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Paleoimagery: The Artistic Restoration of Dinosaurs and Prehistoric Life

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PALEOIMAGERY: THE ARTISTIC RESTORATION OF DINOSAURS AND PREHISTORIC LIFE

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Introduction

For centuries, images of dinosaurs and other prehistoric animals have lingered in the minds and imaginations of many. The remains that have been found of these animals give them an iconic status. Not only do they serve as silent witnesses to distant, alien eras that no human has ever seen, but they also prove the existence of creatures as peculiar and fantastical as those portrayed in myths and legends. Because these animals no longer roam our planet, the visual conceptions we have about them are largely derived from the artistic reconstructions produced by professional illustrators. Such art pieces are referred to as "paleoart" (as well as "paleoimagery") and their goal is "to produce maximally lifelike restorations of prehistoric and extant ecosystems (featuring dinosaurs and all other life forms) using both traditional and digital media" (Csotonyi). These images represent a conversation occurring between the paleontologists uncovering the fossil remains of extinct organisms and the illustrators who work to communicate the information contained in them to the general public. Though this genre has become more established over the last few decades, paleoart is still a relatively new practice. Its origins lie with examples of scientific biblical illustration from the 17th century.

A History of Paleontological Illustration

The foundation for modern paleoart is rooted in the idea of "deep time", another term for the concept of geologic time that was developing and evolving in Europe during the 1600s and 1700s. During this period, art pieces visually portraying the concept of deep time "were firmly embedded in [the] artistic tradition of visual representations of scenes from the *human* past" (Rudwick 2). These ideas of human past and of deep time were principally derived from the biblical record, as the words contained within it were considered to be of overwhelming historical significance at the time. Biblical illustrations attempted to show events such as the

Creation and the Deluge (the story of the Great Flood and Noah's Ark) that were described in the Bible with some degree of realism. These were seen as some of the major events not only in human history, but in the history of the planet as well. Fossils were known about when these drawings were being created, but they were seen by many as supplementary information. In his book *Sacred Physics* (1731), Johann Jacob Scheuchzer included artistic depictions of the Creation and the Deluge in a series of images framed like elaborate paintings. These included representations of each of the first six days of the creation as well as the beginning, middle, and ending of the Deluge. Particularly, in the piece "The Beginning of the Deluge" (Fig 1), depictions of marine fossils are placed around the artificial frame containing the scene of the Deluge. Not only do they create a more elaborate picture and help to frame the scene even more, but the fossils are utilized as a sort of statement by the author. The inclusion of the fossils in this piece was an "emphasis on their status as *witnesses* to a past event" (Rudwick 16). While fossils were not the primary source of information from which this depiction of "deep time" was created, and many people at the time could not have seen

Figure 1

Johann Jacob Scheuchzer's depiction of the Deluge, framed with drawings of fossil specimens.

them as representing moments from times even "deeper" than the Deluge, their importance in the reconstruction of deep time is starting to emerge.

The importance of geological information in the creation of representations of deep time would only increase into the later eighteenth century. Naturalists collecting fossils and studying large section of rock strata were coming to the conclusion that the world was likely much older than originally thought. These ideas were further supported by the discovery of fossil creatures unlike anything known at that time. The remains of extinct animals such as the *Megatherium* and the mastodon were breaking the preconception that the Earth had always had the same assemblage of animals. When people like Georges Cuvier began describing and illustrating these fossil bones and reconstructing the skeletons of these creatures, they were introducing other artistic and scientific ideas to depictions of deep time. "In this way, the pictorial traditions of comparative anatomy, and of natural history in general, became as important as those of biblical illustration in providing precedents for the new genre of scenes from deep time" (Rudwick 32). Such traditions included depicting skeletal remains and reconstructions from a lateral view and reconstructing the skeletons into a vaguely living posture. These principles are utilized heavily in modern paleoart, both in reconstructions of skeletons and of living animals. Cuvier himself took these conventions even further. He began incorporating the anatomical study of modern animals into these drawings, allowing him to reconstruct the skeletons of extinct animals in a more dynamic and natural way. Estimating the musculature, life posture, and body outline of the animals represented by these fossils (as well as the eye and ear placement in some cases) made illustrations of extinct animals seem even more convincing and natural. In particular, Cuvier's reconstructions of creatures such as *Anoplotherium* (Fig 2) were based on a great understanding of the bodies of living mammals and assisted him in making more informed assumptions about

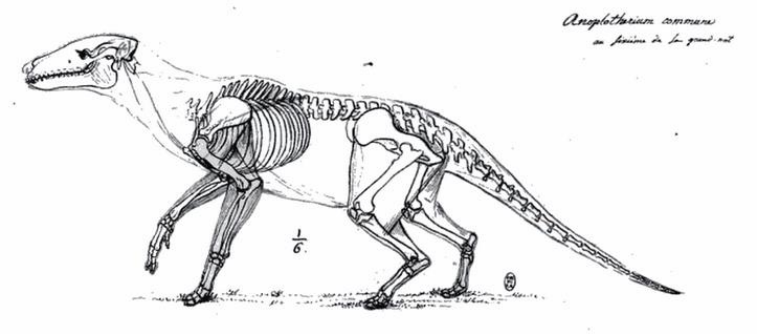

Figure 2

A skeletal reconstruction of the extinct mammal *Anoplotherium commune*, featuring a body outline and light indications of the animal's musculature and form.

the biology of the creatures he found. Although these reconstructions of the fossil mammals Cuvier had found were informed through fairly reasonable assumptions and were likewise very convincing, he worried that publishing these depictions would be seen as overly speculative and would discredit him as a man of science and hard facts. This stigma would remain for a long time and resulted in many reconstructions of extinct life being more rigid and simplistic.

A major turning point in artistic depictions of deep time came with the creation of *Duria antiquior* ("ancient Dorset") (Fig 3). This scene was created by geologist Henry Thomas De la Beche, and featured a fully realized prehistoric landscape complete with newly discovered plesiosaurs, ichthyosaurs, and pterodactyls. Though the piece itself is somewhat imaginative in what is presented, everything featured in it was based on geological and fossil evidence. De la Beche was able to convey inferences paleontologists had made about the animals included in the piece, based on their bones and

Figure 3

An imaginative reconstruction of Dorset, England during the deep past, featuring ichthyosaurs, plesiosaurs, and pterosaurs within an ancient landscape.

body structure to create a cohesive picture. This piece also was one of the first to produce a complete, somewhat realistic environment to serve as a habitat and a context for the creatures depicted as living within it. In addition to all of this, this scene offers up a creative viewpoint that no other pieces of this nature had offered before. The water in this scene is "cut away" in a sense, allowing viewers to see what is going on under the water's surface as though they were looking at fish in an aquarium. This provides a more holistic view of the scene, allowing viewers to objectively look at what is happening both under and above the water in this place. The fact the De la Beche conceived of this viewpoint for his reconstruction is made all the more interesting as this was achieved long before the invention of the marine aquarium where this abstract view would become more comprehendible and commonplace. This piece stands out due to its technical aspects, but this is not the only reason it is notable. This scene was one of the first depictions of deep time to receive even a limited publication. The lithograph produced of *Duria antiquior* became very famous and was able to reach a wide audience within circles of geological study. This representation of deep time is so significant as it was a much more naturalistic and more widely distributed snapshot of the ancient world than any before it, and it helped to establish the look of the prehistoric world and how it would be portrayed from then on.

