INQUIRY & INVESTIGATION

The Coevolution of *Tyrannosaurus* & Its Prey: Could *Tyrannosaurus* Chase Down & Kill a *Triceratops* for Lunch?

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Abstract

Students will analyze the coevolution of the predator–prey relationships between Tyrannosaurus rex *and its prey species using analyses of animal speeds from fossilized trackways, prey-animal armaments, adaptive behaviors, bite marks on prey-animal fossils, predator–prey ratios, and scavenger competition. The students will be asked to decide whether* T. rex *was a predator, an opportunistic scavenger, or an obligate scavenger.*

Key Words: *Coevolution;* Tyrannosaurus rex*; predator–prey relationships; dinosaur locomotion; dinosaur armament; dinosaur behaviors; paleontology.*

Evolution, or the change of living organisms over time, is based on two principles. The first principle is that variation occurs between individual members of a species. Some grizzly bears are larger than other grizzly bears. The second principle is that the environment favors the reproduction of some members of the species over others; this is called "natural selection." Bigger grizzly bears might be able to kill elk and feed themselves and their young, while smaller grizzly bears might not, and their young may starve. Over time, the larger grizzly bears make up more of the population.

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Predator–prey relationships are excellent examples of evolution. A predator is an organism that eats another organism, and the prey is the organism that the predator eats. The slower elk get eaten and don't leave offspring, whereas the faster elk get away from the grizzly bears, and their elk offspring inherit their parents' genes for faster running. So the elk population in general gets faster. But now the grizzly bears must evolve to run faster, too, or they won't be able to catch the elk for food and they will die. This is an example of coevolution, which is the joint evolution of two species, with each species adapting to changes in the other. Coevolution of predator and prey species creates a kind of "arms race" for survival, with adaptations for survival evolving in both species.

○ Coevolution in a Modern Predator–Prey Relationship

On the Serengeti Plain in Africa, the cheetah (*Acinonyx venator*) and Thomson's gazelle (*Eudorcas thomsonii*) have coevolved in their predator–prey relationship. This coevolution has given us a 112–120 km/h cheetah that can run down its gazelle prey (Wikipedia, 2013a). Indeed, cheetahs are the fastest short-distance runners of any animals on our planet (Curiosity Online, 2011). Thomson's gazelle, nicknamed "tommie," can run very fast, 80–96 km/h, but not quite fast enough to avoid being the cheetah's lunch (Wikipedia, 2013b).

But the pressure of the cheetah's success has resulted in the evolutionary selection of other methods for the tommie to survive. The first of these is exceptional peripheral vision that gives the gazelle more of a head start to outrun the cheetah. Second, the tommie has evolved a shorter turning radius to change direction, and it zig-zags when it is being chased, both adaptations that help it gain distance on the cheetah. Third, the tommie relies on large numbers of individuals of its species – 550,000 on the Serengeti Plain – so that the chance of being caught is small (East, 1999; Wikipedia, 2013b).

According to the principle of coevolution, the cheetah has evolved its own enhancements, such as a long muscular balancing tail, grooves on its toe pads like tire treads, and nonretractable claws that act as cleats, all three of which improve its traction and its ability to make more rapid turns (Curiosity Online, 2011). Now let's apply these lessons to the arms race between *Tyrannosaurus rex* and its potential prey species listed in Table 2, and decide whether *T. rex* was a predator, a scavenger eating already dead carcasses, or both.

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Table 1. Questions related to the film clips from *Jurassic Park*, *Clash of the Dinosaurs*, and *Valley of the T. rex* (see text).

Questions
1. In *Jurassic Park*, the jeep was moving about 40 miles per hour (it shifts gears three times), but the *Tyrannosaurus rex* always has one foot on the ground. Can the *T. rex* catch the jeep? Did it catch chaos theorist Dr. Ian Malcolm (played by Jeff Goldblum)? How fast do you estimate the *T. rex* was running?
2. Having viewed *Clash of the Dinosaurs*, are you convinced that *T. rex* was a fierce predator? Why?
3. In *Valley of the T. rex, Part 1*, why does Dr. Jack Horner, a famous paleontologist, think that *T. rex* is a scavenger?

