" Section

STOP 1: "Meet the Family" Section

12. **Observe the model of *Dilong paradoxus* and read the "Fierce and Feathered" panel.** What evidence do scientists use to hypothesize that this animal most likely had simple feathers covering its entire body?

13. **Observe the "*T. rex* Traits" wall.**
    Related species often look similar because they share a common ancestor, from whom they inherited similar traits. This is true of tyrannosaurs. What three traits do all tyrannosaurs share?

    Label them on the skull.

14. **Try the "Tail Balance" interactive and read the "Bodies in Balance" panel.** What evidence do scientists use to hypothesize about how *T. rex* used its tail?

STOP 2: "Getting Big" Section

15. Examine the *Tarbosaurus* adult skull and juvenile skeleton. Sketch each specimen in the boxes below.

adult skull	juvenile skeleton

Scientists think that *Tarbosaurus*, like *T. rex*, lived a very different life as a juvenile than it did as an adult. Compare the adult and juvenile specimens. What does each specimen tell you about how the animal may have hunted at different ages?

16. In the "*Tarbosaurusĩ* panel, read about ecological niches. How does the life history of the living animal Komodo dragon help support the inference that adult *T. rex* and *Tarbosaurus* occupied different ecological niches than their respective juvenile forms?

STOP 3: "Getting Bad" Section

17. Examine fossils of teeth.

Sketch a *T. rex* tooth.

Read the "Tough Teeth" panel. What inference can scientists make by comparing the teeth of a modern predator such as a lion to those of *T. rex*?

18. Read the "Room at the Top" panel. Scientists think that *T. rex* was not the only top predator in its ecosystem; it shared this title with *Alioramus* and *Tarbosaurus*. How could these animals have coexisted?

What evidence from animals living today do scientists use to infer that multiple top predators can coexist in an area?

19. Explore the coprolite and related panels. *T. rex* could digest bone. How do scientists know that?

STOP 4: "Sensitive Side" Section

20. Read the "Eyes of a Killer" panel. What evidence do scientists use to hypothesize that *T. rex* may have seen in the ultraviolet spectrum?

What are the similarities between the eyes of *T. rex* and the mountain lion? How does this evidence support the idea that *T. rex* was a predator?

21. Sketch the *Daspletosaurus* jawbone and mark the small holes.

What do scientists think is the most probable explanation for these structures? Why?

Read the "Touchy Feely" panel. What evidence supports the idea that *T. rex* had a very sensitive face?

22. Read the "Headgear," "Scales and Feathers," and the "Hear Me Roar!" sections. Record one interesting information about *T. rex* appearance or sound and the evidence that supports it.