By the early 1800s, artistic reconstructions of deep time were able to reach more and more potential viewers through new venues. Pieces similar to *Duria antiquior* were being published in magazines and dictionaries. By the 1830s, such art was being published and distributed to the point that "the deep past was made vividly real to the general public in Britain" (Rudwick 60). By being able to reach a wider audience outside of the scientific community (even more specifically the geological community), these images help to separate the fossil-based images of the deep past from the biblical images of the deep past as different genres and to

solidify the concept of the deep past being communicated by the scientific community at the time. Though the reproduction of these images helped to increase the scientific literacy of the European populace at that time, there were still concepts that weren't being communicated effectively. One of these was the idea that all extinct animals lived at the same time as one another ("prehistoric times"). This is still a problem that persists somewhat today, though the context for Europe during the 1800s was somewhat different. The general populace was just being exposed to these images of the deep past, and was also uninformed of much of the science on which the art was based. Though these images were likely published with accompanying text to help give them context, more often than not it seems that people gleam information from images and displays without reading the explanation. Because these images all seemed to represent some fantastical window into the past, many did not understand the distinctions between geological eras and the animals that lived and did not live during each time interval. Though a few different illustrators created singular images to convey this idea of the divisions present in deep time, the first major publication to assert otherwise was *The Primitive World in Its Different Periods of Formation* (1851) by Austrian botanist Franz Xaver Unger. Though (like Cuvier) Unger was initially cautious about being discredited or ridiculed, he commissioned a series of scenes (Fig 4) for the book from artist Josef Kuwasseg depicting the animals and environments of the various periods from Earth's history. These scenes were highly realistic and naturalistic and were placed in Unger's book from earliest to latest. The realism and attention to

detail in this series of scenes was extremely high. Not only do these scenes attempt to accurately represent the animals found in these geological periods and the climates that the rock record indicates were present at the time, but Kuwasseg even tried to incorporate information on fossil plants that had been found at these locations. This results in highly natural looking environments that were fairly accurate representations of what was known at this time. The final series was comprised of fourteen scenes spanning from about the Carboniferous to the modern day and the birth of modern man. Much like *Duria antiquior*, this publication was very important for many reasons. The first was that it stressed the idea of deep time being separate periods based on geological evidence. Not only were these time periods and the changes between them indicative from the rock types themselves but also from the fossils found within them. The scenes created by Kuwasseg showed beautiful, open landscapes with contemporary faunal assemblages that were still accurate to what was known. This created convincing, iconic images for the different periods in Earth's history that readers of Unger's book could associate with the names included within. The second was that it continued to create a believable image of what the Earth could have looked like in its past. Even with the dinosaurs that had been found by the time of this book's publication as well as a menagerie of other strange animals, these landscapes and artistic reconstructions felt plausible. It implies that Earth's history has always been very natural and

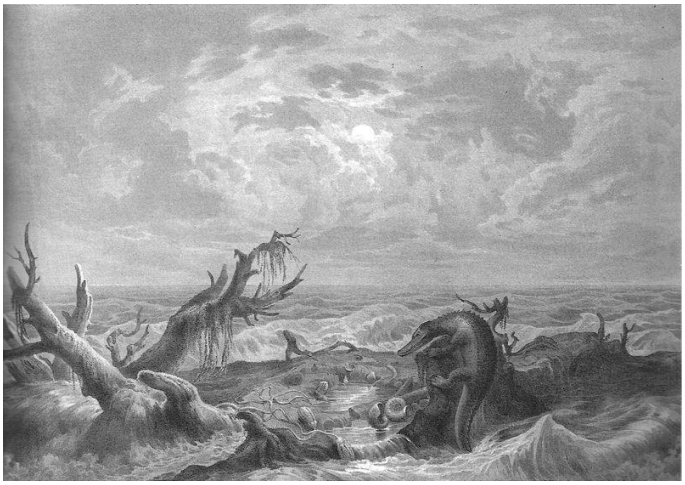

Figure 4

One of Kuwasseg's scenes of deep time featured in Unger's book. This scene in particular portrays an amphibious labyrinthodont climbing onto land.

that these images (as incredible as they are) are further removed from fantasy and pushed more towards the world of reality. If anything, this could make the information and images presented even more interesting and spectacular for readers as the fantastical images are based in something real. Third, this book made a point of bringing credit to the artist who produced the scenes for this publication. In many earlier publications, either the scientist themselves happened to be decent artists and could contribute to their own work, or people who were artists by trade were commissioned to make works and were not credited afterwards. This brings importance and notoriety for the artists themselves. They can make a career by specializing in paleoart or other closely related forms of scientific illustration, making a name for themselves and even developing their own understanding of the science to improve successive works that are produced. All in all, this publication (though not so widely distributed) was very important in what it conveyed to its audience both directly and indirectly. Over the next few years, the idea of a sequence of period within deep time became more publicly available as other prominent scientists and artists would work to produce similar scenes and pieces for later publications. This would help disseminate these ideas to more of the general public.

In 1863, another book was published that made an important change to paleoart as a genre. Louis Figuier published *The Earth before the Deluge* (1863) as part of a series of publications made in an effort to popularize science. Much like Unger's book, this book contained a series of scenes (Fig 5) (more than two dozen) portraying various environments and

Figure 5

One of the scenes produced by Figuier for his book *The Earth before the Deluge*. This scene depicts a Cretaceous forest with the dinosaurs *Megalosaurus* and *Iguanodon* fighting one another.

animals from the periods of deep time. Figuier was well aware of Unger's book and was inspired by the scenes that Kuwasseg produced for it. However, the art in Figuier's book was much less objective than the pieces in Unger's. "As a work that was both instructive and entertaining, Figuier's *Earth before the Deluge* doubtless appealed widely to middle-class adults as a suitable Christmas present for their children" (Rudwick 214). The book was very popular and reached a massive audience. This is at least in part because Figuier supplemented the factual, realistic components present in past examples of paleoart with more entertaining visuals. The art pieces in the book almost seem to take inspiration from the old biblical illustrations from which paleoart derived in the first place. They became much more epic and grandiose, focusing on the spectacle of the deep past. This shift in purpose created a trend that set the standard for the genre that persists to this day, where the animals and locations of prehistory become the players and setting respectively for dramatic narratives. This created problems because the ancient world was made out to be more melodramatic than it likely was. It made media focusing on reconstructions of deep time less dependent on the naturalism that depictions of the modern world rely on and more dependent on what the people creating different forms of media feel would look interesting.

This trend became more and more prevalent through the Victorian era and into the early 1900s. The models of dinosaurs and other prehistoric animals produced by Benjamin Waterhouse Hawkins for the 1851 Crystal Palace Exhibition in Sydenham Park in London (Fig 6) brought prehistoric creatures into the third dimension as well as the modern world. They allowed visitors to immediately grasp the sheer size and monstrous qualities of the fossil creatures that were being discovered. While these models were made according to the scientific ideas and theories present about these animals at the time, the fact that they were on display as a sort of exhibition in a public park in a city as large as London made them somewhat of a spectacle. Part of the entertainment value from these models came from simply observing these models, awesome in scope and intriguing in their appearance. These models walked a line between the known and the unknown, the familiar and the alien. They helped to solidify the appeal of dinosaurs and other prehistoric animals as monsters that once roamed our world. This link between dinosaurs and the stories of monsters and dragons is asserted by John McGowan-Hartmann, largely through the writings of Professor Richard Owen and the Sydenham Project that resulted in Hawkins' models being placed in the gardens at Crystal Palace. In describing many dinosaurs and ancient animals, Owen made numerous comparisons and analogies to dragons. In a self-written guide to an exhibition on the geology and animals of deep

Figure 6

A statue of *Megalosaurus* constructed by Hawkins as one of many for the Crystal Palace Exhibition in Sydenham Park.

time, Owen described the pterodactyl as "a flying reptile or dragon" (McGowan-Hartman). The author argues that Owen utilized this terminology to allow people to more easily and immediately comprehend the beasts that he was attempting to explain and convey from a largely technical and scientific perspective. This kind of co-opting of the term 'dragon' "allows the public to find something recognizable in a new order of technological reproduction – modern primordial imagery" (McGowan-Hartmann). He further argues that because of this initial tie to dragons that Owen persisted in making during his life, even future artistic interpretations of prehistoric animals and dinosaurs in particular are intrinsically tied to this history. This is not to say that the reconstructions of dinosaurs and other creatures from deep time were solely based in spectacle and entertainment value, as famous artists such as Charles Knight reconstructed fossil animals in ways more plausible and convincing than any artist before them. Knight created iconic images of *Tyrannosaurus* in a posture similar to that of kangaroos (Fig 7) and swamp-dwelling sauropods like *Brontosaurus* that were largely popular and quickly ingrained in the public view on dinosaurs. These images would remain a stereotype and even artistic standard for future paleoart for decades.

Figure 7

A reconstruction by artist Charles Knight of two *Tyrannosaurus* fighting. This picture illustrates the "kangaroo-like" posture of many dinosaurs before the 1980s.