○ Student Instructions

First, you will view three short film clips that set the stage for this exercise:

1. The "*T. rex* chasing the jeep" scene from the movie *Jurassic Park* (1993): www.youtube.com/watch?v=n1G6MhFi0cM
2. A clip from the Discovery Channel's *Clash of the Dinosaurs* series episode "Perfect Predator" (2009): www.youtube.com/watch?v=4URe7c7Gq30
3. A clip from the Discovery Channel's *Valley of the T. rex* (2013): www.youtube.com/watch?v=K6ETcq5yPVg

After viewing the clips, answer the questions in Table 1.

Laboratory Part 1: Production of Life-Size Models of Dinosaur Footprint Trackways

In Part 1 of the exercise, you will work in five groups. Each group will produce a life-size model of the dinosaur footprint trackway of one of the following dinosaurs: *Tyrannosaurus*, *Triceratops* (a ceratopsid), *Ankylosaurus* (an ankylosaur), *Edmontosaurus* (a hadrosaur), and *Alamosaurus* (a sauropod). You will be provided a copy of Figure 1 on clear acetate, scissors, paper or plastic sheets, a marking pen, adhesive tape, a metric tape measure, and access to an overhead projector.

The dinosaur footprints in Figure 1 are proportionately correct, but of course they are much smaller than life size. Place the acetate sheet with the footprints on an overhead projector. Tape a blank piece of paper or plastic sheet to a whiteboard or wall. Shine the image of the footprint onto the blank paper or plastic sheet and move the projector forward or back from the wall until the size of the footprint is the same length or width as listed in Table 2, column C. The distance from the wall to the projector will be about 8–10 m. Trace the outline of the footprint onto the paper, cut out the footprint, and repeat for a total of three (*T. rex*) or six (prey) footprints.

The footprints of each dinosaur will be placed on a flat surface, such as a hallway floor, and secured with adhesive tape. The two left footprints will be placed front-and-back one stride length (L) apart, measured toe-to-toe or heel-to-heel. Stride lengths for the five dinosaurs are listed in Table 2, column D. The right footprints will be placed one-half stride length between the two left footprints and one

