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Cover art: *Duria Antiquior* – A more Ancient Dorset, by H. De La Beche (1830). This watercolor is a reconstruction of the Jurassic environment at Dorset based on all the discoveries of Mary Anning. It became the basis of several other paleontological reconstructions and satire later on.

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The Landing: Gallipoli 1915 — Recreating a historical World War I battle as a solo tabletop game

Interview with Joe Schmidt

The Landing: Gallipoli 1915 is a new tabletop game published by Catastrophe Games LLC.[1] The company's motto is "Historical games made differently".[2] That, plus the fact that their new game is about a very specific and generally little-known battle of World War I,[3] got our History sense tingling.

So, we set out to interview Joe Schmidt, the author of *The Landing*, and learn more about how the game came to be. Keep reading to see all the cool behind-the-scenes stuff that we discovered.

Before we start talking games, would you mind sharing a little bit of your background with our readers? What led you to create tabletop games?

I've been playing games ever since I was a little kid. It started with games of Chess with my Dad and then turned into *Risk*, *Stratego*, *Axis & Allies*, *Battle Cry*, and many others. One of my favorite things to do was to take the pieces from a game to see how they would work if I mixed them with a different game. (One of my favorites was taking the pieces from *Risk* and setting them up

on the *Stratego* board with the hotels from *Monopoly*.) Looking back, I realize now that these were my baby steps into game design. I've been actively designing games for about a decade now, and made the decision in 2017 to make it my main hobby.

Your new game, *The Landing: Gallipoli 1915*, has just been released. It is described as a "narrative solitaire wargame"[4], but what exactly is that?

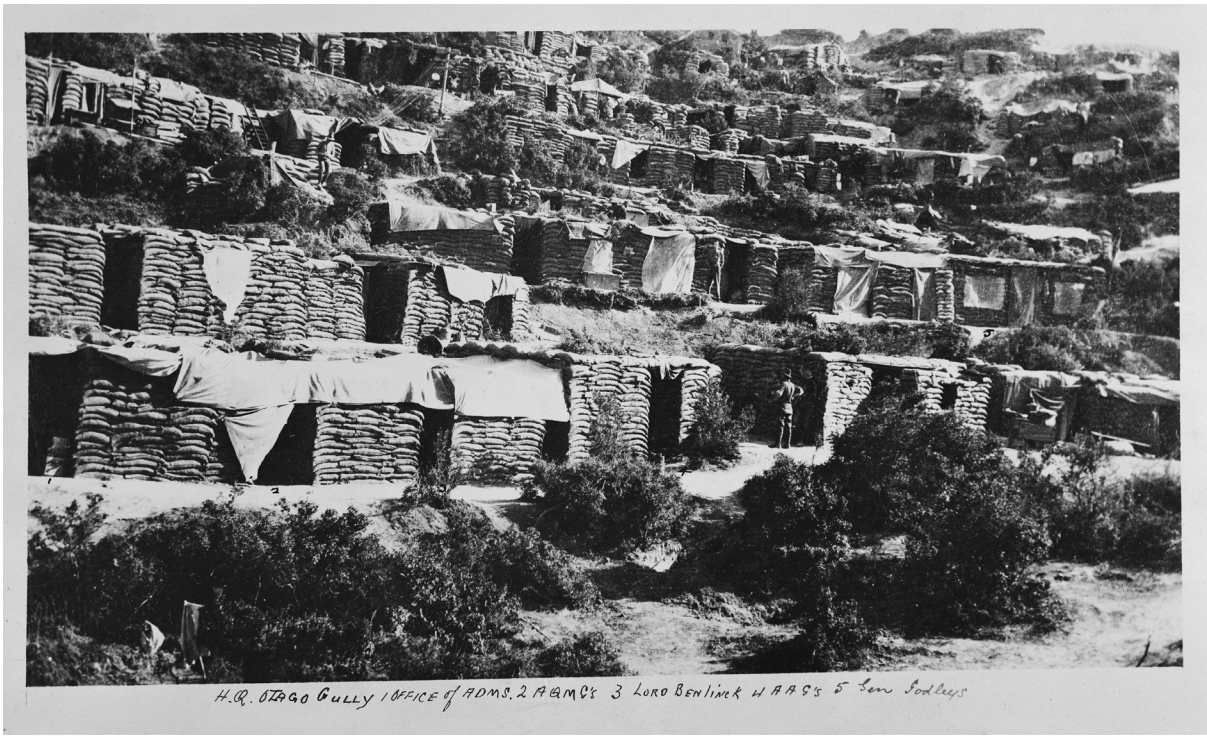
This game was inspired by all of the incredible primary resources that I found while I was researching the Gallipoli Campaign. The letters and stories of the veterans of the conflict are moving examples of our shared humanity. So, when I decided I wanted to design a game about the beginnings of the ANZAC campaign I wanted to make sure I shared these stories.

The Landing is my attempt at creating a wargame that tells the tragic story of the individual soldiers at Gallipoli rather than the glory of battles won or lost. Its purpose is to give the player the tools of war, but not to honor them. To tell a story about the futility of the conflict, and the bravery of all of those who fought. To write and attempt to understand the slightest idea of the pain they experienced.

What were the main challenges when designing *The Landing*? In what ways is creating a solo experience different from designing a "regular" game?

The biggest benefit of designing a solo game is that your individual playtesting in the design process can be really exciting. I still design the games that I want to play, so working on a solo design is really exciting because I am essentially always trying to beat myself at my own game. I feel that solo games also allow for a more narrative experience, so it really allowed me to focus on creating a full experience.

In a solitaire design you have to make the player feel like they are playing against a challenging opponent. The idea here was to create a vibrant AI that would be somewhat predictable, but also create a "fog of



Otago Gully Headquarters; Gallipoli, November 1915. Photo by Lawrence Doubleday, from the archives of Museum of New Zealand Te Papa Tongarewa (NMNZ CA000316/002/0011).

war" that could catch the player unawares. This mystery allows the player to tell a story. Using the mechanics of the game in the same way an artist would use paint and a canvas. Because of this the mechanics of *The Landing* are really baked into the narrative, and I am really proud of that.

The very title of the game, *The Landing: Gallipoli 1915*, already makes the theme crystal clear for many people, but it might leave most people in the dark. The Battle of Gallipoli is a little-known chapter of World War I, so would you kindly briefly describe it?

The campaign was an invasion of British, French, and Commonwealth Forces against the Ottoman Empire on the Gallipoli Peninsula in an effort to seize the forts protecting the Dardanelles and access to the Ottoman capital at Istanbul. While the campaign ended in defeat for the Triple Entente forces, its impact still resonates deeply in the history of Australia, New Zealand, and modern-day Turkey. So much so that April 25th is celebrated every year by Aussies and Kiwis as Anzac Day, and is commemorated with a ceremony at Anzac Cove in Turkey.

Why did you choose Gallipoli to be the backdrop for your game?

It all started thanks to my lovely wife, Melissa. She was invited to a photography workshop in Australia and we decided to use the opportunity to turn it into a vacation for the two of us. So, I decided that I would study and design a game to bring with me on the trip. After some searching, I came across the story of the Gallipoli Campaign and was really taken by the legend that had been built up around it.

Then I decided that I would use the free time I had while my wife was in her workshop to turn it into a research trip as well. I visited the Australian War Memorial in Canberra and spent a couple days there trying to learn as much as I could from the artifacts and resources there. Seeing the boats that landed on Anzac Cove and reading the official histories was a really moving experience, and made me realize the responsibility I had as a designer.

What is the player's goal in *The Landing*? And what do they have to do to achieve it?

The Landing tells the story of the Australian and New Zealand Army Corps (ANZAC) landing on the beaches of Gallipoli in the early morning of April 25th, 1915. You are a Lance Corporal, a Non-Commissioned Officer in the Australian Army. You must lead your fellow Aussies and work together with your Kiwi and Indian allies in the desperate fight to take and hold the heights overlooking the Dardanelles.

Over three Rounds, you will use Operations Cards and Action Dice to push your troops across the 6 Terrain Cards that make up the battlefield. Your AI opponent will fight you from better ground and with equal ferocity. You win by having the only counters on the 6th (last) Terrain Card by the end of the game. Otherwise, you descend into the horrors of trench warfare.

Can the player "rewrite history" and change the outcome of the Battle of Gallipoli?

To an extent, but yes. If you are able to take and hold the 6th Terrain Card (which represents the 3rd Ridge and objective of the operation) then you win the game. But it would have been more of a pyrrhic victory than anything else. Most scholars agree that the campaign was doomed from the start, and that was a key element of the design for me. I wanted the player to experience the futility of the campaign, and the level of difficulty really allowed me to do that.

How faithfully does the game reflect real-life events? And what number of historical facts could you bring into the game?

I feel that *The Landing* does a good job of abstractly reflecting the real-life events of what happened on April 25th, 1915 while also providing an enjoyable gaming experience for the player. While all of the history is there (from the locations to the unit badges), we did take some liberties. For example, because of the random nature of the Terrain Card setup it is possible for the map to be ahistorical. But even this was not without

Otago Gully Headquarters staff; Gallipoli, November 1915. Photo by Lawrence Doubleday, from the archives of Museum of New Zealand Te Papa Tongarewa (NMNZ CA000316/002/0017).

some degree of historical accuracy.

The famed Anzac Cove was never actually meant to be the landing zone for the invasion. So, the maps and orders that the officers had for their soldiers were off from the get go. The random nature of the Terrain cards is meant to represent this. The player has an idea of where they need to go, but they don't know what stands between them and their objective. Game design is an art, but historical game design also requires thorough research and historical fidelity.

What kind of historical source material did you use while designing *The Landing*?

Whenever possible I always try to use primary sources. The two key ones for me in this design were Charles Bean's *Anzac to Amiens*[5] and the wealth of documents that have been digitized by the Australian War Memorial.[6] Then it was important for me to understand the study of the history of the campaign. Reading Peter Hart's *Gallipoli*[7] and other scholarly articles allowed me to put the primary sources in their proper place in time, and to tell the story of the ANZACs with an authentic and modern sensibility.

When preparing this sort of game, is there a golden balance between real-world History, creative license and gameplay? If so, how do you achieve it?