It wasn't until the 1980s that the image of big, slow, cumbersome dinosaurs lumbering through a swampy, primordial world would be challenged. Paleontologist Robert T. Bakker published *The Dinosaur Heresies* in 1986 as a way to present

his radical new theories on dinosaur biology and lifestyles. The book features extensive illustrations by Bakker himself, painting a picture of dinosaurs as extremely dynamic and active animals. These include large herbivores like stegosaurs and sauropods rearing far back on their hind legs and theropods and ornithopods leaping into the air, their legs raised high up. One picture in particular illustrates this pattern well. It shows the stegosaur *Diracodon* fighting the carnivorous biped *Ceratosaurus* (Fig 8). The *Diracodon* is standing on its two right feet with the two left feet outstretched and in the air. Its tail is curled backwards towards the left of its body, as though ready to snap back at its foe. The *Ceratosaurus* is standing on one leg, its other leg lashing out towards the stegosaur. The creature's mouth is wide open and its body tilted not only back towards its tail but sideways in a posture similar to past reconstructions, now appearing energetic and precarious all at once (Bakker 227). While these images are somewhat extreme in how they portray the posture and lifestyle of many dinosaurs, Bakker justifies much of the rationale behind his arguments and illustrations (sometimes with more illustrations). At the time of its release, the book was very popular, as it explained this radical, new thinking about dinosaurs in a way that was easy for general audiences to comprehend. The book and the illustrations in it helped to challenge the stereotype that dinosaurs were dumb, slow, evolutionary failures.

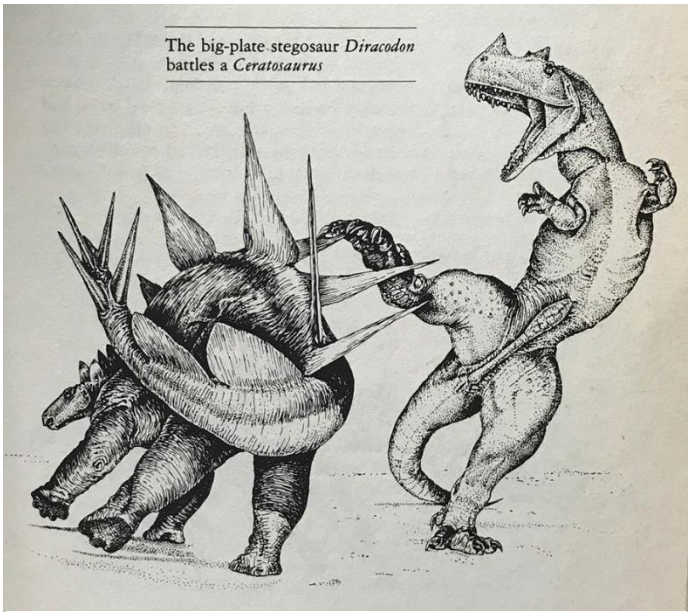

Figure 8

An extremely active depiction of *Diracodon* and *Ceratosaurus* fighting one another by Robert Bakker.

The last jump that paleoart has made approaching the modern day is its application of newly emerging computer technologies. In the late 1990s and early 2000s, computer generated images (CGI) had progressed to the point that three dimensional models of animals such as dinosaurs could be produced, lit, and animated to appear as though they were really filmed. Vincent Campbell stresses the importance of the use of CGI, arguing that "[i]n terms of paleontology, arguably the most significant form of media representations of recent years has been the emergence of a sub-genre of natural history programs that focus exclusively or predominantly on extinct animals, and utilize computer generated imagery (CGI) to bring them back to life, a phenomenon started by the BBC's *Walking With Dinosaurs* series in 1999" (Campbell). CGI allowed dinosaurs to appear more real than ever, as computers allowed for motions and visual details that could not have been achieved without it. And the fact the TV programs like *Walking with Dinosaurs* (1999) (Fig 9) and movies like *Jurassic Park* (1993) reached massive audiences and introduced them to more recent dinosaur science meant that they became integral ways to portray dinosaurs and convey dinosaur science.

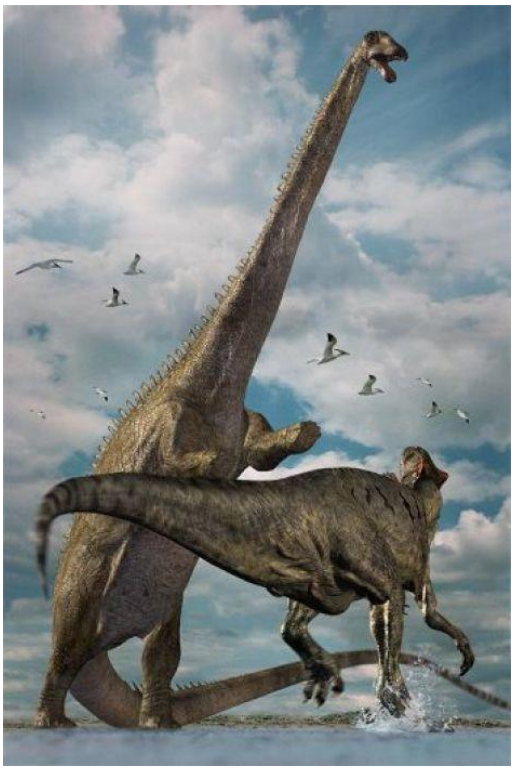

Figure 9

A promotional image from the television show *Walking with Dinosaurs* (1999).

<u>The Communication of Science Through Art</u>

In many ways, science and art are very similar to one another. Both involve creative thought processes as well as dedication to making sure that the ideas being conveyed within an

art piece or a research paper are thoroughly planned and executed. Some argue that art and science have shared an integral tie with one another. In an article summarizing an art exhibit on dinosaurs in Ithaca, New York, Warren Allmon and Robert Ross wrote that "[t]he relationship between art and science is perhaps nowhere more clearly laid out than in the case of dinosaurs. Few other scientific subjects have attracted so much artistic attention" (Allmon). Art not only helps scientists to convey their thoughts in a simple manner, but attractive, well-made art can further interest people in the sciences. Many scientists such as Cuvier and Bakker have used art to do this very thing. The beneficial partnership that exists between science and art was firmly established with the onset of printing. "The 19th-century advances in printing made ongoing scientific dialogue visible to a wide audience. This increased communication aided the advancement of science" (Johnson). The advent of the printed image aided scientific illustration as it created a dynamic between the disciplines of science and art where the two began to encourage the development of one another. Better art allows for the more effective conveyance of ideas as well as more public interest in the sciences while better scientific papers push for figures and diagrams that more effectively convey scientific ideas and better catch the eye of the general public. This use of artistic renderings also allowed for information to be communicated more effectively. Rather than members of the public and even scientific peers needing to mentally assemble the same concepts described by authors based on a wall of dense text, they can quickly understand the author's arguments and easily continue forward when the authors introduce further reasoning. The application of art to science also helps to make science more accessible to both academic circles and a wider audience. Elizabeth Stratton wrote that Cuvier himself was a major supporter of this practice, "preferring to make use of drawings rather than the original specimens." She goes on, explaining that "[a]n entire industry developed around

making fossil surrogates in France and England to support those individuals who wished to use fossils for their research but who were either unable or unwilling to procure the original" (Stratton). The publication of artistic representations of fossil specimens helped to make important fossil specimens more accessible for the people who wanted to utilize them for research and education purposes. The information contained within these fossil specimens (at least visually) could be more easily conveyed to larger audiences with images rather than through technical descriptions.