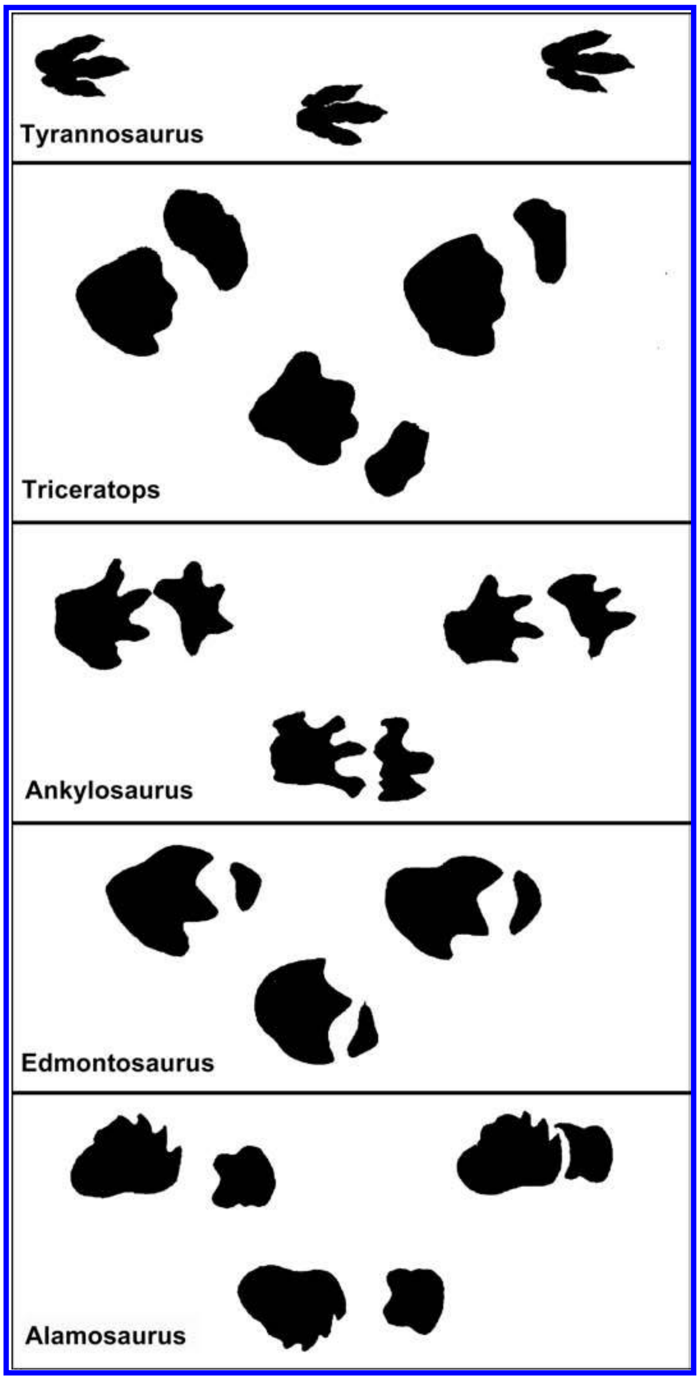

Figure 1. Representative foot imprints from dinosaur trackways (modified from Paul, 2010, p. 30). Foot and stride lengths are listed in Table 2.

track width (TW) to the right. Track-width distances are as follows: *Tyrannosaurus* (31 cm), *Triceratops* (68 cm), *Ankylosaurus* (50 cm), *Edmontosaurus* (50 cm), and *Alamosaurus* (114 cm). View each of the trackways to get a sense of perspective about the dimensions of dinosaur locomotion.

Laboratory Part 2: Estimation of the Rates of Locomotion in Cretaceous Dinosaurs

In Part 2, you will calculate and compare the speed of *T. rex* and four of its large potential prey species (listed in Table 2). While we

Table 2. Trackway Data Form: *Tyrannosaurus rex* and contemporary large-bodied potential prey species from dinosaur trackway data.[a]

	A	B	C	D	E	F	G	H	I	J
Species	**Length**	**Weight (tonnes)**	**Foot Length (FL) or Width (FW)**	**Stride Length (L)**	**Alexander Hip Height (h^A = 4FL or 4FW)**	**Thulborn Hip Height Conversion Factor (CF)**	**Thulborn Hip Height (h^T = CF × FL or CF × FW)**	**Speed, Alexander Formula (km/h)**	**Speed, Thulborn Formula (km/h)**	**Walk, Trot, or Run**[b]
Tyrannosasurus rex (pp. 108–109)	12 m	6	0.69 m (FL)	6.7 m		4.9 FL				
Triceratops horridus (pp. 265–266)	8 m	9	0.57 m (FW)	6.9 m		4.2 FW				
Ankylosaurus magniventris (pp. 234–235)	7 m	6	0.44 m (FW)	2.0 m		3.7 FW				
Edmontosaurus annectens (pp. 297–298)	9 m	3.2	0.43 m (FW)	5.1 m		5.9 FW				
Alamosaurus sanjuanensis (pp. 209–210)	20 m	16, but 50-70 in adult	0.76 m (FL)	5.2 m		5.9 FL				

[a]Species descriptions can be found in Paul (2010); page numbers are in parentheses after species names in the table. Fossil species in this list were chosen on the basis of synchronous time and geographic location so that they would be contemporaries of *T. rex*. Measurements and calculations are according to Thulborn (1982).

[b]Walking ($L/h^T \leq 2.0$), trotting ($2.0 < L/h^T < 2.9$), or running ($L/h^T \geq 2.9$).

can determine the speed of cheetahs and gazelles very accurately because they are alive, one of the only ways to determine extinct dinosaurs' speeds is to use fossilized trackways. Measurements of a dinosaur's footprint length and stride length can be used to calculate speed (Table 2). In the data in Table 2, a footprint length is measured from the longest toe to the heel and sometimes a footprint width is used, measured from side to side at its largest point. The measurements are taken on the larger hind foot in four-legged dinosaurs. Stride length is measured from the heel impression of the left foot to the heel impression when that same left foot is put down again a stride later. Hip height (h) cannot be measured directly from the footprint trackway but can be estimated. Using data from living animals, Alexander (1976) developed a formula for calculating the speed of dinosaurs from trackways of their footprints:

$$\text{Speed (m/s)} = 0.25(\text{acceleration due to gravity})^{0.5} \times (\text{stride length})^{1.67} \times (\text{hip height})^{-1.17} \quad \text{[Equation 1]}$$

where hip height according to Alexander (h^A) is estimated to be 4× footprint length, and acceleration due to gravity (g) is 9.81 m/s.