Yes! This all goes back to games as art. At the end of the day, I am designing a simulation. The history and lessons I implement in the design are my choice, but if I can't forge a balance between entertainment and fact then I'll either end up with an arcade version of the history or an unplayable historical journal article.

My golden rule is always to create a thesis and design around that. What is the history I want to represent, and what is the experience I want the player to enjoy. For *The Landing* the thesis was that the Gallipoli Campaign was a story of incredible bravery in the face of a near impossible task. This was founded in the history and historiography of the battle, and told via accessible and interesting mechanics.

Besides *The Landing*, are you involved in the development of other historical games?

I always try to keep myself busy with new designs! I recently worked on a game about Teddy Roosevelt and the Rough Rider's charge up San Juan Hill called *Kettle Hill*.[8] It shares a lot of the mechanics we refined in The Landing, and it was a great opportunity to talk about the impact that the Buffalo Soldiers had on this famous battle. It's currently in development, and should be published by Catastrophe Games sometime next year.

There are many games out there, tabletop or otherwise, based on real historic events. Do you believe game designers have a responsibility when representing history in their games?

The greatest responsibility a historical game designer has is their fidelity to the subject matter. History is the story of our shared humanity, and the way we tell that story resonates loudly. So, when a designer chooses to use history as their background, I believe it is their responsibility to do so thoughtfully. This was something I thought about a lot when I was designing *The Landing*.

1914-15 Star medal awarded to Private Frederick J. Verney of the Samoan Advance Party; maker unknown, England, 1916–1920. From the collection of Museum of New Zealand Te Papa Tongarewa (NMNZ NU006147); CC BY-NC-SA 4.0.

Do you think you will pick the interest of some players in learning more about Gallipoli and World War I? And if you do, could you recommend them some references about it?

The best place to start is the Australian War Memorial's digital archives.[9] It gives you access to thousands of letters, journals, reports, and photos from the Gallipoli Campaign. And, it is all free! You can spend hours upon hours just looking through their website, and all from the comfort of home. And if you ever find yourself in Canberra, make sure to visit it. It is a trip I'll never forget.

I'd also highly suggest *Gallipoli: A Ridge Too Far*.[10] Edited by Ashley Ekins, this is a collection of the works of historians from seven of the countries that participated in the fighting at Gallipoli. I'd also highly recommend Peter Weir's film *Gallipoli*[11] and the *Gallipoli* miniseries[12] done by Australia's Nine Network. Both are really well done,

Short Magazine Lee-Enfield Rifle Mk III* (typically abbreviated SMLE); BSA, England, 1915. This bolt-action rifle was the standard British infantry rifle during World War I. From the collection of Museum of New Zealand Te Papa Tongarewa (NMNZ DM000426); gift of the New Zealand Army, 1964; CC BY-NC-SA 4.0.

and serve as an excellent visual recreation of the campaign.

About the team

Joe Schmidt is a dad, husband, and board game designer from Berkeley, California. Joe can be reached via Twitter at @josephnschmidt. The team over at **Catastrophe Games** is led by Tim Densham, Aiden Brooks served as the lead developer on *The Landing*, and Grace Densham was the artist for the game. You can find out more about them and their games at their website, catastrophegames.net.

Notes

[1] https://www.catastrophegames.net/products/the-landing-gallipoli-1915

[2] https://www.catastrophegames.net/

[3] On April 25th, 1915, the forces of the British Empire (mostly the Australian and New Zealand Army Corps, or ANZAC) landed at the Gallipoli Peninsula. There, they fought against the Ottoman Turkish forces and ultimately lost.

[4] https://www.boardgamegeek.com/boardgame/313876/landing-gallipoli-1915

[5] Bean, C.E.W. (1946) Anzac to Amiens: A Shorter History of the Australian Fighting Services in the Great War. Australian War Memorial, Campbell.

[6] https://www.awm.gov.au/

[7] Hart, P. (2011) Gallipoli. Oxford University Press, Oxford.

[8] https://boardgamegeek.com/boardgame/310766/kettle-hill

[9] https://www.awm.gov.au/collection/official-histories-rolls-unit-diaries

[10] Ekins, A. (2013) Gallipoli: A Ridge Too Far. Exisle Publishing, Wollombi.

[11] 1981. Associated R&R Films.

[12] 2015. Nine Network. 7 episodes.

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The giant snails of *ARK: Survival Evolved*

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ARK: Survival Evolved[1] is a survival game, as one could expect by its title. It was developed by Studio Wildcard, in collaboration with three other studios, and was launched in its finished form in August 2017. Back then, the game was available on Xbox One, PlayStation 4, and the usual computer operating systems. *ARK* was later released for Android, iOS, and the Nintendo Switch.

The game was received by lukewarm reviews at best: its Metascore is 70 for PCs, and 69 for both PlayStation 4 and XboxOne (Metacritic, 2020).[2] However, through the course of three years and four expansions, the game managed to secure a loyal set of fans and achieve a state of "sustainable revenue" (Batchelor, 2019). As of June 2020, the game had a total of 35 million installs, of which half is estimated to come from mobile platforms (Desatoff, 2020).

Figure 1. Artwork for *ARK: Survival Evolved*. Source: ARK's press kit.

ARK can be played from both first- and third-person perspectives, where the players explore an open-world environment. The game is action-oriented, with plenty of harvesting and crafting activities. The players' goal is to survive and prosper in the game world, called 'Ark', while facing natural hazards and dangerous animals, the most dangerous of which are likely the other players. Most creatures found in the game were based on real animals, typically extinct ones, like non-avian dinosaurs (Fig. 1). As biologists, we are, of course, not interested in those mainstream gargantuan beasts. Rather, we are drawn to another giant of more modest proportions: the giant snail.

ARK'S GIANT SNAILS

Let us start by taking a look at *ARK*'s giant snail, called 'Achatina'.[3] In fact, the "species" received a mock Latin scientific name in the game: *Achatina limusegnis*.[4] Typically, a scientific name is accompanied by the name of the scientist(s) who first described it, like in *Corvus corax* Linnaeus, 1758, the common raven, who received its scientific name from Carl Linnaeus in 1758. *ARK* doesn't pay homage to former scientists and omits the name of the person who described *Achatina limusegnis*.

Helena Walker, a character in *ARK* who's supposedly an Australian biologist, left some notes on Ark's various creatures. Helena's dossier about Achatina can be seen in Figure 2.

Figure 2. Dossier entry on Achatina. Source: *ARK: Survival Evolved* Wiki.

Now let's break that down. First: "very slow, very non-threatening land mollusk" sounds about right, although if Helena was indeed Australian as suggested she would have spelled it 'mollusc' (the 'k' is an American idiosyncrasy, but we prefer it that way). If it is attacked, it retracts into its shell, an obvious and typical behavior of snails.

Second: "meat and chitin". Indeed, several real-world cultures have land snails in their cuisine. But chitin? Well, it's possible, but not easy. Snails do have some chitin in their shell, but that's quite a small amount, especially when compared to arthropods, whose exoskeleton is largely made of the thing. The primary component of snail shells is calcium carbonate ($CaCO^3$). Even so, chitin can be extracted from it with some effort and the right equipment and chemicals (Adeosun et al., 2017; Oyekunle & Omoleye, 2019). Researchers have even extracted chitin from real-world *Achatina* (Gbenebor et al., 2017). Wait a second. Real-world *Achatina*? Don't worry, we'll get to that later on.

Next, there's the whole "Achatina does not defecate normally" thing. *ARK* has a weird fixation with who defecates what and we'll just skip this bit. Snails do poop normally, though. Anyway, Helena says that Achatina "secretes a thick, sticky substance" that dries quickly. That is, of course, slime or mucus. All land snails and slugs produce mucus for locomotion: they actually "glide" on top of it (Fig. 3). The mucus is a mix of chemical substances and can also serve as a defense against predators, microorganisms, and even as a shield against desiccation when the snail is aestivating (Barker, 2001; Cilia & Fratini, 2018).

Figure 3. Snails leave a silvery slime trail in their wake. Source: Wikimedia Commons (snail ho, 2007).

Helena also informs the reader of the in-game use of Achatina's secretions as crafting material ('Organic Polymer' and 'Achatina Paste', a substitute to 'Cementing Paste').[5] Unfortunately, real-world snail mucus cannot be used that way yet, although researchers are trying to get there (Cho et al., 2019).[6] In any event, snail mucus also has other applications. Due to its antimicrobial components, it can be used for cosmetics and skin-care, as well as to treat skin lesions and burns, (Brieva et al., 2008; Tsoutsos et al., 2008). It is even being considered a substitute for surgical glue (Li et al., 2017).

Chitin (and its derivative chitosan) also has several applications in the industry: food, pharmaceuticals, cosmetics, agriculture, textiles, and paper (Hamed et al., 2016). Researchers are also looking at the possibility of using it as a biodegradable substitute for plastic (Fernandez & Ingber, 2014) and also as building material for an eventual colony on Mars (Shiwei et al., 2020).

In *ARK*, Achatina can be domesticated so the players can "farm" the resources it

produces. However, they are not breedable in the game, which is weird given their real-world counterpart (see below). *ARK*'s Achatina can also be a pet and, more importantly, can wear hats!

THE REAL *ACHATINA*

As mentioned above, *Ark*'s giant snails have the "scientific name" *Achatina limusegnis*. As such, it is not a huge leap to conclude that they were based in the real-world *Achatina*.[7]

Achatina is a genus of pulmonate snails. This means that these snails breathe through a lung, instead of the usual gills found in most other molluscs. Lungs have evolved more than once among gastropods, usually in terrestrial taxa[8], rendering the traditional "pulmonate" classification obsolete (albeit sometimes useful) in current taxonomy. However, most lung-bearing snails, including *Achatina* and other iconic species such as the garden snail, are indeed related and gathered in a large group called Stylommatophora.

The Stylommatophora are the most diverse group of land snails, with a whopping 20,000 species total worldwide (Rosenberg, 2014). A distinguishing feature of stylommatophoran snails is having their eyes located on the tip of stalks, in contrast to the position near the base of the tentacles seen on most other gastropods. The eyestalks are also known as ommatophores and are responsible for giving the Stylommatophora their name.