The technical communication of science through image format is an important aspect to consider when creating an art piece relating to scientific concepts. Allmon and Ross argue the importance of art in paleontology: "[i]n paleontology, because we are observing the remains of long-dead organisms rather than the organisms themselves, we are yet another step further removed from objectivity. This makes art even more important, for we rely on artistic interpretation to reconstruct what we do not find in an incomplete fossil record and to restore the soft parts and behavior that we could never observe" (Allmon). The interpretation of an extinct animal, its biology, and ecology by the artist supplements our understanding of said animal. And if the artist is making informed decisions about how this creature is portrayed based on fossil evidence or the natural world, it is optimal for this thinking to be conveyed to viewers who take the time to try and find it. The creation of infographics and images with accompanying text must be treated just as critically, as the way images and text work in conjunction with one another affects how the overall piece and the ideas present in the piece are received. In an article on the effectiveness of visual forms of communication, Jean-Luc Doumont outlines where and how pictures should be used to convey information, what pictures are and aren't effective at doing, and in what ways text should be utilized to convey information in an illustration if at all. In

particular, the author writes that “effective illustrations are truly visual, not verbal. In other words, they do not rely on symbolic association and thus can be interpreted correctly without a verbal step.” This, however, is given as a strong recommendation rather than a rule. When it is necessary for the inclusion of words and text, the author makes the point that [v]isual communication tolerates isolated words better than text” (Doumont). Most examples of paleoart attempt to convey their ideas and information in a purely visual manner, so this information is very important to consider in the creation of such pieces. Any scientific theories or ideas need to be clearly communicated through the image itself. Though an illustration can accompany text, text present within the image itself should remain minimal and light to assure a quick and easy read of the art piece.

When these basic principles (as well as other foundational principles of art) are fully understood and employed by the artist in their work, science can be more effectively communicated to a wide range of audiences. In the sciences it is perhaps most important that science is effectively communicated to the general public so that they can become more scientifically literate. With increased scientific literacy comes not only an increased interest in the sciences (which can be beneficial in a number of ways) but also a greater awareness for science and even higher thinking. Being aware of the discussions occurring in the scientific community is an important part of being informed on the issues in society, so the endeavor of informing the public should be sought after by the general public themselves as well as scientists. It is because of this that the use of art to convey science is important for education and should be carefully considered. Susan Merten asserts the importance of using art to educate elementary to middle school students, writing “[a]rt in science works well as an introduction to concepts, such as the story and pictures of the wind; as an option for a summative assessment, such as lab report

options; or as an enhancement in science, such as pointallism pieces created in art class" (Merten). Establishing scientific literacy early in a student's academic career helps to create a solid appreciation and understanding for the sciences that will carry later into their life. Science can also be communicated in different, equally effective ways depending on the medium used to convey scientific ideas to the public. Comics, for example, can serve as an effective vessel to communicate scientific concepts as they are engaging and are largely dependent on well-constructed visual images. Though comics revolving mainly around scientific concepts may be few and far between, a study on science comics as tools to communicate scientific ideas asserts that "[t]his special genre of educational science-themed comics may help to promote and explain science to students and the general public. There is now some evidence that educational comics and related single-frame cartoons can be useful for teaching science" (Tatalovic). Even still, the author cautions that comics as a tool for communicating scientific ideas have their own unique constraints. Incorrect views of science could be introduced from less objective scientific advisors, the narratives of these comics could be lacking in response to focusing on the science itself, and elaborate images can overshadow the scientific ideas presented. Many different platforms can be used to educate people about science, but each has their pitfalls that need to be taken into consideration. A similar study was performed to gauge whether cartoony, comic-like images placed in subway cars in London would be able to engage subway riders and promote a better public understanding of science. In the conclusion to the paper, the authors noted that the posters they created "raised the awareness and captured the interest of many passengers in science-based questions. This is true for a broad sample of passengers, not only those who are scientifically literate". It was also noted that the creation of these comics "led to significant follow up action on the part of some passengers, including discussion, phoning Science Line,

visiting the web site and even carrying out a practical investigation" (Naylor 1999). The results of this study complement the paper by Tatalovic, but make additional important observations. While the paper by Tatalovic judged the effectiveness of comics conveying science information to those who sought them out, this study dealt more with images placed in the public space and evaluating their effectiveness to people who happened to interact with them. Its results show that well-constructed comics and related images can engage even those who do not identify as scientifically minded and help to educate them and engage them in scientific thinking. The wider implications of this research are that a well-constructed image can inform and interest members of the general public who were not initially invested in the science conveyed by said image.

Other forms of media can also be used to communicate scientific ideas. Television and film, in particular, are powerful ways in which to communicate science and educate the public about scientific concepts as they are able to reach potentially the largest audience of any method for scientific outreach. In an article on scientific advising and the representation of science in film, David A. Kirby concludes that "[f]ilm, in fact, can have a very powerful epistemological impact because of its virtual witnessing capacity. Film has the ability to create an image of the natural world on the screen and can thus shape the thoughts of a huge audience in regard to scientific issues" (Kirby). Film reaches a massive audience, so it is important that films conveying scientific information objectively and accurately present this information to audiences. In his article, Kirby mentions the dangers of having scientific advisors who are not objective in the way they influence the production of such things. "[C]ommunication through film can play a role in the process of knowledge formation in cases where there are disputes among the scientific community. Film not only has the ability to act as a virtual witnessing technology, but also forces consensus on the public by presenting a single vision of nature in a

perceptibly realistic structure" (Kirby). As this quote demonstrates, scientific advisors on movies have a surprising amount of influence and power. If a film features an idea or topic that is disputed by the scientific community, their decision on how to portray it in the movie can set a public consensus on the issue. Even if the advisor tried to pick what they thought to be the best supported option at that time based on evidence, the public could view this as being agreed upon "truth". In this case, a movie should make clear that a topic is still being debated by the scientific community so that the perspective given is not assumed to be fact. Other possible pitfalls can be encountered with film and television. The communication of science can be faltered when the lines between science and entertainment become blurred. Campbell argues that TV documentaries featuring extinct animals can rely too heavily on narrative and story-telling. Campbell quotes D. Bousé (who also published a paper on whether nature documentaries are actually objective) on the show *Walking with Dinosaurs*, stating that it "followed the 'classic' narrative model of wildlife film by creating sympathetic individual dinosaur characters, following them as they embarked on perilous journeys, and using their experiences to dramatize the plight of their species or, more dubiously, to personify behavior patterns assumed to be typical of their species" (Campbell). Campbell argues that this approach overly personifies the natural world in an effort to make the events on screen more interesting and relatable to the viewers. This can discredit the documentary somewhat for the viewers. Campbell quotes Bousé again: "[M]any of the viewers, already suspicious of the material presented to them, will be even harder to convince that what they see in future episodes (or in any other palaeontology-related programmes) bears any resemblance to reality. Palaeontologists find it hard enough to convince people that there is real rigour behind their science" (Campbell). This skepticism is another problem in and of itself. When many viewers are unsure what components of the show they are

watching are based on evidence and which are “artistic liberties”, they stop being receptive to hearing the scientific ideas that the show is attempting to communicate to them. A TV documentary on extinct animals can discredit itself with viewers if they feel that it was constructed purely for entertainment purposes. TV documentaries of this nature should be based in fact rather than perpetuating stereotypes and the research that goes into this process will only translate to the viewers if they can establish the visuals being shown as somewhat credible and rigorous restorations of the ancient world. While the addition of a narrative is done with good intentions (to draw in more viewers and to get them invested in the show they are watching), it can give viewers the impression that there are no ideas to critically think about and they will not be challenged or made more interested in paleontological science.

Taking care to effectively communicate ideas about science through various forms of media means that these forms of media in turn will be more likely to improve science awareness and literacy in those who observe them. Improved scientific literacy in turn creates a kind of cyclical process where scientific fields are able to benefit from extra attention and an attentive public becomes further informed on scientific facts and issues. It is thus imperative to maximize the public’s scientific literacy, and keep it from stagnating and becoming overly reliant on stereotypes or “shared knowledge”. This was the central topic behind a research paper by Robert Ross and colleagues, which focused on the public’s perception of the posture of the dinosaur *Tyrannosaurus rex* and how and why that perception differs from the scientific consensus. The authors found that many people’s perceptions of *T. rex* as dragging its tail with a posture like that of a kangaroo had come from TV shows, movies, books, and other forms of media they had seen in their childhood (Fig 10). They wrote that “[o]nce conceptions form, they tend to be tightly held, and with dinosaur media for young children being populated by tail draggers the

dominance of this kind of image makes more sense." (Ross). It could then be argued that the media should "update" itself, with books, movies, and TV shows continually introducing more current paleontological information to better form kids who will commit the images to memory. What might be a better criticism of this trend of incorrect ideas about scientific ideas is that that critical thinking and a higher level of scientific literacy should be encouraged throughout a person's life. In this way, they continue to stay current with paleontological science and other sciences later in life and can overwrite the images and preconceptions they used to hold with more current ideas.