A little later, Thulborn (1982, 1990) suggested the need to modify the speed estimates for different dinosaur groups, using different leg lengths or heights (h^T) in the calculations. These different hip heights by groups, called hip height conversion factors, were derived from direct measurements taken from dinosaur fossilized skeletons. Thulborn also developed the idea that L/h^A, or relative stride length, could be used to determine whether the animal was walking ($L/h^A \leq 2.0$), trotting ($2.0 < L/h^A < 2.9$), or running ($L/h^A \geq 2.9$).

Table 2 has representative foot-length and stride-length numbers for *T. rex* and four potential prey species, plus columns of numbers calculated using Equation 1 (Alexander, 1976), along with the hip height conversion factors and relative stride length calculations of Thulborn (1982, 1990). Calculate and insert the numbers in columns E and G. You can obtain calculated speeds for both the Alexander and Thulborn methods by inserting the numbers into the online Dinosaur Speed Calculator (Sorby Geology Group, University of Sheffield, 2010). You will input the foot length (Table 2, column C), Thurlborn hip height conversion factor (Table 2, column F), and stride length (Table 2, column D). The Calculator will supply the answers to Table 2, columns H, I, and J. Note that if you use direct measurements and calculate using the formula, the speed (m/s) can be converted into kilometers per hour by multiplying (m/s) by 3.6 = kilometers per hour, and (kilometers per hour)/0.621 = miles per hour. Compare your results with those published by researchers in this field (Table 3). Can you conclude that these estimates of dinosaurs' running speeds are very accurate?

Laboratory Part 3: Animal Armament, Adaptive Behavior, Bite Mark Evidence, Predator/Prey Ratios, & Scavenger Competition

The evolutionary pressure put on prey animals by predators often results in two types of evolutionary changes in the prey: (1) development of defensive and offensive armaments and (2) adaptive behaviors such as high-speed running away and herding together for combined defense, all listed in Table 4. Consider the impact these characteristics would have on the competition between *T. rex* and its potential prey species. In this part, you should discuss with your team members the characteristics reviewed for you in Table 4 and

Table 3. Published calculated speeds of Cretaceous dinosaurs.

Genus	Speed	Maximum Speed
Tyrannosaurus		15–20 km/h (Thulborn, 1982) 32 km/h (Farlow et al., 1995) 18–40 km/h (Hutchinson & Garcia, 2002) 28.8 km/h (Sellers & Manning, 2007) 24 km/h (Zimmermann, 2012) 24–40 km/h (Paul, 2010, p. 31)
Triceratops		25 km/h (Thulborn, 1982)
Ankylosaurus	6–8 km/h (Thulborn, 1982)	6–8 km/h (Thulborn, 1982)
Edmontosaurus	12–17 km/h (Thulborn, 1982)	20–30 km/h (Thulborn, 1982) 61.2 km/h (Sellers et al., 2009)
Alamosaurus	3.6–4.0 km/h (Alexander, 1976) 4.7–4.9 km/h (González Riga, 2011) 12–17 km/h (Thulborn, 1982)	25 km/h (Paul, 2010, p. 31)

Table 4. Comparison of factors affecting armaments and potential attack of *Tyrannosaurus rex* shown by healed bite marks on contemporary large-bodied potential prey species. Data are from Paul (2010; page numbers provided for reference).