Achatina and its closest relatives are grouped in the family Achatinidae (Fig. 4). This is a very diverse family, including around 1,000 species of many shapes and sizes (MolluscaBase, 2020). The Achatinidae range from the tiny awl snails, some of which are just a few millimeters long, to the gargantuan *Achatina* snails themselves, which include the largest of all land snails with shells growing over 20 cm in length.

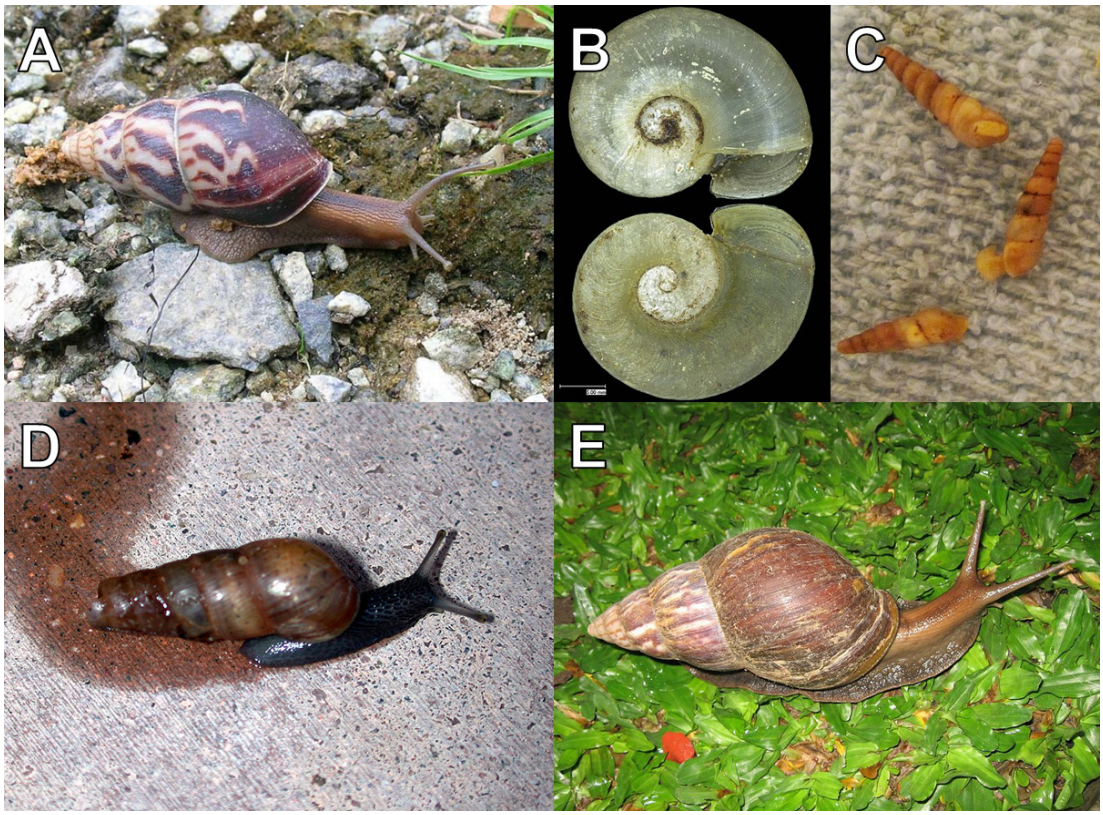

Figure 4. Assorted representatives of Achatinidae. A. *Limicolaria flammea* (Müller, 1774). B. *Thyrophorella thomensis* Greeff, 1882. C. *Subulina octona* (Bruguière, 1789). D. The decollate snail, *Rumina decollata* (Linnaeus, 1758). E. The giant African land snail, *Achatina fulica* (Bodwich, 1822). Source: Wikimedia Commons (A, Siong Kiat Tan, 2011; B, Trochoidea, 2014; C, Invertzoo, 2010; D, Mike, 2007; E, Alexander R. Jenner, 2010).

There are approximately 40 species of *Achatina*, all of which are native to sub-Saharan Africa (Bequaert, 1950; MolluscaBase, 2020). However, some species, such as the infamous *Achatina fulica* (Bodwich, 1822)[9], are highly invasive and are now found in tropical and subtropical areas worldwide. *Achatina fulica* (Figs. 4E, 5) is known by the common name 'giant African land snail'; however, this species is so widespread and well-known that most people are equally comfortable with the scientific name.

Most of the diet of *A. fulica* is composed of vegetable matter of all kinds, including decaying vegetation, fruits, and leaves. In urban areas, it has been observed to eat even paper and cardboard! These snails can also eat meat, often sourced from animal carcasses (including other snails). In more than one instance, *A. fulica* has been reported to attack and consume living leatherleaf slugs (family Veronicellidae), which means they can hunt for meat as well (Meyer et al., 2008).

The invasive nature of *A. fulica* (and, to a lesser extent, other *Achatina* snails) is largely a result of human introductions. This species is native to East Africa and has been introduced to all other continents (except for Antarctica) both intentionally, as a food item or a novelty pet, and accidentally, as the snails can attach themselves to vehicles and survive long travels (CABI, 2020). The results are often disastrous to local ecosystems and crops, as *A. fulica* is capable of consuming hundreds of species of plants. Curiously, grasses, such as sugarcane and maize, suffer little damage from *A. fulica* (Raut & Barker, 2002; CABI, 2020). In addition to this, *A. fulica* adapts quite well to new environments and breeds intensely: a single individual usually lays 100 to 200 eggs at a time, but there are reports of a batch of circa 1,000 eggs (Mead, 1961; Pawson & Chase, 1984). The combination of these characteristics and the ensuing environmental damage led the IUCN[10] to classify *Achatina fulica* as one of the world's top 100 invasive alien species (ISSG, 2003; CABI, 2020).

Beyond the environmental impacts, *A. fulica* is known to carry several parasites. One of them is the nematode *Angiostrongylus cantonensis* (Chen, 1935), which can infect humans and cause severe cases of meningitis. The parasite is usually transmitted by eating the snail, but simply touching it can be enough. Since *A. fulica* is commonly found in urban areas, its invasions prompt a serious public health concern.

Figure 5. A shell of an individual of *Achatina fulica* shown in several different views. The shell is about 7.8 cm in total length and was collected in East Africa. Source: Wikimedia Commons (H. Zell, 2013).

Achatina fulica thus seems to be a poor choice for a pet, but some people like to keep them, arguing they can be quite expressive and fun to interact with. They can live for five to seven years and can grow quite large in captivity: their shells can reach around 20 cm. Given the damage, they can cause to the environment, in many countries it is illegal to keep them as pets. Usual pets (cats and dogs), however, are extremely bad for the environment and are directly responsible for the extinction of dozens of species and still threaten hundreds of others (Medina et al., 2011; Gomper, 2013; Doherty et al., 2016, 2017).

COMPARING THE SNAILS

Clearly, *ARK*'s Achatina was based on *Achatina fulica*. Besides its name, the Wikipedia page of A. fulica is the very first result when you google "giant snail". *ARK*'s Achatina is large for a snail, though, about the

size of a reasonable dog, which is most unfortunately not feasible for real land snails. But other than that, how well does the virtual Achatina compare to its real-world counterpart?

Let's start by taking a look at its external morphology. The shell of *A. fulica* is conical and rather elongated (Fig. 5). While the shell of *ARK*'s snail might look superficially similar, it is not so. It shows a flaw that is a typical mistake of artists when drawing snails: the shell is not spiral (see also Salvador & Cavallari, 2019). Snail shells grow in a spiral manner, with each successive new whorl growing on top of the previous one. While it might be difficult to visualize this just by looking at the photograph of a shell, you can easily see it if you have a shell on hand or by looking at an X-ray image (Fig. 6). *ARK*'s shell (Fig. 2) is like a hollow hood that just sits atop the snail's soft parts like a hat.

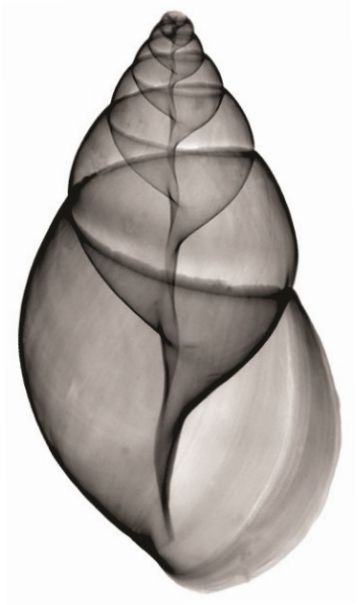

Figure 6. X-ray of the shell, showing its internal structures. Source: Adobe Stock (#376762797).

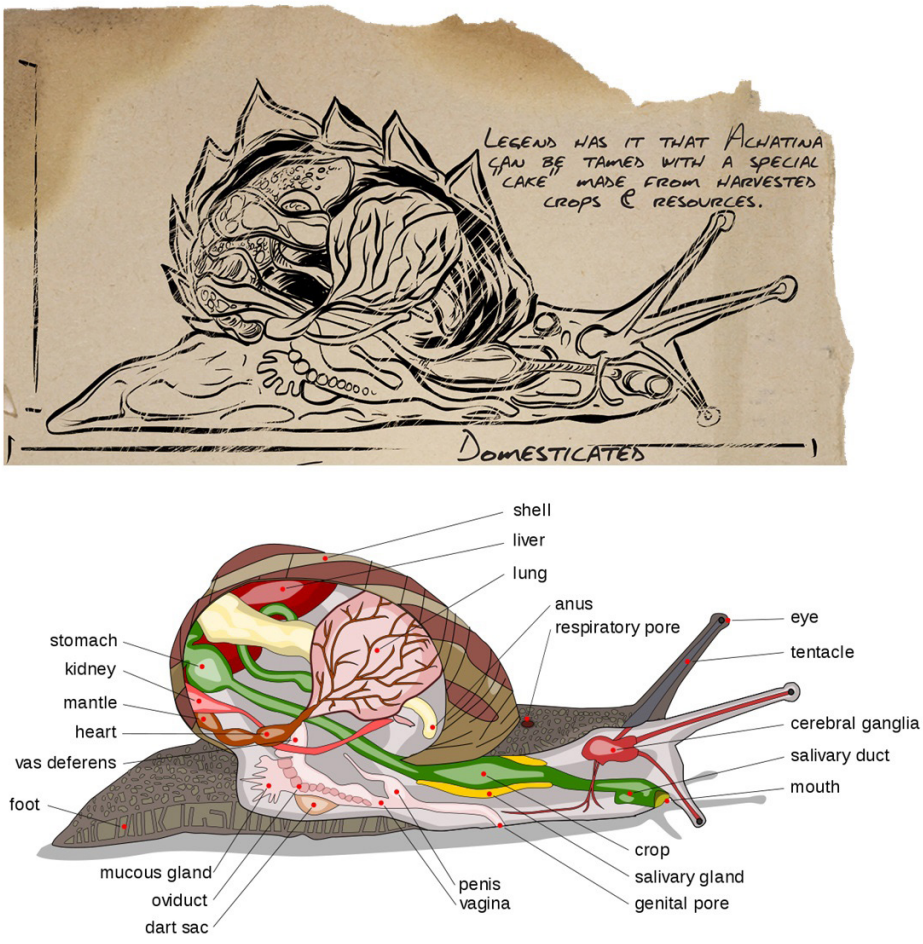

Figure 7. Comparison between the anatomy of *ARK*'s Achatina (above) and a real garden snail, *Cornu aspersum* (O.F. Müller, 1774) (below). *ARK*'s Achatina follows the basic internal anatomy of a snail very closely, but then again, the bottom image was probably the one used to draw *ARK*'s snail. Source: ARK: Survival Evolved Wiki (excerpt from Fig. 2 above); Wikimedia Commons (AI2 & Jeff Dahl, 2007).