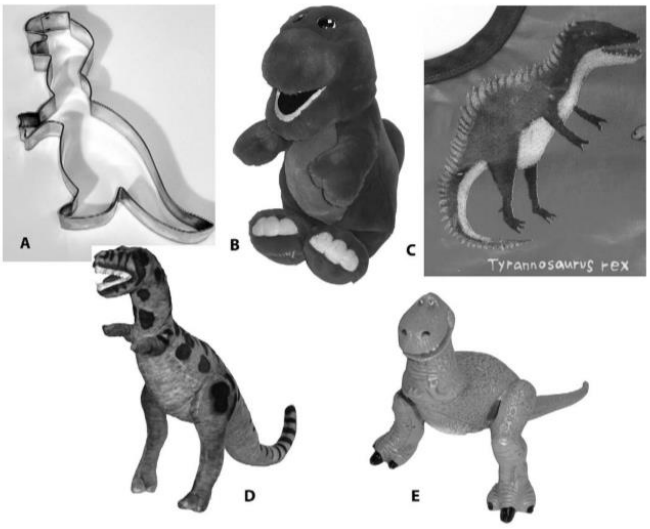

Figure 10

Possible sources for the public's conception of the posture of *Tyrannosaurus rex* from the article by (Ross).

Walking with Dinosaurs follows the former suggestion, attempting to bring realistic, convincing, and up-to-date reconstructions of dinosaurs and their world to viewers in a naturalistic, documentary format. Part of what made the visuals from the documentary so convincing and accurate was the direct communication that occurred between the scientific advisors, technicians, and artists who brought the show to life. Author José Van Dijck focuses in part on this show in a discussion on science documentaries as multimedia spectacles. He specifies that the show was partly authenticated by the inclusion of a segment called *The Making of Walking with Dinosaurs*, where the scientists, artists, and filmmakers alike discuss the process of making the show. Van Dijck focuses specifically on the scientists informing the show,

describing that “in *The Making of Walking with Dinosaurs*, they have ample opportunity to show off their authority and validate the program’s claim to scientific truth. Paleontologists explain head-on what evidence they found to substantiate their claims, before properly instructing computer engineers how to go about ‘animating’ the models.” (Van Dijck). In this way, the show is able to present viewers with the real science present “behind the scenes” of the show they have watched without interrupting the narrative. This use of a “Making of…” piece presents the scientific ideas, concepts, and debates that were going on during the show’s development, allowing the viewer to become informed not only on the show’s production but in the raw, paleontological science that fueled it. Validating the information presented in the show in this way seems ideal for scientific literacy, as the documentary is able to show people their line of thinking in a very obvious and objective way. Rather than needing to receive the communicated science through the visuals, viewers can directly hear the work and thinking that went into such a project.

There can be issues, however, in producing paleoimagery for the purposes of both education and entertainment. Two-dimensional paleoart is much more common than its three-dimensional counterpart as it is much less expensive and takes less time to produce. And although it is arguably simpler to produce as well as experience, it can suffer from similar problems. In a study on the rhetoric present in paleontological illustration, Kathryn M. Northcut interviewed a handful of paleoartists on their work and their experiences. One of these paleoartists, Karen Carr, shared a story about the struggles in being commissioned to produce paleoart for a client. Carr was commissioned to produce a picture of a *Tyrannosaurus rex* and decided to omit a handful of teeth from its mouth as theropod dinosaurs like *T. rex* often lost and regrew their teeth. The teeth that were still present in the mouth were depicted as somewhat

stained, as *T. rex* (being a large carnivore unable to chew its food) would also have been unlikely to keep its teeth relatively clean. The clients instead insisted that the dinosaur be given a full set of bright white teeth, and Carr respected their request even though this was likely less accurate to the real animal's life. Northcut argued that this request was made by the clients because "the argument can be made that part of the aesthetic of a dinosaur picture is exaggeration of elements for effect; in the case of dinosaur paintings, unbroken white teeth fit viewers' expectations better than broken, stained teeth" (Northcut). This story shared by Carr shows how paleoart and the communication of scientific ideas can be hampered by what people feel will be more accepted or what will be expected by the public. Though some paleoartists may stand their ground and argue for total scientific accuracy, Northcut's article shows how some artists need the income they receive from commissions and are willing to sacrifice some scientific accuracy. This tension reveals an important aspect of paleoart that is not often considered or seen when observing paleoimagery. Sometimes, the producers or financers for various forms of media pertaining to paleontological science have specific visuals in mind. Up-to-date paleontological science may not be conveyed in different pieces of media simply because it is not allowed to be incorporated in the first place. This inaccuracy is sometimes because new, stereotype-breaking visuals can be seen as "risky" and producers of media want their product to be as widely and positively received as possible. Though this mentality is somewhat understandable from a financial standpoint, a concerted effort should be made to push against this constraint and continue to convey scientific thinking as objectively as possible.

When science is effectively communicated through an art piece or medium that is able to become very popular and reach a large audience, the process has reached its final, most important stage (at least as far as said sciences are concerned). Here, the studies that produced

and inspired the theoretical movie, TV show, or art piece are able to benefit from the increased exposure and public interest. Kirby noted that "[s]ociologists and historians have often demonstrated that popularization is akin to promotion, especially with regard to obtaining funding or other support for scientific research" (Kirby). Popular forms of media communicating science to the general public will inevitably get more people interested in the science itself. This can result in more money for the researchers and scientists and a greater public awareness for the science and the discussion occurring within it. In the case of paleoimagery, films such as *Jurassic Park* have helped to not only raise public interest and investment in the field of paleontology, but also greatly increase the public's scientific literacy about dinosaurs and what they were like. However, this is not the only way in which the incorporation of scientific thinking into different forms of media can benefit the sciences. Sometimes, the film or show itself can contribute more directly to the science. In discussing *Walking with Dinosaurs,* Van Dijck makes the case that "[v]isualization and scientific argumentation are mutually contingent. As this series seems to sustain, digital 'picturization' is not just an effect but a constitutive tool of science." (Van Dijck). *Walking with Dinosaurs* not only served as a way to convey ad advertise science, but also as a way to practice it. The filmmakers and artists that helped create the show had to make educated guesses about the movement and biology of dinosaurs based on the modern world. How a dinosaur is animated, what colors it is given, and how it behaves on screen are all usually based in something real to make it more convincing. In estimating how these animals functioned and lived based on data and possible explanations, the filmmakers conduct science in their own way. And not only that, this show (and many others like it) trigger new debates within the paleontological community. Scientists will make statements on what they feel was and was not accurate about a piece of dinosaur-related media in an effort to "set the record

straight". New debates can be started on whether or not a creative choice made and presented in a piece of media is plausible or accurate. These are the things that help science to grow and prosper, developing and changing in an effort to come closer to "the truth". Last, and maybe most important, paleoimagery is able to benefit the science of paleontology as it helps to spur on future generations of geologists, paleontologists, and other researchers. Lawrence Witmer discusses the link between dinosaur science and art in a short article from *Science*, stating that "[a]s consumers of popular culture, paleontologists cannot help but be shaped by it, nor can their science. I grew up in the 1960s with the prevailing notion of dinosaurs as dull-witted, cold-blooded swamp dwellers. In the era of *Jurassic Park*, my graduate students grew up believing that dinosaur breath would steam your windows and that dinosaurs were caring parents. Regardless of the veracity of either view, each represents the intellectual backdrops within which we obtained our professional training" (Witmer). Young people can easily get drawn to and inspired by examples of paleoimagery and this may drive them to be a part of the science they love. Inspiration is a large part of why many of today's scientists got to where they are and it will likely continue to be for a long time.