Species	Dinosaur Family	Characteristics, Defensive/Offensive Armaments, & Adaptive Behaviors	Healed *T. rex* Bite Marks on the Head or Body?
Tyrannosaurus rex	Therapods, specifically Tyrannosaurids	Large jaws and banana-size teeth (in this case mainly offensive armaments); strongest bite force of any terrestrial animal then or now; good sense of smell to detect carrion; stereoscopic vision for prey chasing and capture; gigantic size; relatively rapid running speed.	Yes (p. 38)
Triceratops horridus	Ceratopsids	Long brow horns; small nasal horn; beak for biting; large frill protects neck; ribcage cuirass helped protect flanks; large body scales; defensive herding.	Yes (pp. 38, 102, 108)
Ankylosaurus magniventris	Ankylosaurids	Completely armored head, neck, back, and tail; large tail club to damage legs and flanks or to topple *T. rex*; built low to the ground; rarely lived in herds.	Yes (pp. 234–235)
Edmontosaurus annectens	Hadrosaurs	None; defensive herds of hundreds to thousands of individuals; generally ran away from predators.	Yes (pp. 108, 298)
Alamosaurus sanjuanensis	Sauropods, specifically Titanosaurids	Large 16-ton juvenile animal; perhaps lightly armored as adults; defensive herding. Current estimates are that this sauropod grows to 50–70 tonnes (metric tons) when it reaches adult size.	No (pp. 38, 204)

this section, and weigh the relative importance of each as you answer the questions in Table 5.

Recent analysis of bite marks on bones have estimated that *T. rex* had the largest bite force (6410–13,400 Newtons) of any terrestrial animal to date. So it had very strong teeth that could have withstood the stresses associated with prey capture (Erickson et al., 1996). However, if *T. rex* were a scavenger, it would also need strong teeth to crush the bones of the dead prey, and a large, menacing appearance to scare off the prey's original predator and other scavengers.

There are healed bite marks that have been thought to have been made by *T. rex* on *Triceratops*, *Ankylosaurus*, and *Edmontosaurus* (Table 4), which means that the wounds were sustained by living individuals which then healed – signs of attempted predatory behavior. Just this year, Robert DePalma II and his colleagues (2013) have found an actual *T. rex* tooth crown embedded in a hadrosaur vertebrae surrounded by healed bone growth. On the other hand, 18 *Triceratops* from the Museum of the Rockies had *T. rex* tooth marks with no signs of healing. There are also bone beds of hundreds to

Table 5. Student Discussion and Assessment Questions (use a separate sheet for your answers).

Student Discussion and Assessment Questions
1. At the beginning of this laboratory exercise, particularly after watching the three film clips, what was your conclusion about the predatory nature of *T. rex*? Have you modified your opinion after participating in this laboratory exercise? In what way?
2. What are the pitfalls inherent in the animal trackway data?
3. Do we have any tracks of a *T. rex* footprints following the same track as any of the prey species, so we might conclude that it was actively chasing them?
4. Can the trackway data be used to resolve the predator–scavenger debate? Why? Why not?
5. If a *T. rex* were toppled over on its side, with its puny little arms could it stand back up? What effect would this answer have on the effectiveness of the Sauropod tail blow, the Ankylosaur tail club blow, or the Triceratops frontal charge?
6. Which animals have more effective armaments than others? How will this change the actual number of attacked animals of each species?
7. List as many items (anatomy and behavior) as you can that have evolved in other different predator and prey animal pairs.
8. What are the differences between a predator, an opportunistic scavenger or an obligate scavenger?
9. Which of the five potential prey animals appears to have the running speed, armaments, and defensive behavior to avoid being caught, killed and eaten by *T. rex*?
10. If, in your opinion, some of these potential prey animals were well protected from *T. rex* attack, why were there healed bite marks on that species?
11. If *T. rex* was not, in your opinion, the "the fiercest predator that ever lived," then how in evolutionary terms do you account for the large size, large jaws, and banana-size teeth, as well as their binocular vision?
12. Was *T. rex* a predator, a facultative or opportunistic scavenger or an obligate scavenger? Support your answer with data. Describe how you weighted the various points of data in reaching your conclusion.

thousands of *Edmontosaurus* fossils that obviously died of environmental causes such as floods or droughts, and these are covered with *T. rex* bite marks, clear evidence of scavenging (Erickson, 2000, p. 274). In normal habitats, prey outnumber predators by three to four times, but Horner et al. (2011) reported that there were equal numbers of *T. rex* fossils and *Edmontosarus* fossils – that is, predator and prey numbers were equal if *T. rex* was mainly eating unarmed hadrosaurs.