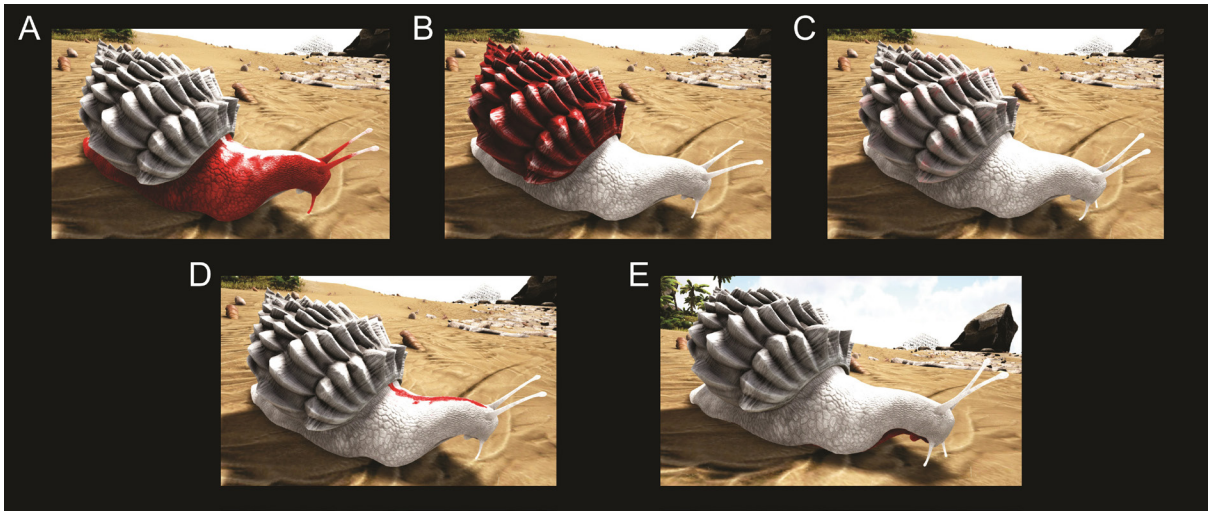

Figure 8. The several colors of Achatina in *ARK*. **A**. Snail from Region 0: red body with a white dorsal stripe and white tips of the ommatophores. **B**. Region 1: red shell. **C**. Region 3: red highlights on shell sculpture. **D**. Region 4: red dorsal stripe. **E**. Region 5: red ventral region. Source: *ARK: Survival Evolved* Wiki.

The soft parts of *ARK*'s snail (except the colors, see below) are spot on (Fig. 2) and were likely drawn based on an actual photograph of *Achatina* (Fig. 4E). It has a pair of eye-bearing stalks (the ommatophores) and a pair of tactile and chemically sensitive tentacles. The skin on the dorsal surface of the snail (on its back, so to speak) is very rugose. But the sole of the snail's foot also seems to be rugose (Fig. 2), which is mistaken. The "sole" of a snail's foot is smooth, which is necessary for adhesion while crawling, especially on vertical surfaces or while hanging upside down.

The internal anatomy of *ARK*'s Achatina (Fig. 7) is also spot on, showing all the organs in the right places. But that is expected, given it was copied from schematics available on Wikimedia Commons (Fig. 7).

BIODIVERSITY ON THE *ARK*

One interesting aspect of *ARK*'s Achatina is that it has five different colors depending on the region of the game (Fig. 8).[11] We shall call these 'color morphs', to use a more biological term.

Typically, when we see two similar snails with different colors they belong to two different species (Fig. 9). However, in *ARK*, all the different color morphs belong to a single species, *Achatina limusegnis*. But is it possible for a single species to have individuals with such varying colors? It turns out it is.

Figure 9. These shells differ in color, size and also a bit in shape. They represent two different species in the same genus. The one on the left belongs to the species *Kora corallina* Simone, 2012 and is about 2 cm tall; the one on the right is *Kora nigra* Simone, 2015, about 3 cm tall. They both live in the savanna-like environments of eastern Brazil. Source: Birckolz et al. (2016).

Take the grove snail *Cepaea nemoralis* (Linnaeus, 1758) from western and central Europe, for instance. It has a wide variety of color morphs: from whitish to yellow, orange, red, and brown, being either of a single color or presenting one or more

dark stripes on the shell (Fig. 10). All these morphs belong to a single, though highly variable, species. Why there are so many different morphs has been hotly debated by scientists since at least the 1950s. Present hypotheses include (1) lighter colors being related to environments with higher temperatures, and (2) the presence of stripes being related to visual protection against predatory birds (Silvertown et al., 2011; Surmacki et al., 2013). Other famous examples of color morphs in land snails include the Cuban painted snail *Polymita picta* (Born, 1778) and the living jewel snail *Liguus fasciatus* (O.F. Müller, 1774) from Florida and Cuba.

Figure 10. Color variation in the grove snail. Source: Helmholtz-Centre for Environmental Research, UFZ (A. Künzelmann, 2011).

The soft parts of the snails can also vary a bit in coloration, which is due to different amounts of pigments on the skin, just like in our species. There are even completely white snails like the ones in *ARK* (Fig. 8), which can be a natural coloration for some species or be "albino" individuals in some cases, like in *A. fulica*.

Now the red color seen in one variety of Achatina in ARK (Fig. 8A) is very unusual among land snails. The most famous example is the Malaysian fire snail *Platymma tweediei* Tomlin, 1938 (Fig. 11), which is a species with very restricted geographic distribution and highly endangered due to deforestation and other human activities. Its heavy metal looks in particular have made it a target for the pet trade, putting the species in even more danger (Foon, 2014).

Figure 11. The Malaysian fire snail has a black and red body pigmentation that seems straight outta the Nine Hells. These photos are courtesy of Azrie Alliamat, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah.

FINAL THOUGHTS

ARK's giant snail has a good bit of reality and a healthy dose of fiction. That is fine, as video games need to have some artistic liberties and not be too strongly anchored in reality. We cannot forgive the wrongly-designed shell, though, because that would be a simple matter to solve and would greatly improve verisimilitude. In any event, it is always good to see underrepresented animal groups in games, as they can help to raise awareness about their real counterparts among players and maybe – just maybe – help create a more environmentally-friendly mindset (Salvador, 2017).

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Image usage

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About the authors

Dr. **Rodrigo B. Salvador** is a biologist specializing in the study of land snails, who – as some would argue – spends way too much time playing video games. He hates survival games but somehow always ends up playing them for a bit. Would that just be an exercise to confirm the hypothesis that he hates the genre?

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Daniel C. Cavallari, MSc., is a biologist and taxonomist specializing in land and marine snails. He is also a passionate shell collector and gamer who loves survival games (especially horror). ARK isn't really a horror game, but he wonders if watching everyone defecate everywhere could be classified as horror.

Notes

[1] The game's name is actually stylized as ΛRK. That's a formatting nightmare, though, so we'll stick to regular letters here.

[2] The Nintendo Switch version has a dismal metascore of 29.

[3] All the in-game information presented here was gathered from the Official *ARK: Survival*

Evolved Wiki.

[4] In Latin, the word 'limus' means 'slime' and 'segnis' means 'slow'.

[5] Another "famous" snail in fiction whose mucus is valuable is the flail snail, from the tabletop RPG Dungeons & Dragons. According to Volo's Guide to Monsters (Wizards of the Coast, 2016: p. 144), a flail snails "leaves behind a shimmering trail that quickly solidifies into a thin layer of a nearly transparent substance [that] can be harvested and cut to form window panes of varying clearness. It can also be heated and spun into glass objects of other sorts. Some humanoids make a living from trailing flail snails to collect this glass."

[6] The authors of that study also have some videos testing how their slimy adhesive can hold heavy loads: https://www.pnas.org/content/116/28/13774

[7] There is a genus closely related to *Achatina* that's called *Archachatina*. That would be a 20% cooler name for a species from *ARK*. If only the game designers had delved a bit more in Wikipedia… Anyway, the prefix 'arch-' means 'chief' or 'principal', like in the words archbishop, archangel, archfiend, etc.

[8] Despite that, some freshwater snails have also evolved lungs, providing a way to obtain oxygen even when they live in low-oxygen waters. An example of this are the apple snails (family Ampullariidae), which are popular aquarium pets.

[9] Sometimes classified as *Lissachatina fulica*, depending on whether *Lissachatina* is considered a subgenus of *Achatina* or a full-blown genus in itself.

[10] International Union for Conservation of Nature.

[11] Excluding the Aberrant and Eerie variants.

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Mary Anning: fossil collector, paleontologist, and heroic spirit

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Portrait of Mary Anning with her dog, Tray; the Golden Cap outcrop is shown in the background. Author unknown, pre-1842; Natural History Museum, London, UK. Source: Wikimedia Commons; public domain.