The Construction of "A Visual History of *Iguanodon bernissartensis*"

I am very interested in paleontology and paleoart myself, having been inspired by films such as *Jurassic Park* and *The Land Before Time* when I was a child. My love of dinosaurs coupled with my affinity for art drove me to draw and sketch dinosaurs all through my education. I would cover the margins of class notebooks with the visages of tyrannosaurs and apatosaurs whenever I didn't need to be taking down notes. And when I was informed that I would need to construct a project as part of my membership in the college's Honors program, I knew I wanted art and dinosaurs involved from the get-go. Besides the broad discussion of

paleoart that would constitute the written component of the project, I wanted to create an art piece to accompany it. Once I established that I would be writing on the history of paleoart, its usefulness to the science of paleontology, and how it and other images are able to communicate scientific ideas, I needed to conceive an art piece that would fit these themes.

As preparation for my piece, I did some preliminary research into paleoart to provide me a better understanding of the genre and how to construct my own piece. I located multiple examples of paleoart from notable and famous paleoartists that I felt were successful in how they were executed and what they were able to convey. I used these pictures to establish four overarching "types" of paleoart into which I feel all paleoart can be placed. I then found examples of each paleoart "type" that I felt were very ineffective to show what exactly was so successful about the "good" pieces. Based on these examples, I established what the defining criteria for each of these "types" were to help objectively describe and classify them. The first type of paleoart I established was "Aesthetic". I defined this category of paleoart as focusing on landscapes where the dinosaur subjects were usually small and not finely detailed. These pieces of paleoart also put a heavy emphasis on "artistic beauty" derived from coherent use of artistic principles such as composition and color theory (Fig 11). I determined that effective examples of "Aesthetic" pieces would feature either soft mixes of color or bold contrasts, the landscapes featured could serve as stand along pieces even without the presence of dinosaurs or other prehistoric animals, and the subjects and environments featured would be accurate to current fossil evidence. The second type of paleoart I established was "Educational". This category was defined as explicitly trying to communicate factual information to the viewer through either

Figure 11

Examples of a successful piece of "Aesthetic" paleoart (left) and an unsuccessful piece of "Aesthetic" paleoart (right).

infographics or the use of accompanying text. This is done in an effort to educate the viewer on a scientific idea, theory, or subject (Fig 12). I determined that effective examples of art within this category would be able to convey the scientific ideas contained in them in a simple, easy to understand way and any subjects or material featured would be accurate to what is known from the fossil record. The third type of paleoart I established was "Exciting/Wondrous". This category was defined as attempting to show the wonder or awesome brutality of the ancient

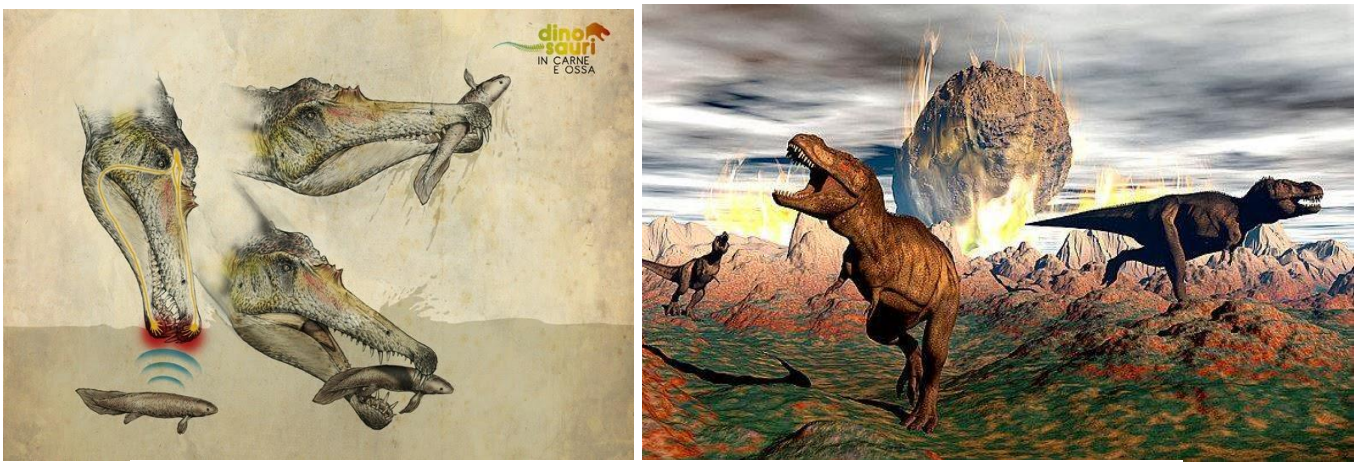

Figure 12

Examples of a successful piece of "Educational" paleoart (left) and an unsuccessful piece of "Educational" paleoart (right).

Figure 13

Examples of a successful piece of "Exciting/Wondrous" paleoart (left) and an unsuccessful piece of "Exciting/Wondrous" paleoart (right).

world, mostly through a dynamic, detailed scene featuring interactions between different animals (usually predator-prey or combat interactions) (Fig 13). I determined that effective examples of art from this category featured exciting yet still fairly plausible scenes featuring prehistoric life that are consistent with what is known from the fossil record. The fourth and final type of paleoart that I established was "Matter of Fact". This category was defined as presenting a fairly detailed subject (usually a singular dinosaur) in a somewhat neutral pose within a simple background/landscape. The perspective in these images is fairly standard, with the whole subject fitting into the frame and no radical distortion occurring on the subject. The subject and landscape in the piece are not overly vibrant or exciting, but still visually interesting and engaging (Fig 14). Pieces that I felt were effective within this category were consistent of what was known about a subject and their habitat based on the fossil record.

Figure 14

Examples of a successful piece of "Matter of Fact" paleoart (left) and an unsuccessful piece of "Matter of Fact" paleoart (right).

Once I established these paleoart categories, I began conceiving the art piece I would produce. As already stated, I needed a piece whose themes would mesh well with the themes discussed in the paper component of the project. I therefore wanted to produce an art piece linked not only to the history of paleoart but also the communication of paleontological thinking to the viewer. I ultimately decided I would create a piece focusing on the history of artistic reconstructions of the dinosaur *Iguanodon bernissartensis*. *Iguanodon* was one of the first discovered dinosaurs and so has a lush history of iconic artistic depictions as paleontological science has progressed since the 1800s. This piece would consist mainly of a timeline of the different "major" reconstructions of the animal that had been produced since its discovery and the pieces of information that led to the evolution of these reconstructions. The piece would include four of these reconstructions, one of my own design based on modern, up-to-date paleontological findings and science and three based on famous past reconstructions. Because I am most comfortable with two dimensional drawing, I decided I would create this piece on paper using pencils. Specifically, the piece would be drawn on an 18 by 24 inch sheet of Strathmore

300 Series drawing paper using Prismacolor brand colored pencils. These materials were chosen partly because of my experience with past two-dimensional art pieces and what would produce a high quality piece and partly at the recommendation of my art advisor, Prof. Tucker. The paper was chosen as it would hold the colors from the colored pencils more efficiently and allow for a more detailed final piece. The colored pencils were chosen as they were made from wax and would produce more vivid colors that could blend together more effectively.

Once I knew the subject for my piece and the materials I would use to make it, I had to decide the specifics about the piece's composition, colors, and the subjects that would be included. I had to decide on the historical depictions of *Iguanodon* that would be preceding mine on the timeline as well as the "objects" that would be featured as supplementary inclusions to the timeline. These inclusions would be contained within circles that would be connected back to the timeline via a line (Fig 15). The first object I utilized was based on the initial remains of *Iguanodon* found by its discoverer Gideon Mantell in 1822 (Iguanodon). Mantell found fossil teeth that were uncannily similar to those found modern iguanas, but much larger. With nothing else to go on, Mantell assumed the teeth were from a gigantic iguana. When he finally described the tooth in 1825, he described the animal to which the tooth belonged as *Iguanodon* (literally meaning "iguana tooth"). By 1834, more bones had been uncovered of the