Wilson and Wolkovich (2011) have argued that scavenging is underestimated in major predator–prey relationships. This opens the possibility that scavenging might have played an important role, along with predation, in *T. rex*. However, Carbone et al. (2011) have pointed out that an adult *T. rex* cannot be said to be only a scavenger (an obligate scavenger) because of the overwhelming numbers of smaller competing theropod carnivores. These smaller theropods represent 80% of all carnivores in *T. rex*'s jurisdiction, and they would get to any dead carcasses and eat them before *T. rex* could get there.

In considering your answers to the questions in Table 5, particularly to question 12, you should be thinking about how the calculated speeds in Part II and the characteristics of each of the prey species would be interacting with the *T. rex* – in what evolutionary direction did the *T. rex* predation push the prey species, and in what evolutionary direction did the *T. rex* coevolve? Think back to the beginning of these relationships and imagine that the *T. rex* was a smaller predator (it was) and that the prey species were smaller and had shorter horns and smaller tail clubs (they did) and couldn't run as fast (they couldn't). How do you think the prey species evolved to where they are today? And how did the *T. rex* cope with their evolutionary development to protect themselves? Explain the coevolution that occurred. It is the answer to whether *T. rex* was a predator, a scavenger, or both.

○ Student Assessment

Students can be assessed by means of the correctness of their speed calculations on the completed Trackway Data Form (Table 2) and from their written answers to the Student Discussion and Assessment Questions (Table 5).

○ Teacher Implementation Suggestions

The exercise addresses the following middle school (MS) and high school (HS) standards of *The Next Generation Science Standards* (National Research Council, 2013): MS-LS2A and HS-LS2A, Interdependent relationships in ecosystems; MS-LS4B and HS-LS4B, Natural selection; and MS-LS4C and HS-LS4C, Adaptation.

The three film clips provide an excellent introduction to the question that we consider in this laboratory exercise. The instructor needs to review how predator–prey relationships can give rise to coevolutionary change in both species. The bear–elk and cheetah–tommie interactions can be reviewed so that the students are completely clear about the evolutionary mechanism involved in predator–prey competition. The characteristics of the four prey species should also be reviewed by the instructor, with images obtained from the Internet. Small dinosaur replicas such as the Carnegie Collection (www.Safari.Ltd.com) can also be used to support visual learning.

Figure 2. Team Tyrannosaurus and their footprint trackway in the hallway of the Health and Natural Science Building at the University of North Georgia (photo courtesy of the University of North Georgia).

The instructor should emphasize that this is not just a laboratory exercise for students, but rather an actual debate among academic paleontologists that has gone on for the past 80 years, beginning with Lawrence Lambe (1917), and continues today. The footprints in Figure 1 should be magnified at least twofold when copied onto clear acetates for projection. The instructor can oversee the overhead projection of the footprints while each group of students, called teams like "Team Tyrannosaurus" and "Team Triceratops." trace the footprints of their dinosaurs. The use of a projector for each group allows simultaneous footprint tracing by the groups, which significantly decreases the time required for the lab.

Once footprint sets have been made, the instructor has the option of using them by setting up the trackways according to the correct stride distances, and then omitting the data from Table 2, columns C and D, and letting the students measure and collect that data from the trackways themselves or the students can use the data in Table 2 to set up the trackway themselves (Figure 2). Once the initial set of footprints has been made, they can be used in subsequent labs. The use of the Dinosaur Speed Calculator needs to be demonstrated to the students by calling up the Website and demonstrating its use during class.

The whole exercise takes a minimum of about 3 hours to complete, depending on the extent of the instructor introduction, whether the students make the trackways themselves or just measure instructor-produced trackways, and whether the group is high school or college students. The University of North Georgia has lab periods of 1 hour and 50 minutes, and two of these have been more than sufficient to complete the lab. High schools with 50-minute periods will need three lab periods for completion.

References

Alexander, R.M. (1976). Estimates of speeds of dinosaurs. *Nature, 261,* 129–130.

Carbone, C., Turvey, S.T. & Bielby, J. (2011). Intra-guild competition and its implications for one of the biggest terrestrial predators, *Tyrannosaurus rex. Proceedings of the Royal Society of London B 278,* 2682–2690.