Mary Anning (1799–1847) was a British fossil collector and self-taught paleontologist who made several important discoveries in the Jurassic rocks around her home in Lyme Regis. Unfortunately, she did not have the acknowledgment in academic circles she deserved during her life. Lately, she has received a bit of the spotlight. First, there is an ongoing movement to build a statue for her. Secondly, there is a movie called *Ammonite* (Lionsgate, 2020) that is a dramatic retelling of her story.

While most paleontologists are happily supportive of the statue-building campaign, the community (and critics) was divided regarding the movie, mostly due to Anning's portrayal as a lesbian.[2] Yep, people still get angry with those sorts of things. Anyway, I will not discuss the movie here, because I'm neither entitled to nor interested in discussing dead scientists' sexuality. Besides, I haven't watched it.

I think, however, that I am in a good position to talk about another representation of Mary Anning in pop culture. As possibly the only – or one of the very few[3] – professional paleontologists invested in the *Fate* franchise,[4] I dedicate this article to discuss Anning's incarnation in *Fate/Grand Order*.

FGO

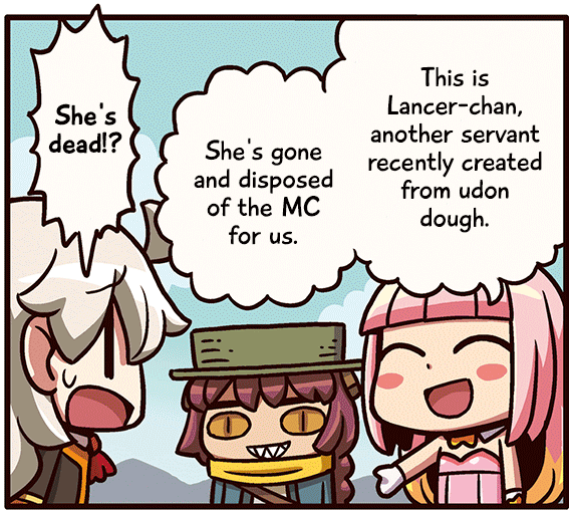
Note that you can (SKIP▶) this section if you play FGO. If you're a normal person, please continue reading for some context.

Fate/Grand Order (henceforth FGO) is a video game developed by Delightworks (mobile version, 2014) and Sega AM2 (arcade version, 2018) and one of the top-grossing games worldwide (SuperData, 2019; Chapple, 2020), even if you've never heard about it, dear reader.

FGO belongs to the *Fate* franchise, which started with the game *Fate/stay night* back in 2004. The franchise revolves around mages fighting for the fabled Holy Grail, summoning heroic spirits to aid them in their quest. The mages are known as 'Masters' and the heroic spirits, as 'Servants'.

Servants come from various places and cultures worldwide. They can be historical figures (e.g., Cleopatra VII and Marie Antoinette), mythological beings (e.g., Herakles and Ereshkigal), or literary characters (e.g., Astolfo and Sherlock Holmes). Unlikely as it may sound, Mary Anning is one of the Servants in FGO – well, sort of.

She is not part of the game (yet[5]) and only appears in a comedy manga about FGO called *Learning with Manga!*[6] That manga initially revolved around explaining the basics of the game in a fun way, with chibi versions of the characters. Later on, however, it developed its plotline (please note that I'm using this term very loosely). *Learning with Manga!* (henceforth LWM) pokes fun at game mechanics and player behavior, also advertising events and (sometimes) merch. The manga series was a success and had a second and third (current) seasons, respectively: *More Learning with Manga!* and *Even More Learning with Manga!* Mary Anning appears in the latter.



In the story of LWM, a group of seven new servants to the franchise was created from the dough used to make udon noodles. Don't ask. Image extracted from Chapter 79 of EMLWM. (Remember this is a manga, so you read it from right to left.)

LANCER

Originally in the *Fate* franchise, the Servants never gave away their true names easily, because that knowledge can impart their opponents with clues about how to defeat them. Just think about Achilles' weak spot, for instance. As such, Servants are referred to by their character class.

You'll likely be familiar with the Dungeons & Dragons character classes, such as Barbarian, Paladin, Rogue, and Wizard; all of which immediately paint a picture in our minds about any given character. The classes in *Fate* include D&D-sounding names (like Assassin and Archer) and also some rather weird choices (like Saber and Rider). In LWM, Mary Anning is introduced as Lancer, the class of spear-wielding heroic spirits.

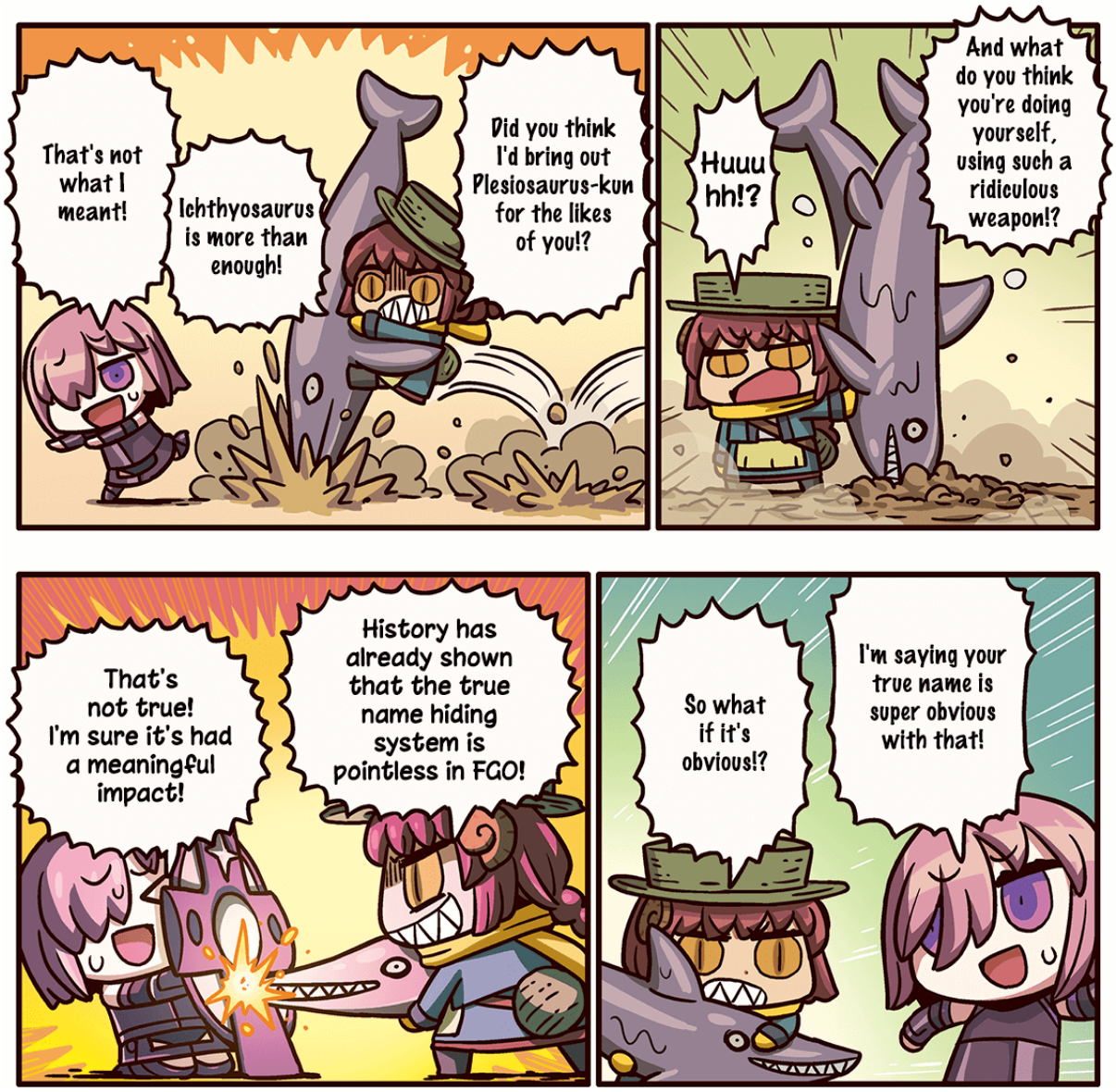
As of writing, Lancer has not yet revealed her true name in the manga, but it is pretty obvious that she is Mary Anning. This has already been observed by best kouhai Mash Kyrielight.

Her identity is easy to figure out due to the abundance of clues: the ichthyosaur, the plesiosaur, the ammonite hairpins, the geological hammer, the basket for putting fossils, and even her clothes. Not to mention her dog, Tray.

In reality, we didn't even need all those clues. Just look at her portrait in FGO/LWM. It is the same as her "official" portrait shown at the beginning of this article. So, true name or not, no questions regarding her identity remain.

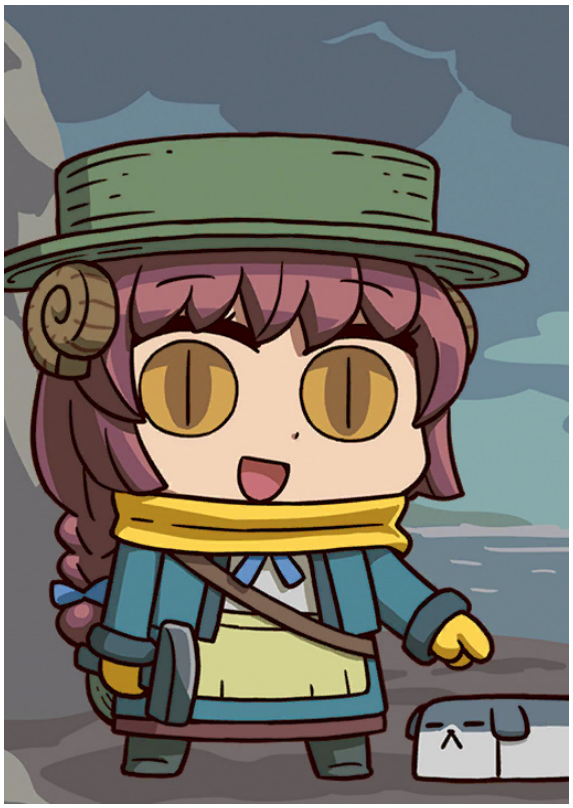
THE PRINCESS OF PALEONTOLOGY

But who was Mary Anning anyway to be dubbed the Princess of Paleontology by later authors (e.g., Tickell, 1999; Huntington, 2005)? And while we're at it, why princess and not queen? Anyway, let us take a look at who she was to understand all the tidbits that made their way into FGO/LWM.