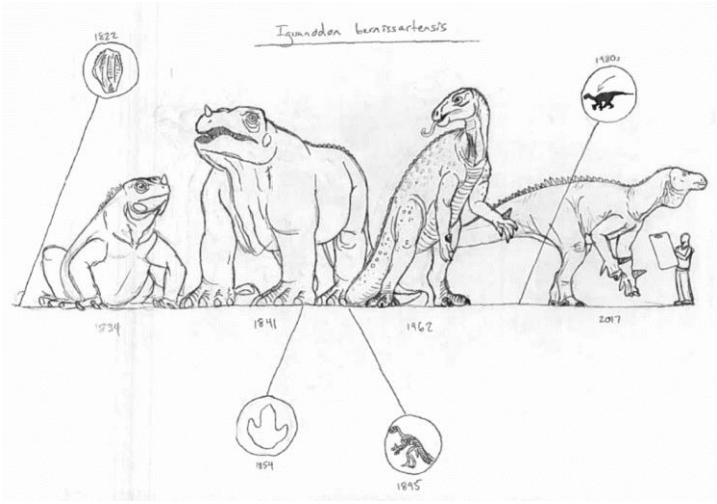

Figure 15

A rough draft of the final art piece. This image shows the general concept of the four reconstructions scaled in relation to one another with additional "objects".

animal, including limb bones and a conical bone that Mantell interpreted as a nose horn (Iguanodon). This "horn" gave the impression of *Iguanodon* appearing like a large rhinoceros iguana, so that was the basis for my first historical reconstruction. The next historical reconstruction was based on the life-sized model of *Iguanodon* that was built by Richard Waterhouse Hawkins (among many other prehistoric animals) for the Crystal Palace Exhibition in Sydenham Park. This depiction was based on much of the same information as the former rhinoceros iguana, but made more elephantine. The next object I included was a fossil footprint assumed to have been made by *Iguanodon*. These footprints were uncovered in 1854 and showed not only that this animal had three-toed feet, but also that it was at least in part bipedal. In 1878, multiple fairly complete specimens of *Iguanodon* were found in Bernissart, Belgium (Iguanodon). This provided us with the first complete look at *Iguanodon*'s skeleton, and made all future reconstructions that much more true to the real animal. My next object was this skeleton, as this helped to specify the animal's form from what was once a vague assumption. Though images of bipedal *Iguanodon* were produced after the discovery of the animal's complete skeleton, the third and final major reconstruction that I chose occurred in 1962. Czech painter Zdeněk Burian created a painting of *Iguanodon* featuring a bright orange head, a darker greenish-black body, a backwards tilted posture where the animal's tail dragged along the ground, and a large dewlap on the neck (Fig 16). This reconstruction became incredibly popular after being published and would

Figure 16

Burian's reconstruction of *Iguanodon*.

be copied or referenced by most artists depicting the dinosaur until the 1980s. During this time, Robert Bakker proposed that dinosaurs were much more active animals than we had previously assumed. Part of the changes made during this time were that most dinosaurs now had more horizontal body postures with their tails lifted off of the ground. Not only that, but many hadrosaurs and other ornithopods (dinosaurs closely related to *Iguanodon*) were now shown as having moved principally on four legs rather than two. Bipedal movement was still possible, but scientists now agreed that these animals walked on four legs more often than they did two. This change in posture served as my final "object" for the art piece, demonstrating this principle shift in movement and posture. The last reconstruction to be included in the piece would be a hypothetical depiction based on the most recent data as well as a healthy dose of speculation.

I constructed my personal reconstruction of *Iguanodon* from scratch. I started by drawing the animal's skeleton based on a skeletal restoration of *Iguanodon bernissartensis* published by artist Scott Hartman earlier this year. Scott Hartman is a professional paleoartist who has been making art pieces for over 17 years, with his work appearing in multiple books and museums (Hartman). He is well known for his rigorous skeletal reconstructions of dinosaurs, and this work served as a sturdy backbone for my reconstruction. I drew my skeleton in a fairly neutral, symmetrical pose that would make "designing" my dinosaur easier than with the skeleton in an asymmetrical walking pose (Fig 17). After that, I drew the animal's muscular system on a separate sheet of paper. The

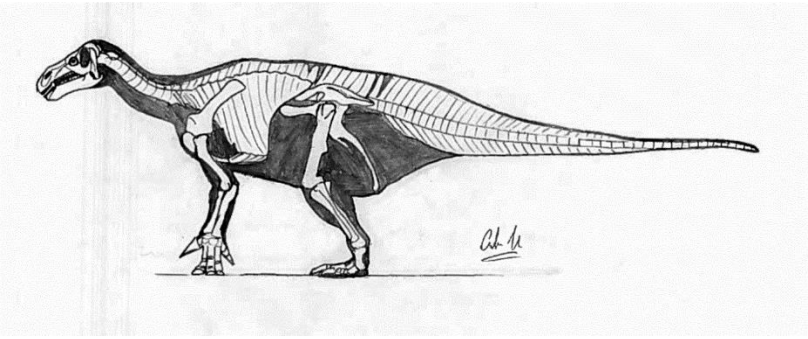

Figure 17

An artistic reconstruction of the skeleton of *Iguanodon bernissartensis*.

placement and arrangement of these muscles was based on hypothetical artwork of *Iguanodon*'s muscles by Gregory S. Paul. Paul is an independent scientist who has also become well known for his rigorous skeletal reconstructions of dinosaurs. In addition to skeletal reconstructions, Paul has also produced numerous paintings and life reconstructions of dinosaurs that have been produced and published for about thirty years (Paul). Though Paul's arrangement of muscles for this dinosaur had to be adjusted somewhat to work with Hartman's skeletal configuration, this combination ended up creating a very convincing muscular system on which the skin and integument could sit (Fig 18). Unfortunately, no fossilized skin samples have been found from *Iguanodon*, so nothing about this dinosaur's skin is known for certain. The look and texture of the skin would then have to be based on educated guesses. Fossilized "mummies" of related dinosaurs such as *Edmontosaurus* have been found, and they feature small, pebbly scales that would not be easily seen when looking at the entire animal. The wrinkles and folds I placed on the animal's skin were more speculative, but are based somewhat on the skin of lizards and featherless chickens. In addition to small wrinkles and folds in the skin, I also added a dewlap to the animal's neck and a row of keratinous spikes along its back. These are both partly because hadrosaurs and other closely related animals have been found with similar structures and the dewlap was a small reference to the design by Burian. One small detail

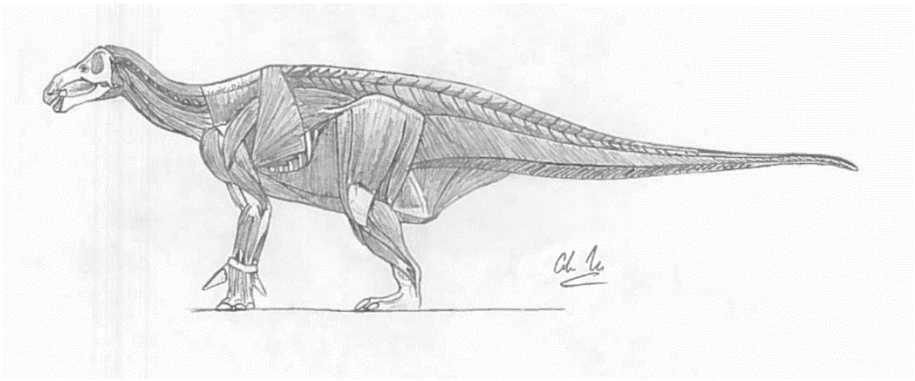

Figure 18

An artistic reconstruction of the musculature of *Iguanodon bernissartensis*.

I added to the integument drawing was horizontal pupils like those of a goat. I felt these could be plausible for an animal like *Iguanodon* as they enable prey items to more clearly see the horizon and look for potential predators (Fig 19).

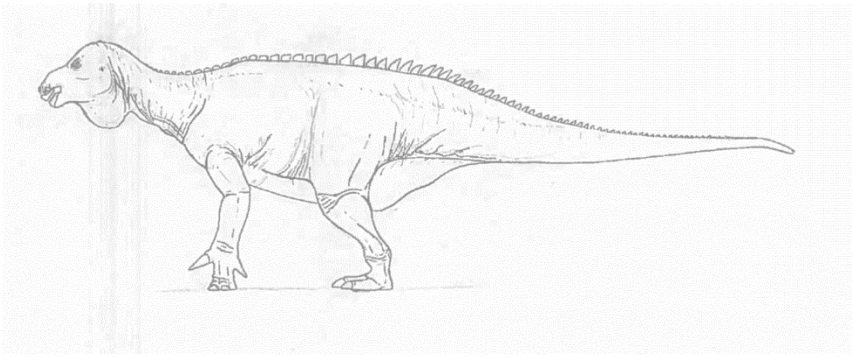

Figure 19

An artistic reconstruction of the skin and integumentary structures of *Iguanodon bernissartensis*.