Curiosity Online. (2011). How fast does a cheetah run? Available at http://curiosity.discovery.com/question/how-fast-does-cheetah-run.

DePalma, R.A., II, Burnham, D.A., Martin, L.D., Rothschild, B.M. & Larson, P.L. (2013). Physical evidence of predatory behavior in *Tyrannosaurus rex*. *Proceedings of the National Academy of Sciences USA, 110,* 12738–12743.

East, R. (1999). *African Antelope Database 1999*. Gland, Switzerland and Cambridge, UK: IUCN.

Erickson, G.M. (2000). Breathing life into *Tyrannosaurus rex*. In G.S. Paul (Ed.), *The Scientific American Book of Dinosaurs*. New York, NY: St. Martin's Griffin.

Erickson, G.M., Van Kirk, S.D., Su, J.-T., Levenston, M.E., Caler, W.E. & Carter, D.R. (1996). Bite-force estimation for *Tyrannosaurus rex* from tooth-marked bones. *Nature, 382,* 706–708.

Farlow, J.O. (1981). Estimates of dinosaur speeds from a new trackway site in Texas. *Nature, 294,* 747–748.

Farlow, J.O., Smith, M.B. & Robinson, J.M. (1995). Body mass, bone "strength indicator," and cursorial potential of *Tyrannosaurus rex*. *Journal of Vertebrate Paleontology, 15,* 713–725.

González Riga, B.J. (2011). Speeds and stance of titanosaur sauropods: analysis of *Titanopodus* tracks from the Late Cretaceous of Mendoza, Argentina. *Anais da Academia Brasileira de Ciências, 83*, 279–290.

Horner, J.R., Goodwin, M.B. & Myhrvold, N. (2011). Dinosaur census reveals abundant *Tyrannosaurus* and rare ontogenetic stages in the Upper Cretaceous Hell Creek Formation (Maastrichtian), Montana, USA. *PLoS ONE, 6*(2), e16574.

Hutchinson, J.R. & Garcia, M. (2002). *Tyrannosaurus* was not a fast runner. *Nature, 415,* 1018–1021.

Lambe, L.B. (1917). The Cretaceous theropodous dinosaur *Gorgosaurus*. *Memoirs of the Geological Survey of Canada, 100*, 1–84.

National Research Council. (2013). *The Next Generation Science Standards*. Available online at http://www.nextgenscience.org.

Paul, G.S. (2010). *The Princeton Field Guide to Dinosaurs*. Princeton, NJ: Princeton University Press.

Sellers, W.I. & Manning, P.L. (2007). Estimating dinosaur maximum running speeds using evolutionary robotics. *Proceedings of the Royal Society B, 274,* 2711–2716.

Sellers, W.I., Manning, P.L., Lyson, T., Stevens, K. & Margetts, L. (2009). Virtual palaeontology: gait reconstruction of extinct vertebrates using high performance computing. *Palaeontologia Electronica, 12*(3), article 12.3.11A.

Sorby Geology Group, University of Scheffield. (2010). Dinosaur Speed Calculator. Available at http://www.sorbygeology.group.shef.ac.uk/DINOC01/dinocal1.html.

Thulborn, R.A. (1982). Speeds and gaits of dinosaurs. *Palaeogeography, Palaeoclimatology, Palaeoecology, 38,* 227–256.

Thulborn, [R.A.] T. (1990). *Dinosaur Tracks* (p. 410). London: Chapman & Hall.

Wikipedia. (2013a). Cheetah. [Online.] Available at http://en.wikipedia.org/w/index.php?title=Cheetah&oldid=550563517.

Wikipedia. (2013b). Thomson's gazelle. [Online.] Available at http://en.wikipedia.org/w/index.php?title=Thomson%27s_gazelle&oldid=554038260.

Wilson, E.E. & Wolkovich, E.M. (2011). Scavenging: how carnivores and carrion structure communities. *Trends in Ecology & Evolution, 26,* 129–135.

Zimmermann, K.A. (2012). *Tyrannosaurus rex*: facts about *T. rex*, king of the dinosaurs. [Online.] Available at http://www.livescience.com/23868-tyrannosaurus-rex-facts.html.

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