Lancer doesn't care whether Mash knows who she is. Image extracted from Chapter 104 of EMLWM.

Can you pet the dog in FGO? Nope, Lancer-chan won't let you. Image extracted from Chapter 102 of EMLWM.



This looks familiar… Image extracted from Fate/Grand Order Wikia.

Anning was born in 1799, in Lyme Regis, county of Dorset, southern England. When she was still 14 months old, Mary was part of a group of four people sheltering from the rain under a tree. The tree was struck by lightning and only Mary survived (Torrens, 1995; Cadbury, 2000). She then grew up to become The Flash, the hero of Central City— oh, wait a sec, I'm mixing things up. Anyway, her family said that Mary became a healthy and curious child after that incident and that the lightning bolt had sparked her intelligence (Torrens, 1995; Emling, 2009). Fittingly, Anning has an electricity-based attack in LWM.

Mary's father, Richard, was a carpenter, but he also collected fossils from the Jurassic sediments in the cliffs around Dorset for selling to visitors. Lyme Regis was then a summer vacation spot for royals and the rich (Norman, 1999). Richard died young, at age 44, but Mary and her only surviving sibling, Joseph, as well as their mother Molly, had been well-instructed in fossil collecting. Mary was exceptionally good at finding fossils, assembling the skeletons, and analyzing them, as time would show.

When Mary was around 10 to 12 years old, she and her brother unearthed a skeleton of an ichthyosaur (Torrens, 1995; Davis, 2009). The Anning siblings' fossil was the first of those animals ever brought to light; it was described by a surgeon called Everard Home (Home, 1814). But the fossil species remained unnamed, because, at that time, scientists didn't know what it was; opinion were divided between crocodile and fish. (If you want to learn more about the fossils, make sure to check the Appendix at the end of this article.)

The "crocodile-fish" fossil was a success among British paleontologists and Mary and her family started to become recognized fossil hunters during the 1810s (Torrens, 1995). The ichthyosaur got its official name in 1817 (meaning "fish-lizard) and was later to be deployed as Anning's main weapon in LWM.

A few years later, another of the Annings' important finds was described: a plesiosaur (meaning "near-lizard"; De la Beche & Conybeare, 1821). The fossil was so weird, that at first people thought it was a forgery, made up of mixed bones (Rudwick, 1985). When it was finally confirmed that the plesiosaur fossil was real, Mary's reputation as a fossil hunter became established. Furthermore, that fossil defined what's possibly Anning's Noble Phantasm in LWM.

Lapras uses Ice Beam— oops, wrong game. Image extracted from Chapter 169 of EMLWM.

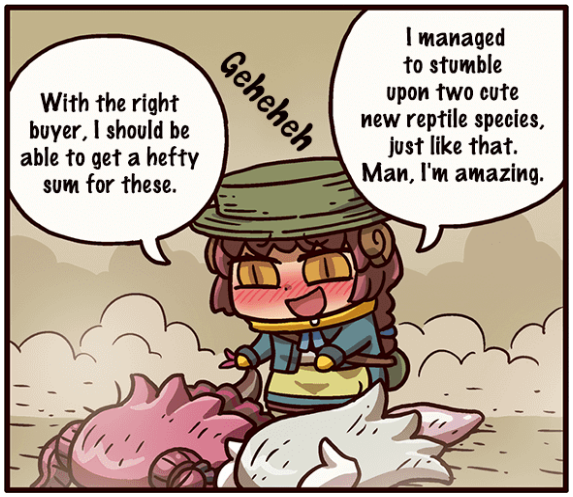
Thor's mighty geological hammer in action. Image extracted from Chapter 94 of EMLWM.

The Annings had some rough times, though, and struggled to make enough money. By 1825, Mary had taken over the fossil business from her mother and brother, and people started coming to Lyme Regis to meet her (Torrens, 1995). Contemporaneous accounts mentioned how Anning was striving to make her way into male-dominated science.

In 1828, Mary made her first discovery on the invertebrate (and coolest) side of the animal kingdom: she found vestiges of an ink sac in belemnites (Buckland, 1829a, 1836). Up to that point, no one was sure what belemnites were and Mary's discovery showed they were cephalopods, related to present-day squids. Reportedly, the fossilized ink sac even had enough ink remaining to use as paint (Buckland, 1829).

This clearly shows how far her knowledge of paleontology went. Anning claimed she was illiterate, but that was not the case, as anyone reading her letters can easily recognize. Besides, she even learned French by herself to read the natural history treatises authored by Georges Cuvier (Tickell, 1999). Another important thing to consider is that Anning was born just a few years after deep

time had been discovered. That means that geologists had just realized that the Earth was way older than the 6,000 years or so supposed by the Church, and that creatures with no living equivalents existed in the past but became extinct. In the British countryside, however, the Bible was still the "law" (McGowan, 2002), so it is even more amazing how Anning, despite that pastoral backdrop, taught herself cutting-edge paleontology. And what's more, she taught herself to such a degree as to be considered the most knowledgeable paleontologist in Britain (Tickell, 1999).



Mary Anning discovered several important fossil species of reptiles during her career, including some SSR ones. She was also a saleswoman and sold the fossils to other researchers and collectors. Image extracted from Chapter 137 of EMLWM.

Still in 1828, Mary made other important findings. First, she showed how coprolites were fossilized animal feces. Yes, that's an odd bit of paleontology, I agree; but hey, it still counts as a discovery. And she found a pterosaur – and that was big news. Pterosaurs were already known from Germany since the previous century, but Buckland (1829b) described Mary's fossil in a very generous manner, to say the least: "a monster resembling nothing that has ever been seen or heard-of upon earth, excepting the dragons of romance and heraldry." It was a different genus from the German fossils, at least.

In 1829, Mary made her only visit to London, staying over at the Murchinsons: the geologist Roderick Murchinson and his wife Charlotte, of whom Mary became a friend.[7] That year she also discovered an important fossil of a chimaerid cartilaginous fish (*Squaloraja*). And on the following years, more ichthyosaurs and plesiosaurs, making her even more renowned; she began to attract international visitors as well, including King Georg of Saxony. By that time, she also started to be known as "princess of Paleontology" or "geological lioness" (Torrens, 1995; Davis, 2009) – or even more dramatically as the "Helen [of Troy] to the geologists" (Roberts,[8] 1834).

However, as things started to get better and she was finally being recognized and more widely accepted in the male-dominated British academy, she was diagnosed with breast cancer, dying, aged 47, in 1847.

Painting by Rev. George Ernest Howman (1829) of Buckland's "flying dragon" in Lyme Regis. This has been considered a naïve attempt of reconstructing past life (Martill, 2014). But because it was made by a priest, it could have been meant to poke fun at paleontologists' "stupid ideas" that flew in the Bible's face.

A BIT BERSERK?

In FGO/LWM, Mary Anning is said to have an abiding love of women and a murderous attitude (Fate/Grand Order Wikia, 2021). The former is shown by Anning being smitten with Artoria at first sight in the manga. That comes as no surprise, as we all know that LWM is a huge Yuri Singularity. As I mentioned above regarding *Ammonite*, many people who have nothing better to do complained about Anning's portrayal as a lesbian in the movie. Thankfully, they don't

play FGO, so we don't need to listen to their drivel here.

Finders, keepers. Just like with fossils? Image extracted from Chapter 102 of EMLWM.

But where does the "murderous attitude" come from? I suppose it's all anger towards the bunch of self-important old British dudes, who knew less than her about fossils but still denied her a place in academia just because she was a woman. That was in the mid-19th century, of course; today, the old dudes in academia are… pretty much the same, really.

Despite all the fossils she found and collected, the scientific publications describing and discussing them were all done by those old dudes.[9] What's more, she got scarce to no acknowledgement as the discoverer of the fossils (Dickens, 1865; Torrens, 1995; McGowan, 2002). The species she discovered were all named in honor of those men who bought the fossil from her.[10] That left her exasperated; so, understandably, her Servant incarnation would want to make use of her newfound powers. Maybe she would be better as a Berserker, like her compatriot (and equally fantastic scientist) Florence Nightingale.[11] In LWM, however, the Berserker role was already taken by Paul Bunyan.

Taphonomy is the science that studies how organisms become fossilized. Image extracted from Chapter 94 of EMLWM.

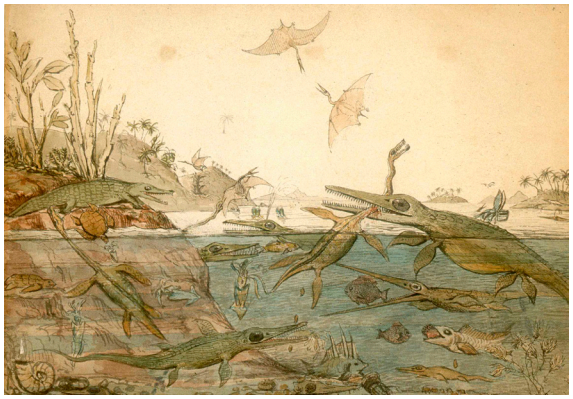
Anning's efforts and expertise, surprisingly, were better acknowledged outside the UK (Dickens, 1865). At home – and with a few exceptions aside – she had less recognition (Roberts, 1834; Dickens, 1865; Forde, 1925). Almost two decades after her death, Charles Dickens[12] wrote about Anning's life, remarking the lines on her memorial at Lyme Regis about her "usefulness in furthering the science of geology" (Dickens, 1865). Dickens then argued that geology was barely a science before Anning's discoveries and that she was one of the people who turned it into a proper science. (Yes, it's a bit of an exaggeration, I agree, but it's a good one, so let's leave it at that).

Since then, many articles and books were written about her. Granted, the majority of those is made up of children's books and heavily romanticized stories, as there was already a myth forming around her during her lifetime – a fact that makes her even more suited to be a Servant in FGO. Nowadays, Anning has justly become a textbook role model for those who want to pursue their interest in science, especially for young girls (Davis, 2009).[13]

FINAL THOUGHTS

If there are any lessons to be learned here, one would be that academia still has a long way to go until it becomes more inclusive and makes up for all the coprolites in its past. Secondly, it's clear that LWM has a far superior story to regular FGO (not considering special events, of course) and some of its servants are way more interesting characters than the typical yet-another-samurai/ninja/Artoria we usually get in the main game. We definitely need more sciency Servants!