The color pattern for my reconstruction of *Iguanodon* was something to which I paid close attention. I've always especially enjoyed seeing the different ways artists would color their dinosaurs to create vibrant and visually interesting designs. I wanted to make sure that when I came up with a color scheme for my dinosaur, it would be visually interesting, plausible, convincing, and fitting given the environment the dinosaur lived in. Before I started playing with color options and looking at modern animals for inspiration, I did some research into what the rock record says about the environment in which *Iguanodon* lived. In the Upper Weald Clay Formation (Lower Cretaceous) from which *Iguanodon* remains have been found, the depositional setting has been interpreted as a marshy floodplain to tropical lagoon (Nye). After learning this, I decided to look for animals that I thought might be physically, evolutionarily, or ecologically similar to *Iguanodon* from which to draw inspiration. After some research, I focused on spiny-tailed iguanas (coastal iguanas from Central America) and Assateague wild horses (feral horses that live on the eastern coast of the United States). I felt that together these two animals would be somewhat fitting analogies for *Iguanodon*, as they both live in similar habitats to *Iguanodon*, fill similar roles in their respective ecosystems as herbivores, and possess somewhat similar

anatomies. I then created less detailed, blank copies of the integument concept drawing of my *Iguanodon* and used these to create templates for potential color schemes. At first, I copied the color schemes of the animals I had identified as possible analogs onto these color template drawings. When I felt that these color schemes were not visually interesting enough, I decided to blend some of the concepts and ideas present in the individual color schemes together into one custom color scheme. I tried to incorporate the overall "feel" of the spiny-tailed iguana and wild horse into the design, convey a sense of camouflage for a coastal marsh environment, and above all create an interesting and original design. I ended up with a design that was largely constructed from grays, blues, and greens as I felt these colors "fit" well with the coastal marsh environment that *Iguanodon* would have called home. Dark stripes were added to the tail and hind limbs due to similar patterns being detected on the *Edmontosaurus* mummies and a bright red color was given to the animal's dewlap as it would likely serve as a display structure. The final color scheme on the whole seemed very visually appealing while still paying slight homage to the two animals from which I had been taking inspiration. The somewhat constant tones spread across the animal's body were more reminiscent of the wild horse, while the vibrant colors especially over the torso and pelvis were inspired by the vibrant orange colors featured on the back of the spiny-tailed iguana (Fig 20).

When laying out the different elements comprising my piece, I wanted to make sure that the *Iguanodon* reconstructions were fairly

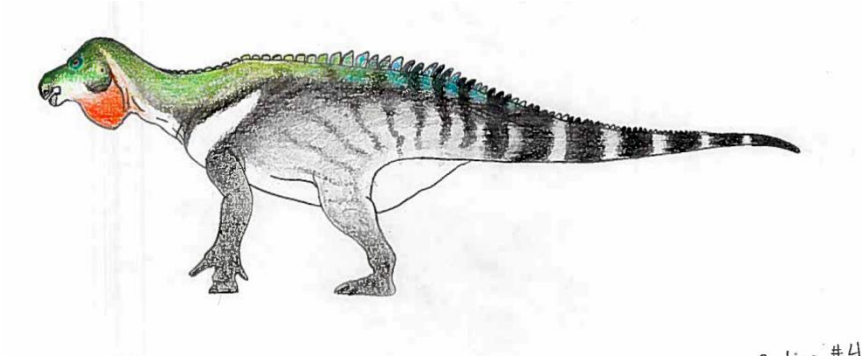

Figure 20

An artistic reconstruction of the skin and integumentary structures of *Iguanodon bernissartensis* with a hypothetical color scheme.

spaced out on the timeline and that they were drawn to scale not only with one another but also with a human being. This layout would give a more accurate sense for how this dinosaur's image has changed since the time of its discovery. The spacing would also allow the "objects" in the piece to more clearly and cleanly be applied to the timeline. The final touch for the piece was placing years next to each object and reconstruction as a way to establish the timeline element of my art piece and to help the piece efficiently communicate the details and history behind it (Fig 21).

In terms of the categories of paleoart I established earlier on, my piece feels largely "Educational" with a bit of "Matter of Fact". The reconstructions themselves are the reason for the "Matter of Fact" influence, as the piece is trying to communicate information to the reader about how and why paleontological science and the image of *Iguanodon* have changed over

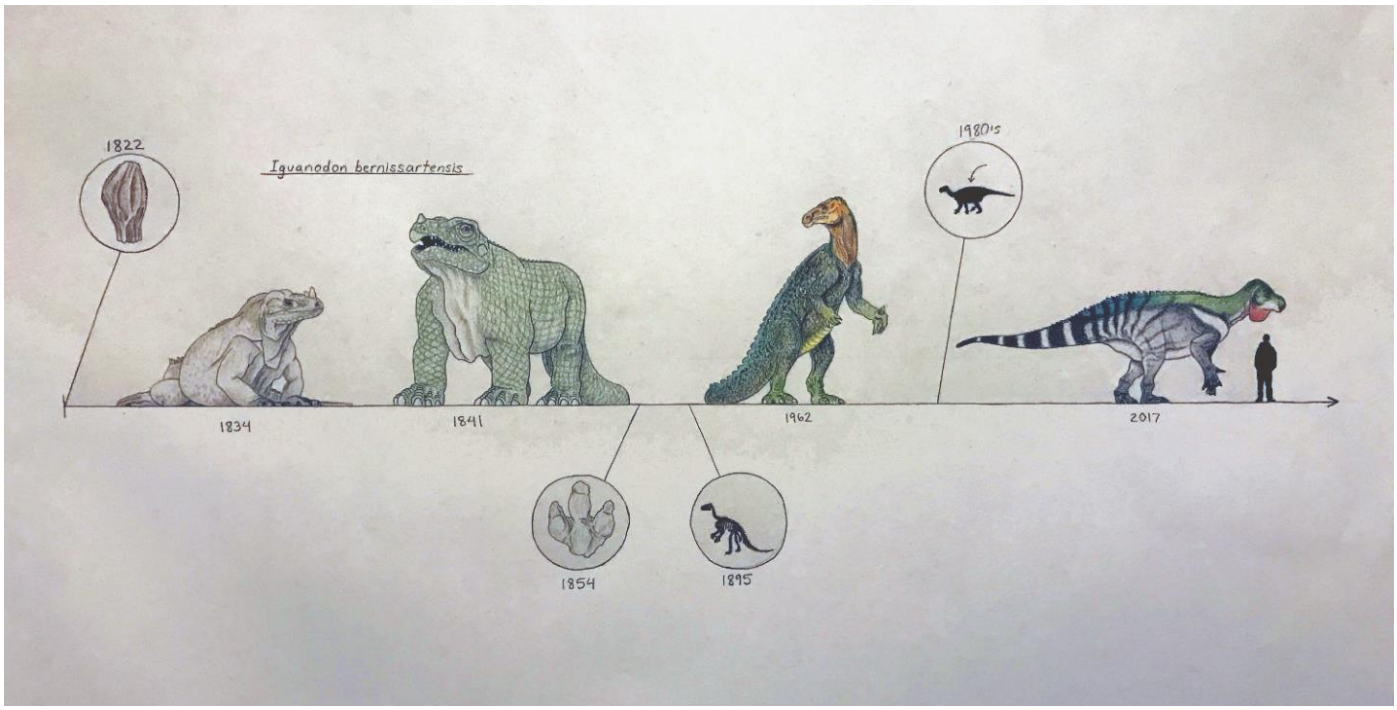

Figure 21

"A Visual History of *Iguanodon bernissartensis*" (2017). The final art piece of the project, with four reconstructions of *Iguanodon bernissartensis* throughout history since the discovery of the genus.

time. Overall, I was very happy with how this piece came out and feel as though it is able to communicate the science behind it fairly effectively.

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Fig 20: McNulty, Colin. *Color Concept of Iguanodon bernissartensis*. 2017. Pencil and colored pencils on paper.

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