Finally, most people will turn their noses up at FGO, considering games to be below their academic attention. But I argue, as I've done before (Salvador, 2020), that games such as FGO can serve as a starting point for players to look for more information about their favorite characters – and to learn a good deal in the process. If that's not a good platform for science outreach, then I don't know what is. And if that's true and you're interested in reading more about Anning – and my article fell short of your expectations – fear not! There are some good biographies out there that you might want to check out: Pierce (2006), Emling (2009), and Sharpe (2020).



Duria Antiquior – A more Ancient Dorset, by H. De La Beche (1830). This watercolor is a reconstruction of the Jurassic environment at Dorset based on all the discoveries of Mary Anning. It became the basis of several other paleontological reconstructions and satire later on.

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Data and Credits

Many Anning (Lancer) is featured in the following *Even More Learning with Manga!* chapters: 77, 79, 85, 90, 94, 102, 104, 105, 112, 114, 117, 119, 121, 122, 132, 137, 144, 157, 166, 169.

The images from *Even More Learning with Manga!* used herein were extracted from Fate Grand Order Wiki - GamePress (https://gamepress.gg/grandorder/). Given that there is no official translation of those chapters yet – and my Japanese skills are useless to read anything more complex than the kids' menu – I'm relying on the translation by TFO Scans.

Acknowledgements

Many thanks to João Vitor Tomotani, who stopped farming during the Beni-Enma event for a while to compile the list of chapters where Lancer appears.

About the author

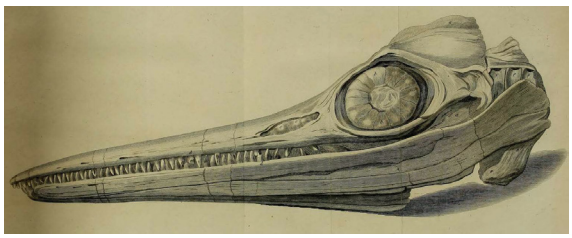
Dr. **Rodrigo Salvador** is a paleontologist who studies the evolution of land snails. He would like Mary Anning to become a playable character in FGO, but he also knows he would never get her from a gacha roll – he couldn't pull any Servant he wants if his life depended on it. Rate up is a lie!

APPENDIX: SSR FOSSILS

Mary Anning discovered several important fossils during her career. In the gacha system of fossil outcrops, she managed to pull some amazing SSR specimens, so let's take a look at them. And no, I haven't made a tier list; the fossils are listed here in the same order as they were mentioned in the main text.

Ichthyosaur

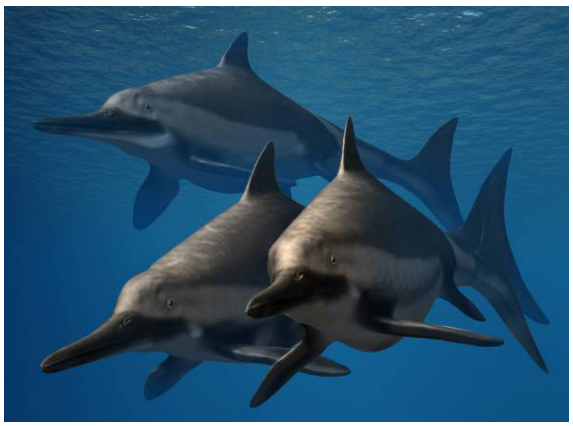
That first ichthyosaur skeleton discovered by the Annings (the one described by Home in 1814) was later deemed to belong to the species *Temnodontosaurus platyodon* (Conybeare, 1822). Other of Mary's findings belonged to the species *Ichthyosaurus communis* De la Beche & Conybeare, 1822.



The skull of *Temnodontosaurus platyodon* found by the Annings (Natural History Museum, London) and the illustration from Home (1814).

Ichthyosaurs (Order Ichthyosauria) were marine reptiles. They were completely unrelated to dinosaurs, by the way, although their actual position within the tree of life remains contentious. There are around 50 genera of ichthyosaurs known (Maisch, 2010) and they lived during the Mesozoic Era, from roughly 250 to 90 Ma (millions of years ago). Anning's fossils date from the

Early Jurassic, circa 200 to 175 Ma. When alive, these animals could range from 1 to 15 m in length, and – broadly speaking – would have lived pretty much like dolphins (Dick & Maxwell, 2015).



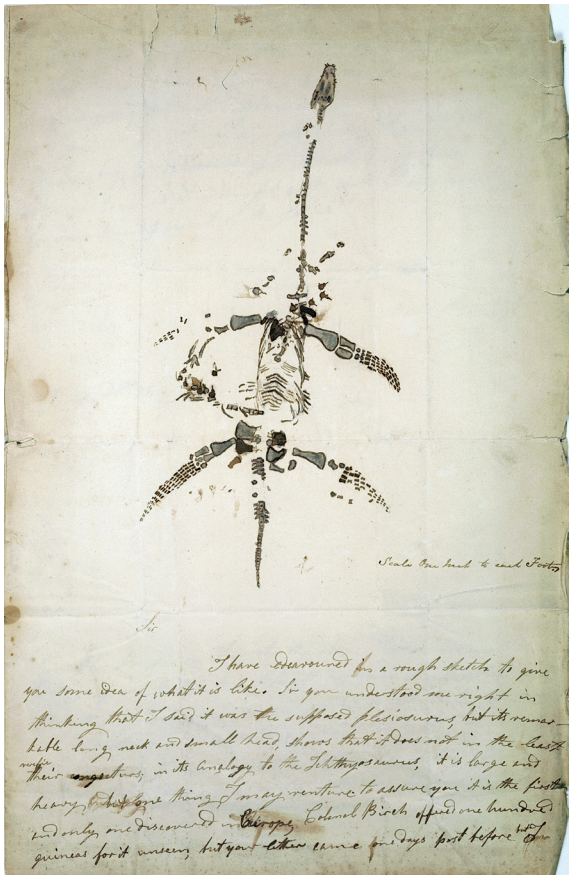
In artistic interpretations, ichthyosaurs even look almost as silly as dolphins. Life reconstruction of *Ichthyosaurus anningae*, by N. Tamura (2016); extracted from Wikimedia Commons.

To my knowledge, however, the possibility of using ichthyosaurs as lances has not been empirically verified by any paleontologist.

Plesiosaur

The plesiosaur was considered to be Anning's greatest discovery by her contemporaries. The genus *Plesiosaurus* was first described by De la Beche & Conybeare (1821), but the species was only named a few years later: *Plesiosaurus dolichodeirus* Conybeare, 1824.

Plesiosaurs (Order Plesiosauria) were marine reptiles as well, but not closely related to ichthyosaurs – nor to dinosaurs, for that matter. They lived all around the world from the Late Triassic to the end of Cretaceous (roughly 204 to 65 Ma) and died out in the same extinction event that wiped out all non-avian dinosaurs (the so-called K–Pg extinction event). Most plesiosaurs species had long necks and powerful flippers and some species could reach 15 meters in length. They were carnivorous: some were apex predators, but others specialized in smaller prey. However, no one is sure what sort of pressure could have selected for such long necks (Troelsen et al., 2019). The short-necked members of the group are generally called pliosaurs; while they have typically been considered a separate suborder of Plesiosauria, there might be more to their evolutionary history than that simple division (O'Keefe, 2002).



Letter from Anning (1823) about the discovery of a nearly complete skeleton of *Plesiosaurus*, later named *Plesiosaurus dolichodeirus* by Conybeare (1824).

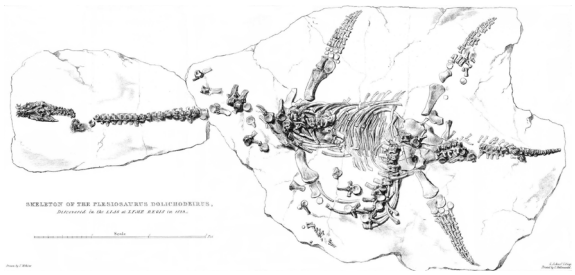


Illustration of *Plesiosaurus dolichodeirus*; from Conybeare (1824).

Belemnites

As mentioned above, Anning discovered a fossil belemnite with a vestige of an ink sac, thus determining they were cephalopod mollusks. Class Cephalopoda, in the Phylum Mollusca, contains squids, octopuses, cuttlefish, and nautiluses, as well as the also-extinct ammonoids (or ammonites); all of them are marine animals. Belemnites lived from the Late Triassic to the end of the Cretaceous (roughly 240 to 65 Ma), becoming extinct in the K–Pg event. Ammonites were also a causality of that event.

Belemnites were rather squid-like in appearance but had an internal bullet-shaped shell. That shell is what is typically preserved as fossils, although some specimens (like Mary's) can retain vestiges of their soft bodies too. Belemnites would have lived from littoral areas to the outer continental shelf, preying upon crustaceans and fish, as well as other cephalopods (Hoffmann & Stevens, 2019).

The belemnite *Passaloteuthis bisulcata* (de Blainville, 1827), showing the conical shell (to the right), as well as parts of its squid-like soft body, such as the spike-bearing arms (to the left). From the Jurassic sediments of Ohmden, Germany; extracted from Wikimedia Commons (Ra'ike, 2008).

Shell, in two views, of *Passaloteuthis bisulcata*; courtesy of the Muséum national d'Histoire naturelle, Paris.

On a side note, ammonites have external shells, just like present-day nautiluses. There is a variety of ammonite species in Lyme Regis and undoubtedly Anning would have come across tons of them. But they are otherwise well-known mollusks and would not have made headlines like the reptiles and the belemnites did. It's still cool, though, that Anning has ammonite hairpins in LWM.

Fossil of *Asteroceras obtusum* Sowerby, 1817 from Lyme Regis; courtesy of the Yale Peabody Museum of Natural History.

Coprolites

Anning was likely the first one to notice (perhaps around 1824) that the so-called "bezoar stones" found in the abdomen of fossil ichthyosaurs were fossilized feces. She noted that if you split one of those stones up, you'd find fragments of the prey items that the ichthyosaur had eaten, such as fish bones. The official scientific acknowledgement of this find was published by Buckland (1829c). The name coprolite is – and I kid not – Greek for "dung-stone".

Despite all the jokes one can make about this topic, coprolites can be very important in paleontological research. That's because they tell us a lot about the diet and behavior of extinct animals; information that we would not necessarily be able to figure out otherwise.

Whodunnit? – Coprolite version. Believe it or not, this image was extracted (and cropped) from an actual scientific article: Dentzien-Dias et al. (2018). The fossils are from the Miocene (roughly 11.5 to 5.3 Ma) of Venezuela.

Pterosaurs

The pterosaur discovered by Mary is called *Dimorphodon macronyx* (Buckland, 1829) and, contrary to the painting by Reverend Howman above, it was raven-sized. Pterosaurs, like others above, lived during the Mesozoic (roughly 230 to 65 Ma) but died in the K–Pg extinction event. But contrary to the ichthyosaurs and plesiosaurs, pterosaurs (Order Pterosauria) are indeed closely related to dinosaurs, although they are not dinosaurs themselves. Recently, it was discovered that animals of the family Lagerpetonidae, previously thought to be an early offshoot of the dinosaur tree, might instead be immediately related to pterosaurs (Ezcurra et al., 2020).

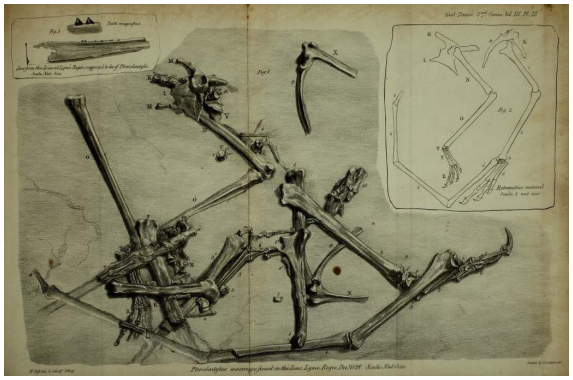


Illustration of *Dimorphodon macronyx* from Buckland (1829b).

There are a little over a hundred pterosaur species know. They were active animals that could go from very small (about 25 cm wingspan) to surprisingly large (about 11 m wingspan) (Witton & Habib, 2010). Pterosaurs were covered by feather-like structures called pycnofibers that may have the same origin as bird (and dino) feathers (Yang et al., 2019). Finally, despite the prevalent view that they all fed on fish, many species had other habits, from terrestrial carnivores to omnivores or specialized insectivores (Hone et al., 2017).

Life reconstruction of *Dimorphodon macronyx* by M.P. Witton; extracted from Witton (2015).

It would be great if LWM's Anning had some pterosaur themes to her character as well. Unfortunately, that idea was already taken (read: wasted) in FGO by Quetzalcoatl for no reason other than the fact that one pterosaur genus was named *Quetzalcoatlus* in honor of that Aztec god.

Notes

[1] Find out more (and contribute!) here: https://www.crowdfunder.co.uk/maryanningrocks

[2] If you're interested, you can start delving in that huge discussion by reading the pieces by BBC News (2019), Herridge & Sykes (2019), and Black (2020). They are all listed in the References section below.

[3] If you're another one, kindly send me a note – and also your User ID so I can add you to my Friend List!

[4] I already wrote a rather long article about the Egyptian characters in FGO: Salvador (2020), listed in the References section below.

[5] One can hope.

[6] Written and illustrated by Riyo, published by Kadokawa Shoten and Aniplex of America (2015–ongoing).

[7] In *Ammonite*, Charlotte is Mary's romantic interest.

[8] I suspect this poor fellow was friendzoned.

[9] Anning only managed to publish a single academic article in her life, which was a letter to the editor of the Journal of Natural History (then Magazine of Natural History) questioning one of their published articles about a fossil shark (Anning, 1839).

[10] Mary Anning finally got an ichthyosaur species named after her in 2015. Yes, you read that right, two centuries late. *Ichthyosaurus anningae*, from Dorset, was described by Lomax & Massare (2015).

[11] That's right, she's a servant too and I promise to write about her later on. I know I had already promised that when I wrote about *Assassin's Creed Syndicate* (Salvador, 2019). I'm getting there, alright?

[12] Come on, DW, we've only got Shakespeare and Andersen right now representing Western literature. Dickens Servant when? Not to mention the brothers Grimm, Edgar A. Poe… We haven't even got Homer, for Zeus' sake, despite all the recent focus on Greece.

[13] Many other (scarcely recognized) women were contributing to the budding sciences of geology and paleontology at that time. They are not fossil-wielding servants, so I won't write about them here. But you can check, for instance, Burek & Higgs (2007) and Vincent (2009).

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Using *How to Train Your Dragon* to teach about endangered species, the scientific method, and popularization of science

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How to Train Your Dragon (2010) is one of DreamWorks' most famous movies and is set on the fictional Berk, a place where fighting between Vikings and dragons is pretty common. The movie focuses on Hiccup, a teenage Viking, who despite being rather clumsy, is willing to defeat his first dragon. He ends up eventually capturing one of the most powerful dragons known: a Night Fury (nicknamed Toothless during the plot).

Movie poster. Image extracted from IMDb.

After capturing the dragon – and not feeling right about it – Hiccup chooses to free it and a friendship between the two is formed. Hiccup then finds himself in a dilemma: to face a dragon and make the other Vikings (including his father, Stoick the Vast, leader of the village of Berk) proud or to convince them that dragons are not as dangerous as they think and that it is possible to live in harmony with them.

Well, as it is not my intention to give bigger spoilers, I think it is better to go for what really matters: how the movie can help people understand the need to protect endangered species, how the scientific method works, and the importance of popularization of science. Each of these topics will now be discussed in more detail.

PROTECTING ENDANGERED SPECIES

If dragons were classified according to their extinction risk (just as real species are classified by the International Union for Conservation of Nature, IUCN, for example), Night Furies would surely be classified as 'Threatened'. Widely hunted in the past, Toothless is one of the few remaining individuals of the species.

Even though behavioral comparisons between Toothless and cats are common on the Internet, a large part of the franchise's fan-

base believes Night Furies were inspired, at least partially, by axolotls, *Ambystoma mexicanum*. Those are salamanders (amphibians) known for not undergoing full metamorphosis process and for their capacity for regeneration. Axolotls are classified as 'Critically Endangered' (the highest level of threat) by IUCN mainly because they suffer from invasive species and diseases and their habitat is seriously degraded by residential development, tourism activities and pollution (IUCN SSC Amphibian Specialist Group, 2020).

An axolotl. Image extracted from Wikimedia Commons (Faldrian, 2013).

Some of the main similarities between Toothless and axolotls are the physical form, and the presence of certain structures close to the head (equivalent to the axolotl gills). The coloring, in turn, also deserves to be highlighted. While Toothless has an entirely black body, a female of the species introduced in the third movie of the franchise is completely white. The colors of axolotls, however, are quite variable, although black and white are common. Unfortunately, Toothless does not have the regenerating power of axolotls (but, to compensate, it does have scales and can fly). Perhaps we can all learn from Hiccup about protecting endangered species, as one of the things he is concerned throughout the movie is protecting his new friend from the other Vikings.

It is also worth mentioning that DreamWorks has already participated in conservation campaigns of the World Wildlife Fund for Nature (WWF) and WildAid using some of its characters (for an example, see WildAid, 2019). Using characters that are popular among the public not only increases the visibility of those campaigns, but also makes the target species better known to the society. So why not use Toothless to draw attention to the conservation of axolotls? Even if Toothless was not really inspired by axolotls, since the public already made the association, there would be no reason not to help the conservation of that species.

THE SCIENTIFIC METHOD

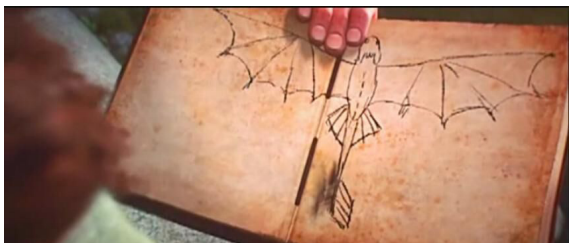
The rational and objective methodology used by scientists to acquire knowledge is what is called the scientific method. Its main steps are the observation (of certain fact), the proposal of a question (related to the problem), the formulation of a hypothesis (a proposed explanation), the experiment to test the hypothesis, and the conclusion/result signaling whether the hypothesis is objectively true or not (Popper, 1959). But what does this have to do with the movie?

Well, Hiccup, in addition to being an endangered species protector, seems to be a scientist using the scientific method to learn more about the biology, ecology, and behavior of dragons. It is exactly by watching his friend Toothless and testing some hypotheses with other dragons that Hiccup learns, among other things, that dragons do not like eels and love some types of grass. The movie provides, thus, an excellent visualization of how the scientific methods works, something that can be difficult to explain theoretically, functioning as a teaching tool that could be useful for teachers and researchers when communicating science.

THE IMPORTANCE OF POPULARIZING SCIENCE

Popularization of science can be understood as bringing the science to the public, that is, the dissemination of scientific knowledge. In a world where conflicts be-

tween Vikings and dragons are frequent, Hiccup believes that if he shows what he has discovered (or, in other words, if he popularizes science), he may end up saving the dragons. Nonetheless, convincing his friends will be infinitely easier than convincing his father that dragons are kind but misunderstood creatures.



Hiccup's sketch of the Night Fury. Screen capture from the movie; © DreamWorks.

Science communication is becoming increasingly important, since scientists from all over the world have understood that knowledge should not only remain in academic circles but permeate throughout society (Feliú-Mójer, 2015). The movie, in this way, can act as an inspiration for such professionals.

CONCLUSIONS

How to Train Your Dragon proves to be an excellent learning opportunity from which everyone can benefit. Helping to understand the need to protect endangered species, how the scientific method works, and the importance of popularizing science is just a part of its potential, which could also include, for example, historical aspects regarding Vikings and cultural aspects concerning mythological creatures.

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About the author

Matheus Drago is an environmental scientist whose research focuses on the conservation of endangered species. He is extremely interested in science popularization and *How to Train Your Dragon* is one of his favorite animated movies.